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Lastly, we also remember with sadness our colleague, Tayfur Altiok, who designed the simulation models, and led his students on the streets of Lower Manhattan, estimating the nature and size of the enterprises on the streets to be modeled. Tayfur passed away before this project could be completed, but his spirit is with us this report.

Stephen Hora, CREATE
Brian Jenkins, MTI
Fred Roberts, CCICADA
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<td>Labor Sector of the Regional Economy</td>
</tr>
<tr>
<td>LA</td>
<td>Los Angeles</td>
</tr>
<tr>
<td>LM</td>
<td>Lower Manhattan</td>
</tr>
<tr>
<td>LMSI</td>
<td>Lower Manhattan Security Initiative</td>
</tr>
<tr>
<td>MATLAB</td>
<td>Matrix Laboratory</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>--------------</td>
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<tr>
<td>MIG</td>
<td>Minnesota IMPLAN Group</td>
</tr>
<tr>
<td>MNY</td>
<td>Metropolitan New York Area</td>
</tr>
<tr>
<td>MOND</td>
<td>Other Non-Durable Manufacturing</td>
</tr>
<tr>
<td>MSEM</td>
<td>Electronics Sector of Regional Economy</td>
</tr>
<tr>
<td>MPI</td>
<td>Message Passing Interface</td>
</tr>
<tr>
<td>MTI</td>
<td>Mineta Transportation Institute</td>
</tr>
<tr>
<td>NAICS</td>
<td>North American Industrial Classification</td>
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<tr>
<td>NFL</td>
<td>National Football League</td>
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<tr>
<td>NCTC</td>
<td>National Counterterrorism Center</td>
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<tr>
<td>NTSCOE</td>
<td>National Transportation Security Center of Excellence</td>
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<tr>
<td>NJ OHSP</td>
<td>New Jersey Office of Homeland Security and Preparedness</td>
</tr>
<tr>
<td>NY-NJ-PA</td>
<td>New York, New Jersey, Pennsylvania</td>
</tr>
<tr>
<td>NYPD</td>
<td>New York Police Department</td>
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<tr>
<td>NYC</td>
<td>New York City</td>
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<tr>
<td>NYCGE</td>
<td>New York Computable General Equilibrium Model</td>
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<tr>
<td>NYSE</td>
<td>New York Stock Exchange</td>
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<tr>
<td>OBSV</td>
<td>Other Business Services</td>
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<tr>
<td>OEM</td>
<td>Office of Emergency Management</td>
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<tr>
<td>O&amp;M</td>
<td>Operating and Maintenance</td>
</tr>
<tr>
<td>OUP</td>
<td>Office of University Programs</td>
</tr>
<tr>
<td>PANYNJ</td>
<td>Port Authority of New York and New Jersey</td>
</tr>
<tr>
<td>PATH</td>
<td>Port Authority Trans-Hudson</td>
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<tr>
<td>PELE</td>
<td>Electricity Sector of the Regional Economy</td>
</tr>
<tr>
<td>PIE</td>
<td>Precision Information Environment</td>
</tr>
<tr>
<td>PNNL</td>
<td>Pacific Northwest National Laboratories</td>
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<tr>
<td>RDD</td>
<td>Radiation dispersal device, “dirty bomb”</td>
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<tr>
<td>RITA</td>
<td>Research and Innovative Technology Administration</td>
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<tr>
<td>ROC</td>
<td>Rank Order Centroid weights</td>
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<tr>
<td>PRG</td>
<td>Rudder Property Group</td>
</tr>
<tr>
<td>SAM</td>
<td>Social Accounting Matrix</td>
</tr>
<tr>
<td>SME</td>
<td>Subject Matter Expert</td>
</tr>
<tr>
<td>START</td>
<td>National Consortium for the Study of Terrorism and Responses to Terrorism</td>
</tr>
<tr>
<td>TTP</td>
<td>Tehrik-e Taliban Pakistan</td>
</tr>
<tr>
<td>UCASS</td>
<td>Urban Commerce and Security Study</td>
</tr>
<tr>
<td>USBEA</td>
<td>United States Bureau of Economic Analysis</td>
</tr>
<tr>
<td>US DOT</td>
<td>United States Department of Transportation</td>
</tr>
<tr>
<td>VBA</td>
<td>Visual Basic for Applications</td>
</tr>
<tr>
<td>VSL</td>
<td>Value of a Statistical Life</td>
</tr>
<tr>
<td>WITS</td>
<td>Worldwide Incident Tracking System</td>
</tr>
<tr>
<td>WTC</td>
<td>World Trade Center</td>
</tr>
<tr>
<td>WTP</td>
<td>Willingness to Pay</td>
</tr>
<tr>
<td>YOA</td>
<td>Year Old Adults</td>
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</tbody>
</table>
EXECUTIVE SUMMARY

The Problem and the Approach

People often perceive a conflict between freedom of economic activity and security against threats to society. But are the goals of enhanced economic activity and increased security necessarily in conflict? That is the question underlying the Urban Commerce and Security Study (UCASS), sponsored by the Department of Homeland Security Office of University Programs and involving a unique partnership of three DHS university centers of excellence. The problem that motivated the UCASS study arose from the rebuilding of the World Trade Center. Two seemingly opposing forces dictate activities around the new WTC site and, more generally, Lower Manhattan: the need to deploy security measures to deter, prevent, or reduce the occurrence and impact of future terrorist attacks; and the desire to enhance commerce and economic activity. Related problems arise in almost every situation involving security. However, rarely do (or even can) the authorities take into account the potential economic impact of their actions, whether to prevent an incident or to respond to it. While such accounting would most likely not be practical or appropriate during an incident, it would be appropriate to understand the relationship between security and commerce in the context of strategic planning.

This report describes the UCASS study, the project’s interactions with stakeholders in Lower Manhattan and the economic modeling and computer simulation modeling that resulted. It describes a decision support tool that planners and decision makers can use to make choices about security initiatives by assessing relevant costs and benefits of various combinations of security measures and policies, including estimates of the behavioral responses to those security measures and policies by the affected individuals. The report summarizes the key components of the UCASS study, how they integrate, and the results obtained by pilot instantiations of the decision support tool. The report also describes potential applications and limitations of the tool.

This study concentrates on security and commerce in Lower Manhattan, as a concrete application area. The long-run goal is to develop a methodology applicable also to other urban areas. It appears that the methodology can also apply to a wide variety of other types of venues and problem areas in homeland security. The methodology is exhibited through pilot models and software tools and illustrated with realistic data. It is important to emphasize that the problems
that UCASS addresses are complex, and many of the data required for modeling are subjective and therefore subject to considerable uncertainty. Because of these facts, the specific numerical estimates presented in this report are not as important as the methodologies and concepts. Moreover, the tools presented are intended for strategic planning purposes, and are not expected to be utilized by first responders in the midst of an event.

The UCASS project has been a unique effort by three DHS university centers of excellence to address the fundamentally multi-disciplinary challenges arising from the commerce-security interplay. The Center for Risk and Economic Analysis of Terrorism Events (CREATE), based at the University of Southern California, the Command, Control, and Interoperability Center for Advanced Data Analysis (CCICADA), based at Rutgers University, and the National Transportation Security Center of Excellence (NTSCOE), and in particular its partner the Mineta Transportation Institute based at San Jose State University, together combine expertise in domains as diverse as probabilistic risk assessment, economic modeling, discrete event simulation, and data science. One goal of UCASS is to demonstrate integration of research methods drawn from several domains and disparate areas of expertise.

The project sought input from many stakeholders, including government agencies and the private sector. It also distinguished among workers in area offices and shops, residents, business owners, and those coming to Lower Manhattan for shopping, dining, or tourism.

A review of the current terrorist threat to the U.S. led to selection of five representative scenarios, used throughout the project: teams attacking a number of large buildings and hotels (Mumbai-like scenario); release of a chemical agent in the subway (Tokyo-like scenario); multiple explosions on subway trains during rush hour (Madrid-like scenario); detonation of a suitcase bomb on a bus during rush hour (London-like scenario); and a suicide bomber at a checkpoint (Israel-like scenario).

Seven established countermeasures were considered in UCASS: random vehicle inspections, permanent street closures to vehicular traffic, temporary perimeters and access control, random bag and parcel inspections at subway stations, increased visible presence of police, CCTV cameras, and x-ray magnetometers in building or business establishment entrances.
The Methodology

Countermeasures reduce risk by lowering the probability that an attack will succeed. Estimates of the probability that each countermeasure will deter or will interdict the attack were determined using expert elicitation methods. When combined with estimates of the present probability of each type of attack, these estimates support an estimate of the reduction in expected losses for each of the five attack scenarios, using each of the countermeasures. The capital, operating and maintenance costs of countermeasures were obtained from a variety of public sources. The unintended (or spillover) effects of security countermeasures, on the behavior of individuals in the region, were estimated, based on information provided by individuals responding to an online survey, and then translated into economic impacts.

The behavioral information was integrated using discrete event simulation software to estimate the aggregate effects and their random variation. Two software tools were used to develop the models and simulations: Arena, a commercial product, and OMNeT++, which is open source.

Survey data was used to estimate monetary equivalents of impacts from delays, inconvenience, changes in business environment, etc. The local economic effects resulting from behavioral responses to the presence of security countermeasures also have indirect regional effects that have been estimated using a computable general equilibrium (CGE) model. This model was also used to estimate the indirect regional economic impacts of countermeasures and of terrorist attack scenarios.

Overall, the UCASS methods and tools allow decision makers to combine threats, security measures and consequences to find the combination, or portfolio, of security measures most appropriate given the decision makers’ goals and constraints.

A Selection of UCASS Study Conclusions

The following are key concepts that have emerged from the UCASS study.

1. All countermeasures that increase public safety also affect public behavior, and the resulting changes in public behavior will have economic consequences, both positive and negative.
2. Decision makers representing various stakeholder groups balance risks and costs differently. An effective research tool must show them the choices between risks and costs, and must accurately capture each stakeholder group’s perception of risks and costs.

3. In presenting risks and costs to stakeholders, it is important to emphasize that all projections and calculations have a range of error associated with them. They are not single, unique, accurate points but have uncertainty, which should be made apparent to the decision makers. Moreover, the uncertainty in attack cost avoided typically swamps the uncertainty in cost of a countermeasure, making it very difficult to assess tradeoffs.

4. Problems of this kind are best solved with immediate and continued stakeholder involvement. The political complexity of the Lower Manhattan setting, compounded by extended negotiations related to the redevelopment of the World Trade Center, impaired continuity of stakeholder involvement. However, engagement with other entities made it possible to test the key ideas of the analysis.

5. Alternatives should be presented in a clear and useful way. Because different stakeholders and decision makers assess costs and benefits in different ways, and because of varying degrees of uncertainty in estimating costs of countermeasures and of attacks avoided, plots showing errors bars or error ellipses can be a useful way to present alternatives to decision makers.

6. The methods developed for UCASS are the first steps\(^1\) in development of a more extensive set of tools for analyzing the broader economic impacts of security initiatives.

7. The methods developed for this specific venue can be extended to other venues, but each new application requires a specific model and thus requires a significant investment in data gathering and model parameterization. It would be valuable to identify a number of typical venues and develop models for each, which could then serve as templates for others of the same type.

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\(^1\) Among the considerations not incorporated in this analysis are countermeasures that affect moving vehicles, the detailed modeling of transit systems, and the psychological impacts of either countermeasures or terrorist events.
8. The methods and concepts developed as part of the UCASS project have potential applications to protection in other settings. Among these applications might be mall security, sport stadium security, special event security, more general facility security and decision support for choices affecting large enterprises such as ports or airports. These methods can also be used to assess the impact of alternative orders of reopening facilities after a closure due to a natural disaster or a terrorist attack.

9. It is possible to perform a complex, integrated, multidisciplinary project as a harmonious and effective collaboration among experts in different disciplines. This conclusion validates the Department of Homeland Security’s decision to involve three Centers of Excellence jointly in the project and to have them work together.

We emphasize that users of the UCASS method will have to generate their own cost data relevant to their particular applications (or use one of a number of representative models that might be developed in the future). We emphasize that since the UCASS project primarily sought to develop methods, readers ought not rely heavily on the specific numerical estimates presented in this report.

Outline of the Technical Report
This report is structured as 21 chapters, with a detailed introduction (overview) of the UCASS study in Chapter 1. Chapter 2 presents a review of the scant literature examining security through an economic lens, the newly evolving area of study termed “security economics,” and the literature on assessing, managing and financing security options and security decision-making. Chapter 3 reviews the current terrorist threat to the U.S., discusses methods used to analyze the threat, reviews how security has changed since the 9/11 terrorist attacks, and introduces basic principles in examining security options for counter-terrorism. Chapter 4 outlines the example scenarios and security measures used here to which the methods were applied. Capital and operating cost estimations for each security measure are presented, as well as the estimated spillover costs. Chapter 5 expands the theoretical discussion of the economic impacts of security. Specifically, benefit-cost analysis is reviewed, as is the framework of economic consequence analysis used in this study. This chapter defines three categories of security costs: direct costs, spillover costs and indirect (multiplier) effects. Chapters 6 through 9 focus on the primary
components of the UCASS study, including for each the methods used to collect data, and in the case of model construction, to populate the models. The technical, scientific or political challenges that accompany each UCASS methodology are also reviewed. Specifically, Chapter 6 provides an overview of the stakeholder engagement activities. Chapter 7 presents a discrete event simulation, using the ARENA model. Chapter 8 details the CGE model. Chapter 9 discusses the risk modeling activities being used to define the expected costs savings of portfolios of security measures. Chapter 10 discusses in detail how the components are linked in an Interface, using the web-based OMNeT++ simulation environment. Chapter 11 is a descriptive case study of the economies of New York State and New York City. Chapters 12 and 13 respectively present the qualitative and quantitative findings from in-depth interviews with stakeholders and experts, and an analysis of the data collected via an on-line survey. Chapter 14 presents the CGE analysis of the implementation of increased security in the New York metropolitan area. Chapter 15 presents direct consequence costs of a terrorist attack. Chapter 16 presents the CGE analysis of business interruption impacts of terrorist attacks on New York City. Chapter 17 explores the preservation values of four iconic New York City buildings, as examples of this challenging area of loss estimation. Chapter 18 examines the direct and indirect impacts of countermeasure spillovers on the New York metropolitan area economy. Chapter 19 describes elicitation of the critical threat, deterrence, and interdiction probabilities. Chapter 20 presents the analysis of security measure portfolios, including a spreadsheet-based portfolio application. Finally, Chapter 21 presents conclusions of the study and observations about the UCASS methodology; it includes recommendations for future work, describing other contexts and environments in which the methods and tools developed here could be applied. Finally, it reviews the lessons learned about working in this new kind of collaborative arrangement.

Acknowledgement ADD

A report of this size, integrating the work done by a large team over the span of several years is, in itself, a substantial project. Thanks are due to Cecilia S. Gal for editing the overall document.
1 INTRODUCTION
Since the September 11, 2001 terrorist attacks against the World Trade Center (WTC) complex, New York City has made two initiatives a top priority: the security of Lower Manhattan and the economic revitalization of New York City’s downtown district\(^2\). Both priorities were imperative for the survival and growth of the nation’s 4\(^{th}\) largest business district\(^3\). However, there is often a perceived conflict between economic vitality and increased security. Economic vitality requires the free movement of people, and goods and services, but the implementation of security measures implies that freedom of movement is restricted or at the very least controlled. But are the goals of enhanced economic activity and increased security necessarily in conflict? Are there not instances when security stimulates or enhances economic activity rather than suppressing it? How much security is enough and how much is too much? These questions serve as the foundation for the Urban Commerce and Security Study (UCASS), a multi-disciplinary and multi-institutional project sponsored by the Department of Homeland Security Office of University Programs. Few sites are as suitable as downtown Manhattan to investigate such questions. The area is a hub of economic activity and a vibrant city center that has a history of terrorist attacks and remains an attractive terrorist target.

1.1 UCASS Purpose and Goals
While the effects of terrorism on society have received substantial attention over the past decade, there has been substantially less focus on the impacts of security, in general, and on the balance between security and economic activity specifically. Economically, it is unclear how security initiatives affect productivity. In which contexts and under what conditions do security practices and policies stifle, or promote, overall economic performance at the micro-, meso- and macro-levels? The UCASS study seeks to improve our understanding of these issues by pursuing a number of objectives.

There are three specific objectives. First, the UCASS research team has developed a set of general methods to investigate the interplay between security and commerce, methods that are widely applicable to varied situations in diverse urban settings around the country, and to other

\(^2\) Lower Manhattan is New York City’s downtown business district, excluding the larger midtown business district.
contexts where the interplay between security and economic activity is of interest. Not only will these methods enable both researchers and practitioners to identify cases where increased security actually enhances commerce; these methods also provide tools for understanding how to minimize the negative impacts of various security initiatives on economic activity.

Second, the UCASS research team has applied these methods to explore the complex, and, in some cases uncertain, relationships between security and economic activity, including the direct and indirect economic impacts of security in the specific environment that is Lower Manhattan.

Third, the resulting tool can be used for strategic and tactical planning. We do not intend that our tool be used in the heat of an actual event. Economic consequences of security measures are important to consider in the context of planning. But first responders will not, and should not, take the time to consider economic effects as they take action.

More specifically, the UCASS research team has developed economic and risk models to estimate the relevant costs and benefits of various combinations or “portfolios” of security measures and policies. These models, combined with discrete event simulation, are systematically integrated towards a prototypical decision-support tool that can be customized to different stakeholders’ strategic planning and response needs. Not only will such a tool be able to assist practitioners and public officials in preparing for planned events, but also it can assist as a post-event recovery tool, when the private and public sectors must collaborate to restore normalcy and functionality as quickly as possible.

While there is a strong technical component to the UCASS methods presented here, the project is also an exercise in knowledge accumulation. Thus, we hope that the findings and methods will be of value to both the operational and the research communities. The project has involved students from many disciplines, giving them firsthand experience at building a variety of models and creating new technologies.

The UCASS project has emphasized the development of a methodology, with a particular region in mind, namely Lower Manhattan. To apply the methods to a small region around the World Trade Center site requires detailed information about the stores, residences, and other establishments in the area studied, while some data were gathered, on businesses in the area,
much of the data could only be estimated. A detailed economic survey is far beyond the scope of this project. To illustrate the principles, a model of a small imaginary four block (2x2) area is developed in detail. This is referred to as the small simulation.

1.2 UCASS as a Collaboration of DHS Centers of Excellence (COEs)
The complexity of the commerce-security interplay required that the UCASS project combine research activities requiring distinct areas of expertise. The multi-disciplinary team includes mathematicians, economists, computer scientists, engineers, social scientists, and experts in terrorism and risk assessment, and spans three Department of Homeland Security (DHS) Centers of Excellence (COEs). The Center for Risk and Economic Analysis of Terrorism Events (CREATE), based at the University of Southern California, specializes in analyzing risk and modeling economic impacts. The Command, Control, and Interoperability Center for Advanced Data Analysis (CCICADA), based at Rutgers University, specializes in managing large and complex problems involving massive amounts of data of all kinds, under varying conditions of certainty and accuracy, from multiple, distributed sources, and varying in quality. The National Transportation Security Center of Excellence (NTSCOE), and in particular its partner the Mineta Transportation Institute (MTI) based at San Jose State University, has studied the world-wide structure and form of terrorist events.

1.3 Overview of UCASS Study
The CCICADA/CREATE/MTI collaboration has revealed both expected and surprising synergies in the research approach, and has accelerated development of a usable planning and analysis method, applicable to many kinds of threats and responses. The UCASS approach balances the direct benefits associated with threat reduction and risk mitigation against the direct costs (and, in some settings, secondary benefits and costs) of security measures. The problem is best understood by a simple example of threat and countermeasure, as shown in Exhibit 1-1.

Exhibit 1-1: An Active Shooter Example
Suppose the threat is that someone might bring a handgun into an office building, and begin shooting people in the lobby. This case is not that of someone who has a specific target in the building, but rather someone seeking to cause general harm and panic. The initial threat level (i.e., chance per day that this will happen) is, in fact, very low. It might happen once every five to ten years, somewhere among the thousands of buildings in Lower Manhattan. Let the threat probability be set at 1 in (365 days x 10 years x
10,000 buildings) or \((1/365) \times 10^{-5}\), which is about \(2.7 \times 10^{-8}\) per building per day. This number is in the range shown in Table 2.1 in Chapter 2, for large buildings, when converted to a threat per day. It is a very small number, and one might consider that it is not worth worrying about at all.

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Most buildings in Lower Manhattan do not have any specific security measures in place, other than video cameras. However, the harm from one such random shooting could easily reach millions of dollars in direct loss of life, medical costs for survivors, expenses of police and judicial response, and collateral losses to businesses in the building. If this loss is set at, nominally, 50 million dollars (somewhat more that $6 million per death, times 8 deaths), the expected loss (i.e., the probability times the loss) is \(2.7 \times 10^{-8} \times 5 \times 107\) or \$1.35 per day. Over a single year, this comes to \(365 \times (1.35)\) or almost \$500. Hence, if there was a security measure that could eliminate this risk, and it did not cost more than \$500/year, it would make economic sense to implement the measure. If a measure were to cut the risk by only 30%, then on a strict expected cost basis, we would only be willing to spend \$150/year, and so forth.

Note that this example depends crucially on the estimate of 8 deaths. If that number is changed to 2 deaths, then the “justifiable expense” will decrease by a factor of 4. In other words, the uncertainties about the impact of an attack are comparable to, or larger than, the costs of countermeasures. The expected benefit of the countermeasure also depends crucially on the estimate of the threat. If this estimate drops by a factor of 100, then the apparent benefit each year is worth only \$5. Because of this, it is recommended that decision makers be given information about the fraction reduction in probability of attack, as well as the estimated probability of attack.

Note also that the event might trigger various other economic losses, such as instilling fear in the general population to the extent that business activity is reduced in this building or its neighborhood. In turn, such a reduction in economic activity affects other businesses in the broader region or nation via upstream and downstream ripple effects throughout the supply chain. These impacts in addition must be multiplied by the probability of occurrence.
The discussion in Exhibit 1-1 is a direct Benefit-Cost Analysis (BCA). However, the full situation is more complicated in three important ways. First, several countermeasures can be combined into portfolios, and the results (i.e., the risk reduction) will depend on the relations among those measures in ways that are sometimes surprising. For example, two or more independent measures, that each cut the risk in half, do not combine to eliminate the risk completely. Rather, they reduce it to one-half, one-fourth, one-eighth, and so on, as they are combined. These issues are examined in depth in Chapter 9.

Second, when countermeasures are introduced, they affect the behavior of people and organizations in ways that may generate additional benefits or additional costs (spillover effects) to the region. For example, the introduction of a metal detector in the lobby of a store might make some people decide not to shop there any longer. This would result in lost revenue to the shop, although some part of that loss might be displaced to other competing shops in the neighborhood. On the other hand, some people may feel safer shopping at a secure store, resulting in increased revenue at those shops that adopt the screening. To include these effects in the analysis, one must know something about how people would actually behave, or say they would behave, when faced with various countermeasures. In the UCASS project, inexpensive methods have been developed and piloted, using an online survey tool, Mechanical Turk, to estimate what fraction of the population will respond in each of several economically significant ways. Sophisticated methods of simulation, specifically discrete event simulation methods, are then used to integrate the behavior of many random individuals, to determine the range and likelihood of various local economic impacts. Finally, when people do change their behavior locally, the effects of that change spread out to other parts of the region and other sectors of the economy. A powerful economic tool, computable general equilibrium (CGE) analysis, has been adapted and applied to the study’s context to estimate the “ripple,” or “indirect,” impacts of local changes in behavior.

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4 These methods represent agents and activities and update their situations at discrete intervals, such as every ten seconds, rather than continuously.
5 For detailed discussion see Chapter 8.
These steps create elements in a chain: threats call for countermeasures; countermeasures cost money; countermeasures reduce risks; countermeasures affect behavior; both countermeasures and changes in behavior generate both costs and benefits. The key goal of UCASS has been to develop and pilot an integrated approach to this complex problem. Because the teams have worked closely together, with support from the DHS Office of University Programs, progress has been much faster than it would be if the several teams of experts were communicating only through the usual scholarly literature. In fact, since the team is multi-disciplinary, it is quite possible that its members might never even have become aware of each other’s key strategies for approaching the problem, as these appear in previously unrelated literatures.

1.4 Bringing Economics into Security Decisions

Two different economic tools, Benefit-Cost Analysis (BCA) and Economic Consequence Analysis (ECA), are used to evaluate policies intended to counter terrorism. They differ in significant ways and we review those differences here.

1.4.1 Benefit-Cost Analysis (BCA)

BCA includes all costs and benefits, both those valued in the market place and those that require non-market valuation (e.g., the historic or iconic value of the World Trade Center, inconvenience to shoppers who are made to traverse security checkpoints, etc.). Benefits and costs are separated in this analysis. To support direct summation with costs, benefits must be represented by the expected losses (that is, losses weighted by the probability that they will occur) avoided as a result of having the countermeasure in place. Costs, on the other hand, are limited to real resource costs (including opportunity costs\(^6\) and disutility\(^7\) to consumers) but do not include transfers from one entity to another, such as taxes\(^8\). The indirect effects of implementing countermeasures (including economic multiplier effects of their construction or operation) are usually not included in a BCA, in part because of the difficulty of deciding whether they represent costs or benefits. For example, hiring someone to operate a checkpoint is a cost, but economy-wide employment gains could reasonably be interpreted as a benefit. That approach is

\(^6\) That is, cost taking into account the most favorable alternative that could be chosen instead.

\(^7\) This includes non-monetary costs, such as delays.

\(^8\) A particularly thorny issue is the question of how to cost the allocation of persons already on payroll, to specific defensive activities. Some might argue that there is zero cost, since they would be paid anyway. We adopt an intermediate position, as described below.
inconsistent with BCA. BCA results are expressed in two ways: 1) net benefits, in dollar terms, and 2) welfare (well-being measures), sometimes also converted into dollar terms. The latter are not generally well known outside of economic circles. They typically place a dollar value on benefits in terms of “willingness to pay” for or “willingness to accept” an action. This represents an assessment of the “consumer surplus,” or the difference between what a consumer is willing to pay (or accept) for a certain quantity of a good, and the market price of the good (technically, it is the area under the demand curve and above the market price). In the BCA of this project, we have only used the first measurement approach (direct costs compared with expected reduction in losses), because it is a more transparent formulation of BCA.

However, because the impacts of successful attacks are so large, and the corresponding probabilities are so uncertain, as a technical matter, the uncertainty in the expected savings is often far larger than the direct cost of the countermeasure (see Exhibit 1-1). This means that, within the range of uncertainty, the net impact of a countermeasure might come out either positive (overall beneficial) or negative (a waste of money). As a way of isolating this huge uncertainty, in the UCASS approach, data presentations for decision makers include these two variables: the direct costs that they will experience in implementing the countermeasure, and the reduction in chance of a successful attack represented as a probability or percentage. Thus, if a countermeasure is considered, by experts, to reduce the chance of a successful attack by \( r = 16\% \), that probability \( r \) is presented directly to the decision makers in comparison to the dollar cost of the countermeasure itself. Different decision makers, holding different beliefs about the probability of the attack itself, will draw different conclusions from this information.

There are several groups of decision makers (or stakeholders). Each of them may assess the direct costs in different ways. The following methods have been adopted for computing those costs. For any specific countermeasure, a total annual cost is computed as operating cost plus amortized capital expenditures. This quantity is referred to as \( C \).

1. For the cost per resident, one would use \( C \) divided by the population of all of Manhattan.

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9 This relates price to demand, and is defined in elementary economics texts.
b. For the cost per business establishment, one would use $C$ divided by the number of businesses in Lower Manhattan. As the size of businesses varies immensely in Lower Manhattan, a more realistic method of assessment is to apportion the cost by size of business.

c1. For the cost to the government of New York City, $C$ itself is the obvious cost. Note that at least some parts of city government might take a broader view, and be concerned about the broader economic impacts on the entire city or larger regional economy. These do have an effect on voter behavior, and therefore merit attention.

c2. One may, in principle, further extend the analysis, by estimating the effects of, for example, an improved business climate. This will have impacts on the businesses, but will also be something about which the government may feel a responsibility, and it may also result in increased sales taxes and similar direct income for the government.\(^\text{10}\)

Economic analysis does not determine public policy, nor does it correctly describe the behavior of individual decision makers unless it is carefully tailored to capture both the costs and the benefits as seen by those decision makers. For example, a business stakeholder’s decisions are based on private profitability. Here, the costs and benefits are much narrower. In particular, business managers would not include any of the following in their assessments of the benefits of a countermeasure, from the standpoint of the firm:

- Indirect impacts on regional GDP from expenditures on the countermeasure;
- Spillover effects that do not affect the firm, but may inconvenience many persons;
- Reduction in the direct and indirect impacts of an attack not affecting the firm, even if it were successful.

### 1.4.2 Economic Consequence Analysis (ECA)

Economic Consequence Analysis chooses as its “bottom line” the net impacts (of both costs and benefits) on the economy, related to a course of action. It is typically measured in terms of gross

\(^{10}\) Increased taxes are what is called a “transfer payment” from the standpoint of the economy as a whole and thus make no difference in a BCA context. However, they may be viewed as a benefit from the standpoint of their individual recipients and the local government.
domestic product (GDP) or in terms of employment. It typically includes only market impacts, or, in cases where broader impacts are considered, it is limited to those that can be quantified in dollar terms. For the UCASS ECA, these effects include the direct and indirect impacts of implementing countermeasures. These effects would not necessarily be seen as costs per se, but would be viewed in terms of their net effects on the regional GDP, which might be either positive or negative. The net impacts may in fact be positive if unemployed resources are put to work. If the economy is in a state of full employment (taken as 4 percent to allow for frictional unemployment, or normal job switching) then because wage rates might be bid up, or the countermeasures might result in net increases in direct operating cost, they may have overall negative impacts on the regional economy.

The ECA only includes impacts on the region\textsuperscript{11} in question; therefore spending on countermeasure resources produced in other regions and imported into New York would not be included. Benefits are similarly evaluated in terms of the region in question. This analysis may be applied strictly to the impacts of the direct and spillover expenses of countermeasures. As with BCA, ECA may also include estimates of the expected reduction in loss, which requires careful analysis of both the impacts and the probabilities, and faces the same difficulties noted above.

It is important to note one major, surprising aspect of ECA. In conditions of less than full employment and/or the infusion of funds from outside the region to pay for countermeasures, the direct and indirect expenditures on countermeasures will yield a positive impact on GDP. This means the economy receives not only the benefit of reduction in future potential losses from terrorism, but also receives a type of “benefit” from the dollars spent on the countermeasures themselves. There would appear to be “no cost” in the ECA approach. Nonetheless, if a countermeasure has severe negative spillover effects, these could overbalance such positive impact on the GDP and shift the implementation benefits of the security decision into negative territory. If it is possible to control the uncertainties regarding the threat probability and the threat impact, these quirks do not prohibit rational comparison of different countermeasures, in relation to specific threats.

\textsuperscript{11} A 21-county region. See Chapter 14.
1.5 The UCASS Approach

The UCASS approach is to present the decision maker with the probability of preventing (deterring or interdicting) an attack and the direct costs of the countermeasure as two distinct characteristics of the countermeasure. One can also present the estimated reduction in harm suffered, with the caveats noted above. For completeness, many analyses have been conducted: costs of implementation (BCA); direct benefits as probabilities (BCA); benefits as a reduction in expected losses (BCA), and the full effect of costs through their impact on the larger economy (ECA). A spreadsheet program accommodates data entry, refinement, and calculation, using both the BCA and ECA approaches, as does the integrated user interface, called the Precision Information Environment (PIE), which is defined and described in Chapter 10.

The effect of taking any specific stakeholder perspective is likely to yield smaller benefits than if the issue is examined from the standpoint of society as a whole. However, enhanced security is a “public good.” That is, it can be shared by many firms (and households), and its total value is much higher than that perceived by any individual supplier. Such goods will be underprovided if left to market forces alone.

1.6 Presentation to the Decision Makers

Before detailing the interactions among the UCASS components, it is important to address the question: why not suppress or condense all this complex analysis, and simply publish tables of the various interesting portfolios, each accompanied by its risk reduction impact and its total economic impact? While this is attempted in some cases, it is important to emphasize that the meanings of the words “cost” and “benefit” will depend on the stakeholders’ perspective. Therefore, to make a generally useful tool, it is important to permit users to tailor some parameters of the analysis, as they replicate this analytic process. When the user has identified which flows of cash are costs, and which are benefits, it will then be possible to summarize each portfolio as a single point on a “risk reduction” diagram, such as is shown in Figure 1-1. Even then, all estimates involve uncertainty—an issue examined briefly in Section 1.12. Representing Uncertainty.

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12 For example, when a city must pay a police officer overtime, the city counts this as a cost, but the stores at which the officer shops count it as a benefit. Similar arguments apply to equipment that is purchased locally.
A notional chart of costs and benefits (i.e., risk reduction) with several security measures and combinations is shown. Portfolio P5 costs a good deal more than portfolio P3, but has a greater chance of deterring or preventing a successful attack. In contrast, portfolio P3 provides less protection than either P1 or P2, but at a lower cost. Note that portfolios may be combined, as indicated by P1+P2, which has the greatest reduction of risk for the alternatives shown here, but is among the most expensive alternatives. Note that some portfolios, denoted by a cross-hatched pattern, will not ever be preferred because it is possible to achieve both a greater reduction in risk and a lower cost, by choosing another portfolio or combination.

1.7 The Flow of Data and Analysis in UCASS

The overall UCASS analysis requires a complex flow of information as shown in Figure 1-2. For each threat scenario of interest, the users can examine a variety of countermeasures. Then, for each of these countermeasures, the users can estimate both the reduction in risk, and the direct costs. Next, replicating the UCASS process, the users can determine individual responses (based on prior experience, Mechanical Turk, expert judgment, and/or survey methods). These data can then be used with simulation model(s) to determine the local impact of countermeasures. These local impacts, and the direct costs, can be entered into the regional equilibrium calculation. In this way, the stakeholders will be able to examine the beneficial impact (i.e., risk reduction) and the impacts on commerce, and make an informed decision among the portfolios of measures considered. Stakeholders with more limited perspectives may omit one or more of these steps,
but the UCASS method presented here is the first analytical method to ensure that every stakeholder may participate.

**Figure 1-2: The Overall Flow of Information & Calculation in the UCASS Framework**

The light blue components represent the work used in this approach. The pink components are combined to represent the full economic costs. The green component represents the expected benefit of the security measure. Note that the complete analysis depends on the specific combination of threats and countermeasures; however, the computational steps (shown by the red arrows) depend on the countermeasures, and can be reused with different threats, once they have been determined. The result finally determines the coordinates of a point in Figure 1.1.

### 1.7.1 Detailed Discussion of the Project Components

Moving from left to right in the diagram of Figure 1-2, a threat scenario and a security measure or combination of security measures (i.e., a portfolio) are generated. There are multiple iterations or layers in the diagram to signify that the same methods are used for each of a number of different scenarios. In the UCASS study, five example scenarios have been used, which have been modeled after past major terrorist attacks in Mumbai, Tokyo, Madrid, London, and Israel. There are also seven security measures that have been examined in the UCASS study: random

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13 Each of these scenarios is detailed in Chapter 4 of this report.
vehicle inspections, permanent street closures to vehicular traffic, temporary perimeters and access control, random bag and parcel inspection, increased visible presence of police, CCTV cameras, and X-rays and magnetometers in building lobbies. The UCASS method is flexible, and allows users to study additional scenarios and security measures.

The capital, operating and maintenance costs (collectively, the “direct costs”) for each of the seven security measures are estimated. The capital, operating, and maintenance (O&M) costs of traffic checkpoints and closed-circuit television (CCTV) cameras are estimated first. These data then serve as the basic data for the subsequent cost estimates, and various adjustments are made accordingly (see Chapter 4). Since many of the cost components (wages, equipment, etc.) are the same across all seven security measures, the cost estimates from CCTV cameras and traffic checkpoints were combined with cost estimates from additional references, to yield the capital and operating costs of the other UCASS security measures. In the UCASS study, these cost data have been used in our representative calculations. Users of the UCASS method must generate their own cost data relevant to their particular applications. We emphasize that since UCASS sought, primarily, to develop a method, readers ought not rely heavily on the specific numbers presented here and elsewhere in this report.

1.8 A Working Example of the UCASS Methods

Each of the steps in Figure 1-2 represents a complex research area in itself. It is helpful, therefore, to give an example of one specific calculation, from the beginning to the end. Consider a particular threat, such as an attacker bringing a handgun into a public building and shooting as many people as possible before the police are able to stop him or her. Assume that the attacker is suicidal, and, having arrived at the scene, takes no particular measures to protect himself.

Furthermore, imagine that there has been advance warning as to the location, such as the particular building that will be attacked, and the day of the attack, such as a particular Wednesday. Finally, consider a specific countermeasure, such as the implementation of police security checkpoints at both ends of the block, including bag inspection of every pedestrian.

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14 See Appendix 1 for a summary of the data sources used to estimate the capital, operating and maintenance costs of the security measures used in the UCASS study.
before permitting the pedestrian to continue on to the block. A “portfolio” of countermeasures (i.e., more than one), such as conducting more detailed ID checks, can also be analyzed.

The probability that the attacker will make his attempt on Wednesday is not known; however, based on the analysis by CREATE, it is reasonable to believe that setting up these two checkpoints will reduce the chance that an attacker succeeds by 16%. In addition, this 16% estimate contains a kind of error bar indicating that the reduction in the probability of success of the attack might be as high as 24% or as low as only 8%. In short, having the checkpoint in place reduces the chance of a successful attack. It is anticipated that decision makers may be comfortable working with this information, and with the related direct costs of the countermeasures.

The next step is to calculate the costs of this countermeasure. We know from first responders that the direct costs of implementing this countermeasure, including the amortized cost of the wand equipment and of training for this kind of activity, and police personnel, and incidental expenses is $175 dollars for the day. Since there is some uncertainty depending on the availability of personnel, the cost might be as low as $149, or it might be as high as $209.

Finally, there are costs that affect enterprises on the block, as the barrier may prevent some people from carrying out their normal business on the block. For this, the results from the web...

---

15 This is based on “The deterrent effect of such random vehicle inspections against such an attack has been estimated to be nearly 16%” applying it to pedestrian inspection. Inspecting at both ends of the block is taken to reduce the overall chance that the threat enters the block by this same fraction. If only one end of the block is closed, the attacker could go around to the other end and attack.

16 This range corresponds to plus or minus one standard deviation of the mean, treating the probability as if it were based on N=20 actual observations. We do not have data on the empirical basis for this estimate at this time.

17 As noted in Section 1.4, there is a “totally economic” approach, in which, economic analysis would ask that we convert the cost of a successful attack to dollar values. We could then calculate the “expected” cost of a successful “attack” given that the countermeasure is in place, as 84% of the “expected cost of a successful attack.” This latter number requires a highly complex computation that uses methods first developed by CREATE to measure the impact of the 9/11 attacks. It takes into account both direct and indirect effects of an attack, seeking to put a value on human life, as well as physical and economic damage, etc. In this project we have chosen to concentrate on risk reduction per se, for reasons discussed in Section 1.4.

18 This is based on $30.20 as the hourly mean wage in New York for police and sheriff’s patrol officers (Source: http://www.bls.gov/oes/current/oes333051.htm). However, we make the specific assumption that the regular salary is not an expense of this activity, but we count 50% of salary to represent an overtime expense, if this is treated as a special assignment requiring overtime compensation. For lower and upper bound estimates of overtime payment, we assumed 30% and 40% increase in the hourly mean wage so that the increase (overtime) in the hourly wage is above the base (median) hourly wage.
based survey are used. The survey data provide estimates of the probabilities of various actions (e.g., do not shop; wait in a queue) for each of several kinds of people who use the block (residents, workers, visitors) and with regard to several possible reasons that might bring them to the block (shopping, dining, working).

These data are fed into the simulation model (see Chapters 7 and 10), which generates a typical Wednesday flow of pedestrian traffic in the neighborhood of that block and then modifies that traffic according to these behavioral probabilities. In other words, a person who would have gone on to the block to do some particular activity, such as shopping, now is randomly assigned either to continue, or to do another activity that people are likely to do when they encounter a barricade.\(^{19}\)

This results in a fractional change in commerce on the block, which can further be allocated to particular economic sectors. For other kinds of countermeasures that remain in effect longer, there will be interest in measuring their effect/cost over different periods of time, e.g., a day, a week, a month, a year, several years. Note that even a rather large fractional change in the commerce on one particular block (say a 50% or even 70% loss for the day) is a tiny change in the economy of Lower Manhattan. This fact becomes useful when calculating the regional economic consequences.

The direct impact of lost business is based on nominal models of small, medium and large retail establishments on the affected streets. The numbers presented in Table 1-2 are based on ten random replications in the simulation of a period from 8:00 a.m. to 5:00 p.m. on a Wednesday. The block has a bag check set up at each end, and the probability of choosing not to go through the check point has been set as 10%. The simulation shows that the expected retail expenditure drops from 104 persons spending $2,829 per hour to 98 persons spending $2,734 per hour. The drop is not actually 10% of the number of persons, but the inconsistency is reasonable for random simulations. This drop, extended over the 8 hours of closure, becomes $760, as shown above. Note that the loss of commerce, even with only 10% of the patrons discouraged, is more than four times the direct cost of the countermeasure.

---

\(^{19}\) The randomization of peoples’ movements depends upon the probabilities obtained from the UCASS survey.
Table 1-2: Costs and Impacts of Security Measures in Working Example

<table>
<thead>
<tr>
<th>Threat</th>
<th>Security Counter Measure</th>
<th>Low-end Risk Reduction (1)</th>
<th>High-end Risk Reduction (2)</th>
<th>Low-end Counter Cost (3)</th>
<th>High-end Counter Cost (3)</th>
<th>Low $ Impact (4)</th>
<th>High $ Impact (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attacker with a handgun in a public building</td>
<td>Checkpoint at both ends of block for 4 hours</td>
<td>8%</td>
<td>24%</td>
<td>$149</td>
<td>$209</td>
<td>$4 million</td>
<td>$12 million</td>
</tr>
</tbody>
</table>

Notes:
(1) The low-end of a range is the expected value, minus one standard deviation. There is only one chance in 6 that the correct value is lower than this.
(2) The high-end of a range is the expected value, plus one standard deviation. There is only one chance in 6 that the correct value is higher than this.
(3) These costs represent 30% and 40% of overtime expenses (see text).
(4) These numbers assume that the shooting attempt does occur. The chance of such an event is very small, which is why we do not try to balance these savings against the cost of the countermeasure directly. The specific numbers for this example are:

1. Reduction in chance threat succeeds (average): 16%  
2. Direct cost of the countermeasure: $175  
3. Direct loss of business on the block: $95 x 8 hours = $760  
4. Indirect loss or (gain) to the regional economy: 2 x (760 + 175) = $1,870

Using a generic multiplier for regional impact, whose value is 2, a regional impact is estimated\(^\text{20}\). In principle, the regional impact of the local change in economic activity, is computed by inserting the two small changes, (2) and (3) into the Computable General Equilibrium analysis (CGE), a complex, non-linear model of the regional economy. While the model is non-linear with many interlinked sectors, the fact that the impact of this countermeasure on commerce is very small means that a simple multiplier can be used to determine the effect of the ripples of this change into other sectors of the economy, as noted here.\(^\text{21}\)

\(^\text{20}\) As discussed, an alternative interpretation is that increased spending on security should be **subtracted** from this number. The situation is further complicated by the fact that the 10% who went elsewhere might shop on another street, where the shops are more expensive. Complete modeling would require a model of individual persons, which is beyond the scope of the UCASS project.

\(^\text{21}\) This fact is an extension of a rule from calculus, called Taylor’s Theorem. For a very small change \(d\) in a variable \(x\), the change in any function \(f(x)\) is approximately given by \(f(x+d) = f(x) + d f'(x)\), where \(f'(x)\) is the derivative of the...
In this analysis, certain “non-monetary” or “spillover” costs, such as the discomfort people experience because of the inspection, are not considered. They are, however, captured to some degree in the information that was gathered about how people will behave in the presence of particular countermeasures, and their associated intrusion on daily life. The complex array of costs is summarized in Table 1-3.

Taking all of this information together, a single point can be placed on any one of several possible charts, such as a chart of the direct cost and the reduction in threat (see Figure 1-1). Such charts summarize the analysis for a particular threat and particular countermeasures. The process can be repeated for any threats of interest, and for any available countermeasure or mix (“portfolio”) of countermeasures.

<table>
<thead>
<tr>
<th>Table 1-3: Kinds of Costs Analyzed in the UCASS Technical Report</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Costs of Providing Countermeasures</strong></td>
</tr>
<tr>
<td>Direct Costs</td>
</tr>
<tr>
<td>Indirect Costs</td>
</tr>
<tr>
<td><strong>Costs Resulting from the Impact of Countermeasures on Persons and Businesses</strong></td>
</tr>
<tr>
<td>Spillover Costs</td>
</tr>
</tbody>
</table>

Note: The costs that would flow from a successful attack are not included in these calculations. See text.

### 1.9 Review of Data Sources

Each kind of information used in the UCASS models must be obtained in a suitable way. Risk reduction was estimated using expert elicitation methods. Probability estimates covering three aspects of the problem were elicited: the probabilities that each of the five attack scenarios would be attempted in a year, the effectiveness of various security measures in deterring the five attack function at exactly the point $x$. In these analyses, this multiplier is approximately 2; thus, spending $50 on security has a benefit of approximately $100 to the regional economy.

The discomfort could conceivably be “negative.” That is, some people may feel safer shopping on a block where they know all of the pedestrians have been screened.
scenarios, and the effectiveness of the seven sampled security measures in *interdicting* and *terminating* each of the five attack scenarios.\(^{23}\)

The capital, operating and maintenance costs of the countermeasures needed for estimates of local cost and impact on the region\(^{24}\) were based on information from a variety of public sources.

To consider the additional effects of security countermeasures through their effect on the behavior of individuals in the region, two methods are combined. These effects are estimated, based on information provided by individuals responding to a survey. That information is integrated using discrete event simulation software to estimate the aggregate effects and their random variation. Two software tools were used to develop the models and simulations, ARENA and OMNeT++. ARENA is a commercial product of Rockwell and OMNeT++ is open source.\(^{25}\)

These local effects (in this study, the streets that have been modeled in Lower Manhattan) then have indirect regional effects, which are computed using a model of General Regional Equilibrium. The regional economic equilibrium model takes into account additional data, reflecting the aggregate of the individual behaviors of people as *their economic activity is affected by each security measure*.

Data on individuals’ spending behavior and movements were obtained through an online survey\(^{26}\) of different groups of people (e.g., residents, workers, tourists or other visitors, and business owners) in Lower Manhattan or in the areas surrounding New York City.\(^{27}\) The survey data was also used to estimate the non-monetary impacts of the several security measures. These non-monetary impacts were then used to monetize the *spillover* costs from implementing the security measures (e.g., delays, inconvenience, changes in the business environment, etc.).

\(^{23}\) For a detailed description of the risk estimation methods and findings, see Chapters 9 and 19.

\(^{24}\) For technical reasons, the long-term equilibrium impact of such spending, which may well be a sustained growth in the national GDP, are not computed. Such a finding is not useful for local decision makers, who must work with personnel and funds that are available to them at the time the decision is taken.

\(^{25}\) For a detailed description of the discrete event simulations, see Chapter 7.

\(^{26}\) The bulk of this data was collected using the Amazon Mechanical Turk mechanism. Thus the respondents may or may not actually be persons of the type that they represent in the survey. See Chapter 13.

\(^{27}\) For a detailed description of the survey methods and findings, see Chapter 13.
These inputs together were used to calculate the overall regional economic impact of security measures, in the model calculations presented here. In general, decision-makers can combine risk calculations and portfolios of security measures to ask what combination of security measures are most appropriate given their goals, constraints and concerns.

In this study, after the models were developed in ARENA, an end-user interface was then created using OMNeT++, an open source discrete simulation environment. OMNeT++ was used to replicate the ARENA model, thus making the interactive tool accessible to user groups via the internet. This decision-support tool is being created as a Precision Information Environment (PIE) prototypical tool. A PIE is an interactive work environment that allows users to tailor system information to their needs to help support public safety and emergency management activities (see Chapters 7 and 10).

1.10 Numerical Materials and Examples

1.10.1 Expert Assessments of Probability

Expert assessments of the probability that a particular counter measure will either deter an attack (that is, prevent the attackers from trying) or interdict an attack (that is, block the attack once it is attempted, and reduce the harm to zero) are shown in Table 1-4, Table 1-5, and Table 1-6. They were elicited using the methods described in Chapter 19, working with people who are expert in security in the New York City area.

The combined effect of a particular countermeasure is estimated as somewhat less than the sum of the two reductions due to deterrence, \( r_1 \), and the reduction attributed to interdiction, \( r_2 \). This is because an attack that is deterred cannot be interdicted.

The resulting formula is:

\[
R_{\text{combined}} = r_1 + r_2 - r_1 r_2.
\]
Table 1-4: The Probability That Specified Security Measures Will Deter a Specific Scenario, By Expert Elicitation

<table>
<thead>
<tr>
<th>Security Measure</th>
<th>Total GDP Impacts* (thousand 2009$)</th>
<th>Deterrence Probability per Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mumbai Scenario</td>
<td>Tokyo Scenario</td>
</tr>
<tr>
<td>Random Vehicle Inspections</td>
<td>13,212</td>
<td>2.90%</td>
</tr>
<tr>
<td>Permanent Closure of Certain Streets to Traffic</td>
<td>35</td>
<td>2.40%</td>
</tr>
<tr>
<td>Temporary Perimeters &amp; Access Control to Certain Restricted Areas of the City</td>
<td>1,148</td>
<td>0.90%</td>
</tr>
<tr>
<td>Random Bag &amp; Parcel Inspection on Subways</td>
<td>7,052</td>
<td>1.80%</td>
</tr>
<tr>
<td>X-rays &amp; Magnetometers in Building Lobbies</td>
<td>49</td>
<td>2.70%</td>
</tr>
<tr>
<td>Increased Visible Police Presence</td>
<td>0</td>
<td>3.10%</td>
</tr>
<tr>
<td>CCTV Cameras</td>
<td>11,409</td>
<td>1.10%</td>
</tr>
</tbody>
</table>

* Total impact on GDP of implementing anti-terrorist countermeasures is the sum of annualized capital and adjusted annual operating expenditure impacts (in 2009 dollars). Note that the annualized capital costs are determined for a 10-year time horizon and do not include any interest payment stimulus. Operating costs are adjusted in the cases where the countermeasure is provided by government to reflect substitutions within the overall government budget (see Chapter 4). Note also that these impacts are positive as contributions to the regional economy. To get an approximate estimate of the corresponding Cost, for BCA, we may divide these by a factor of 2.

Table 1-5: The Probability That Specified Security Measures Will Interdict a Specific Scenario, by Expert Elicitation

<table>
<thead>
<tr>
<th>Interdiction</th>
<th>Total GDP Impact</th>
<th>Interdiction Probability per Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mumbai</td>
<td>Tokyo</td>
</tr>
<tr>
<td>Random Vehicle Inspections</td>
<td>13,212</td>
<td>9.90%</td>
</tr>
<tr>
<td>Permanent Closure of Certain Streets to Traffic</td>
<td>35</td>
<td>1.30%</td>
</tr>
<tr>
<td>Temporary Perimeters &amp; Access Control to Certain Restricted Areas of the City</td>
<td>1,148</td>
<td>20.10%</td>
</tr>
<tr>
<td>Random Bag &amp; Parcel Inspection on Subways</td>
<td>7,052</td>
<td>15.80%</td>
</tr>
<tr>
<td>X-rays &amp; Magnetometers in Building Lobbies</td>
<td>49</td>
<td>33.10%</td>
</tr>
<tr>
<td>Increased Visible Police Presence</td>
<td>0</td>
<td>14.00%</td>
</tr>
<tr>
<td>CCTV Cameras</td>
<td>11,409</td>
<td>1.60%</td>
</tr>
</tbody>
</table>
Table 1-6: Combined Expert Estimates That a Security Measure Will Either Deter or Interdict a Specific Threat Together With the Impact on GDP

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Random Vehicle Inspections</td>
<td>13,212</td>
<td>12.5%</td>
<td>3.6%</td>
<td>5.0%</td>
<td>11.6%</td>
<td>3.8%</td>
</tr>
<tr>
<td>Permanent Closure of Certain Streets to Traffic</td>
<td>35</td>
<td>3.7%</td>
<td>0.5%</td>
<td>0.5%</td>
<td>1.5%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Temporary Perimeters &amp; Access Control to Certain Restricted Areas of the City (Temp Rest)</td>
<td>1,148</td>
<td>20.8%</td>
<td>4.8%</td>
<td>8.4%</td>
<td>5.5%</td>
<td>7.2%</td>
</tr>
<tr>
<td>Random Bag &amp; Parcel Inspection on Subways</td>
<td>7,052</td>
<td>17.3%</td>
<td>9.4%</td>
<td>14.6%</td>
<td>8.5%</td>
<td>3.4%</td>
</tr>
<tr>
<td>X-rays &amp; Magnetometers in Building Lobbies</td>
<td>49</td>
<td>34.9%</td>
<td>0.5%</td>
<td>0.5%</td>
<td>1.0%</td>
<td>2.7%</td>
</tr>
<tr>
<td>Increased Visible Police Presence</td>
<td>0</td>
<td>16.7%</td>
<td>6.6%</td>
<td>9.0%</td>
<td>19.2%</td>
<td>11.1%</td>
</tr>
<tr>
<td>CCTV Cameras</td>
<td>11,409</td>
<td>2.7%</td>
<td>1.3%</td>
<td>1.1%</td>
<td>5.9%</td>
<td>4.1%</td>
</tr>
</tbody>
</table>

* Total impact on GDP of implementing anti-terrorist countermeasures is the sum of annualized capital and adjusted annual operating expenditure impacts (in 2009 dollars). Note that the annualized capital costs are determined for a 10-year time horizon and do not include any interest payment stimulus. Operating costs are adjusted in the cases where the countermeasure is provided by government to reflect substitutions within the overall government budget (see Chapter 4).

Note that the results above pertain to an Economic Consequence Analysis approach to cost estimation, which is confined to actual stimuli to the economy and measured in terms of GDP. Thus, it includes only quantifiable and market-based calculations for spending within the 21-county New York Metro Region. A national perspective on Benefit-Cost Analysis approach would include all spending, whether in-region or not, and would measure “welfare” (well-being) effects on consumers of all interactions. As discussed above, the selection of costs to include, and the effects to consider depends on the perspective of the stakeholder.

1.11 Combining Costs and Risk Reduction

Finally, some representative countermeasures, and their direct costs and risk reductions, are presented here in Figure 1-3 a-e. Note that different threats have quite different scales for their amounts of risk reduction: the Mumbai style threat is considered to be much easier to reduce than the Tokyo (gas attack) threat. Experts note that a group of armed men is easier to spot than a handful of persons carrying a chemical agent.
Figure 1-3 a-e: The Annual Costs of Countermeasures, and the Summation of Expert Estimates of the Total Risk Reduction Chance, by Attack Type

**Figure 1.3a:** The *annual* cost of various countermeasures, and the summation of expert estimates of the total reduction of the chance of a successful Mumbai-style attack, combining both deterrence and interdiction.

**Figure 1.3b:** The *annual* cost of various countermeasures, and the summation of expert estimates of the total reduction of the chance of a successful Tokyo-style attack, combining both deterrence and interdiction.

**Figure 1.3c:** The *annual* cost of various countermeasures, and the summation of expert estimates of the total reduction of the chance of a successful Madrid-style attack, combining both deterrence and interdiction.

**Figure 1.3d:** The *annual* cost of various countermeasures, and the summation of expert estimates of the total reduction of the chance of a successful London-style attack, combining both deterrence and interdiction.
Important overall note. These charts illustrate specific applications of the methods developed. However, as noted elsewhere in the report, these should not be regarded as definitive statements about the real reduction in risk, or about the cost of implementation, for the region as a whole.

**Figure 1.3e:** The *annual* cost of various countermeasures, and the summation of expert estimates of the total reduction of the chance of a successful Israel-style attack, combining both deterrence and interdiction.

### 1.12 Representing Uncertainty

It has been noted that estimates of cost, and estimates of risk reduction carry uncertainty. This means that the points shown in Figure 1-3 a-e are not precisely known. To give decision makers a more honest representation of the state of the analysis, a concept from ballistics, called the “Circular Error Probable”\(^{28}\), can be adopted. When a missile or cannon is aimed at a target, it will not hit it exactly. There is a region around the aim point, which contains 50% of the probability – that is, there is a 50% probability that the missile will fall within that curve. An even larger curve can be drawn, which contains 95% of the probability. In the same way, our estimates are subject to considerable uncertainty, and should be thought of as the “aiming points” and not the “guaranteed outcome.” We represent this by describing a “region of possibility” on the chart of cost versus risk reduction (see Figure 1-4 a-c).

With this understanding, the Benefit Cost Analysis can be summarized by diagrams that show alternative countermeasures, each with its own region of possibility. These are computed from the uncertainties of the estimates, together with standard assumptions about the normal distribution of uncertainty. Some examples of the concept are shown in Figure 1-4 a-c.

---

Figure 1.4a-c: Regions of Possibility Associated with Costs or Risk Reduction Estimates

These figures illustrate notionally, the regions of possibility that are associated with any estimates of either costs or reductions in risk. In (a) three countermeasures are shown with a “50% region,” meaning a region that is estimated to contain the true cost and true reduction in risk, 50% of the time. In (b) the (larger) 95% region is shown as well (note the change in scale). These larger regions may even overlap, indicating the possibility that the left-most policy might turn out to be more effective than the higher-scoring policy to its right. In diagrams (a,b) it is assumed that the uncertainties about the cost and about reduction in attack success are independent. If they are positively correlated for some countermeasures, then the “region of possibility” becomes not only elliptical, but also slanted. This might happen if using more expensive and highly trained personnel yields more reduction in risk, as suggested by the narrow elongated (blue) possibility regions in (c).

1.13 Details of the Small Simulation Model

As noted in Section 1.1, an imaginary small simulation model illustrates the main points in the UCASS analysis. In the example shown in Table 1-7 the notional street included in this model has a collection of enterprises, and each has a given probability that a passerby will engage in the corresponding commercial activity.
Table 1-7: The Probability That a Person Passing in Front of an Establishment Will Enter and Complete a Transaction

<table>
<thead>
<tr>
<th>Small Business</th>
<th>Probability*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subway</td>
<td>20%</td>
</tr>
<tr>
<td>Manon Café</td>
<td>80%</td>
</tr>
<tr>
<td>Bostonian Market</td>
<td>20%</td>
</tr>
<tr>
<td>BLT Bar</td>
<td>80%</td>
</tr>
<tr>
<td>Copy Center</td>
<td>20%</td>
</tr>
<tr>
<td>Corner Store</td>
<td>20%</td>
</tr>
<tr>
<td>Variety Market</td>
<td>20%</td>
</tr>
<tr>
<td>Podmororo Pizza</td>
<td>80%</td>
</tr>
<tr>
<td>Planet Gyro</td>
<td>80%</td>
</tr>
<tr>
<td>Caracellos</td>
<td>80%</td>
</tr>
<tr>
<td>Dry Cleaner</td>
<td>20%</td>
</tr>
<tr>
<td>Café Bravo</td>
<td>80%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Medium-Tier Store</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlotttes</td>
<td>70%</td>
</tr>
<tr>
<td>Budharasa</td>
<td>70%</td>
</tr>
<tr>
<td>Joe's Garden</td>
<td>10%</td>
</tr>
<tr>
<td>Cordatos</td>
<td>70%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High-Tier Store</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Berlitz</td>
<td>5%</td>
</tr>
<tr>
<td>Masterpiece</td>
<td>5%</td>
</tr>
<tr>
<td>Morans</td>
<td>5%</td>
</tr>
</tbody>
</table>

* These numbers are not based on an analysis of the specific enterprises, but are introduced in order to demonstrate the simulation.

In this prototype, the same transaction value for each establishment of a given type has been used. It is assumed that the amount of time people spend in the establishment is random and between zero and 60 minutes for a small business.\(^{29}\) For a medium or large business, it is assumed a person will spend between 30 and 60 minutes. Finally, there is a distribution of the possible spending in the establishment, which is based on information from the online survey of surrogate residents and business people, as modified from Lower Manhattan to this small model. Spending is capped at $50 for a small establishment, $250 for a medium, and $1,000 for a large. Each enterprise also has a maximum capacity, not shown here, and if it is full no one else enters until some people have left.

\(^{29}\) Randomness here is treated as uniform between the indicated limits, so that any number between zero and 60 is equally likely.
All of these values are approximations, guided by a block-to-block survey of the area done on the last week in May 2011. With this information, the simulation can be run without any countermeasure, and with one or more countermeasures. The simulation must be run several times in each condition, to account for randomness. Then the difference between the average spending with no countermeasure, and the average spending with a countermeasure in place, is the cost to local business of having the countermeasure in place. As with all of the other economic considerations, the significance of this number depends on the stakeholder perspective.

Using this model, the simulated loss of business for an 8 hour closing, from 9a.m. to 5p.m. on a typical Wednesday has been estimated at: $760 as used in Section 1.7 above.

1.14 A Selection of Study Conclusions
The UCASS project has demonstrated that it is possible to do a complex integrated multidisciplinary project as a harmonious collaboration among experts in survey methods, risk analysis, data analysis, discrete event simulation, and economics. In doing this, the team faced the challenge of finding the best ways to share information among the several disciplines, in ways that respect disciplinary standards but isolate those particular facts that are needed and used by researchers working on the other components. The following are the key concepts that have emerged from the UCASS study.

1. All countermeasures that increase public safety also affect public behavior, and the resulting changes in public behavior will have economic consequences.
2. Decision makers representing the various stakeholder groups will balance risks and costs differently. An effective research tool must show them the choices between risks and costs, and must accurately capture each stakeholder group’s perception of what risks and costs are.
3. In presenting risks and costs to stakeholders, it is important to admit that all projections and calculations have some region of error associated with them. They are not single unique accurate points but they have uncertainty, which should be made apparent to the decision makers.
4. Problems of this kind are best solved with immediate and continued stakeholder involvement. We found that the political complexity of the Lower Manhattan setting,
compounded by extended negotiations related to the redevelopment of the World Trade Center, prevented us from achieving this immediate and ongoing stakeholder involvement. However, we were lucky to have the engagement of other entities that enabled us to test out our ideas.

5. The methods developed for UCASS are only the beginning of what could be development of a more extensive set of tools for analyzing the economic impacts of security initiatives. Among the considerations we have not been able to incorporate in our analysis are the inclusion of entities such as moving vehicles, the detailed modeling of transit systems by which individuals arrive or leave an area, and more extensive psychological impacts of either countermeasures or terrorist events.

6. The methods developed with one venue in mind can be extended to other venues, but each venue requires a different model and a large part of the challenge in UCASS has been to develop a detailed model reflecting local conditions and local population. It is potentially useful to identify a number of sample venues and develop models for each since the development of detailed models for each user as an individual entity might be prohibitively expensive.

7. The methods and concepts developed as part of the UCASS project have potential applications other than in protection of urban areas. Among the applications might be mall security, or more generally, facility security and decision support for choices affecting large regions such as ports or airports.

The UCASS project convincingly demonstrates that this type of integrated model-building, coupled with development of the methodologies and the tools needed to model related problems in several areas greatly accelerates identifying and sharing knowledge among the various disciplines. It validates the Department of Homeland Security’s decision to involve three Centers of Excellence jointly in the project and to have them working together.

1.15 Outline of the Rest of the Technical Report
This report is structured into 21 chapters, including this introduction, reviewing the context and components of the UCASS study. Chapter 2 consists of a review of the scant literature examining security through an economic lens, the newly evolving area of study, termed “security
economics,” and the literature on assessing, managing and financing security options and security decision-making. Chapter 3 reviews the current terrorist threat to the United States and discusses the methods used to analyze the terrorist threat. Chapter 3 also reviews how security has changed since the 9/11 terrorist attacks and introduces some basic principles in examining security options for countering the threat of terrorism.

Chapter 4 outlines a set of example scenarios and security measures being used here to develop the methods. In addition, capital and operating cost estimations for each security measure are presented, as well as the estimated spillover costs. Chapter 4 also presents estimates of the affected areas from each attack scenario. Chapter 5 is a theoretical discussion of the economic impacts of security. Specifically, the benefit-cost analysis framework in general is reviewed, as is the economic consequence analysis framework. This chapter defines the three categories of security costs: direct costs, spillover costs and indirect (multiplier) effects.

Chapters 6 through 9 focus on each of the primary components of the UCASS study, including a detailed description of each component in the methods used to collect data, and in the case of model construction, to populate the models. The technical, scientific or political challenges that accompany each UCASS methodology are also reviewed within each chapter. Specifically, Chapter 6 provides an overview of the stakeholder engagement activities. Chapter 7 presents the discrete event simulation activities, including a detailed discussion of ARENA and OMNeT++. Chapter 8 details the computable general equilibrium model. Chapter 9 discusses the risk modeling activities being used to define the portfolios of security measures. Chapter 10 discusses in detail how the components are linked.

Chapter 11 is a descriptive case study of the economies of New York State and New York City. Chapters 12 and 13 respectively present the qualitative and quantitative findings from the in-depth interviews with stakeholders and experts, and an analysis of the data collected via an online survey. Chapter 14 presents the CGE analysis of increased security in the New York metropolitan area. Chapter 15 presents the direct and indirect consequence costs of a terrorist attack. Chapter 16 presents the business interruption impacts of terrorist attacks on New York City and Chapter 17 explores the preservation values of four iconic New York City buildings. Chapter 18 is concerned with the impacts of countermeasure spillovers on the New York
metropolitan area economy. Threat, deterrence, and interdiction probabilities are critical to the UCASS analysis, and these are discussed in Chapter 19. Chapter 20 presents the analysis of security measure portfolios, including the spreadsheet-based portfolio application and the Tableau-based Portfolio Visualization. Finally, Chapter 21 presents our conclusions from the study and about the UCASS methodology, and includes recommendations for future work on the UCASS study, including other contexts and environments in which the methods and tools developed here can be applied, as well as recommendations for transferring the UCASS methodology to other environments. In addition, the lessons learned from the collaborative arrangement among three DHS COEs are reviewed.
CONVERGENCE OF SECURITY, RISK AND ECONOMICS

While the 9/11 attacks spurred substantial research on the impacts of terrorism; there has been less research focused on counterterrorism and security. Correspondingly, the relationship between security procedures and economic activity has received little scholarly attention. This chapter reviews the literature on security, including an introduction to an emerging area in the literature referred to as security economics.

Since the 9/11 terrorist attacks, security personnel have focused particularly on infrastructure protection and other physical security needs. Security measures should be commensurate with risk. While there is no single way to assess and manage risk, particularly due to significant inter-industry and even intra-industry variability, it remains important. Providing security requires significant limited resources, both financial and human. These resources must be allocated in the face of conflicting priorities and dynamic threats, some of which are low probability-high consequence events. Not all persons and property can be protected from all threats at all times. Maintaining security in its many forms requires various tradeoffs and restrictions, many of which are not conducive to a free or economically productive society.

Researchers have investigated the impacts of the 9/11 attacks on the overall U.S. economy (Blomberg & Hess, 2009; Roberts, 2009; Rose, Oladosu, Lee, & Asay, 2009), as well as on various geographical regions (Chernak, 2005; Bram, Haughtwout, & Orr, 2009), on individual industries (Werling & Horst, 2009; Treyz & Leung, 2009; Grossi, 2009), on employment (Park, Gordon, Jun, Moore, & Richardson, 2009), on real estate (Dermisi & Baen, 2005; Dermisi, 2006, 2007; Fuerst, 2009; Haughwout & Rabin, 2005), on tourism (Goodrich, 2002; Blake & Sinclair, 2003), and on those victimized both directly and indirectly by attacks (Schuster, Stein, Jaycox, et al., 2001; Silver, Holman, McIntosh, et al., 2002). The literature still lacks investigations into how security responses have impacted society—financially, culturally, politically or psychologically. More specifically, there is very little research examining how security, or classes of responses implemented to reduce risk (both real and perceived), affects a society economically.

From an economic perspective, it is unclear precisely how security initiatives affect productivity, namely in which contexts and under what conditions security practices and policies either stifle
or promote growth at both the macro- and micro-levels of the economy. However, as various government and private entities continue to invest in security, it becomes imperative that the economic tradeoffs of security be explored and better understood.

2.1 Security Economics

In the years since the 9/11 terrorist attacks, interest in the economics of security has grown in both the academic and practitioner circles, yet systematic and empirical research on the topic has significantly lagged (Schneider, Brück & Meierrieks, 2010). There is not a universally accepted definition of security economics (Engerer, 2009). However, Schneider et al. (2010, 11) defined it as the study of “those activities affected by, preventing, dealing with and mitigating insecurity (including terrorism) in the economy.” Furthermore, Schneider et al. (2010, 18) suggested that security economics “refers to the application of economic tools to analyze the origins and dynamics of (in)security.” Security economics, then, may be best understood as an umbrella term that refers to the exploration of the numerous and complex relationships between security and the economy.  

Security economics explores how sources of insecurity, such as terrorism, impact the economy, as well as how security measures and policies affect the economy and, in turn, impact the sources of insecurity. Research on security economics is varied in focus from the macro-level to the micro-level, addressing international economies or incrementally narrowing its focus on the nation, state and local economies or specific industries. Furthermore, such research may examine security in both the public spheres, such as government, and private industry, including the areas where the public and private spheres overlap. Within the field of security economics, security policies and practices may be viewed as defensive or proactive (Enders & Sandler, 2006). Defensive measures and policies are intended to focus on protection and threat mitigation, while proactive measures and policies seek to undermine the source of threats directly. Finally, in studying the economics of security one may seek to understand both the direct and indirect costs that threats and security practices and policies impose in both monetary and non-monetary terms.  

Though the above description is brief (see Figure 2.1), it highlights

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30 Individual researchers may adopt narrower definitions.
31 Non-monetary costs include psychological, social, political, environmental or cultural consequences.
the complexity and diversity of this newly emerging field.

**Figure 2.1: Security Economics Framework**

Based on the perceived need for enhanced security against a greater range of threats, including terrorist threats, the security industry has thrived in a post-9/11 environment (Alexander, 2004). Security investments have flourished with little to no analysis of whether such investments have improved individuals’, companies’ or governments’ level of protection against particular threats, in what ways, and at what cost. While the existing literature has largely focused on the negative impacts of terrorism at both micro-economic and macro-economic levels, minimal attention has been given to the economic repercussions of security responses from the public or private sectors at either the macroeconomic or microeconomic levels (Engerer, 2009; Brück, Karaisl, & Schneider, 2008). Moreover, the distinction between analyzing the effects of security measures and analyzing the effects of security spending is equally lacking in the literature; yet both security spending and security measures have strong effects (Brück, 2004). However, it is unclear how these effects differentially influence economic activity, such as productivity, growth and trade.

Security initiatives can be analyzed through an economic lens using two different approaches (Cordes, Yezer, Young, Foreman, & Kirschner, 2006). The first approach, Cost-Benefit Analysis, assesses the social efficacy of a particular initiative by examining whether a particular initiative will produce social benefits that are proportional to the social value of the invested resources. If analyzing multiple security initiatives, cost-benefit analysis can be used to determine which alternative will best achieve the stated goal(s) at the least cost to society. The second approach, Impact Analysis, examines how a particular initiative may affect different
variables, such as profits and employment, of a specific industry or region. From the impact analysis perspective, changes in demand for goods and services can be traced to determine how these changes affect economic variables, such as productivity. This approach is also known as Economic Consequence Analysis (see, e.g., Rose, 2009a).

Analyzing security initiatives from an economic perspective treats security as a good or service, and as such, finds it subject to both direct and indirect pressures. Brück (2004) conducted an economic analysis of security policies from both national and international perspectives, focusing largely on the direct and indirect effects of insecurity, the tradeoffs between security means and ends, as well as viable policy options for nations when these issues are considered. He argued that insecurity not only imposes costs directly to affected parties, but indirect costs are also imposed in one of two ways, which he termed first-order and second-order indirect effects. First-order indirect effects result from an agent’s reaction to the threat, such as security spending, while second-order indirect effects result from costs accrued from policy reactions to both the threatening event itself such as government regulation, and to agents’ reactions. Moreover, he reviewed a number of security tradeoffs including: security spending versus other spending, economic efficiency, globalization and technological change, equity and civil rights, privacy and individual freedoms.

In 2008, Brück, Karaisl and Schneider extensively surveyed the literature that investigated the relationship between economy and security, focusing specifically on the “human-drivers of insecurity” (i.e., terrorism). Their survey identified research that addressed macroeconomic impacts of both terrorism and security measures or policies, as well as research that examined the impact of security at the micro-level, including the impacts on consumers, households, and the private sector. As Brück et al. (2008) explained:

At micro-economic level, security measures of economic agents can include direct expenditures on security technologies or indirect changes in consumption and investment behaviour to hedge against the risk of falling victim of a terror

32 An agent refers to the person or entity responsible for making security decisions. For example, an agent may be a government, a security planner or security officer.
33 At the household level, the scant research available indicates that, in general, individuals rarely invest in security measures to protect themselves from threats of terrorism.
attack; in addition, dynamic impacts of these changed consumption and investment patterns have to be accounted for. (p. 46)

Generally, the existing research has suggested that at the micro-economic level, investment in security technologies and equipment within the private sector has been largely a function of management decision making, depending on how risk averse a company’s managers are. Perceptions of risk vary across individual CEOs and managers, geographic areas and economic conditions. At the micro-economic level, the risk aversion to terrorism in the private sector appears low; thus, investments in anti-terrorism measures are relatively low. Moreover, research has suggested that security spending does not appear to significantly impact profitability to a degree that U.S. businesses would pull out of countries affected by terrorism (Purnell & Wainstein, 1981). However, it may be the case that terrorism affects industries differently, and thus may be addressed by businesses differently. A business may not directly address terrorism-related threats, but instead indirectly address them within a wider set of risks, such as changes in demand or disruption in supply chains or other operational risks (Brück et al., 2008). The authors concluded that it is unclear if low security spending is justified by the low probability of a terrorist event or if decision-makers are under-funding security at the expense of their own businesses, due to the overwhelming complexity inherent to managing terrorism risk.

When investigating the impact of security at the macro-economic level, Brück et al. (2008) stated that the following variables should be accounted for: the direct effects of increased security spending (i.e., the fiscal effects) and its effects on aggregate consumption and investment; the indirect impact of increased transaction costs and the repercussions on the economy’s competitiveness; and the aggregate impact of changes in consumption and investment spending that result from risk aversion rather than direct security investments. In their review of the literature, they found that fiscal spending on defense and homeland security redirects spending from other growth-enhancing investments; however, separating the budgetary impacts from economic impacts is complicated. While the budgetary impacts may be insignificant, the economic impacts may be substantial. For example, Gupta, Clements, Bhattacharya, and Chakravarti (2004), examining the fiscal effects of armed conflict, found that in low to medium income countries, money directed towards defense investments will detrimentally redirect spending away from other social and economic problems.
In 2003, Hobijn projected that the total direct expenditures of both the public and private sectors combined on homeland security initiatives would cost the U.S. approximately $76 billion, or about 0.7% of the 2003 gross domestic product (GDP)—an arguably small fiscal impact. Moreover, he argued that while the private sector’s increased expenditures on protection would shift resources away from productivity, the overall impact on productivity would be negligible. Due to the relatively insignificant cost of homeland security measures, Hobijn concluded that even if security initiatives thwarted one terrorist attack, then the return on homeland security expenditures would be high.

Subsequently in 2007, Hobijn and Sabir conducted a retrospective assessment of homeland security expenditures from 2001-2005, calculating the impact of spending on the overall U.S. economy. Using data from federal reports, the private sector’s security-related labor and capital expenditures, as well as additional sector-specific information, they estimated that homeland security spending rose from $56 billion in 2001 to $99.5 billion in 2005. Of the $45.5 billion dollar increase, they estimated that $34.2 billion was spent by the federal government and $9.4 billion was spent by the private sector. Specifically, they calculated that the private sector’s security costs rose from $36 billion to $45 billion, the 9 billion increase accounting for only .46% of the private sector GDP from 2001 to 2005. The authors again concluded that increased security spending in either the public or private spheres had not significantly impacted the U.S. economy, due largely to the sheer size and resiliency of the U.S. economy. Finally, at the macro-economic level, Hobijn and Sabir noted that changes in investment levels are influenced by greater risk aversion. The literature suggests that transnational capital flows are negatively affected by security measures adopted to avoid terrorism risk.

Based on the limited availability of empirical research, Brück et al. (2008) concluded that the economic repercussions of security are varied and depend on a combination of many factors, including: which measures are adopted, by whom they are adopted, in which economic context they are implemented, and their actual impact on future terrorist behavior. The authors also concluded that evaluating the consequences of security practices and policies is much more difficult compared to assessing the impacts of terrorism.
2.1.1 Limitations of the Security Economics Research

While research within the newly emerging field of security economics is beginning to surface, such pursuits are hindered by several limitations, primarily the availability and quality of data (Schneider et al., 2010; Drakos, 2009). Furthermore, how to prioritize and measure non-monetary costs and benefits of security policies and practices, such as prevention, deterrence and mitigation, and how to account for unintended consequences are not straightforward tasks.

Minimal data are available to accurately determine the probabilities of future terrorist attacks. Yet rational security decision-making is, in part, dependent on the (real or perceived) presence, frequency and severity of threats. Moreover, a majority of the available terrorism-related databases are largely chronological archives of terrorist events. As event-driven databases, a great deal of relevant information is simply not captured. In addition, much of the data in such databases is collected from public sources, such as media reports, which are known to have errors and omissions. Although databases that collect terrorist-related data are limited, they do exist. Data on counterterrorism activities, including expenditures, are fragmented, decentralized or simply not available. The limited available information primarily traces government expenditures on security measures. Having information on security expenditures from the private sector would enable analysts to better understand the total costs of security to the larger society (Drakos, 2009), particularly since an estimated 85% of U.S. infrastructure is owned by the private sector (GAO, 2006).

While some limited research is available regarding U.S. security-related expenditures, this collection of studies has focused on the fiscal costs of security, not taking into account the outcomes of security investments. This is a function of the inherent difficulties of translating non-monetary consequences, which vary over time and place, as well as by decision-makers’ needs and resource availability, into fiscal terms. Cohen (2005) noted that cost-benefit and impact analyses of criminal justice and crime prevention programs are also rare. Economic analyses of counterterrorism security measures are even more rare, particularly since terrorism is a significantly lower probability event.

Finally, when security policies or practices are implemented to minimize risk, measuring their effectiveness is not a straightforward task. One must account for, and if possible control for,
extraneous factors that are occurring simultaneously in the environment that may affect a security measure’s performance, while also remaining cognizant of the secondary (or even tertiary) consequences of a particular policy or program. For example, the closure of a portion of Pennsylvania Avenue in front of the White House provides an interesting case study from which the unintended social and economic impacts of security activities can be illustrated. In 2002, Hoffman, Chalk, Liston and Brennan from RAND prepared a report for the Federal City Council for the District of Columbia regarding the closure of a portion of Pennsylvania Avenue, which was largely in response to the 1995 Oklahoma City bombing. They conducted a detailed literature search and interviews with law enforcement officials and other key persons regarding the street’s closure. While arguments for both the permanent closure and the reopening of Pennsylvania Avenue were reviewed, the authors noted the negative repercussions of the stringent security measures at the U.S. Capitol. They concluded that (2002):

Disrupted traffic and commuting patterns adversely affected local businesses and hampered access to the newly revitalized downtown city center. The closure, moreover, has not only created inconvenience and led to revenue loss, but it was also seen to project an image of fortification and security that is both undesirable and inappropriate given an open and democratic society that is the defining characteristic of our nation. (p. 2)

The partial closure of Pennsylvania Avenue, in addition to symbolic repercussions, had direct and indirect economic impacts on both local government and local businesses. Reduced parking meter and ticket revenue, as well as increased expenses to re-route the Metrobus, negatively impacted the local economy. Whereas the inner downtown Washington, D.C. area had once been a lucrative commercial location to conduct business due to both its proximity to the many government buildings, now the traffic and congestion resulting from the closures had a number of negative consequences. For example, employee commuter times increased due to the closures, thus lowering productivity, and many firms chose to relocate due to traffic congestion and inconvenience, thus impacting both retail sales and property tax values. While only a single example, the closure of Pennsylvania Avenue demonstrated the dynamic, and often unintended, consequences of security policies and practices on both the public and private sectors. Although
there has been a proliferation of security initiatives, and thus expenditures, there is little knowledge concerning whether they are effective and, if so, under what conditions.

Since security policies and practices that were originally intended to prevent or deter terrorist actions have in some cases had unintentional economic impacts, it would be negligent to assume that either the intended or unintended effects of a given security policy or practice will necessarily be either negative or positive. For example, when evaluating the costs of crime and the responses to suppress crime, Cohen (2005) argued that crime indirectly impacts even those whom have not been victimized by increasing society’s fear of crime. When the general fear of crime increases, society accrues costs associated with avoiding future crime, including investing in various forms of security. While increasing security may create a sense of safety as intended, Zedner (2003) cautioned that, among other paradoxes, security measures and policies may create anxiety and exacerbate fear by alerting citizens to risk, regardless of how probable the risk may be. As the closure of Pennsylvania Avenue demonstrated, the negative outcomes of security included inconvenience and a loss of revenue, and a loss of productivity.

2.2 Assessing, Managing and Financing Security

Estimating, managing and financing security measures are substantial undertakings, particularly when having to do so in response to low probability-high consequence events or threats, such as terrorism. A universal framework has yet to emerge for assessing, managing and financing security protection and mitigation measures. As Richardson, Gordon and Moore (2007) stated:

> Despite a rational concern with terrorist vehicle-bomb attacks and other threat scenarios, a coherent, cost-effective strategy for protecting buildings and facilities while maintaining full and free access to them has yet to emerge. As a result, building owners and managers have been forced to implement ad hoc approaches targeted more at generic vulnerabilities than at actual threats—not necessarily an effective, yet alone cost-effective approach to urban terrorism. (p. 6)

The probability of a terrorist attack occurring is extremely low (see Table 2-1); thus, justifying and committing resources towards securing people, property and other assets further strains organizational productivity and profit. Hence, it is important for decision-makers to understand the probability and distribution of terrorism risk (Willis, Morral, Kelly, & Medby, 2005). As
Willis et al. (2005) argued, just as techniques for assessing risk and risk reduction strategies are useful for evaluating the effectiveness of countermeasures, these same techniques can be used to evaluate the effectiveness of resource allocation. Moreover, even when risks are not fully eliminated or mitigated, such assessments may assist future security planning. Finally, understanding and tracking how risk changes over time will likely help with the assessment of the effectiveness of security efforts, as well as the emergence of new risks.

Table 2-1: Estimates of Annual Attack Probability (per building/per year) for Non-specific Threats

<table>
<thead>
<tr>
<th>Source</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ellingwood (2006) *</td>
<td>2×10^{-6}</td>
</tr>
<tr>
<td>Little (2007) **</td>
<td>4×10^{-6}</td>
</tr>
<tr>
<td>Stewart (2007) ***</td>
<td>1.2×10^{-7}, 5.1×10^{-6}</td>
</tr>
</tbody>
</table>

* Minimum attack probability may be increased to 10^{-4} for high density occupancies, key government and international institutions, monumental or iconic buildings, or other critical facilities.
** Against U.S. government-owned buildings; this is estimated to be at least 500,000.
*** For U.S. commercial buildings. The first estimate is for all (4.7 million) buildings and the second estimate is for large (108,000) buildings. Buildings categorized as “large” have floor areas greater than 9,300 m^2 and are typically five to twenty stories high.

While some scholars and practitioners may argue that the infrequency of extreme events and the unpredictability of man-made threats are justification for a “do nothing” security option, few stakeholders would publicly agree that their organizational resources can be better spent increasing productivity and profitability, particularly after extraordinary events, such as the 9/11 terrorist attacks, have occurred. On the contrary, after 9/11, public and private entities alike scrambled to implement various security responses, some of which were responses based on the precautionary principle (O’Riordan & Cameron, 1994), which follows a “better safe than sorry” mantra.

While evaluation studies within the security literature are limited, a small number of scholars and security experts have developed models that can quantitatively evaluate counterterrorism security measures (Little, 2007; Stewart & Muellor, 2008; Stewart, 2007, 2008). Their research primarily examined the effectiveness of physical security measures against events such as

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34 The cybersecurity literature is a subsidiary area of the general security literature that has received greater scholarly attention and evaluation; however, evaluations of cybersecurity are not included here.
bombings. They offer usable frameworks for estimating terrorism risk and evaluating the effectiveness of security measures.

Little (2007) argued that a traditional risk assessment approach, although simplistic, can adequately assess target-hardening\textsuperscript{35} measures to protect buildings from vehicular bomb attacks. While acknowledging that traditional risk assessments are valuable for estimating potential threats and event probabilities, Little (2007) suggested that the traditional approach does not help decision-makers understand what protective strategies may be appropriate or help them manage risk. Specifically, he argued that while risk assessments are useful for identifying, estimating and prioritizing risk, they fail to address which security measures are most appropriate in particular situations. Rather, he suggested that to manage risk successfully, three questions should be posed:

1. Which security options are available?
2. What are the associated tradeoffs, including economic costs and opportunity costs to each option?
3. What could be the expected impact of a particular security option on future options?

There are no clear answers to these highly context-dependent questions, but they do offer a guiding framework for security planners and decision-makers to examine security options.

Stewart (2007) addressed the cost-effectiveness of risk mitigation measures to protect buildings from terrorist threats. He developed a quantitative risk-based procedure that calculated risk using two measures: (1) fatality risks and (2) cost effectiveness of protective measures expressed in terms of expected cost spent on risk reduction per statistical life saved from terrorist threats to built infrastructure. He then used well-established risk acceptance criteria to compare his calculations of fatality risks to determine how much risk is acceptable and whether expenditures spent on risk reduction measures are cost-effective.\textsuperscript{36} Assigning a value of $7.5 million as the

\textsuperscript{35} Target-hardening refers to reinforcing the physical environment to protect physical assets, such as buildings or property, in an effort to make it a less attractive target to criminals or terrorists and to mitigate the effects should a crime or terrorist activity occur.

\textsuperscript{36} Stewart used generic quantitative safety goals adopted by various government regulators for low probability-high consequence threats for involuntary fatality risk:

- If annual fatality risks $> 1 \times 10^{-3}$ deemed unacceptably high
- If annual fatality risk is in range of $1 \times 10^{-3}$ to $1 \times 10^{-6}$ generally acceptable if benefits outweigh risks to provide economic or social justification of risk
threshold, he determined that if a risk reduction measure’s cost exceeds this amount per statistical life saved, then the measure should not be considered cost-effective. The equation for annual fatality rate $Pr(L)$ he used is expressed as:

$$Pr(L) = \frac{(100 - R)p_{attack}Pr(L|H)}{100}$$

where $R$ is the percentage risk reduction, $p_{attack}$ is the attack probability (annual rate of occurrence) and $Pr(L|H)$ is the probability of occupant fatality given a terrorist attack and assuming no protective measure. He proposed that the expected cost spent on risk reduction per life saved ($E_{LS}$) can be expressed as:

$$E_{LS} = \frac{100C_R}{p_{attack}Pr(L|H)RN}$$

where $C_R$ is annual cost spent on protective measures, $p_{attack}$ is the attack probability, $Pr(L|H)$ is the baseline individual annual fatality risk assuming no protective measures, $R$ is the percentage risk reduction as a result of protective measures, and $N$ is the number of people exposed to the hazard. He found that the annual fatality risks are very low for both small and large commercial buildings in the U.S. not facing a specific threat. He concluded that for buildings subjected to non-specific threats, expected expenditures far exceed the $7.5$ million dollars per life saved threshold; thus, the expenditures are not cost effective. However, he argued that if the annual attack probability and/or the number of building occupants significantly increased, then security expenditures become more cost efficient.

Stewart (2008) again conducted a basic cost-benefit analysis of risk mitigation measures to protect buildings from terrorist threats using damage costs as a primary decision-making criterion. He approached the problem by asking: *is the reduction of risk worth the added

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37 Stewart estimated attack probability as number of attacks divided by (number of years x number of potential targets).
expenditure? Using economic decision theory, Stewart argued that if protective measures are cost effective, then their expected costs should be less than the expected costs of not implementing the protective measures, which he expressed as $C_R < R \frac{p_{\text{attack}}}{100} C_F$ where $C_R$ is cost of the protective measure; $R$ is the percentage of reduced risk due to the protective measure; $p_{\text{attack}}$ is the attack probability (annual rate of occurrence); and $C_F$ is the cost consequence in case of failure.

If the costs of the protective measures are greater than the reduction of risk attributed to the security measures, then it is more economical to divert the resources towards mitigating risks from other hazards. He then applied his decision-making model by estimating the cost effectiveness of protective measures for U.S. commercial buildings based on a series of assumptions and attack probabilities. He concluded that for non-specific threats, increased expenditures greater than a few thousand dollars needed to strengthen new and existing commercial buildings are not cost effective, unless the annual attack probabilities increase. However, for buildings with higher damage consequences or those facing specific threats, he argued that it might be cost effective to implement security protective measures that cost more than a few thousand dollars.\(^\text{38}\)

When assessing security measures, it is important for decision-makers to keep sight of two important factors. First, not every potential target can be protected at all times, it is simply impractical due to the infinite number of potential targets, as well as the costs such a defensive strategy would require. Second, benefits derived from security measures against terrorist attacks are only truly realized if an attack occurs (Little, 2007). If an attack never occurs, then the investments are never recouped. Economically, those sunken security costs have then been forfeited at the expense of other potentially lucrative investments. Based on Stewart and Little’s research, except for a very limited sample of possible targets, security spending in the form of infrastructure hardening, from a purely monetary standpoint, may not be an effective or an efficient allocation of financial resources unless terrorist attacks on U.S. soil become more frequent.

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\(^{38}\) Buildings that may be more attractive terrorist targets of vehicular bombs include key governmental buildings, international institutions, monumental or iconic buildings, and critical infrastructure facilities.
Mueller (2006) suggested that a significant portion of the money spent to date on counterterrorism initiatives since the 9/11 attacks has likely been wasted—a suggestion that challenges other researchers’ conclusions (see Hobijn, 2003; Hobijn & Sabir, 2007). Similarly, analyzing homeland security spending since 9/11, de Rugy (2004) concluded that since homeland security money has been allocated based on a political basis rather than sound cost-benefit analyses, much of the resulting security has likely been ineffective and has come at a significant expense. Mueller’s subsequent writings suggested that not only have limited resources been wasted, but also they will likely continue to be wasted unless several factors are considered when formulating security policies (see Table 2-2). While Mueller (2010) argued that there are conditions in which investing in security is futile, he has maintained that there are contexts where security investments are sensible, such as the security of nuclear and chemical plants, key infrastructure nodes, major ports and symbolic targets. He argued that for these types of targets, it may be worthwhile to implement security measures when it is feasible to protect an entire set of targets or when the destruction of a target within a set would cause large physical, economic, psychological, and/or political consequences.

**Table 2-2: Eight Premises for Security Policy Consideration**

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Number of potential targets is essentially infinite.</td>
</tr>
<tr>
<td>2.</td>
<td>Numbers of terrorists appear to be small, and their efforts and levels of competence limited.</td>
</tr>
<tr>
<td>3.</td>
<td>Target selection is largely a random process based disproportionately on convenience and proximity.</td>
</tr>
<tr>
<td>4.</td>
<td>The probability that a specific target will be attacked is extremely low in almost all cases.</td>
</tr>
<tr>
<td>5.</td>
<td>Protection of one target may simply displace terrorist target selection to another location.</td>
</tr>
<tr>
<td>6.</td>
<td>As a result of displacement, protection of one target may make others less safe.</td>
</tr>
<tr>
<td>7.</td>
<td>Vulnerable targets if damaged can be repaired relatively quickly at a tolerable expense.</td>
</tr>
<tr>
<td>8.</td>
<td>Protecting a potential target is never absolute unless a facility is completely closed down.</td>
</tr>
</tbody>
</table>

Adapted from Mueller (2010).

39 Mueller focuses his discussion on prevention measures, specifically excluding mitigation measures, policing and other active defense measures, or measures that promote resilience.
2.2.1 Challenges of Assessing the Impacts of Security

There is no single best approach to assess the overall effectiveness of security measures. While quantitative tools are helpful, they are not the only measure on which security decisions should be based, particularly in environments that are dynamic and uncertain. As Stewart (2007) states:

While quantitative decision-support tools hold some appeal to decision-makers, they cannot capture the full and diverse range of societal considerations of risk acceptability… [quantitative assessments] should be viewed only as an aid to decision support, where decisions about public safety will often require social, economic, cultural, environmental, and political and other considerations. (p. 8)

First, such quantitative assessments are highly dependent on many value judgments and assumptions, which are problematic when faced with multiple and conflicting priorities. Quantitative assessments of security risks and the expected costs of security are important tools in strategizing security spending, as well as estimating counter-measure effectiveness (Pate-Cornell & Guikema, 2002); however, such assessments are imperfect and limited by several factors, particularly the substantial difficulty in quantifying security risks (Willis et al., 2005; Stewart, 2007). Substantial assumptions need to be made to quantify risks since there is a significant degree of uncertainty inherent in evaluating security. True values for risk of a terrorist attack are impossible to calculate; thus, estimates are used. As Willis et al. (2005, 14) stated, “Estimation introduces uncertainty and error.” Moreover, the more complex the tools and models are for economic analyses, the more structurally unstable they become. Instability in the models then contributes to weak and imprecise assessments and poor decision-making outcomes (Joint Transport Research Center, 2009).

Second, the model inputs are largely derived from intelligence and expert opinion, rather than empirical data (Willis et al., 2005; Kunreuther, Michael-Kerjan, & Porter, 2003). Due to the necessity of secrecy and the security classification of information, there is no single database of information from which all experts may extract security information and make judgments, nor is that information readily shared, especially with the public. Moreover, expert opinion is imperfect since it is based on an individual’s assumptions, as experts are subject to personal biases and misperceptions. For example, if an attack occurred recently, experts may over-inflate
the likelihood that subsequent attacks will occur in the near future (Kunreuther et al., 2003). While subjective probabilities of a terrorist attack may be calculated, truly objective ones are infeasible (Joint Transport Research Center, 2009). As Kunreuther et al. (2003) noted, a collection of expert opinions does not guarantee that threats are being assessed accurately. Nevertheless, expert opinion is often utilized since there are few other alternatives from which to draw information.

Finally, security threats are transient and may change rapidly. Information gathered regarding particular threats is time-sensitive, and its brief shelf life often makes strategic planning very difficult. Moreover, terrorist groups intentionally adapt in direct response to protective measures (Jackson, 2008). Terrorist groups or other criminals may alter their operational practices, change technologies, avoid defensive measures, or attack defensive measures directly. The dynamic nature of threats makes security assessments, planning and allocating resources particularly challenging.

2.3 Security and Decision-Making

Though imperfect, the goal of quantification of both risk and security costs supports security decision-making. In reality, the number of plausible threats are infinite; however, resources are limited. Given this reality, security planners and decision-makers make concrete decisions about where and how best to allocate resources most efficiently and effectively. To efficiently allocate resources, the cost effectiveness of various risk reduction measures should be calculated (Willis et al., 2005). This, in part, requires assessing and choosing various tradeoffs between security options and improving business productivity and business continuity.

To fully understand the security decision-making process, it is important to recognize the purposes of security, as well as to identify useful frameworks and portfolios for planning security practices and policies, as these two components will play pivotal roles in the security-decision making process and the development of an agency’s or business’ security portfolio (Jackson, 2008; Kunreuther, 2002; Schneier, 2008, 2003). Moreover, how decision-makers and other stakeholders, particularly in the context of extremely rare threats, perceive risk will influence which security options are chosen and why they are chosen. Since security cannot be absolute, decisions must be made regarding where on the insecurity-security spectrum one is willing to
place themselves or their entities (Baldwin, 1997). Since security practices and policies are used to mitigate risk, decision-makers must determine how much risk they are willing to expose themselves or their entities to.

2.3.1 Functions of Security
Understanding the purpose of security is critical for security planning. Once security risks have been identified, the challenge is then to determine how best to address these risks within a set of given restrictions and limitations. This challenge is complicated in the presence of low probability-high consequence threats, and decisions regarding resource tradeoffs become substantially more difficult. Kunreuther (2002) posed two important questions that security decision-makers need to keep in mind, particularly when faced with consequential but highly unlikely threats:

1. How much should we be willing to pay for small reductions in probabilities that are already extremely low?
2. How much should we be willing to pay for actions that are primarily reassuring, but do little to change the actual risk?

From a business perspective, the goal of security planning and decision-making is to develop cost-effective and sustainable security capabilities (Jackson & Frelinger, 2009). Thus, fostering such capabilities necessitates a security portfolio that can address not only known and predictable threats facing a particular entity, but also threats that are surrounded by substantial uncertainty, such as low-probability high-consequence threats. The functions of security practices and policies are to reduce risk via detection, deterrence, mitigation, as well as response and recovery mechanisms (Jackson, 2008).

From a prevention perspective, security measures and policies should detect threats and reduce the likelihood of risk exposure through deterrence mechanisms. If prevention is unsuccessful, security mechanisms should then limit the consequences of risk exposure via target hardening and other mitigation strategies. From a resiliency perspective, security should also aid in the response and recovery from successful breaches or attacks, and support investigative activities.
These activities will then be fed back into the planning process, which will in turn influence future security options.

Security planning is at the core of the security decision-making process since those responsible for planning and selecting security options must assess and balance a number of competing business priorities, in addition to security priorities. Also, security investments are subject to the law of diminishing returns (Baldwin, 1997), whereby investing in security may be beneficial to a point, after which the investment costs will outweigh the protection garnered from the security policy or measure. The challenge then lies in deciding which security policies or measures will have the greatest impact by providing the greatest level of protection, or conversely by minimizing the greatest amount of risk. Not only do decision-makers seek to reduce risk and avoid wasteful spending, but they must also balance a number of additional objectives, such as avoiding business interruption, avoiding misdirecting attention from other legitimate threats, avoiding creating unnecessary anxiety and fear for the public, and maintaining security credibility (Jackson & Frelinger, 2009).

2.3.2 Security Frameworks and Portfolios
Traditionally, security portfolios have been prevention- and deterrence-focused since ideally it is best to prevent attacks or criminal activity from occurring in the first place. However, in an imperfect world absolute prevention is impossible. Since security decisions necessarily rely on incomplete knowledge, assumptions and uncertainty, Jackson (2008) suggested that rather than focusing on prevention measures, security portfolios should also incorporate both mitigation and resiliency measures that will aid security personnel in response and recovery efforts, resulting in an integrated security portfolio. He did not argue that prevention policies and measures should be abandoned, but rather that a hybrid approach, which integrates mitigation and resiliency-promoting mechanisms, should be taken. Resilient strategies not only focus on building redundancy and flexibility into organizational infrastructure and technological systems, but such strategies also enhance an organization’s adaptability and agility to respond to disruptive events and repair damage when an incident occurs (Jackson, 2008).

While the prevention of terrorism is ultimately desired, Jackson (2008) argued that the probability of preventing a terrorist attack (and subsequent damage) is low. Although mitigation
and resiliency measures do not prevent terrorist attacks from occurring, they should prevent certain attack outcomes and, therefore reduce the damage inflicted from an attack, hasten the economy’s ability to better absorb the shocks of a terrorist incident, and ultimately make it possible to recover faster. He further argues that if mitigation and resiliency measures are invested in, then the inherent uncertainty of terrorism threats becomes less important and influential. In a hybrid security portfolio, the tradeoff then is the acceptance of some damage in return for the predictability of the ways in which threats may manifest. Therefore, over time, risk will be better balanced and returns on security more stable.

When taking into account security options, Schneier (2003) suggested that security decision-makers should focus on addressing whether a particular security option will be a good tradeoff for their goals, rather than whether a security option is generically effective. It is the tradeoffs that are important since security is not an isolated good, but rather one component in a dynamic environment. Scheiner (2008) argued that there are several potential trade-offs, including the severity and probability of risk, the magnitude of costs, how effective countermeasures will mitigate risk, and how well various costs and risks can be compared.

Estimating security costs and benefits is difficult since benefits are uncertain and difficult to quantify (Joint Transport Research Center, 2009). It is difficult to reliably and validly measure an event, such as a prevented terrorist attack, that never happened (West, 2008). Nevertheless, several scholars have argued that scenario analysis is one valuable approach for exploring how security portfolios or countermeasures will perform under different assumptions (Jackson, 2008; Gordon, Moore, & Richardson, 2007; Kunreuther et al., 2003; Paté-Cornell & Guikema, 2002).

In scenario analyses, assumptions regarding threats, vulnerabilities and consequences can be manipulated, probabilities can be assigned to scenario components, and sensitivity analyses run to estimate how changes in inputs affect the assigned probabilities. Risk and security measures can then be ranked by priority. For example, the higher the potential consequences, the more prioritized the threat should be to security decision-makers (Jackson & Frelinger, 2009). Threat factors that could be manipulated in such an analysis might include levels of terrorist threat,

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40 Sensitivity analysis is the study of how the uncertainty in the output of a model (numerical or otherwise) can be apportioned to different sources of uncertainty in the model input.
sources of terrorist threat, variation in attack types and variation in adversaries’ strategic behavior (Jackson, 2008). Vulnerability factors that could be manipulated in such an analysis might include varying the types of security measures, varying the orientation of security measures (i.e., prevention, mitigation, or resiliency), as well as testing a “do nothing” null option. This approach can better enable decision-makers to then assess which security portfolio combination will best address their needs within their budgetary limits and other business constraints.

2.3.3 The Influence of Risk Perceptions on Decision-Making

While academic discussion of risk analysis tends to be framed in a way that suggests scientific precision, this is often not an accurate presentation. Risk is a subjective concept shaped by the varied values and judgments of cultures and institutions. Analyzing risk is as much an art as a science, and as a subjective endeavor it is shaped by perceptions. Therefore, it is prudent to review how risk is perceived and the roles these subjective perceptions play in security decision-making processes. It is the perceptions of risk, in addition to any seemingly objective assessments of risk, which affect security choices.

Perceptions of risk oftentimes diverge from the reality of risk, particularly when risks are dreaded and unknown, such as in the case of terrorism (Schneier, 2008; Slovic & Weber, 2002). As Little (2007) argued, security countermeasures are often motivated by the perceived need or desire to protect people and assets, rather than motivated by an accurate assessment of the actual risk posed. Similarly, Schneier (2008) noted:

> The reality of security is mathematical, based on probability of different risks and the effectiveness of different countermeasures ... But security is also a feeling, based not on probabilities and mathematical calculations, but on your psychological reactions to both risks and countermeasures. (p. 1)

What Schneier and other scholars (Slovic & Weber, 2002; Kunreuther, 2002) articulated the distinction between security as a reality and security as a feeling. Security as a feeling is based

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41 Slovic (2002) explained that dreaded risks refer to those risks that are perceived as uncontrollable, have catastrophic potential, and fatal consequences, while unknown risks are those which are judged to be unobservable, new, and delayed in their manifestation of harm.
entirely on risk perceptions. Pidgeon (1998) defined risk perception as the beliefs, attitudes, judgments, feelings, and cultural and social dispositions adopted towards threats to valued objects and principles. The perception and communication of risk has direct influence on risk attitudes and tolerances (Mellers, Swartz, & Cooke, 1998; Sjöberg, 2000)—or how willing a person or entity is to accept risk, and how much risk they are willing to accept—and consequently their choice of security (i.e., the management of risk).

Risk is evaluated, and hence perceived, by separate components of our mental processing systems—the first affective, the other cognitive (Fischoff, Bostrom, & Quaddrel, 1993; Mellers, Swartz, & Cooke, 1998; Slovic & Weber, 2002). The affect-driven system is the intuitive, evolutionary system that is automatic, fast, relies on images and associations, and links experience to emotions. The cognitive system, in contrast, is a slower, rule-based processing system that relies on algorithms and requires control and awareness. While rational decision-making requires the integration of both systems, affect-driven and association-based processes guide risk perceptions more than rational, rule-based processes, particularly in contexts with substantial uncertainty and when people feel highly threatened (Slovic & Weber, 2002; Gordon & Arian, 2001).

While utility theory posits that decisions are made based on straightforward calculations of gains and losses, prospect theory argues that decision-making where risk is present risk introduces uncertainty into the decision-making process (Kahneman & Tversky, 1979). When facing uncertainty, perceptions of gains and losses to which people assign subjective values drive decision-making behaviors rather than known probabilities. When there is substantial uncertainty, risk perceptions often do not match the reality of a situation. When one’s perceptions of risk diverge from the reality of risk, unreasonable security decisions are made and tradeoffs become more irrational (Schneier, 2008).

In order to estimate risk and evaluate potential tradeoffs, heuristics, or mental shortcuts and biases developed through experience and other learning-based processes for problem solving, are used to guide decision-making behavior. As Schneier explained (2008), “heuristics affect how we think about risks, how we evaluate the probability of future events, how we consider costs,
and how we make trade-offs” (p.8). Heuristics help shape conventional wisdom regarding risk in everyday life, and this conventional wisdom in turn affects security decision-making.42

While not an exhaustive list, there are several generalizations regarding the influence of heuristics on decision-making processes when applied to the relationship between risk and security (Schneier, 2003, 2008; West, 2008; Kahneman & Tversky, 1979). First, spectacular but rare risks tend to be overestimated, while common, everyday risks tend to be underestimated. Similarly, risks that are both unfamiliar and uncontrollable tend to be overestimated. Moreover, recently experienced events are easier to remember than distant ones; therefore, they are perceived to be more frequent or probable. Finally, risks that are openly discussed and exposed to public scrutiny tend to be overestimated. Overestimated risks tend to solicit disproportionately excessive reactions.

Terrorism risk can be described as: spectacular, rare, recent, publicly debated, unfamiliar and uncontrollable. It is then no surprise that terrorism receives considerably more attention than other risks that pose much graver dangers to our daily lives. Sunstein (2003) argued that society’s excessive reaction to terrorism is an example of what he has termed probability neglect. The actual probability of a risk manifesting and inflicting harm is ignored, and the negativity of the (highly unlikely) outcome is focused on. Whether security decision-makers themselves are subject to probability neglect or are responding to political and public demands for security, the issue remains that security measures intended to thwart terrorism may be misplaced.

Second, as Schneier (2008) noted, people are more likely to avoid risk when alternatives are presented as gains, and conversely, people are more likely to take risks when alternatives are presented as losses. Research shows that people will accept smaller gains that are certain rather than risk them for larger but uncertain gains. Similarly, people tend to risk larger losses rather than accept smaller losses. Schneier argued that it is reasonable to assume that these principles would in fact transfer to a terrorism context, although there is no literature available investigating whether these general principles hold true in a security decision-making context.

42 In general, risk is conceptualized differently, particularly between laypersons and experts, with experts’ estimations more closely correlating with technical estimates of risk (Slovic & Weber, 2002).
Finally, both risk and security are abstract concepts, and as abstract concepts there are no tangible outcomes readily attached to them. When security is effective, an adverse event is prevented from occurring. The absence of the outcome (i.e., nothing bad happened) makes it very difficult to accurately understand and evaluate a security measure’s effectiveness. Since there are no immediate or tangible returns, or even intangible ones if a risk never materializes, the investments in and the evaluation of security efforts are difficult to gauge. Those behaviors and circumstances that do not receive routine, positive reinforcement tend to be given less attention and merit, particularly when they are competing against priorities that do yield tangible returns and profits.

2.3.4 Social Amplification of Risk

On the one hand, financial planning for security is oftentimes a de-prioritized task, particularly when adverse threats or hazards are presumed to have a low probability of occurrence. On the other hand, security measures and policies in response to low probability threats, such as terrorism, are sometimes adopted as automatic reactions in an effort to demonstrate that an entity is “doing something.” This paradox of security behaviors is driven by changes in risk perceptions, which are often instigated by poorly understood or adverse events. These reflex reactions can be largely attributed to what Kaspersion et al. (1998) referred to as the social amplification of risk.

Kasperson et al.’s (1998) social amplification of risk is a conceptual framework describing a phenomenon in which events create secondary or tertiary ripple effects in response to an initial hazard or threat, resulting in heightened public perception of risk and risk behaviors, which in turn results in substantial economic and social consequences for society. The social amplification of risk occurs in two major stages: during the risk event itself when information regarding risk is transferred (largely through interpersonal contacts or networks and the media) and during society’s behavioral responses to the event (see Giesecke et al., 2012 for an analysis of the economic impacts of the social amplification of risk following a terrorist attack). These behavioral responses, in part, prompt changes in security behaviors, which in turn impact the environments in which the security mechanism or policy operates.
One consequence of the social amplification of risk is what Schneier (2003) called *security theatre*. Security theatre occurs when security measures are implemented to convey a sense of reassurance rather than to reduce risk. Security theatre can have either positive or negative consequences. Having a constituency whose feelings of security match the actual level of security is important. Security theatre comes at a cost, however. When security theatre portrays a false sense of security at the cost of actual security, or where resources could garner greater benefits, or when it has the adverse consequence of increasing fear, then security theatre is undesirable.
3 CURRENT TERRORIST THREAT TO THE UNITED STATES

The security initiatives and the environment in which the UCASS study is based have been implemented largely in response to the threat of terrorism. Therefore it is important to review current understanding of the terrorist threat to the U.S. Terrorism threat analysis is heavily dependent on studying past successful and unsuccessful terrorist campaigns, plots and actual attacks. Additional methods, such as studying terrorist, intercepted communications, Internet communication and propaganda; eliciting expert opinion; and red team exercises help to fill out a picture of the current threat environment. It is important to remember that there is a strong psychological dimension to terrorism. While terrorists desire successful attacks, the fear imposed on the citizenry by even a thwarted attack is an accomplishment in and of itself. Not only do such incidents create fear within the community; the security responses implemented because of an unsuccessful attack impose a range of costs, many of which are considered in this study.

3.1 Current Trend

The United States currently faces several sources of terrorist threats. While the left-wing extremism responsible for much of the terrorist violence in the 1970s has since subsided, protests generated by the economic crisis could provoke a resurgence. In addition, white supremacists and anti-federal government extremists remain a constant undercurrent in American history. In addition, various issue-oriented groups—e.g., animal-rights extremists, eco-terrorists, anti-abortion extremists — continue to carry out acts of violence. However, the principal terrorist threat comes from the global terrorist enterprise inspired by al Qaeda, which has both an international and a domestic dimension.

The al Qaeda of today differs from the al Qaeda of 9/11. In 2001, al Qaeda was a small core of extremists; it was always a tiny army, but it located itself at the center of a global network of terrorist operatives constantly trying to expand its relations with other groups and to establish new footholds. It benefited from Taliban protection in Afghanistan and from benign neglect, if not active assistance, from Pakistan. It ran easily accessible training camps, which were magnets.

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43 At the time of this writing it is not known whether the Boston Marathon attack had a concrete linkage to al Qaeda.
for recruits to its ideology of global jihad. Its terrorist operations were ambitious, strategic and centrally directed. However, since 2001, the U.S. and its allies have made undeniable progress in degrading al Qaeda’s operational capabilities, and in the capture and execution of its leader. Unprecedented cooperation among the world’s intelligence services and law enforcement organizations has made al Qaeda’s operating environment significantly more dangerous for the terrorist group. There may be no longer a wide global network run directly by al Qaeda itself, although al Qaeda in the Arabian Peninsula and operations carried out in Yemen remain a current concern for the U.S.

Although “al Qaeda Central” remains in business, the sinews of command are weakened. Its global terrorist campaign is now more decentralized, and more dependent on local affiliates and allies. Between 2002 and 2005, while the organization’s core was under immense pressure, its alumni launched a series of spectacular and successful attacks in Tunisia, Kenya, Indonesia, Saudi Arabia, Morocco, Turkey, and Egypt. The attacks provoked crackdowns—in some cases by governments that might have preferred to be spectators to a conflict between al Qaeda and America, but which, when directly threatened retaliated firmly against the terrorist group. At the same time, al Qaeda found new sources of support and new theaters of operation in Iraq, Somalia, Algeria, and Yemen. Attempts to clone al Qaeda-like organizations in Lebanon and Palestine have thus far proved less successful. Al Qaeda is, in a sense a “parasitic enterprise,” which is strongest where it can attach itself to local conflicts in weak states.

Al Qaeda also benefits from its relationship with like-minded groups that are not under its control, groups which have their own political and military agendas such as Afghanistan’s Taliban, the Tehrik-i-Taliban Pakistan (TTP), Laskar-e-Taiba, and others in Pakistan and India. These groups are now operating internationally. Beyond disseminating its ideology of global struggle, al Qaeda’s contribution to these movements is unclear. Some analysts have seen these dependencies on other groups as evidence of al Qaeda’s weakness, but the radicalization resulting from the relationships and the fact that recruits from the various groups are increasingly commingled in training camps and terrorist operations suggest that they may be a source of strength or a guarantee of long-term survival. The capability of al Qaeda’s central commanders to project power in the form of terrorist attacks has diminished. Global attacks are concentrated in a broad arc from the Maghreb to Mumbai, and occasional attacks occur in more distant
Muslim regions. Al Qaeda–inspired jihadists have not been able to carry out a significant terrorist operation in the West in many years, although numerous plots have been uncovered and thwarted.

Al Qaeda’s paramount objective remains building an army of believers who will take up arms, provoking a worldwide armed movement. Its determination is undiminished. The volume and sophistication of its communications have increased. There are now thousands of websites devoted to exhortation and violent instruction. Osama bin Laden has been killed, but al Qaeda’s second in command, Ayman al-Zawahiri, has risen to leadership and remains a spokesman who speaks to international constituents. A tier of online jihadists adds to the “retail outlets” on the Internet broadcasting al Qaeda’s message. When leaders of al Qaeda talk, many listen, but this has not translated into a fundamentalist Islamic uprising, or a global intifada. Nevertheless, al Qaeda appears determined to continue the armed struggle. Al Qaeda’s affiliates demonstrate a continuing capacity for violence, and al Qaeda has been able to exploit the uprisings in the Middle East to expand its activities. Al Qaeda’s campaign may morph, but it is likely to continue for many years.

There has been an increase in homegrown plotters, as well. Al Qaeda’s recruiting was always global, but getting its acolytes to training sites in Pakistan and Afghanistan has become more difficult. Recognizing this reality, the organization now places increased emphasis on “do-it-yourself” terrorism, urging local would-be warriors to do whatever they can, wherever they are. Al Qaeda’s communicators know that home-grown attacks, while less ambitious, still provoke greater alarm than engagements on distant battlefronts. They can count on the news media, partisan politics, and public anxiety to exaggerate the threat posed by these local plotters.

### 3.2 Public Response and Radicalization

People in the West tend to view any terrorist attempt as a failure on the part of those charged with protecting the populace. Attacks by homegrown terrorists arouse suspicion of local Muslim communities, and prompt rhetoric and reactions that can be portrayed as anti-Muslim, thereby fostering resentment in the Muslim community and facilitating al Qaeda recruiting. Even foiled attempts and deliberate hoaxes have utility since they require little investment and bring high returns. High casualty rates remain a desirable terrorist goal, although creating terror will
suffice. This change in al Qaeda’s rhetoric of embracing useful failure represents a fundamental shift in the group’s goals. Thus far, however, the number of would-be warriors responding to al Qaeda’s appeals remains small. Between 9/11 and the end of 2010, only 176 homegrown terrorists were arrested or otherwise identified for providing material support to jihadist groups or plotting to carry out terrorist attacks in the United States. Most of the terrorist plots uncovered in the United States appear to be one-off efforts. They indicate veins of resentment and pools of radicals and terrorists but they do not show evidence of extensive terrorist undergrounds or armies of sleepers in the United States.

The radicalization process has become fairly well understood, but it is not possible to predict who will become a terrorist. No doubt, some start down the path but drop out before crossing into well-defined terrorist activity. We know only about those who have carried out attacks or have been discovered as they plotted to carry out attacks, attempted to join terrorist groups abroad, or provided terrorists with material assistance. They appear to be a diverse group.

The majority of al Qaeda homegrown terrorists in the United States are U.S. citizens; the others are legal permanent residents. They come from a number of Arab and South Asian immigrant communities, with Pakistan and Somalia heavily represented. Ages range from the teens to the seventies, with the median in the late twenties, a bit older than most criminal offenders. Some of these homegrown terrorists are dropouts, while some have advanced university degrees (Jenkins, 2011c).

Some of the 176 terrorists arrested in the United States or identified as having joined terrorist groups abroad between 9/11 and 2010 could be described as having the experience and skills that would make them dangerous. Some have seen military service; some have attended terrorist training camps; some gained their experience on the streets. Twenty-three had criminal records for activities including petty crime, armed robbery, and drug dealing. Almost all were self-radicalized rather than recruited, although companions who are more fanatic may have swept others along with them.

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Most began their journey to terrorism on the Internet, where they could readily find resonance and reinforcement of their own discontents, and interlocutors who would legitimize and direct their anger. Many operated alone. Most of the terrorist plots have been amateurish, displaying limited capabilities. This is not to say that the plotters were not dangerous. No great distance separates a half-baked plot from a lethal terrorist attack. The critical ingredient is often no more than one determined and reasonably competent individual. At issue here are intentions, not competence. The would-be jihadists who have been arrested or identified demonstrated earnest intent.

3.3 Post 9/11 Terrorist Plots in the United States

A substantial amount of information about terrorists’ intentions and capabilities can be gained by analyzing recent terrorist plots in the United States. Terrorist attacks may occur anywhere terrorists happen to reside, but New York City is still the target of most planned attacks. This is consistent with the history of terrorist violence in the United States. Over the past half-century, terrorist attacks have occurred throughout the country, but six metropolitan areas predominate as targets: Washington D.C., Miami, Chicago, San Francisco, Los Angeles, and above all, New York City. New York City’s predominance as a target reflects its ethnically diverse population and its wealth of political and iconic economic targets, from the corporate headquarters of major financial institutions to the United Nations Headquarters. While eco-terrorists and animal-rights extremists seek targets directly connected with their issues, they rarely kill. Jihadist terrorists focus on iconic venues and financial institutions but seem also determined to inflict high casualty rates and, therefore, favor heavily trafficked public transportation systems.

Almost all the terrorist plots that have been uncovered have involved improvised incendiary devices or explosives (or what the terrorists thought were explosives but were dummy bombs provided by undercover agents). This apparent uniformity of modus operandi reflects not only the imitative quality of terrorism, but also the role played by confidential informants and undercover agents. Again, the prevalence of bombings is consistent with the history of modern terrorism. Interestingly, two of the three plots that succeeded in killing anybody involved lone gunmen: Carlos Bledsoe killed one soldier and wounded another at an Army recruiting center in Little Rock, Arkansas and Major Nidal Hasan killed 13 and wounded 31 at Fort Hood, Texas. All of the plots involved only one person or a tiny conspiracy, which is not surprising since
enlisting more accomplices risks exposing the operation. Under current circumstances in North America, recruiting 19 suicidal operatives, as was done in the 9/11 attacks, or even the ten determined attackers seen in Mumbai would be a challenge. Interestingly, virtually none of the U.S. targets attacked or contemplated were heavily defended. All were readily accessible by the public or, in the case of Fort Hood, by the Army officer who carried out the attack.

It is important to avoid exaggeration and hyperbole in discussing casualties from a terrorist attack. For example, field tests replicating what the would-be Times Square Bomber Faisal Shazad was trying to build show that had he acquired the correct ingredients and assembled his device properly, he could have created a powerful explosion and fireball. However, media statements that Shazad’s device would have killed hundreds, possibly thousands, were not accurate. Shazad himself hoped to kill 40 people. It seems that most of the jihadist terrorist plots between 9/11 and 2011, had they succeeded, might have caused fatalities in the dozens. History suggests that, absent another 9/11, or the effective use of weapons of mass destruction, fatality estimates are likely to run between handfuls and a few hundred.

### 3.4 Terrorist Urban Disasters

At present, the organization and underground coordination needed to support a continuing high-level terrorist campaign does not appear to exist in the United States. The issue-oriented campaigns (eco-terrorism, animal rights, anti-abortion) do resurface sporadically, but at very low levels of violence. Therefore, current concerns focus on a major terrorist event—a single assault, although perhaps with multiple parts. The list of terrorist-caused urban disasters is not long, and it includes the following notable events:

1992 – London (Baltic Exchange bombing)
1993 – New York (World Trade Center bombing)
1993 – Mumbai (multiple bombings)
1993 – London (Bishopsgate bombing)
1995 – Tokyo (subway sarin attacks)
2001 – New York (9/11 attacks)

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45 It should be noted that the economic impact of serious injury, as occurred with the Boston Marathon attack may exceed the nominal economic impact assigned to loss of life.
2001 – Washington (9/11 attack)
2002 – Moscow (large-scale hostage event)
2004 – Madrid (train bombings)
2005 – London (subway bombings)
2006 – Mumbai (train bombings)
2008 – Mumbai (armed assaults)
2013 – Boston Marathon (improvised explosive devices)

Nine of the 13 events involved world financial centers (New York, London, Tokyo, and Mumbai). Seven involved political capitals (Washington, London, Madrid, Tokyo, and Moscow). Most involved specific targets of enormous symbolic importance (New York’s World Trade Center, London’s financial center, the Pentagon, Mumbai’s Taj Mahal Hotel and Jewish Community Center, the Boston Marathon\(^46\)). One-third of the events (Tokyo, Madrid, London, Mumbai) involved surface transportation targets, where the terrorist objective was body count—indeed, all except the London attacks in the 1990s aimed at high body counts. This was achieved in seven cases with multiple, near-simultaneous attacks.

More than 4,200 people died in these 13 urban attacks. To get some idea of scale, this is roughly the equivalent of the number of American soldiers killed in the Iraq War, or an average of 323 persons per event. Moreover, it is equivalent to the bloodiest terrorist attacks seen before 9/11, most of which involved the detonation of large truck bombs or the sabotage of commercial airliners. The 9/11 attacks on the World Trade Center, however, account for nearly two-thirds of the total fatalities. The median number of fatalities per event runs much lower—around 150. There are few terrorist events in which more than a hundred persons were killed. In terms of fatalities, the average number of fatalities in a terrorist disaster is not very high. It is simply hard to kill a lot of people in a single event.

But the 9/11 terrorist attacks push our thinking towards what future catastrophes might be—terrorist use of weapons of mass destruction to kill thousands, tens of thousands, even hundreds of thousands. Some U.S. government officials see such attacks as inevitable, “not if, but when”

events. However, such a focus on chemical, biological, radiological, or nuclear disasters overlooks the small but far likelier events.

Most of the attacks to date have caused massive property damage—a billion dollars or more in the case of the Baltic Exchange and Bishopsgate bombings in London, tens of billions in direct and indirect damage in the 9/11 attacks. The immediate losses were in the tens of billions but the indirect economic effects of 9/11 reached hundreds of billions of dollars in business disruptions and lost revenue. All of the events caused major urban disruptions, some of which lasted months, and left deep psychological scars on the countries affected, including a continuing sense of fear.

3.5 The Psychological Dimension of Terrorism
To be successful, terrorists do not always have to directly defeat security measures. In fact, they often seek ways of carrying out attacks that obviate security. For example, in December 2009, al Qaeda on the Arabian Peninsula, one of al Qaeda’s regional affiliates, sent Umar Abdulmutallab, a Nigerian student with a small bomb concealed in his underpants, to destroy a Northwest Airlines flight from Amsterdam to Detroit. Abdulmutallab managed to get on board with his device, but when he tried to ignite the bomb it did not work, and passengers quickly immobilized him. Despite the failure of the attack, the U.S. government responded by deploying 1,000 body scanners at airports at a cost of hundreds of millions of dollars and implementing new and more thorough pat-down procedures, provoking short-term anger among airline passengers.

Although they failed to bring down the plane, the terrorists achieved significant psychological and economic effects, demonstrating that government security expenditures and psychological effects can be achieved independent of either loss of life or physical destruction. These reactions were based solely upon perceptions of risk, which can be distorted by fear and alarm and can be exacerbated by public reactions and partisan politics.

The jihadists clearly have discovered that even operational failures can produce disproportionate effects in terms of publicity, alarm, and security expenditures and have recently modified their strategy to exploit these vulnerabilities. Jihadist rhetoric now urges followers to launch attacks, even if they are likely to fail, confident that public and political reactions will still provide a good
return on the terrorist investment. The attempt in October 2010 to detonate bombs in cargo aircraft over the United States, for example, appears to have been motivated by the desire to create economic disruption (achieved when authorities impose inspection on the cargo that regularly flies on these aircraft), with the possible, but unlikely side benefit of killing people on the ground (Gebauer, 2010; Wikipedia, 2013).

All of this suggests that security measures should not consist solely of physical measures, but should also address social consequences. What might be done to create a more resilient society and a political environment that discourages rather than encourages overreaction? The psychological effects of terror plots also suggest that the damage to commerce derives not only from what terrorists do, but also from the disruptive effects of security measures demanded and imposed as a consequence of those actions.

3.6 Terrorist Threat Analysis Methods

In addition to examining current intelligence, threat analysis can be extrapolated from what terrorists themselves say they will do, what terrorists have planned to do—their thwarted plots—and what they actually have done in past attacks. To forecast what terrorists might do in the future, analysts also rely on expert opinion and assemble red teams of analysts and operators who try to simulate terrorist ways of thinking and planning to anticipate attacks.

3.6.1 Combining Methods

The results of these various approaches—extrapolations from what terrorists say and what they have plotted, databases and case studies of what terrorists have done, expert opinions, and attack scenarios produced by red teams—can be amalgamated into a combined threat analysis. This is often done by quantifying or scoring the results of each approach, then combining them mathematically. However, this is a complex undertaking. The spectrum of possible actions might conceivably be comprehensive, and it might be possible to do some rough ranking according to likelihood, but assigning probabilities is perilous, and uncertainty is unavoidable.

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3.6.2 What Terrorists Say

Terrorists say and write a lot. They make threats; they boast about their achievements and actions to come; they explain their actions; and they exhort others to join them, to take up arms on behalf of their cause. Some terrorist leaders issue broad statements in the form of audio or video commentaries. Others debate terrorist strategy; increasingly they do so on the Internet. Official spokespersons of terrorist groups offer further elaborations and appeals to perceived or potential constituents. In the age of the Internet, an army of online participants also interprets, applauds, endorses, threatens enemies, proposes new schemes, debates, questions, and criticizes all official communications from the leadership.

As in all wartime communication, the principal objective is to exhort supporters—the terrorists themselves, the persuaders, the enablers, and the pretend terrorists who participate in the campaign by talking to each other and their perceived or imagined constituencies. Frightening their foes is often the secondary objective. Much of the terrorists’ rhetoric is pure propaganda; although among fanatics, it is difficult to distinguish between what people believe, what they want to believe, and what they pretend to believe.

3.6.3 Terrorist Plots

There is often a large gap between the fantastical scenarios of terrorist chatter, and what they actually try to do. However, the more ambitious failures provide clues about what terrorists may try in the future. The 1995 Bojinka plot, uncovered by authorities in the Philippines, aimed at bringing down 11 airliners flying over the Pacific with explosives smuggled on board in components; but the plotters also discussed crashing an airplane into Central Intelligence Agency (CIA) headquarters48. Authorities uncovered and stopped the plot, but the idea of suicide attacks involving airplanes was ultimately refined into the 9/11 attacks.

3.6.4 Terrorist Attacks

What terrorists have done before they may try to do again. Therefore, much of threat analysis involves extrapolation of what terrorists actually have done to indicate what security planners must, at a minimum, be prepared for. The limitation of this approach is that while it can be used to identify trends, it will probably not anticipate major tactical innovations.

3.6.5 Expert Opinion

Many risk models are informed by expert opinion. In some cases, the process is informal: a group of recognized authorities are assembled and they are asked what they think about future terrorist attacks. Specific questions may relate to the likelihood of terrorists using certain weapons or attacking certain categories of targets. The experts may meet and discuss their views, or they may be polled separately. The discussions may be unstructured, or the experts may be asked to respond to questionnaires or to score the likelihood of specific events. The advantage of expert-opinion elicitation is that it can diverge from what terrorists have already said, plotted, or done and point to new possibilities. The disadvantage lies in the limited accuracy of expert opinion. Expert views may be quantified, but they are still guesses about what may occur. Consensus does not necessarily imply accuracy.

3.6.6 Red Teams

Red teams approach the subject of threat from the terrorists’ point of view. Comprised of experts in terrorism—persons knowledgeable about the worldviews, mindsets, and strategies of specific groups—red teams try to mimic terrorist thinking and play the role of operational planners to conjure up new terrorist schemes. Red teams differ from expert panels in that rather than trying to predict what they think terrorists will do, red teams plan actual attacks as surrogate terrorists. They are not asked to assign probabilities.

3.7 Thinking About Security Since 9/11

The terrorist attacks on September 11, 2001, were traumatic for the nation. Caught by surprise, neither government officials nor ordinary citizens could know whether more attackers were on the way. Security against terrorism became the top national priority, but in the atmosphere of fear and uncertainty that prevailed, it was hard to know what the terrorists might do next.

After the attacks, a subtle but significant shift took place in the way threats were assessed. Traditional threat assessments had been based on analysis of the enemy’s intentions and capabilities. This was easy to do during the Cold War. Soviet intentions could be deduced, and intelligence analysts could count Soviet missiles and tank divisions. Terrorists, however, are more difficult foes; their actions are harder to predict and their targets unlimited. Intelligence failed to provide specific warning of the attacks on 9/11, and no one was confident that we would
have warning the next time. This uncertainty caused analysts to shift from threat-based assessments to vulnerability-based assessments. The shift to vulnerability-based assessments did not reflect a conscious decision, but it was a development that had far-reaching consequences.

As the term implies, vulnerability-based assessment begins by identifying vulnerability. The target can be anything of interest to those with security concerns—a government building, a subway system, a nuclear reactor, or a football game. The analyst then postulates a hypothetical terrorist foe and constructs a scenario, usually a worst-case scenario, which often begins something like, “Suppose that terrorists were to attack a passenger liner. . . .”

Although this type of vulnerability analysis can be useful for examining potential terrorist actions, exploring how security might respond to certain events, or understanding the consequences of a successful attack, it is not a substitute for threat assessment. It does not tell us whether terrorists are likely to mount an attack. In other words, the presence of a vulnerability does not mean that a threat exists. Even so, what begins as the hypothetical possibility of attack may evolve into a scenario that is viewed as probable, then somehow appear inevitable, and, by the end of the assessment, is imminent.

In any large industrial country, vulnerabilities to attack are virtually unlimited. A complete catalog would include commercial aircraft, airports, subways and trains, train stations and tracks, cruise ships and ferries, cargo vessels and port facilities, bridges and tunnels, refineries and pipelines, power plants, power lines and transformers, reservoirs and waterworks, farms and food-processing facilities, financial institutions, government buildings, foreign embassies, landmark properties, commercial and residential buildings, tourist sites, churches, synagogues, temples and mosques, sports arenas, shopping malls, and places where people gather. In fact, terrorists have thought about all of these. Consequently, all these potential targets vie for government attention and security measures.

Unlike vulnerabilities, resources for security are finite, and the competition for them is intense. This, in turn, stimulates what might be called “threat advocacy,” which involves competing campaigns to arouse public concern and prompt government measures to protect the target set being championed. Advocates often lead with worst-case scenarios, aiming to frighten people
into action. Unfortunately, public warnings contribute to public alarm. Public warnings also
give terrorists something specific to talk about, and when they do, we listen, and worry that our
worst fears are confirmed.

3.7.1 Basic Principles of Securing Against Terrorism
Terrorism poses novel problems for security planners, as it differs from more conventional
modes of armed conflict and from ordinary crime. Although thousands of terrorist incidents may
occur worldwide every year, causing casualties and property damage, outside of conflict zones a
terrorist attack is still a remote possibility, and the effects of terrorism are above all
psychological. Terrorism, therefore, is much more a matter of perceptions than of easily
quantifiable risks or losses.

Although a small number of terrorist attacks have resulted in hundreds of fatalities over the past
40 years, with 9/11 causing thousands, the threat terrorists have posed to human life thus far
remains minuscule compared with the threat from other forms of collective and individual
violent conflict—wars and violent crime. Since the beginning of the 21st century, roughly
200,000 people have died in wars worldwide each year, a vast improvement over the roughly
half-million deaths that occur annually as a consequence of homicide49, and a vast improvement
over the first half of the 20th century, when 60 million people died in two world wars. In the
United States alone, the annual homicide rate is more than five times the number of persons
killed in the 9/11 attacks.50 Nevertheless, terrorist incidents are inherently dramatic, attract more
public attention, and cause greater alarm than ordinary crimes—and they often create political
crises. Moreover, the violence is not entirely symbolic: large-scale, indiscriminate terrorist
attacks have become more common, and in the future terrorists could conceivably resort to
weapons of mass destruction.

As a result, security planners must deal with considerable uncertainty in assessing the terrorist
threat and in calculating the appropriate response. What is the level of risk? How much security
is enough? How far should security planners go in dealing with terrorist scenarios that are
theoretically plausible but have not yet occurred? And if an attack judged to be remote then does

50 Moreover, annual automobile deaths are at least ten times as great.
occur, how can security planners respond to the inevitable subsequent allegations that security was inadequate?

Many years of research have led to the identification of a number of basic rules or principles, or what might be called “almost axioms,” that govern security against terrorism. Currently, there are more than 40 of them,\textsuperscript{51} and they can be organized into several categories.\textsuperscript{52} For purposes of this report, the categories are: principles of security, general principles of terrorism, principles regarding terrorist threats, principles regarding terrorist behavior and decision-making, risk-related principles, and public expectations/reactions regarding security.

\textsuperscript{51} It should be noted that these principles are a work in progress. 
\textsuperscript{52} For a current list of all the principles, see Appendix 5.
4 EXAMPLE SCENARIOS AND SECURITY MEASURES

As an organizing framework for this report, a set of five scenarios was created, each borrowed from historical and well-studied terrorist events. In addition to these attack scenarios, a set of seven security measures were chosen for the UCASS study.

The five scenarios are modeled after past major terrorist attacks in Mumbai, India; Tokyo, Japan; Madrid, Spain; London, United Kingdom; and Israel. Each has a brief narrative describing the hypothesized event. The five scenarios are shown in Table 4-1.

Table 4-1: The UCASS Threat Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Narrative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Mumbai Scenario:</strong></td>
<td>Several small teams of attackers shoot their way into a number of large office buildings and hotels surrounding the World Trade Center construction site and begin killing everyone they encounter.</td>
</tr>
<tr>
<td><strong>2. Tokyo Scenario:</strong></td>
<td>In five coordinated attacks, perpetrators release a chemical agent on several lines of the New York City subway and PATH (The Port Authority of New York and New Jersey) trains passing through Lower Manhattan and the World Trade Center Station.</td>
</tr>
<tr>
<td><strong>3. Madrid Scenario:</strong></td>
<td>During the peak of New York City rush hour, attacks trigger multiple explosions aboard New York City subway trains heading into Lower Manhattan. These include the 7th Avenue express and local, Lexington Avenue express and local, 8th Avenue express and local, Queens/Broadway/Brooklyn express and local, and Nassau Street express and local. [10 lines in all].</td>
</tr>
<tr>
<td><strong>4. London Scenario:</strong></td>
<td>Terrorists detonate one suitcase bomb aboard a Manhattan express bus heading into Lower Manhattan, targeting civilians who are using New York City’s public transportation system during the morning rush hour.</td>
</tr>
<tr>
<td><strong>5. Israel Scenario:</strong></td>
<td>A suicide terrorist with explosives strapped to his chest detonates a bomb at a checkpoint at an outside entrance of the New York Stock Exchange.</td>
</tr>
</tbody>
</table>

When engaging with the decision tool (described in Chapter 10), a user is able to choose among the scenarios as part of the simulation and analysis. This allows the user to tailor strategic planning activities around more specifically defined threats rather than an ill-defined notion of “some terrorist attack.” The five scenarios vary in attack target (i.e., office building,
transportation systems, and financial center) and attack modus operandi (i.e., coordinated explosions, gunmen, chemical attack). Considering a range of different attack scenarios requires that one consider different forms of security to effectively and efficiently deter or interdict them.

A set of seven security measures were selected for the UCASS study. They are shown in Table 4-2:

Table 4-2: The UCASS Countermeasures

<table>
<thead>
<tr>
<th>Countermeasures</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Random vehicle inspections</td>
<td>This security measure involves the creation of a perimeter of checkpoints at the entry/exits points around Lower Manhattan. Security inspections that entail the search of persons and their vehicles are conducted on a random basis. We relate this to random pedestrian inspection. (See the Behavioral Survey, and countermeasure 3 below, and Chapter 10). It is reasonable to suppose that the response behaviors of drivers would be similar to those of pedestrians, as they are driven by the same human factors (e.g., the likely behaviors of pedestrians/drivers and screeners in various circumstances; the ability of the security workforce to remain effective during potentially lengthy, monotonous, and/or physically demanding shifts; and attitudes toward safety).</td>
</tr>
<tr>
<td>2. Permanent street closures to vehicular traffic</td>
<td>This initiative closes the portion of Broad Street in front of the New York Stock Exchange and Federal Hall to vehicular traffic. Pedestrian and bicycle traffic, however, would still be permitted on the sidewalk. Traffic in this area would be redirected as appropriate to create minimal disruption for vehicles.</td>
</tr>
<tr>
<td>3. Temporary perimeters and access control</td>
<td>This security measure involves putting into place street restrictions and security checkpoints affecting pedestrian traffic. The checkpoints would include temporary barricades at various intersections in the area. Anyone traveling into or within the area would be subject to a “stop and search” by a uniformed New York City police officer.</td>
</tr>
<tr>
<td>4. Random bag and parcel inspection in rail or subway stations</td>
<td>This program allows security personnel to conduct random inspections of bags and parcels at rail and subway stations heading to or leaving Lower Manhattan. The random searches are carried out 24 hours a day, 7 days a week. Police use visual checks, bomb-sniffing dogs and explosive detection technology to check bags for hazardous materials.</td>
</tr>
<tr>
<td>5. Increased visible presence of police</td>
<td>This measure would increase visible police presence throughout Lower Manhattan as a means of deterring threats. Police officers will not be targeting specific individuals, but will be instructed to be more vigilant in pursuing tips and leads and analyzing patterns of unusual behavior (that is, police officers will not conduct “stop and search” activities or bag checks).</td>
</tr>
</tbody>
</table>
6. CCTV cameras

This measure would add an additional 1,700 close-circuit television (CCTV) cameras (resulting in 3,000 cameras total) located throughout Lower Manhattan. The CCTV cameras will help police assess suspicious activity or actual events, reduce incident response time, and strengthen a common technological infrastructure for security surveillance.

7. X-rays & magnetometers in building lobbies

This measure would upgrade security by hiring additional protection officers, installing magnetometers to detect metal items, such as guns and knives, and installing X-ray scanners to inspect bags and packages at the entrances of selected major/large buildings in Lower Manhattan.

These security measures were selected because they not only represent a wide range of measures that are available, but each is already employed in Lower Manhattan (and other urban environments). They range from technological to human, from visible to invisible, from permanent to temporary, and from screening people to screening vehicles. Such security measures may either prevent or deter an attack. Offering stakeholders a range of different security measures enhances their strategic planning and recovery abilities, as they are able to compare the economic impacts of security measures used in isolation or in combinations or “portfolios.”

4.1 Estimates of Areas Affected by Attack Scenarios

This section examines the areas affected in the Lower Manhattan area by each of the five terrorist attack scenarios. The analysis is based on a review of the literature, definitions of a given security measure’s area of effectiveness as defined in the UCASS project, and the U.S. Environmental Protection Agency’s atmospheric dispersion modeling software (US EPA, 2012). The full Lower Manhattan area is designated as the area south of 14th Street and is estimated to be approximately 10.6 km² (Daftlogic.com, 2012).

4.1.1 Mumbai Scenario

The attacked area is consistent with the area assumed in the calculation of the capital and operating costs of access control to the area surrounding the World Trade Center site, the area

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53 Since this countermeasure was defined the number of CCTV units in Lower Manhattan is reported to have surpassed 3,000 by May 2013 (Kelly, 2013).
bounded by West Street, Barclay Street, Church Street/Trinity Place, and Rector Street. It is estimated to be approximately 0.183 km² (See Figure 4.1).

**Figure 4.1: The World Trade Center and Surrounding Area**

![Image of the World Trade Center and Surrounding Area](source: Daftlogic.com (2012))

### 4.1.2 Tokyo Scenario

The U.S. Environmental Protection Agency’s Aerial Locations of Hazardous Atmospheres (ALOHA) software (US EPA, 2012) was used to estimate the threat zone for a release of Sarin gas in a train passing through Lower Manhattan. Data on chemical properties of Sarin are included in that software, and information related to the attack site, atmospheric conditions, and the source of release was assembled by the authors. These model input parameters and corresponding references are summarized in Table 4-3.

**Table 4-3: Atmospheric Dispersion Model Input Parameters & References**

<table>
<thead>
<tr>
<th>Input Parameter</th>
<th>Value</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air exchanges/hour</td>
<td>24</td>
<td>American Society of Mechanical Engineers, 2012</td>
</tr>
<tr>
<td>Wind speed</td>
<td>9.3 miles/hour</td>
<td>National Climatic Data Center, 2008b</td>
</tr>
<tr>
<td>Wind direction</td>
<td>West</td>
<td>New York State Climate Office, 2012</td>
</tr>
<tr>
<td>Air temperature</td>
<td>54.6° F</td>
<td>National Climatic Data Center, 2008c</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>72%</td>
<td>National Climatic Data Center, 2008a</td>
</tr>
<tr>
<td>Release amount</td>
<td>991.8 grams</td>
<td>Haberfeld &amp; vonHassell, 2009 Riegle Jr., D’Amato, 1994</td>
</tr>
<tr>
<td>Release duration</td>
<td>60 minutes</td>
<td>Haberfeld &amp; von Hassell, 2009</td>
</tr>
</tbody>
</table>
A Gaussian model simulation run resulted in a threat zone estimate plot, indicating three regions with varying levels of concern (See Figure 4.2). Using Figure 4.2, the area within the confidence lines (i.e., the affected region including possible changes in wind direction) is estimated to be 0.18 km$^2$. Assuming five separate releases on trains, the estimated total affected area is 0.90 km$^2$.

**Figure 4.2: Sarin Threat Zone Estimate**

4.1.3 Madrid Scenario

To estimate the range of impact of explosive, we consulted the National Counterterrorism Center (2012), which estimates a preferred evacuation distance, defined as a region where evacuation of people in buildings and outdoors is mandatory, of 0.56 km for a briefcase/suitcase bomb. The affected area from a single explosion is calculated as the area of a circle with the preferred evacuation distance as the radius (See Figure 4.3). Assuming five separate explosions on the train lines as indicated above,$^{54}$ the estimated total affected area is 5.0 km$^2$.

---

$^{54}$ Since the trains in New York run underground, there is not a precise match between the estimates from the NCTC and the specific impact in Lower Manhattan.
4.1.4 London Scenario
As noted above, the National Counterterrorism Center (2012) estimates a preferred evacuation distance of 0.564 km for a briefcase/suitcase bomb. Assuming an explosion on a Manhattan express bus, the estimated affected area is 0.999 km².

4.1.5 Israel Scenario
The same data, from the National Counterterrorism Center (2012) are used for a suicide vest bomb. Assuming a suicide bombing outside the New York Stock Exchange, the estimated affected area is 0.843 km².

4.1.6 Summary and Comparisons
The estimates of affected areas from threat scenarios in the Lower Manhattan area are summarized in Table 4-4. As shown in Table 4-4 below, the largest affected area is associated with the Madrid scenario, followed by the London and Tokyo scenarios.

Table 4-4: Estimates of the Affected Areas from the UCASS Attack Scenarios

<table>
<thead>
<tr>
<th>Attack Scenario</th>
<th>Affected Area (km²)</th>
<th>Affected Area as a Proportion of the Lower Manhattan Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mumbai</td>
<td>0.183</td>
<td>1.72</td>
</tr>
<tr>
<td>Tokyo</td>
<td>0.896</td>
<td>8.44</td>
</tr>
<tr>
<td>Madrid</td>
<td>4.999</td>
<td>47.06</td>
</tr>
<tr>
<td>London</td>
<td>0.999</td>
<td>9.41</td>
</tr>
<tr>
<td>Israel</td>
<td>0.843</td>
<td>7.94</td>
</tr>
</tbody>
</table>
4.2 Direct Capital, Operating and Maintenance Costs of Security Measures

This section presents the direct capital and operating cost estimates of seven security measures for enhancing security against terrorism in urban areas. Most of the security measures considered elsewhere in this study are small, localized approaches. The capital and operating cost estimates for these measures can be scaled up or down to generate estimates for similar security measures in areas of varying size. The analysis in this section is based on a literature review and cost engineering. The results are presented in disaggregated form and can be used as input for economic models, such as input-output (I-O) and Computable General Equilibrium (CGE) models, to determine indirect (narrow multiplier) or general equilibrium (broader price and quantity) effects of various security measures.

Both capital and operating and maintenance (O&M) costs of traffic checkpoints and closed-circuit television (CCTV) cameras are estimated first. These data serve as the basis for subsequent cost estimations. The majority of cost components (wages, equipment, etc.) are similar in type across all seven security measures. These cost estimates combined with cost estimates from other sources are applied to determine capital and operating costs of the other UCASS security measures. Alternative approaches to estimating, for example, the level of wages for specific measures can be justified, depending on the specifics of the implementation of a countermeasure.

4.2.1 Permanent and Tactical Traffic Checkpoints

The U.S. Border Patrol operates permanent and tactical traffic checkpoints. A permanent checkpoint includes physical infrastructure (i.e., tollbooth-like structures), remote video surveillance, electronic sensors, and agent patrols (GAO, 2005). A tactical checkpoint, which is temporary, might consist of vehicles, traffic cones, warning signs, and portable rest facilities (GAO, 2009). In urban areas, sobriety checkpoints are an example of a tactical or mobile checkpoint.

Stevens et al. (2004) suggest that adding permanent vehicle security checkpoints with bomb detection capability at the Los Angeles International Airport would involve an estimated capital expenditure cost of $7 million and an annual recurring operating cost of $11 million. The breakdown of Stevens’ cost estimates is illustrated in Table 4-5.
Table 4-5: Cost Estimates for Permanent Checkpoints (in 2004$)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($million)</th>
<th>Subsystem/Unit Cost Element</th>
<th>O&amp;M Cost ($million/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barriers to set up inspection lanes for 20 stations across five locations</td>
<td>0.8</td>
<td>Average number of inspectors—between 40 (20 per shift assuming as an average over 16 hrs/day) and 153 - at a salary including benefits of ~$100,000 per year</td>
<td>4.0 - 15.3</td>
</tr>
<tr>
<td>Construction cost of shelter/ restroom facilities (12 ft. x 12 ft. each at all locations)</td>
<td>0.8</td>
<td>$5,000 per year per inspector for training</td>
<td>0.2 - 0.77</td>
</tr>
<tr>
<td>77 sets of bomb detection related equipment at $25,000 each</td>
<td>1.9</td>
<td>Maintenance of the shelter and restroom facilities and roadway repairs</td>
<td>0.5</td>
</tr>
<tr>
<td>Roadway construction</td>
<td>3.0</td>
<td>Total</td>
<td>10.6*</td>
</tr>
</tbody>
</table>

Source: Stevens et al. (2004).
* Total of mid-point costs

A study by the Pacific Institute for Research and Evaluation (2005) estimated the total annual cost of operating a sobriety checkpoint three times each week to be $1.6 million. This includes $1.26 million in overtime wages and fringe benefits for police officers, $23,000 for checkpoint equipment, $69,000 in travel delay costs from stopping sober drivers, and $248,000 for trying and punishing violators.

The U.S. Department of Transportation’s (US DOT) Research and Innovative Technology Administration (RITA) office maintains an Intelligent Transportation Systems (ITS) costs database (US DOT, 2010). A summary of unit cost estimates of different elements that may be included in permanent and tactical traffic checkpoints is presented in Table 4-6. Detailed descriptions of these system elements are also available in the database.

---

55 We do not mean to propose that such checkpoints would only operate at overtime wages, but are simply reporting the method used in the literature.
56 This data was used to construct Table 4.9 in the Data Adjustments section below.
Table 4-6: Cost Estimates for Checkpoint Elements (in 2009$)

<table>
<thead>
<tr>
<th>Type</th>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($K)</th>
<th></th>
<th>O&amp;M Cost ($K/year)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Permanent</td>
<td>Electronic Toll Reader*</td>
<td>1.61</td>
<td>4.01</td>
<td>0.16</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>Electronic Toll Collection Software*</td>
<td>4.97</td>
<td>9.94</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Electronic Toll Collection Structure</td>
<td>14.36</td>
<td>21.54</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Toll Administration Hardware*</td>
<td>4.25</td>
<td>6.38</td>
<td>0.21</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>Toll Administration Software*</td>
<td>39.78</td>
<td>79.56</td>
<td>3.98</td>
<td>7.96</td>
</tr>
<tr>
<td></td>
<td>Electronic Toll Equipment*</td>
<td>0.03</td>
<td>0.07</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Toll Tag/Transponder*</td>
<td>0.02</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Hardware, Software for Traffic Surveillance</td>
<td>134.25</td>
<td>164.09</td>
<td>6.71</td>
<td>8.20</td>
</tr>
<tr>
<td></td>
<td>Machine Vision Sensor on Corridor*</td>
<td>18.02</td>
<td>24.08</td>
<td>0.17</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>Machine Vision Sensor at Intersection*</td>
<td>13.87</td>
<td>22.10</td>
<td>0.17</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>Passive Acoustic Sensor on Corridor*</td>
<td>3.02</td>
<td>6.53</td>
<td>0.15</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Passive Acoustic Sensor at Intersection*</td>
<td>4.01</td>
<td>12.04</td>
<td>0.16</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>Remote Traffic Microwave Sensor on Corridor*</td>
<td>7.80</td>
<td>11.27</td>
<td>0.09</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Remote Traffic Microwave Sensor at Intersection*</td>
<td>14.45</td>
<td>n.a.</td>
<td>0.08</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Infrared Sensor Active*</td>
<td>4.66</td>
<td>5.82</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Infrared Sensor Passive*</td>
<td>0.57</td>
<td>0.98</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Driver and Vehicle Safety Sensors, Software*</td>
<td>0.73</td>
<td>1.46</td>
<td>0.03</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>Cargo Monitoring Sensors and Gauges</td>
<td>0.11</td>
<td>0.23</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Sensors for Lateral Control*</td>
<td>0.53</td>
<td>0.73</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Mayday Sensor and Processor*</td>
<td>0.10</td>
<td>0.43</td>
<td>0.00</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Sensors for Longitudinal Control*</td>
<td>0.20</td>
<td>0.33</td>
<td>0.00</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Environmental Sensing Station (Weather Station)*</td>
<td>25.13</td>
<td>41.60</td>
<td>1.61</td>
<td>3.40</td>
</tr>
<tr>
<td></td>
<td>Portable Traffic Management System</td>
<td>66.43</td>
<td>83.04</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Autonomous Tracking Unit*</td>
<td>0.29</td>
<td>0.66</td>
<td>0.12</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>Vision Enhancement System*</td>
<td>1.66</td>
<td>2.08</td>
<td>0.08</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>Driver and Vehicle Safety Monitoring System*</td>
<td>0.44</td>
<td>0.83</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>Pre-Crash Safety System*</td>
<td>0.73</td>
<td>1.43</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>Wages and Benefits</td>
<td>n.a.</td>
<td>n.a.</td>
<td>320.12</td>
<td>391.43</td>
</tr>
<tr>
<td>Tactical</td>
<td>Rail Crossing Pedestrian Warning Signal, Gates*</td>
<td>6.64</td>
<td>9.96</td>
<td>0.13</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>Dynamic Message Sign – Portable</td>
<td>15.86</td>
<td>20.80</td>
<td>0.52</td>
<td>1.56</td>
</tr>
</tbody>
</table>


*Indicates item used for traffic control but not for security.
4.2.2 Closed-Circuit Television (CCTV) Cameras

CCTV camera cost estimates were obtained from the US DOT ITS costs databases (U.S. Department of Transportation, 2008, 2010). A summary of these cost estimates is presented in Table 4-7, while Table 4-8 contains estimates for the State of New York. Detailed descriptions of the system elements in Table 4-7 and Table 4-8 are also available in the DOT ITS database.  

Table 4-7: Cost Estimates for CCTV Cameras (in 2009$)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($K)</th>
<th>O&amp;M Cost ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>CCTV Video Camera</td>
<td>7.80</td>
<td>16.47</td>
</tr>
<tr>
<td>CCTV Video Camera Tower</td>
<td>4.53</td>
<td>13.59</td>
</tr>
<tr>
<td>CCTV Camera (without installation)</td>
<td>1.73</td>
<td>4.33</td>
</tr>
<tr>
<td>Traffic Camera for Red Light Running Enforcement*</td>
<td>60.22</td>
<td>109.21</td>
</tr>
<tr>
<td>Inductive Loop Surveillance on Corridor*</td>
<td>2.41</td>
<td>6.42</td>
</tr>
<tr>
<td>Inductive Loop Surveillance at Intersection*</td>
<td>7.45</td>
<td>13.26</td>
</tr>
<tr>
<td>Machine Vision Sensor on Corridor*</td>
<td>18.02</td>
<td>24.08</td>
</tr>
<tr>
<td>Machine Vision Sensor at Intersection*</td>
<td>13.87</td>
<td>22.10</td>
</tr>
<tr>
<td>Portable Speed Monitoring System*</td>
<td>4.08</td>
<td>12.24</td>
</tr>
<tr>
<td>Portable Traffic Management System*</td>
<td>66.43</td>
<td>83.04</td>
</tr>
<tr>
<td>High-Speed Camera*</td>
<td>5.81</td>
<td>8.30</td>
</tr>
<tr>
<td>Security Package*</td>
<td>2.77</td>
<td>5.37</td>
</tr>
<tr>
<td>Vision Enhancement System*</td>
<td>1.66</td>
<td>2.08</td>
</tr>
</tbody>
</table>

*Indicates item used for traffic control but not for security.

Table 4-8: Cost Estimates for CCTV Cameras in the State of New York (in 2009$)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($K)</th>
<th>O&amp;M Cost ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCTV Video Camera Tower</td>
<td>19.14</td>
<td>n.a.</td>
</tr>
<tr>
<td>CCTV Video Camera</td>
<td>25.50</td>
<td>1.28</td>
</tr>
<tr>
<td>CCTV Video Camera</td>
<td>7.83</td>
<td>n.a.</td>
</tr>
</tbody>
</table>


57 Costs for CCTV are also available for the following states: California, Colorado, Florida, Idaho, Kentucky, Michigan, North Carolina, Texas, and Washington.
4.2.3 Data Adjustments

Cost estimates for permanent and tactical checkpoints selected for this study are summarized in Table 4-9. Table 4-9 is derived from the above data, which includes items used for security but not for traffic control. Since in Table 4-5 the capital cost estimates for barriers are given for 20 stations, this estimate is used to generate per unit station cost ($0.8 million / 20 = $400,000 in 2004 U.S. dollars). A similar approach is applied to estimate the capital cost of shelter construction per location ($0.8 million / 5 = $0.16 million in 2004 U.S. dollars). The unit capital cost of bomb detection equipment is also given in Table 4-5 ($25,000 each in 2004 U.S. dollars). If we assume 50 detectors in each location, we obtain the total capital cost estimate of $1.25 million ($25,000 x 50 = $1.25 million in 2004 U.S. dollars).

The cost of labor (wages and benefits) is given in Table 4-5 and Table 4-6. The latter includes low and high cost estimates of $320,120 and $391,430 for three people, which is consistent with the $100,000 per person estimate from Table 4-5. Thus, a labor cost estimate for 20 personnel of $2.13 million to $2.60 million is obtained. Similarly, the cost of training is obtained for 20 people by using the per person estimate of $5,000 in 2004 U.S. dollars from Table 4-5 ($5,000 x 20 = $100,000 in 2004 U.S. dollars). As indicated in the Pacific Institute for Research and Evaluation (2005) study, overtime wages and fringe benefits for police officers are $1.26 million in 2005 U.S. dollars for a tactical checkpoint operating three times each week. This estimate is used to derive the upper bound of tactical checkpoint wages and benefits, while for the lower bound we assume operation of two checkpoints per month.

Cost estimates for CCTV cameras selected for the UCASS study are presented in Table 4-10. To estimate the capital and operating costs of CCTV cameras the following formulae are used.

\[
C^k = (m + n) \times C_c^k + (b \times C_c^k) \\
C^o = (m + n) \times C_c^o
\]

(4.1)  (4.2)

where

- \(C^k\) is the total capital cost of CCTV video cameras and towers;
- \(m\) is the number of CCTV cameras installed on towers;
- \(n\) is the number of CCTV cameras installed on buildings;
- \(C_c^k\) is the unit capital cost of CCTV cameras;
$b$ is the number of CCTV camera towers;  
$C_k$ is the unit capital cost of CCTV camera towers;  
$C^o$ is the total operating cost of CCTV video cameras;  
$C^e$ is the unit operating cost of CCTV cameras.

**Table 4-9: Cost Estimates for Checkpoint Components Related to Security (in 2009$)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($K)</th>
<th>Costa ($K/year)</th>
<th>O&amp;M Costa ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Permanent</td>
<td>Barriers</td>
<td>195.40</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Construction of Shelter</td>
<td>195.40</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Bomb Detection Equipment (50 detectors)</td>
<td>1,061.00</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Electronic Toll Collection Structure</td>
<td>14.36</td>
<td>21.54</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Hardware, Software for Traffic Surveillance</td>
<td>134.25</td>
<td>164.09</td>
<td>6.71</td>
</tr>
<tr>
<td></td>
<td>Cargo Monitoring Sensors and Gauges</td>
<td>0.11</td>
<td>0.23</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Portable Traffic Management System</td>
<td>66.43</td>
<td>83.04</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Wages and Benefits (20 people)</td>
<td>n.a.</td>
<td>n.a.</td>
<td>2,134.2</td>
</tr>
<tr>
<td></td>
<td>Inspector Training (20 people)</td>
<td>n.a.</td>
<td>n.a.</td>
<td>115.71</td>
</tr>
<tr>
<td></td>
<td>Maintenance of the Checkpoint Structure</td>
<td>n.a.</td>
<td>n.a.</td>
<td>115.71</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>1,666.95</strong></td>
<td><strong>1,720.70</strong></td>
<td><strong>2,372.34</strong></td>
</tr>
<tr>
<td>Tactical</td>
<td>Checkpoint Equipment</td>
<td>19.93</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Wages and Benefits (per person)b</td>
<td>n.a.</td>
<td>n.a.</td>
<td>0.67c</td>
</tr>
<tr>
<td></td>
<td>Dynamic Message Sign – Portable</td>
<td>15.86</td>
<td>20.80</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>35.79</strong></td>
<td><strong>40.73</strong></td>
<td><strong>1.19</strong></td>
</tr>
</tbody>
</table>


*a* The producer price indices from 1995 to 2009, used in US DOT (2010), were applied to unadjusted dollar values to account for inflation.

*b* Pertaining just to tactical checkpoint activity (wages include overtime).

*c* Assumes two checkpoints per month.

*d* Assumes operating a checkpoint three times a week.

Using Tables Table 4-7 and Table 4-8, the unit cost estimate ranges for CCTV cameras are derived. As illustrated in Table 4-10, the lower limit for the capital cost of CCTV cameras is $7,800 (available from Table 4-7). While for the upper bound, the capital cost figure of $25,500, which is available from Table 4-8, is used. Following the same approach, the lower and upper capital cost limits for camera towers are derived. For the operating costs, the upper and lower limits of CCTV camera operation and maintenance costs from Table 4-10 are used. According
to US DOT (2010), camera towers require minimal maintenance, and, therefore, their operation and maintenance costs are assumed to be zero.

Table 4-10: Unit Cost Estimates for CCTV Cameras Related to Security (in 2009$)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($)</th>
<th>O&amp;M Cost ($/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>CCTV Video Camera</td>
<td>7.8</td>
<td>25.50</td>
</tr>
<tr>
<td>CCTV Video Camera Tower</td>
<td>4.53</td>
<td>19.14</td>
</tr>
</tbody>
</table>


4.2.4 Cost Estimates for the Seven UCASS Security Measures

Capital and operating cost estimates of the seven security measures included in the UCASS study are summarized below. The seven security measures used in the UCASS study are random vehicle inspections, permanent street closures to vehicular traffic, temporary perimeter and access control, random bag and parcel inspection, use of X-rays and magnetometers in building lobbies, increased visible presence of the police, and the use of CCTV surveillance cameras. These costs are derived from the adjusted cost estimates for checkpoints and CCTV cameras along with other references. All cost estimates assume Lower Manhattan area designated as the area below 14th Street.

4.2.4.1 Random Vehicle Inspections

Description: This security measure involves the creation of a perimeter of checkpoints at the entry/exit points around Lower Manhattan. In order to contribute to the security of Lower Manhattan, security inspections that entail the search of persons and their vehicles will be conducted on a random basis.

Table 4-11 presents the cost estimates for random vehicle inspections. It is assumed that there are permanent checkpoints on each of the 26 entry/exit points, and the cost estimates (per location) are adapted from Table 4-9 (scaled to relevant size).
Table 4-11: Cost Estimates for Random Vehicle Inspections (in 2009$)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost&lt;sup&gt;a&lt;/sup&gt; ($K)</th>
<th>O&amp;M Cost&lt;sup&gt;a&lt;/sup&gt; ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Barriers</td>
<td>5,080.40</td>
<td>n.a.</td>
</tr>
<tr>
<td>Construction of Shelter</td>
<td>5,080.40</td>
<td>n.a.</td>
</tr>
<tr>
<td>Bomb Detection Equipment (50 detectors)</td>
<td>27,586.00</td>
<td>n.a.</td>
</tr>
<tr>
<td>Electronic Toll Collection Structure</td>
<td>373.36</td>
<td>560.04</td>
</tr>
<tr>
<td>Hardware, Software for Traffic Surveillance</td>
<td>3,490.50</td>
<td>4,266.34</td>
</tr>
<tr>
<td>Cargo Monitoring Sensors and Gauges</td>
<td>2.86</td>
<td>5.98</td>
</tr>
<tr>
<td>Portable Traffic Management System</td>
<td>1,727.18</td>
<td>2,159.04</td>
</tr>
<tr>
<td>Wages and Benefits (520 people)</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Inspector Training (520 people)</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Maintenance of the Checkpoint Structure</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>43,340.70</strong></td>
<td><strong>44,738.20</strong></td>
</tr>
</tbody>
</table>


<sup>a</sup> The producer price index from 1995 to 2009 used in US DOT (2010), was applied to unadjusted dollar values to account for inflation.

4.2.4.2 Permanent Closure of Certain Streets to Traffic

**Description**: This security initiative closes the portion of Broad Street in front of the New York Stock Exchange and Federal Hall to vehicular traffic. Pedestrian and bicycle traffic, however, would still be permitted on the sidewalk. Traffic in this area would be redirected as appropriate to create minimal disruption for vehicles.

Table 4-12 presents the cost estimates for permanent closure of certain streets to traffic. It is assumed that barriers on both sides of the street are permanent, and the cost estimates of traffic
signs and police personnel wages (assuming two persons) for tactical checkpoints are adapted from Table 4-9 (scaled to relevant size).

**Table 4-12: Cost Estimates for Permanent Closure of Certain Streets to Traffic (in 2009$)**

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost$^a$ ($K)</th>
<th>O&amp;M Cost$^a$ ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Barriers</td>
<td>97.70</td>
<td>n.a.</td>
</tr>
<tr>
<td>Wages and Benefits (assuming 2 persons)</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Dynamic Message Sign – Portable</td>
<td>15.86</td>
<td>20.80</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>113.56</strong></td>
<td><strong>118.50</strong></td>
</tr>
</tbody>
</table>


$^a$ The producer price index from 1995 to 2009, used in US DOT (2010), was applied to unadjusted dollar values to account for inflation.

$^c$ Assumes police presence two times per month.

$^d$ Assumes police presence three times a week.

**4.2.4.3 Temporary Perimeters and Access Control**

**Description**: This security measure involves putting into place street restrictions and security checkpoints affecting pedestrian traffic. The checkpoints would include temporary barricades at various intersections in the area. Anyone traveling into or within the area would be subject to a “stop and search” by a uniformed New York City police officer.

Estimates from Table 4-9 are adapted (scaled to relevant size). Table 4-13 presents the cost estimates. The areas surrounding the World Trade Center site and the Financial District are considered as two major restricted areas from which to derive our cost estimates. It is assumed that approximately 30 intersections are bounded by West Street, Barclay Street, Church Street/Trinity Place, and Rector Streets (the World Trade Center area), and approximately 70 intersections are bounded by Broadway, Fulton Street, and Water Street, which results in a total of 100 intersections or tactical checkpoints operating 7 days a week.
Table 4-13: Cost Estimates for Temporary Perimeters and Access Control to Certain Restricted Areas of the City (in 2009$)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost$^a</th>
<th>O&amp;M Cost$^a</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(SK)</td>
<td>($K/year)</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Checkpoint Equipment</td>
<td>1,993.00</td>
<td>n.a.</td>
</tr>
<tr>
<td>Wages and Benefits (assuming 200 persons)</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Dynamic Message Sign – Portable</td>
<td>1,586.00</td>
<td>2,080.00</td>
</tr>
<tr>
<td>Total</td>
<td>3,579.00</td>
<td>4,073.00</td>
</tr>
</tbody>
</table>


$^a$ The producer price index from 1995 to 2009, used in US DOT (2010), was applied to unadjusted dollar values to account for inflation.

4.2.4.4 Random Bag and Parcel Inspection on Subways

Description: This security program allows security personnel to conduct random inspections of bags and parcels at rail and subway stations heading to or leaving Lower Manhattan. The random searches are carried out 24 hours a day, 7 days a week. Police use bomb-sniffing dogs and explosive detection technology to check the bags for hazardous materials.

Table 4-14 presents the cost estimates for random bag and parcel inspection on subways. It is assumed that there are approximately 50 subway stations in Lower Manhattan, 10 police officers per station (operating 7 days a week), 2 dogs per station, and 20 detectors per station. In addition to references in Table 4-9 (scaled to relevant size), canine cost estimates are adapted from an Idaho State Police study (Wing, 2004).

4.2.4.5 X-rays and Magnetometers in Building Lobbies

Description: This security initiative would upgrade security by hiring additional protection officers and installing magnetometers (to detect metal items such as guns and knives) and X-ray scanners (to inspect bags and packages) at the entrances of major or large buildings in Lower Manhattan.
Table 4-14: Cost Estimates for Random Bag and Parcel Inspection on Subways (in 2009$)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost&lt;sup&gt;a&lt;/sup&gt; ($K)</th>
<th>O&amp;M Cost&lt;sup&gt;a&lt;/sup&gt; ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Bomb-Sniffing Dogs (assuming 100 dogs)</td>
<td>2,743.51</td>
<td></td>
</tr>
<tr>
<td>Wages and Benefits (assuming 500 persons)</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Bomb Detection Equipment (1000 detectors)</td>
<td>21,220.00</td>
<td>n.a.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>23,963.51</strong></td>
<td><strong>4,774.58</strong></td>
</tr>
</tbody>
</table>

Sources: US DOT (2010); Wing (2004).
<sup>a</sup> The producer price index from 1995 to 2009, used in US DOT (2010), was applied to unadjusted dollar values to account for inflation.

Table 4-15 presents the cost estimates for X-rays and magnetometers in building lobbies. It is assumed that there are approximately 50 major, large buildings in Lower Manhattan. In addition to references in Table 4.9 (scaled to relevant size), we adapt cost estimates from SecurityProUSA (2011) and FoxNews.com (2009).

Table 4-15: Cost Estimates for X-rays and Magnetometers in Building Lobbies (in 2009$)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost&lt;sup&gt;a&lt;/sup&gt; ($K)</th>
<th>O&amp;M Cost&lt;sup&gt;a&lt;/sup&gt; ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Magnetometer</td>
<td>750.00</td>
<td>n.a.</td>
</tr>
<tr>
<td>Wages and Benefits (assuming 100 persons)</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>X-ray Scanner</td>
<td>1,611.66</td>
<td>n.a.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,361.66</strong></td>
<td><strong>938.00</strong></td>
</tr>
</tbody>
</table>

<sup>a</sup> The producer price index from 1995 to 2009, used in US DOT (2010), was applied to unadjusted dollar values to account for inflation.

4.2.4.6 Increased Visible Presence of Police

Description: Police presence would be increased throughout Lower Manhattan as a means for raising the visibility of security. Police officers will not be targeting specific individuals, but will be instructed to be more vigilant in pursuing tips and leads and analyzing patterns of unusual
behavior. Table 4-16 presents the cost estimates for the increased presence of police. Cost estimates from Table 4-9 (scaled to relevant size) were adapted, and it was assumed that increased police presence would be mostly concentrated in the restricted areas defined under this countermeasure resulting in an additional 200 police officers.

### Table 4-16: Cost Estimates for Increased Visible Presence of Police (in 2009$)

<table>
<thead>
<tr>
<th>Subsystem/Unit cost Benefit</th>
<th>Capital Cost ($K)</th>
<th>O&amp;M Cost ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages and Benefits (assuming 200 persons)</td>
<td>n.a.</td>
<td>1,876.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,890.00</td>
</tr>
</tbody>
</table>


* The producer price index from 1995 to 2009, used in US DOT (2010), was applied to unadjusted dollar values to account for inflation.

4.2.4.7 CCTV Cameras

**Description:** An additional 1,700 close-circuit television (CCTV) cameras (resulting in a total of 3,000 cameras) will be located throughout Lower Manhattan. The CCTV cameras help police assess suspicious activity or actual events, reduce incident response time, and create a common technological infrastructure for security surveillance.

The total cost estimates of checkpoints and CCTV cameras are reported in Table 4-17 and Table 4-18, which have also been derived from Table 4-9 and 4-10 (scaled to relevant size) and using expressions (4.1) and (4.2). According to various sources (Government Computer News, 2010; Gothamist, 2010; New York Civil Liberties Union, 2006), the installation of a total of approximately 3,000 CCTV cameras in the Lower Manhattan was planned by 2011. We have been unable to identify the number of CCTV cameras installed on buildings versus camera towers. Therefore, upper and lower limits for the total capital cost estimates of CCTV cameras in the considered area have been derived. In all cases, it is assumed that there is one camera per tower. For the upper limit estimate, it is assumed that there are 2,000 cameras installed on towers and 1,000 cameras on buildings, while for the lower limit estimate it is assumed that 1,000 cameras have been installed on towers and 2,000 cameras have been installed on buildings (see equations (4.3) and (4.4)).
(m + n) = 3,000 for both upper and lower limit estimates \hspace{1cm} (4.3)

b = \begin{cases} 
1,000 & \text{for lower limit estimate} \\
2,000 & \text{for upper limit estimate} 
\end{cases} \hspace{1cm} (4.4)

The operating and maintenance cost range is the same for 3,000 CCTV cameras, regardless of their location (i.e., buildings or camera towers). As shown in Table 4-17, the total capital costs of the CCTV security system range from $27.93 million to $114.78 million (a one-time expenditure). The operating and maintenance costs range from $2.55 million to $5.85 million annually.\textsuperscript{58}

**Table 4-17: Total Cost Estimates of 3,000 CCTV Cameras (in 2009$)**

<table>
<thead>
<tr>
<th>Cost Element</th>
<th>Capital Cost ($K)</th>
<th>O&amp;M Cost ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>CCTV Video Camera/Towers</td>
<td>27,930</td>
<td>114,780</td>
</tr>
</tbody>
</table>


Since the additional measure would be 1,700 cameras instead of 3,000 cameras, the rescaled total cost estimates are presented in Table 4-18.

**Table 4-18: Total Cost Estimates of 1,700 CCTV Cameras (in 2009$)**

<table>
<thead>
<tr>
<th>Cost Element</th>
<th>Capital Cost ($K)</th>
<th>O&amp;M Cost ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>CCTV Video Camera/Towers</td>
<td>15,830</td>
<td>65,040</td>
</tr>
</tbody>
</table>

Table 4-19 below summarizes the total costs of the seven security measures being considered in the UCASS. As shown, the largest capital and operating costs are associated with the random vehicle inspections, followed by random bag and parcel inspections on subways and the

\textsuperscript{58} CCTV cameras have both capital and operating/maintenance costs, but camera towers have only capital costs. We assume 2,000 cameras installed on towers and 1,000 cameras on buildings, thus our cost estimate of $2.55 million to $5.85 million refers to this combination of cameras and towers.
installation of CCTV cameras. We note that this section has only estimated the costs associated with implementing and operating each of the seven security measures. No assessment has been made regarding the effectiveness of each security measure.

**Table 4-19: Summary of Total Capital and Operating Costs of the UCASS Security Measures (in 2009$)**

<table>
<thead>
<tr>
<th>Cost Element</th>
<th>Total Capital Cost ($K)</th>
<th>Total O&amp;M Cost ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low High</td>
<td>Low High</td>
</tr>
<tr>
<td>Random Vehicle Inspections</td>
<td>43,341 44,738</td>
<td>61,681 74,080</td>
</tr>
<tr>
<td>Permanent Closure of Certain Streets to Traffic</td>
<td>114 119</td>
<td>2 10</td>
</tr>
<tr>
<td>Temporary Perimeters and Access Control to Certain Restricted Areas of the City</td>
<td>3,579 4,073</td>
<td>1,928 2,046</td>
</tr>
<tr>
<td>Random Bag and Parcel Inspection on Subways</td>
<td>23,964</td>
<td>4,775 4,810</td>
</tr>
<tr>
<td>X-rays and Magnetometers in Building Lobbies</td>
<td>2,362 938</td>
<td>938 945</td>
</tr>
<tr>
<td>Increased Visible Presence of Police</td>
<td>n.a.</td>
<td>1,876 1,890</td>
</tr>
<tr>
<td>CCTV Cameras</td>
<td>15,830 65,040</td>
<td>1,450 3,320</td>
</tr>
</tbody>
</table>

**4.2.5 Alignment of Detailed Estimates with CGE Sectors**

The cost elements from Table 4-9 and Table 4-11 are mapped to specific economic sectors, in the New York Computable General Equilibrium (NYCGE) model, sectors based on the mapping scheme presented in Table 4-20. The latter is derived from the IMpact Analysis for PLANning (IMPLAN) system and the NYCGE sector classification table. Using the IMPLAN – NYCGE relation of sectors, some of the capital cost elements are mapped directly to the Electronics (MSEM) and Construction (CSNR) sectors. Hardware and Software for Traffic Surveillance is allocated to two sectors - Information (INFO) and Electronics (MSEM). The operating costs associated with each cost element are mapped to Labor (LAB) and Electricity (PELE) in the NYCGE model.

---

Table 4-20: Alignment of Security Option Cost Elements with NYCGE Sectors

<table>
<thead>
<tr>
<th>Cost Element</th>
<th>Capital Cost</th>
<th>O&amp;M Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Description</td>
<td>NYCGE code</td>
</tr>
<tr>
<td>Barriers</td>
<td>Other Non-Durable Manufacturing</td>
<td>MOND</td>
</tr>
<tr>
<td>Construction of Shelter</td>
<td>Construction</td>
<td>CNSR</td>
</tr>
<tr>
<td>Bomb Detection Equipment</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>Electronic Toll Collection Structure</td>
<td>Construction</td>
<td>CNSR</td>
</tr>
<tr>
<td>Hardware, Software for Traffic Surveillance</td>
<td>Information</td>
<td>INFO</td>
</tr>
<tr>
<td></td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>Cargo Monitoring Sensors and Gauges</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portable Traffic Management System</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>X-ray Scanners</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>Magnetometers</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>Bomb-Sniffing Dogs</td>
<td>Other Business Services</td>
<td>OBSV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Checkpoint Equipment</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>Dynamic Message Sign – Portable</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCTV Video Camera/Towers</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance of the Checkpoint Structure</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspector Training</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Wages and Benefits*</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

* Wages include overtime.

Since the source databases lack details on the operating and maintenance costs, we assume that for CCTV cameras, labor and electricity costs are 90% and 10% of the total operating costs, respectively.\(^{60}\) In the case of checkpoints, we assume labor and electricity costs to be 95% and 5% of the total operating costs, respectively.

\(^{60}\) This is a rough approximation gleaned from data in a New York City Police Department annual budget summary (NYC Council, 2011).
5 ECONOMIC IMPACTS OF SECURITY

5.1 Benefit-Cost Analysis Framework
Benefit-cost analysis (BCA) serves as an excellent organizing framework, and one possible decision rule, for measuring and evaluating many of the aspects of counter-terrorism measures. Benefit-cost analysis’ emphasis on measuring all benefits and costs compels us to consider not only direct impacts, but also various spillover and macroeconomic impacts. These indirect effects are likely to be especially important in an urban area, where population density heightens the likelihood of spillovers and where strong economic interdependencies generate many quantity and price multiplier effects.

On the cost side, an analysis must include not only labor and equipment, but also spillover costs like increased inconvenience and congestion. At the same time, there may be offsetting positive spillovers of heightened security, such as prevention of ordinary crime, and/or a feeling of greater safety with respect to the terrorist threat. In addition, spending on security can have a positive direct and indirect economic stimulus effect, to the extent that it does not displace other expenditures. For example, it may attract outside investment or federal/state government subsidies.

One way to measure the benefits of heightened security is the “probability-weighted damages” that the countermeasures prevent. For a complete analysis, we must also estimate the direct and indirect economic consequences of successful attacks in the absence of the security measures. These should include not only ordinary economic impacts but also those caused by heightened fear and those muted by the resilience of individual businesses, households and government agencies, as well as the resilience of the urban economy as a whole.

Presented here is the organizing framework for the evaluation of the various costs and benefits, their data requirements, and an outline of the models that will be used to perform the Economic Consequence Estimation (ECE). Microeconomic models of security costs and spillovers are used (e.g., models that estimate the effect of security measures on traffic congestion and on property values). At the macroeconomic level, a computable general equilibrium (CGE) model is used to ascertain the behavioral response of businesses and individuals to changes in prices, economic shocks and stimuli, and constraints on economic activity.
5.2 CREATE’S Economic Consequence Analysis Framework

CREATE’s expanded framework for estimating economic consequences of terrorist attacks and natural disasters is shown in Figure 5.1. This model has been formulated to account for several standard and new considerations that affect the bottom-line, or comprehensive total impacts (Rose, 2009b). Until recently, estimation of economic losses focused almost entirely on standard target-specific (direct) economic impacts and loss of life, and, to a limited extent, ordinary indirect effects represented by multiplier impacts.

The first major refinement on the benefits estimation side of the framework is the inclusion of resilience, which refers to actions that mute the initial shock of an attack and that hasten recovery. Rose (2007) has proposed an operational metric for resilience defined as the avoided losses resulting from implementing a given resilience tactic divided by the maximum potential losses for a given event in the absence of that tactic. This metric has been applied to the World Trade Center Attacks and the London Subway bombings in Rose et al. (2009) and Cox et al., (2011), respectively. Second, a major extension of economic consequence analysis has been to include behavioral considerations. A prime example is the “fear factor,” which refers to changes in risk perception that drive changes in economic behavior, such as demands for higher wages to work in a location that has been contaminated or fear of flying in the aftermath of a successful, or even thwarted, attack on an airliner.

**Figure 5.1: Economic Assessment Framework Overview**
On the cost side, there are three other aspects that must be included in the overall picture, whose implications are sometimes misinterpreted. The first is remediation, which is typically not part of traditional economic impact analysis although it has a conventional role in hazard loss estimation as “repair and reconstruction.” In the case of a terrorist attack, remediation can take on a much larger role, especially if a chemical, biological, or radiological agent has been used, and must be cleaned from a wide area.

The cost of mitigation tactics is included in a comprehensive economic consequence framework for the BCA. The interpretation sometimes seen is that remediation and mitigation have benefits stemming from their direct expenditures alone, aside from the standard benefits of avoided losses (Bastiat, 1850). This ignores the basic fact that the resources expended in the course of implementing remediation or mitigation typically must be diverted from productive use elsewhere. More advanced models, such as computable general equilibrium (CGE) analysis, can sort out these issues and more accurately assess impacts, as discussed below.

### 5.3 The Economic Components of Security

Table 5-1 summarizes benefits and cost components that must be converted into the common measure of dollars when evaluating any tactic or strategy to improve urban security. Under the heading of Costs of Mitigation are the relatively straightforward direct expenditures on capital equipment and its operation and maintenance. These costs have an ordinary indirect (quantity and price multiplier) stimulating effects associated with them as well, working through the market system. However, the mitigation effort also generates various types of “non-market” spillover effects, which may be positive or negative. These include congestion, delays, inconveniences, changes in property values, changes in the business environment, and changes in the natural environment. In Table 5-1, a “plus” sign indicates that the entry is cost-incurring, while a “minus” sign indicates it is cost-saving.

The Costs of (that is, caused by) the Attack are the basis against which to measure the benefits of the mitigation effort. Various direct impacts include death, injury, property damage, business interruption, and loss of iconic values. Direct business interruption has multiplier effects of its own, leading to indirect business interruption throughout the economy. The benefits of the
mitigation measures are the (probability-weighted\textsuperscript{61}) costs that are avoided by their implementation. Risk reduction pertains to lowering both the costs and the probabilities.

\textbf{Table 5-1: Costs and Benefits of Security}

<table>
<thead>
<tr>
<th>Costs of Mitigation</th>
<th>Costs of Attack (Benefits)</th>
<th>Transfers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>Indirect</td>
<td>Direct</td>
</tr>
<tr>
<td>Capital</td>
<td>Multiplier Effect (+,-)</td>
<td>Death</td>
</tr>
<tr>
<td>Operating</td>
<td></td>
<td>Injury</td>
</tr>
<tr>
<td>Costs of Spillovers</td>
<td>Property Damage</td>
<td>N/A</td>
</tr>
<tr>
<td>Congestion</td>
<td></td>
<td>Business Interruption</td>
</tr>
<tr>
<td>Delays</td>
<td>Iconic Value</td>
<td>N/A</td>
</tr>
<tr>
<td>Inconvenience</td>
<td>Multiplier Effect (+,-)</td>
<td>“Fear Factor”</td>
</tr>
<tr>
<td>Change in Business Environment (+,-)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Quality (+,-)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property Values (+,-)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textit{Transfers} are listed here with a caveat. They do not represent a real (total) resource cost, but rather a shift of dollars from one entity to another. For this reason they are not typically included in a BCA. They are listed here for two reasons. First, to distinguish them clearly from more concrete costs and benefits. Second, disaster assistance, insurance payments, and subsidies from outside the region for future mitigation are types of benefits to a region that was attacked; even though they are a drain on the remainder of the nation. It is important to note that the choice of stakeholder perspective has some bearing on the role of these transfers. For example, public officials may be strongly interested in \textit{tax and fee revenues} for reasons other than BCA, so these are worth measuring. Local leaders may be in favor of a transfer into the region, even if it is a net national drain on the economy.

\textsuperscript{61} That is, if a particular kind of attack is very unlikely, the (expected) benefits of preventing it are correspondingly reduced.
5.4 The Direct and Indirect Costs of Security

When a security measure or initiative successfully prevents or deters a terrorist attack, the post-event costs of an attack are thwarted; however, the security measures impose a combination of direct, spillover and indirect costs. While the direct costs of security measures are largely straightforward, the spillover and indirect costs are more difficult to estimate. This section defines the various costs of mitigation and the methods used in the UCASS study to estimate them.

5.4.1 Direct Costs

The direct costs of security are easily understood: they entail both the capital and operating and maintenance costs of a particular security measure. Security measures, such as surveillance cameras, traffic checkpoints and street closures, require initial investment expenditures, as well as subsequent operation and maintenance costs. Examples of the former include the cost of a camera and remote operating equipment to view camera shots, construction of traffic checkpoint booths, and the manufacture of barricades. The various security measures also incur direct expenditures to operate them, including labor, electricity, and maintenance. Moreover, security measures and initiatives must be routinely upgraded or replaced as technology improves and manpower resources change.

A key issue is whether these impacts are benefits or costs to society. Initially, their construction and operation creates demand for goods and services, which, in turn, generates new production and jobs. By itself, this has a positive impact on the economy. However, if funds used for the security measure must come from a shift of funds from another existing economic activity in the region, the net effect (positive or negative) must be computed. This displacement effect is less likely to occur if the security option is being paid for by federal dollars injected into the region. In addition, in an economy with even a normal amount of unemployment, labor displacement need not occur when the countermeasure implementation represents new employment for, primarily, unemployed labor. In this case, the on-site gross job gains are likely to be realized as true net gains.

Data on capital and operating costs of security options are drawn from local emergency management offices and literature searches. These cost categories are disaggregated by type of
input and location of production (within the New York Metro Region or imported from other states or foreign countries) and input into the CGE model. Only those goods produced within the region have multiplier effects.

5.4.2 Spillover Effects
Spillover effects refer to non-market, unintended consequences of constructing and operating the security measure. Both businesses and individuals incur these costs when encountering a security measure or initiative. Unlike direct costs, spillover costs may be either negative or positive (that is, benefits). They include congestion and delays, as well as the associated inconvenience, changes in the natural environment, changes in the business environment and changes in property values. Determining the spillover effects of security policies or practices is tricky given the number of factors influencing the effects.

Congestion, delays and inconvenience are the most typical negative effects related to the implementation and enforcement of security practices or policies. Congestion creates delays for both people and businesses, which in turn creates lost economic opportunity and inconvenience. Inconvenience is itself a general category, involving outcomes such as changes in routing that do not result in delays but may result in less sightseeing, greater invasion of privacy, greater levels of frustration, etc. Some of the effects, such as business delivery delays and changes in the business environment will show up in economic indicators such as gross regional product or employment. Others, such as sightseeing enjoyment and invasion of privacy, do not show up in standard economic accounts, but do affect the quality of life or consumer satisfaction, i.e., utility or welfare (well-being) in more formal models. In addition, some security measures indirectly affect the natural environment, such as air pollution created by carbon dioxide emissions and other air pollutants from idling vehicles waiting to pass through security checkpoints. In addition, the presence or use of security measures may have either positive or negative effects on the business environment and on property values.

Security measures, whether implemented by the private sector or by the government, may influence the commercial sector’s operating environment by affecting production levels and/or sales of goods and services. Similarly, the presence or visibility of security might negatively affect property values by creating a “culture of fear,” which in turn reduces the incentive to live
and/or work in an area, thus decreasing the demand for housing or commercial rentals and purchases. On the other hand, the presence or visibility of security measures might strengthen perceptions of safety, which in turn increases the incentive to live and/or work in an area and stimulates demand for housing or commercial rentals and purchases.

The spillover effects of security measures are rarely analyzed, a primary exception being the examination of delays caused by airport screening; however, a variety of techniques can be used to estimate them, particularly revealed preference and stated preference methods. The revealed preference approach analyzes the impacts of individual decisions after the fact. A prime example would be to compare property values in two geographical areas after the implementation of a security option in one of them (see, e.g., Smith, Mansfield & Clayton, 2008). After controlling for other changing factors, the difference in property values might be attributed to the security measure. In contrast, the stated preference approach asks individuals to estimate various spillover impacts and the value they place on them, using surveys, interviews, or experiments. In this study, survey methods were used to estimate the spillover impacts in terms of stated preference.

For the UCASS study, the research team designed an online survey, whose questions were designed largely on the stated preference approach. The survey questions were tailored to four subgroups of respondents: individuals who reside in Lower Manhattan, individuals who work in Lower Manhattan, individuals who visit Lower Manhattan to socialize or as tourists, and owners of businesses located in Lower Manhattan. Each sub-group was presented with two out of three possible security measures, described in a paragraph (See Appendix 3). The three security measures presented to elicit stated preferences were: (1) pedestrian street closures and restrictions, (2) the use of closed-circuit television (CCTV) cameras in public spaces, and (3) subway baggage checks. These mirror the three security measures implemented in our ARENA and OMNeT++ discrete event simulations.

All survey subjects were asked a variety of questions to assess their perceptions of the security measures and to estimate the monetary value they place on each measure. For example, subjects were asked if they would be willing to accept increased costs in the form of transportation costs or taxes to support different types of security measures. Respondents answering "yes" were
prompted to answer a series of questions that capture the upper and lower dollar values the subject placed on the particular security measure.

Business owners were asked additional questions for each security measure to estimate the impact on their monthly revenues, whether they would relocate to avoid the effects of security, and whether they would be willing to offer their customers/clients discounts to offset any inconvenience they may experience trying to access their business. Again, respondents who answered “yes,” were prompted with a series of questions to capture the upper- and lower-bound of discounts they would be willing to offer their clients, as well as an open field for respondents to indicate the maximum discount they would be willing to offer customers. Together these answers from the four subject pools lead to monetary estimates of some parts of the spillover effects.

5.4.3 Indirect (Multiplier) Effects

Broader economic impacts, often referred to as multiplier or general equilibrium effects, arise from the fact that a physical security measure requires the manufacture of various component parts, such as a camera’s lens, aluminum casing, wiring, etc. In turn, each of these constituent parts stimulates the demand for materials. The total of all of these various rounds of "up-stream" production is some multiple of the direct expenditure, hence the term multiplier effect. In a similar manner, cost increases will be passed along, to the extent possible, in the form of higher prices, not just to the immediate customer but also along the entire supply chain. The price changes and the substitution and interaction effects they engender, together with the quantity multiplier effects, are referred to as general equilibrium effects.

Note that if the item, such as a camera, is imported from outside the geographic area of focus (i.e., Metropolitan New York or the U.S.), there are no regional multiplier effects but only the direct expenditure. In fact, in such cases there is no direct stimulus to the host economy in the purchase of the item either, except for the retail or wholesale trade margin. However, installation, operation and maintenance of the security measure are services that are likely to be purchased locally.
A computable general equilibrium (CGE) model is used to estimate the multiplier effects. This is a multi-market model of the behavioral responses of individual producers and consumers to price signals in the context of constraints on labor, capital and natural resources. CGE is the state of the art approach to economic consequence analysis, as it accommodates multi-sector detail, explicit functioning of markets, behavioral responses, and explicit constraints.

5.5 Benefit-Cost Analysis and Economic Consequence Analysis

Strictly speaking, the approach we use in this study is not a Benefit-Cost Analysis (BCA) in the pure sense but rather a close cousin known as Economic Consequence Analysis (ECA). The two differ in some significant, but relatively minor ways.

BCA includes all direct cost and benefits, both those valued in the market place and those that require non-market valuation, as well as some indirect costs. To provide comparison with costs, benefits are represented by the direct and indirect expected losses avoided as a result of having the countermeasure in place. Costs pertain to the value of resource (including opportunity costs and disutility to consumers) but do not include transfers from one entity to another, such as taxes or subsidies. The indirect effects of implementing countermeasures (i.e., the economic multiplier effects of their construction or operation) are usually not included in a BCA, in part because of the difficulty of deciding whether they represent a cost or benefit. For example, hiring someone to operate a checkpoint is a cost, but economy-wide employment gains are often presented as if they are a benefit, which is inconsistent with BCA. BCA results are expressed in two ways: net benefits, in dollar terms, or (more often) in terms of economic “welfare” (well-being) measures, sometimes also converted into dollar terms. The latter are not generally well known outside of economic circles. They typically place a dollar value on benefits in terms of “willingness to pay” for or “willingness to accept” an action. This represents an assessment of the “consumer surplus,” the difference between what a consumer is willing to pay (or accept) for a certain quantity of a good, and the market price of the good (technically, it is the area under the demand curve and above the uniform market price). The bottom line is net benefits expressed in dollar terms or in terms of whether a “welfare index” increases or decreases.
ECA uses as its “bottom line” the net impacts (of both the measured costs and benefits) on the economy, and is measured in terms of changes in gross domestic product (GDP) or employment. Welfare measures are difficult for non-economists to interpret, and policy makers are more comfortable with macroeconomic measures such as GDP and employment. ECA typically includes only market impacts, or, in cases where broader impacts are considered, it is limited to those that can be quantified in dollar terms. For ECA, these effects would include the direct and indirect impacts of implementing countermeasures. These would not necessarily be seen as costs a priori, but would be viewed in terms of their net effects on GDP, which could be either positive or negative. The net impacts are likely to be positive if unemployed resources are brought into play. If the economy is in a full employment situation (taken as 4 percent to allow for frictional unemployment, or normal job switching), the implementation of countermeasures may pull resources away from more productive uses elsewhere and is thus likely to have an overall negative impact on the economy. Also, if the countermeasures result in net increases in direct operating costs of business, they are likely to have a negative effect on GDP. The outcome (e.g., net increase or decrease in GDP) is not known until the ECA is completed.

We should mention that a third decision rule is operative in the economy—private profitability. Here, the costs and benefits are much narrower. For example, a business manager would not include the following in his/her assessment of the worthiness of a countermeasure from the standpoint of his/her firm:

- Indirect impacts on GDP from expenditures on the countermeasure
- Spillover effects that do not affect the firm
- Avoidance of direct and indirect impacts of a successful terrorist attack that do not affect the firm

Essentially, the benefits in this approach are much smaller. However, enhanced security is a “public good” in the sense that it can be shared by many firms and (households), and its total value is much higher than that considered by an individual supplier. Hence, it will be underprovided if left to market forces alone.
6  STAKEHOLDER ENGAGEMENT
To develop a strategic decision-making tool that is intended for real-life planning and response applications, it is critical that the tool meet the needs of its users. Stakeholders are the key to linking this research to reality since they are both experienced in and knowledgeable about the environments and contexts in which the tool will be implemented. Stakeholders are best positioned to articulate their needs and provide guidance about the utility of such a tool. Therefore, by engaging the different stakeholder communities in the research and evaluation process, the research team increases the likelihood that the findings are relevant, useful and credible (Preskill & Jones, 2009). Engaging stakeholders increases the scope, quality and depth of the issues under study; it acknowledges the political contexts in which stakeholders and their organizations operate; and it fosters relationships and partnerships between the researchers and the various stakeholder groups.

Using qualitative methods, rich data has been elicited from various stakeholder groups, including the law enforcement and public safety community, the business community and the residential community in Lower Manhattan. Different stakeholders’ needs, perspectives and their perception of costs were explored using both semi-structured interviews and surveys. Information from stakeholders supports the development of the economic, risk and simulation models. All the models were, in turn, systematically integrated into a prototypical decision-support tool that can be adapted to a user’s operating environment and, thus, able to be customized to different stakeholders’ planning and response needs.

6.1  Roles of Stakeholder Groups in UCASS
Many stakeholders have (or should have) an interest in the economic impacts of security. However, different stakeholder groups often have contending security and economic goals for Lower Manhattan. From our interviews with different stakeholder groups, many important insights have emerged.

Some specific examples of public sector stakeholders in Lower Manhattan include the New York City Police Department, the Port Authority of New York and New Jersey, which owns the World Trade Center site, and various local and state government agencies, including the Mayor’s Office and the NYC Office of Emergency Management. The private sector stakeholders include private
security firms, financial sector firms, business development organizations, and other businesses affected by security initiatives, and private sector partnerships, such as the New York City Economic Development Corporation and the 9/11 Memorial. In addition to the public and private sectors, the people who work in Lower Manhattan’s many shops and offices and those who live in Lower Manhattan are impacted by security. Collectively, these groups compose Lower Manhattan’s constituency and are neighbors in geographically confined spaces. Therefore, the conflicts and synergies resulting from the friction between security and economic performance will affect each group, albeit in different ways and to differing degrees.

Stakeholders play two roles in this study. First, stakeholders’ input was instrumental in understanding the different benefits and costs of security initiatives in Lower Manhattan as stakeholders view them and understanding their perceptions of fear and safety in the area. Second, as the UCASS decision support tool was refined, stakeholder input was critical to ensure that the tool has utility in real-world applications, since we aimed to develop a tool that is widely usable and applicable to many stakeholder groups.

6.2 Methods

Data from various stakeholder groups has been collected using two methods: one-on-one informational interviews with various stakeholders and subject matter experts, and a survey of surrogate residents, workers, visitors and business owners. Subject matter experts are individuals who are knowledgeable about high-level security issues, such as retired law enforcement officers, security officers or security consultants, academics, security architects, business owners, and individuals who are expert in Manhattan's diverse business environment. Subject matter experts are distinguished from stakeholders in that they do not necessarily have a stake in or a commitment to Lower Manhattan’s economic vitality. Stakeholders, on the other hand, were interviewed with the goal of establishing facts that informed the development of the risk and economic models and simulation tools; these individuals have direct investment in and commitment to Lower Manhattan’s economic growth and success. Some individuals interviewed fell into both categories, both stakeholder and subject matter expert.
Both in-person interviews and a survey were used to engage various stakeholders throughout the UCASS study. These approaches paved a way for the stakeholders to influence the overall direction of the project and the eventual end-products. This is important since it is the practitioners’ responsibility, and not that of a researcher, to balance the demands of security with the need for economic revitalization and prosperity. These decision-support tools will assist stakeholders who must balance the demands of security with the need for economic growth and productivity.

For the informational interviews, several purposive sampling techniques were used to generate a sample: heterogeneity sampling, expert sampling, and snowball sampling. Twenty-four (N=24) interviews were conducted. This sampling strategy better enabled the research team to investigate and understand the key variables that stakeholders and critical decision-makers prioritize (Patton, 2002) and to include a diverse set of perspectives and to generate a sample that reflects the heterogeneity of Lower Manhattan.

The semi-structured interviews played three roles. First, we sought information regarding how different groups view the trade-offs between security and commerce. Chapter 12 presents the results from the one-on-one interviews. Second, the interviews inform stakeholders about the scope and goals of the UCASS study. Stakeholders’ support of the project was prioritized from the start as an important step to promote and legitimize the study within the community of Lower Manhattan. Finally, the data generated from the interviews, in part, guided the design of the survey instrument.

The survey was conducted online and made use of stated preference methods, including contingent evaluation techniques, since such methods are useful when estimating non-market values and services. Stated preference methods are used in economic surveys by asking the respondent to state what they would be willing to pay to obtain a benefit or would be willing to accept to tolerate a cost. Contingent evaluation techniques are used to frame the question as a hypothetical scenario to the survey respondents. The purpose of the survey was to collect data on people’s movements and transactions, and to estimate the spillover costs of security. These results were then used to populate the models. Stakeholders’ input gives us the most proximate

62 See Appendix 3 for a selection of interview questions used.
and credible information, defining the key elements and parameters of the models and simulations developed for the UCASS study. Economic impacts quantified for the survey include: delays; inconvenience; and changes in the business environment. The survey also sought to study stakeholders’ perceptions of security in Lower Manhattan, and to assess their sense of fear and their sense of privacy due to the proposed security measures.

The survey was programmed using Qualtrics, an online survey software provider and administered via Amazon’s Mechanical Turk, a crowdsourcing internet marketplace. Survey subjects had to meet a set of qualifications, corresponding to our specific targeted groups, prior to accessing the survey site. The survey was designed around three security measures: street closures or restrictions to pedestrian traffic, CCTV cameras, and subway baggage checks. A specific narrative describing the security measure in detail and a set of questions accompanied each security measure (see Appendix 4). Each subject was randomly presented with two of the three security measures and accompanying questions. The survey was designed to take approximately fifteen minutes to complete. The survey was piloted to identify problems, and text that was unclear was revised. A detailed discussion of the survey methods and findings appears in Chapter 13.

6.3 Challenges

The challenges related to engaging stakeholders were: developing interview guides and the survey instruments, recruiting subjects, and eliciting relevant and necessary information from stakeholders. Designing the interview and survey instruments required iterative refinement. The issues explored in this project are largely uncharted and are complex, requiring that the interview guides be significantly flexible and constantly adjusted. Questions were written to capture the information needed for the project’s computational and simulation modeling. The team had to identify, coordinate, operationalize, and integrate the team members’ discrepant needs into clear, coherent and manageable research instruments.

63 For more information, see http://www.qualtrics.com/
64 Mechanical Turk is an online service typically used for market research. For more information, see https://www.mturk.com/mturk/welcome
65 As an example, researchers from differing disciplines use different terminology to describe the many kinds of costs that arise. We have tried to hew to the terminology of economic analysis in that part of the discussion.
The survey instrument was revised to meet the diverse needs of the UCASS team. Programming and formatting the survey tool was also complex. The survey flow and skip logic necessary to randomize the security measures across four separate groups was exceptionally detailed and layered.

Soliciting participation for the interview portion of the study was also challenging. First, acquiring access to stakeholder groups was extremely difficult and often required third-party introductions. This was particularly true in Manhattan where agencies are adversarial, politics governs both the political and economic arenas, and informal networks and personal contacts dominate professional relationships. Moreover, New Yorkers’ attitudes are cynical and tough, making access particularly difficult.

Communicating the study’s purpose, goals and expectations to the stakeholder groups was difficult since the academic and practitioner communities often understand and prioritize academic research differently. In order to access and foster the support of diverse stakeholder groups and key informants, the research team invested considerable time and energy building credibility, rapport and trust with individuals and organizations. Since the interviews probed sensitive security-related issues, data protection plans were put in place.⁶⁶

The challenge of recruiting survey subjects stems primarily from the fact that Lower Manhattan is a geographically very small area, barely larger than one square mile. To solicit large subsamples across multiple groups (i.e., residents, workers/commuters, visitors/tourists, and business owners) was impossible. Several data collection service providers declined to even bid on the task. Initially, one company agreed to collect the survey data, but after several months, they concluded that they would be unable to collect even a modest sample and the contract was voided. As a solution, Amazon’s Mechanical Turk service was selected as a way to distribute the survey to a large pool of subjects. To improve sample size, the geographical area eligible was widened beyond the boundaries of Lower Manhattan to include the five boroughs of New York City, multiple counties in northern New Jersey and one county in Connecticut. After a

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Similarly, “risk” is defined by a notional equation that can be interpreted as an expected loss. But we are expressing risk reduction in terms of the fractional decrease in that quantity, without monetizing it.

⁶⁶ The Rutgers Institutional Review Board approved all protocols and instruments.
series of screening questions, subjects took the survey, answering questions that posed hypothetical scenarios rather than recounting actual experiences. We regard the survey respondents as surrogates because of these methodological limitations.

The final challenge involved eliciting relevant information from stakeholders once they were engaged. Stakeholder groups and expert informants bring very distinct knowledge and terminology to the interview. There is significant variation between and even within stakeholder groups. To ensure that accurate and valid information was elicited from the different participants, the interview guides were tailored to specific industries or even individual organizations. Since the study was largely exploratory, there was substantial uncertainty regarding the types of questions needed and exactly how to present them. Given time restrictions and participant fatigue, only a few alternatives could be addressed to any one participant. While follow-up meetings would have been ideal, generally there was only one opportunity to meet with a particular individual. These constraints required that questions be prioritized; therefore, not all questions of interest could be asked of all participants.

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67 See Appendix 4
7 DISCRETE EVENT SIMULATION

Discrete event simulation models were developed to assess economic impacts of various security measures in Lower Manhattan, using two simulation environments, ARENA\textsuperscript{68} and OMNeT++\textsuperscript{69}. The ARENA software is a powerful tool, with which the CCICADA team has extensive experience (Altiok & Melamed, 2007). Since ARENA is proprietary and not a web-enabled tool, OMNeT++ was also used (see Chapter 10).

Simulation studies use computer programs to represent a large collection of persons (they can also represent vehicles) moving through the region of interest (i.e., Lower Manhattan). Their positions are updated, at a rate corresponding to a minute or so of real time. At each update, random variables reflecting the available information about how people behave are used to decide what each simulated person or vehicle will do in the next minute. Each simulation “run,” since it involves randomness, will be different from any other. However, a collection of such runs gives information about the average behavior of the people and gives some idea of the range of variation of that behavior. The difference between simulations with and without given security countermeasures, indicate the behavioral and economic impact that these measures have.

Technically, simulation can be used to compress and expand time, to control sources of variation, to stop and review system evolution, to replicate system experiments under various conditions. Simulation, as a process, has three primary phases: modeling, simulating, and analyzing. \textit{Modeling} refers to the construction of a conceptual framework (i.e., a model) that describes a system. There are generally two ways to construct a software model. One is to script the model topology in a text editor using a modeling language. The other is to use a graphical user interface (GUI) to layout and connect the components of the model. \textit{Simulating} involves running multiple experiments using a computerized implementation of the model, and \textit{analyzing} refers to drawing conclusions from the output in order to support the decision-making process.

There are several kinds of models available for use. In a discrete event model, the state of the system evolves by changing in discrete steps, like the ticking of a clock. Such models can

\textsuperscript{68} ARENA is a trademark of Rockwell Software (http://www.arenasimulation.com/Arena_Home.aspx)

\textsuperscript{69} OMNeT++ is in the public domain (http://www.omnetpp.org/).
describe queuing, inventory, scheduling, and the motion of persons in an area, where the state changes in increments. Discrete event simulation is appropriate for modeling the behavior of persons, because the time step is small compared to changes in the person’s behavior. Examples of discrete events are: arrival of a customer to a business, service and departure of a customer, security check of an individual or object, passing of a motor vehicle through a tunnel. The other kind of simulations, continuous event models, are needed for areas such as computational fluid dynamics and weather prediction. They are used, for example, in the determination of the plumes for release of chemical agents, discussed in Chapter 4.

The simulation models described here use data from the online survey, such as the probability that pedestrians will proceed through a security measure or the probability that they will “balk” and do something else instead. These parameters are then used to generate the flow of simulated persons to the various businesses in the affected area. A decision maker can vary security measures, or sets of measures, and compare the resulting differences, as given by the model. A policy causing extended wait times and queue lengths may discourage people from entering an area.

The discrete event models used in the UCASS project accurately and effectively support the goals of the study, including the development of a Precision Information Environment (PIE) simulation tool. The goal of creating a PIE is to improve the way decision makers interact with each other and with information throughout the emergency management lifecycle, from planning to response, through mitigation and recovery (http://precisioninformation.org/). For the PIE of the UCASS study, a web-based modeling and simulation tool overlays (i) commerce models and (ii) security measures models, to facilitate evaluation and decision-making.

In a typical decision support tool, the discrete event simulation and user input for the model is defined and built offline by a model builder. The default event scenarios, security measure options and other select parameters are programmed into the application during the building process, and a decision-making user cannot alter these components, though such a user can choose which of them is “active” during any given run.
Because the vision of a PIE is to allow users from different backgrounds to interact with the models, it is important to have a simple design interface.

The two key elements of model building are topology and behavior. Topology describes the connections among elements – for example, adjacent shops on the same side of a block are connected because a pedestrian passes them in order. Simulations also include abstract entities, which represent things like “the amount of time a customer waits to be served.” Behavior describes the properties of entities (in this case, enterprises) and processes. An example of behavior is distribution of customer spending attributed to a particular store. The simulation models described here are focused on the enterprises, although, in ARENA, the pedestrians are also modeled as specific objects.70

The following sections detail the ARENA simulation tool. The discussion of the web-support tool, OMNeT++, and the PIE web-based interface, are presented in Chapter 10.

7.1 ARENA
As presented in Figure 7.1, the geographic area of Manhattan that we began to model is the area around the World Trade Center complex (i.e., Lower Manhattan).

In ARENA, the user builds a model using a graphical design interface to place and connect modules (represented by icons of different shapes) that represent processes or logical decision points. Connecting lines are drawn to join these modules together and specify the flow of the simulated persons. Each module supports specific actions affecting the flow of persons. The precise flow, and timing, , i.e., the parameters of each module and pedestrian, must be specified by the modeler. For example, to experiment with various possible personal inspection processes (e.g., a bag check), the modeler can set up the simulation for a variety of processing time distributions.71 Statistical data, such as the rate of throughput, the average delay, and the amount

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70 When a pedestrian is modeled as an “object” he or she may, for example, have a pre-set goal when entering the modeled area, may have a limited amount of money to spend, and would, after having eaten, not immediately stop in another restaurant, for another lunch. Not all of these complexities have been programmed into our ARENA simulations. In OMNeT++ (See Chapter 10) pedestrians are not modeled as objects.

71 Because processing time is random, it is described by a distribution such as “5 seconds plus an exponential random additional time with an average value of 4.” The leads to a random variation that is never less than 5 seconds, and that has an average value of $5+4=9$ seconds.
of “countermeasure idle time” can be recorded by the software and reported.

**Figure 7.1: The UCASS Model Geography in the Lower Manhattan Area**

The ARENA model describes two types of components: mobile components and stationary components. People (pedestrians) are the mobile components of the model. In particular, people are classified into three classes: tourists, workers (of all kinds) and residents. They enter the simulation randomly at “source points” which are the corners of blocks at the edges of the geographic region, or (if residents) come out of residential buildings at the start of the day. Tourists and workers may also arrive from subway stations. All of these also serve as “sink points” at which they leave the model. Stationary components include streets, office buildings, residential building, hotels, shops, subway stations and restaurants, and countermeasure check points.

The model creates objects\(^{72}\) representing people of various types, directing them to walk on the streets, go to their destinations, visit shops and restaurants and do other similar activities, as demonstrated in the screenshot presented in Figure 7.2. The particular security measures being modeled are CCTV security cameras on streets, bag and parcel checks in subway stations, and

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\(^{72}\) The word “object” is used here in the technical sense of computer programming. One may think of the object as a part of the program encapsulating the history and behavior of the corresponding person or vehicle.
closure of streets to pedestrians. These three measures vary in their degree of visibility and, thus, will likely have different economic impacts. The impact is represented by the decision of customers to proceed or turn away, when they encounter the countermeasures. In this model, people who cannot or do not enter a particular street will enter other streets, and commercial activity as a result will shift among streets.

This model connects the micro-level behavior of individuals to micro-level economic consequences of disruptions in the daily life of the geographic area of interest. When properly calibrated, the model represents the consumer behavior in normal times and also reflects stated behaviors\textsuperscript{73} in response to security initiatives. The dynamics modeled in ARENA include people’s movements in designated areas, their arrivals and departures, their shopping and restaurant activities, etc.

Figure 7.2: A Snapshot of Occupancy on Broadway in Lower Manhattan.
The small squares represent the occupancy of the several enterprises. The colors indicate whether they are occupied by workers (red) or customers (green) or both. Each is normalized to its own capacity.

The key to making effective use of this tool is to populate the model based on realistic data, which must be gathered, analyzed, simplified as appropriate, and then incorporated in the model. The ARENA tool is only as useful as the extensive data collection and the data fed into the model makes it. Model building requires considerable intuition since many modules can be chosen to represent actual subsystems in the conceptual model or the real-life system under study.

\textsuperscript{73} Recall that we gather data on behavior by asking respondents what they “would do,” and not by observing what they “do do.”
ARENA produces two types of statistics: time-average statistics (such as average pedestrian traffic, or building occupancy) and customer statistics (such as average time a person spends on a city block).

The notable features of the ARENA model built for this project include:

- A daily timing mechanism generates time-dependent activities such as the morning rush hour, lunch break, departure from work, etc.

- At the beginning of each replication, residential buildings are populated with residents. People are introduced into the model from the edges of the geographical area of interest, subways and the residential buildings based on some arrival processes created by the researchers. People move to “sink points” towards the end of their stay in the UCASS area of interest, to come back again the next day.

- People walking on the street typically have a destination, even though a fraction of the tourists may wander during their stay in the area. An efficient shortest path algorithm is designed (although real people may not always take the shortest route) to guide people's movements on the street to direct them to their destination. Thus, when a street on someone's path is blocked off, the person continues to his or her destination using a new path.

- The security countermeasures implemented in the model include placing CCTV security cameras on streets, introducing bag and parcel checks in subways, and street closures. CCTV security cameras and bag and parcel checks may impact the likelihood of people entering those streets and using the subway where these measures are implemented. Street closures may completely block off the street, while pedestrians may enter the street after a bag check. People who cannot enter a street use other streets. Camera placements are viewed as permanent security measures, while bag and parcel checks and pedestrian street closures can either be permanent or temporary security measures.

- Commercial activity takes place in stores, shops, restaurants, parking lots, health clubs among others. Each venue has its own operational principles and characteristics
regarding the range and distribution of customer spending and the time customers spend in the establishment.

- Currently, the UCASS ARENA model contains 24 blocks and 96 streets (note that each side of the street is treated separately), with 96 street intersections. There are 71 stores, 19 businesses, and 22 residences. The number of people within the model varies throughout the day. There is no maximum limit to the number of people within the model, but there are approximately 250 people on a street. However, the number of people notionally drops to zero as the day ends, to be repopulated the following morning. However, because of the large amount of data required to populate the model and the computing power required to run it, not all components have been completed.

- Submodels have been created to represent residences, offices, subway stations, and shops. Using these submodels, the ARENA simulation can be transferred relatively easily to another location as long as there is a grid-like structure in the geography.

The simulation model, of course, runs more quickly for a smaller area. For demonstration purposes, we have also built a smaller ARENA model describing an imaginary neighborhood. See Section 7.1.3 for details.

### 7.1.1 Parameter Settings

The ARENA model has a user-friendly interface that allows a user to easily navigate the model and input specific parameters for each of the three security measures. To initiate the model, the user first selects among security options shown in Figure 7.3.

From the screen shown in Figure 7.3, a user may choose the security measures to be modeled, and to set other input and output parameter options, such as which side of the street (i.e., north or south, Figure 7.4) is affected, and the number of days\(^\text{74}\) (Figure 7.5) the simulation should model. Figure 7.4 and Figure 7.5 show the options available in the model.

\(^{74}\) Since each day represents a fresh start, the number of days is the number of random replications that are created. These help to define the average impact of a measure, and the variability of that impact.
For each of the three security measures, a user can manipulate a number of variables at specific locations (i.e., streets or intersections) within the modeled area (Figure 7.6), such as: the number of officers at each checkpoint; whether bags are checked at each security checkpoint; and the probability that a pedestrian enters the queue.\(^75\) (Figure 7.7).

For security cameras and subway bag and parcel checks, a user can set additional security-specific variables (Figure 7.8).

\(^{75}\) Note that this is taken to be a property of the checkpoint, and not a (variable) property of the individuals arriving at it.
Figure 7.6: ARENA Input Screen for Street

Figure 7.7: ARENA Input Screen for Bag and Parcel Check.

The notation “UNIFORM 0.5 2” means that the length of time it takes for a bag to be checked is random, with equal probability, between half a minute, and two minutes.

Figure 7.8: ARENA Input Screens Additional Security-Specific Variables.

The “repulsion rate” is the probability that a pedestrian will not proceed into an area containing a camera. The number 0.5 is much higher than what is actually reported.

7.1.2 Output

The display in Figure 7.9 represents a simulation output for the ARENA model. In this instance, both sides of the street are modeled independently. Each side of the street has a queue at each end. When the simulation is run, a set of statistics related to the number of people on the street, the average queue length and the wait time are generated. These are shown as cumulated plots, with time as the independent variable. The simulation begins early in the morning and at the end of each day all of the simulated persons either leave the area, or return to residences.
Figure 7.9: ARENA Model Simulation Output

The identical graphs shown here are notional, and do not actually represent the cumulated data from a particular run. Similarly, the counters do not show real totals.

Data required for the model includes: the capacities of buildings, the number of stores, shops and restaurants in the area, time-dependent arrival rates of people into the area, subway schedules, probabilities describing how people move within the system, and economic/commercial parameters. Partial data to meet these requirements were obtained in several ways, including the UCASS online survey (see Appendix 3), estimations from direct observation in the area and existing commercial and economic data. For example, data has been collected on the number of residential and office buildings, shops, restaurants in the modeled area, as well as data on subway ridership and schedules.

The ARENA model is sophisticated, including many streets, many residential buildings and many office buildings, and can represent thousands of people present for various reasons at different times of a given day in the geographic area of interest. However, we do not have ground truth data on the implementation of the security measures employed in this study, in this location, although law enforcement authorities have implemented similar security measures in various parts of Manhattan. Therefore, validation of such a complex model is an extremely
challenging process. The model has been verified by several methods, including model walkthroughs, observation of people’s behavior over different times of the day, survey data on the impact of security measures on the movement of people and estimations of the effect of security measures on the daily economic activity of the area. However, the methodology and the ability to do “what-if” experiments with the model are the key take-aways of the UCASS study, and readers ought not rely heavily on the specific numerical estimates presented in this report.

### 7.1.3 The Small Model

Due to the data-gathering and computational challenges of the complete model of Lower Manhattan, a smaller scale model was constructed on the same principles. In particular, the smaller model made it possible to do demonstrations and “what-if” experiments in real time for potential users of the UCASS methodology. The smaller model represents an imaginary 2x2 block region, and includes 20 shops, 6 residential buildings and 4 workplaces. The smaller region and population allows smoother animation and display of real time data, as well as faster runs. Below is a screenshot of the region (Figure 7.10).

![Figure 7.10: ARENA Small Model](image)

Both models produce Excel outputs, which show selected information for economic activity on the street:
1. Average number of people on the street

2. Average ($$) amount spent on a street every hour

3. Number of people who chose to or have been forced to go in another direction due to street closure, bag and parcel check, or CCTV camera placement.

Below is the screenshot (Figure 7.11) of such output created for the smaller model.

**Figure 7.11: ARENA Output for Small Model.**
For example, on the average, on the north side of the upper left block, in an average hour, there were 38 pedestrians, and they spent 0 dollars (no shops on the block).
In the small model, bag and parcel checks can be implemented within shops. The output for the small model has an additional feature, which allows a user to see the impact of security measures on a specific business. Below is a screenshot (Figure 7.12) of output related to the retail shops.

**Figure 7.12: ARENA Output in Small Model for Retail Shops.**
This display details the number of patrons in each of the shops. Comparison of these numbers with and without the countermeasure will indicate the impact of the countermeasure. After discussion with DHS subject matter experts, the reporting was changed to the format shown in Chapter 10.

7.2 Selection of a Web-based Simulation Environment
OMNeT++ is another discrete simulation environment. While OMNeT++ was originally created for the simulation of communication networks, it has a generic and flexible architecture ([http://omnetpp.org/](http://omnetpp.org/)). It is becoming popular as a network simulation platform within the scientific and industrial communities.
The UCASS team chose OMNeT++ after evaluating ten potential candidates\textsuperscript{76} on three primary criteria: a no cost, open-source option; able to duplicate the functionality of ARENA; software use and execution must be platform independent. Six metrics to help guide the evaluation were:

1. With what ease can the supplied models be translated using the candidate tool?

2. Of what quality is the web-based interface that allows for the construction or manipulation of a model?

3. Of what quality is the visualization of the simulation result?\textsuperscript{77}

4. With what ease are the model-building interface and visualization aspect of the candidate tool separated and ported to Flash 4?

5. Of what quality is the algorithmic efficiency/scalability of the processes in the candidate tool?

6. With what ease can aspects of the candidate tool be ported to our open-source framework?

Ease and quality were measured \textit{relative to ARENA} and according to the following scale:

\begin{tabular}{ll}
\textbf{Ease Scale} & \textbf{Quality Scale} \\
1 - Trivial & 1 - Exceeds expectations \\
2 - Easy & 2 - Meets all expectations \\
3 - Straightforward & 3 - Meets most expectations \\
4 - Hard & 4 - Meets some expectations \\
5 - Impossible & 5 - Unacceptable \\
\end{tabular}

It was determined that OMNeT++ was the most appropriate tool for the current study since it met most of the above prerequisites, has good documentation,\textsuperscript{78} and has current and active technical support. OMNeT++ is written and runs in the C++ programming language, and it has a

\textsuperscript{76} The additional nine candidates were: ASCEND, Blender, Delta3D, Facsimile, GarlicSim, JavaSim, OpenSim, SimPy, and Tortuga Scoring

\textsuperscript{77} Subsequent experience revealed that the OMNeT++ simulator can not replicate some important features of ARENA, including the depiction of multiple pedestrians at the same time.

\textsuperscript{78} See \url{http://www.omnetpp.org/documentation}
well-developed GUI to construct queuing networks and limited output visualizations. OMNeT++ supports message-passing-interface (MPI)-based parallel execution; its integrated design environment is based on the Eclipse platform; and there are several component libraries available. Chapter 10 includes more details of the OMNeT++ tool.
8 ECONOMIC MODELING: COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

Computable general equilibrium (CGE) is a model of an entire economy based on decisions by individual producers and consumers in response to price signals, within limits of available capital, labor, and natural resources. CGE is thus a comprehensive model with behavioral content that mimics the workings of markets under explicit constraints (see, e.g., Dixon & Rimmer, 2002). CGE is the state of the art in regional economic impact analysis, having more than a twenty-year history in fields closely related to the economic impacts of terrorism, such as natural hazards and climate change (see, e.g., Kokoski & Smith, 1987; Rose & Liao, 2005). In this chapter, we describe the components of CGE. A variety of technical terms from economics are used. The reader is referred to Dixon and Rimmer (2002), and Rose (2013) for definitions of these terms and relevant economic background. To assess the suitability of CGE for the analysis of the consequences of terrorist threats to the economy, we identify ten important considerations, and examine how the modeling framework can address them:

1. **Specific targets.** The basic unit of analysis in CGE models is an individual firm or household, even when these are aggregated into producing sectors and socioeconomic groups.

2. **Individual behavior.** CGE has the ability to model both normal behavior and the broader category referred to as “bounded rationality,” which includes myopia, fear, and departures from standard assumptions of maximizing profits or utility (consumer satisfaction).

3. **Market behavior.** In CGE models, prices provide signals to allocate resources. Community resilience is greatly aided by the workings of markets in guiding optimal resource allocation.

4. **Full accounting of all market inputs.** Intermediate (goods used to produce other goods) inputs are measured, and not just primary factors of production.

5. **Non-market considerations.** Many terrorist attacks are intended to have a symbolic impact (e.g., iconic targets such as the Statue of Liberty). Another example of non-
market impacts relates to infrastructure, including highways, electric and water utilities, and communication networks. Both categories can be taken into account.

6. **Economic resilience to terrorist attacks.** The model has extensive flexibilities (e.g., input substitution, conservation, relocation), reflecting resilience.

7. **Recovery processes.** CGE models have been extended to a dynamic form, including incorporation of changing conditions and adaptations, to trace the entire time path of adjustment.

8. **Economic disequilibria.** A shock to the economic system from a terrorist attack will cause the economy to be out of equilibrium, and its return to equilibrium may take some time. CGE models can be adapted to take into account various disequilibria with respect to input availabilities.

9. **Macroeconomic repercussions.** This includes the range of effects, beginning with more basic multiplier effects (as described in Chapter 5), then general equilibrium impacts, and then broader, less tangible macroeconomic effects, including synergies.

10. **Distribution of impacts across socioeconomic groups.** Economic losses are unlikely to be evenly spread, and any equivalent loss will have a more adverse effect on low-income populations. Because CGE models are disaggregated by income bracket, they can readily evaluate distributional consequences.

A CGE model will be capable of incorporating all of the cost components identified in the Benefit Cost Analysis (BCA) section of this report. This includes both direct (partial equilibrium) and indirect (general equilibrium) effects. It includes stock variables (deaths and changes in property values) and the remaining flow variables. It includes direct stimuli, such as capital and operating costs and business interruption, as well as spillovers that change the cost of doing business, such as delays and fear. The CGE model can also be extended to include non-market values, such as the iconic value of buildings, monuments, and natural settings, or things such as the value consumers place on delays and inconvenience. Transfer payments, such as tax revenues and insurance (see Chapter 5), are modeled as flows between institutions, including
households. Moreover, a CGE model calculates the interactions of all these cost components and provides a bottom line result in terms of the common denominator of dollars.

CGE models maintain most of the advantageous features of input-output (I-O) models (e.g., full accounting of all inputs, multi-sector detail, and the ability to measure interdependence) while overcoming many of their limitations (e.g., absence of behavioral content, linearity, lack of substitution, and absence of prices and markets). CGE models have many valuable attributes that make them well suited to the analysis of terrorist attacks (Rose, 2005) and are increasingly being used to analyze these and related issues (Rose et al., 2007; Dixon et al., 2007; Giesecke et al., 2012). In short, they have the ability to incorporate estimates of direct effects and to translate them into economy-wide (general equilibrium) effects through the interaction of producers and consumers within markets and subject to the constraints imposed by the attack, such as destruction of the capital stock (property damage). The behavioral, market, and flexible basis of CGE models gives them an edge in modeling most types of resilience (see, e.g., Rose & Liao, 2005). Substitution among inputs is readily addressed in production functions (which reflect how inputs are combined to produce outputs in each sector) and household expenditure systems (which reflect how consumers allocate their spending across various goods and services), as is substitution of imports for goods in short supply in the region. Price adjustments are an inherent feature of these models. Excess capacity and relocation can easily be modeled through relaxing constraints on the system, and several other resilience adjustments can be incorporated through changes in parameters (e.g., adaptive input/import substitution, adaptive conservation) or side calculations (e.g., production rescheduling).

8.1 Model Design
Static CGE models of the U.S. economy and the New York Metro Region consisting of 57 producing sectors have been updated for the UCASS project. Institutions in the model are households, government, and external agents. There are nine household income groups and two categories each of government (State/Local and Federal) and external agents (rest of the U.S. and rest of the world). The four major features of the model are: production; supply and trade of goods and services; income allocation, final demand and investment; and equilibrium/disequilibrium conditions.
Production activities are specified as constant-returns-to-scale (linear), nested constant elasticity of substitution (CES) functions, consisting of six nests (or levels) (see Figure 8.1). The top level consists of substitution possibilities among sub-aggregates made up of capital (K), labor (L), energy (E) and materials (M) to form a KELM aggregate. The next level reflects the choice of a material input aggregate and a capital-energy-labor input combination. On the third level, the capital-labor-energy combination is made up of labor and a capital-energy combination. On the fourth level, the capital-energy combination is made up of capital and energy aggregates. In order to capture the role of electricity more explicitly, we include an energy sub-nest consisting of fuels and electricity. Fuel use is a CES function of petroleum, coal and gas, while overall electricity use is derived as a Leontief (fixed, or constant, ratio of each input to the output it produces) aggregation of private electric utilities and state/local electric utilities. The nested CES function model of producer behavior provides a flexible structure of input substitution in the production of goods and services as illustrated in Figure 8.1.

The second major feature of the model is the supply and trade of goods and services. Transactions between the New York Metro Region and the rest of the U.S. and the rest of the world have been specified in the model using tradeoff relationships known as the constant elasticity of substitution (CES) function for imports and the constant elasticity of transformation function for exports. The former is specified according to the “Armington assumption,” which allows for imperfect substitution between domestic goods and competitive imports in demand. The latter is analogous to a CES function on the output side and reflects the revenue-maximizing distribution of domestic output between exports and domestic markets. Export and import prices are based on exogenous external prices plus percentage taxes and tariffs. The New York Metro Region model incorporates trade between the region and the rest of the U.S. Calculation of how security affects trade patterns is important for two reasons. If enhanced security or a successful attack make the region’s goods more expensive, and hence less competitive, this will have an adverse effect on GDP. Also, if a region imports much of its security equipment, the amounts produced in other regions do not generate any multiplier effects, i.e., the capital and operating

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79 “Elasticity of substitution” refers to the ease at which (or ability to avoid additional costs) one can substitute one input for another in the production process. The term “constant” refers to the condition where this elasticity does not change as one substitutes increasing amounts of one input for another.
expenditures have a greater economic stimulus effect if they are for locally produced goods and services.

Figure 8.1: Nested CES Function Model of Producer Behavior

The third major feature of the model is income allocation, final demand, and investment. Incomes from labor and capital employment in the economy are shared among institutions after the following deductions are made. Governments collect profit taxes on capital and employer-paid social security taxes on labor income, while industries deduct depreciation charges and retained earnings before paying capital incomes. The remaining incomes are then distributed to
households and external agents according to fixed shares. Institutions also receive inter-
institutional transfers, such as subsidies, social security, and income taxes.

Household consumption behavior in the model is represented by a Linear Expenditure System of aggregate commodities, which posits some minimum level of subsistence and limited substitution among goods and services that consumers purchase. The commodities are food, housing, gasoline, local transit, other transportation, health, equipment, water and sanitary services, electricity, other fuels, other goods, and other services. The commodities are produced from market goods and services by household production functions.

Government consumption is specified as a Leontief expenditure function (where consumers purchase goods and services in fixed proportions). Savings by households and governments are fixed proportions of disposable income, while external savings balance out this account. Households, government, and external entities also borrow from the capital account. Net savings by institutions, plus depreciation charges and retained earnings, are used to finance investment in capital goods. Investment in individual capital goods categories is a fixed proportion of total investment funding.

The fourth major feature of the model refers to equilibrium/disequilibrium conditions. These conditions balance supply and demand in goods and services markets. Capital endowments (or the initial stock of factories, stores and equipment) in the economy are fixed (held constant) to reflect the short-run nature of our simulations. In the labor market, the Keynesian closure rule is used to allow for unemployment even in equilibrium. This disequilibrium condition (where labor supply exceeds labor demand) prevents the muting of impacts inherent in the forcing of an equilibrium by the application of the Neoclassical closure rule (zero unemployment equilibrium).

Disequilibrium is introduced into the model in several other ways (see e.g., Rose & Liao, 2005; Rose et al., 2009). Most important are constraints on supplies of sectors directly hit by the terrorist attack. This causes a shift away from an efficient equilibrium to a “second-best” world. Another source of disequilibrium stems from temporary imbalances in trade and financial flows in and out of the region or country. An increased demand for imports will likely be required to offset the reduced production within the U.S.
Finally, the CGE model can incorporate fiscal imbalances. This would include debt, as well as other options (increased taxes, user fees or outside aid) to fund mitigation, and deficit spending to fund recovery and reconstruction. These various alternatives are likely to have significantly different impacts on a regional economy. An infusion of outside aid will translate into an unfettered boon, and the economy might expand or contract depending on shifts in spending from one stream to another (fewer consumer goods and more public services from tax increases, or shifts from ordinary consumer expenditures for repair and reconstruction expenditures).

### 8.2 Model Construction

The classification of businesses into distinct sectors (or aggregations that produce the same product) in the models was selected to highlight businesses that are prevalent in urban areas, e.g., finance, retail trade and transportation. Much of the data for the model is obtained from the detailed 2009 Social Accounting Matrix (SAM) for the U.S. derived from the Impact Planning and Analysis (IMPLAN) system (MIG, 2009). This is based on the National Income and Product Accounts and an update of the benchmark U.S. Department of Commerce Input-Output Table.

A review of the literature was conducted to update the various elasticity parameters needed in the model. These include input substitution elasticities in production, trade elasticities, household income and price elasticities of demand (the percentage change in quantity demanded of each good or service caused by a one percent change in its price), and household substitution elasticities. For Armington elasticities, previous estimates were compared with Tsigas (1997), Donnelly et al., (2004), and Dixon et al., (2007). Although having different sectoral classifications, it was found that these elasticities were generally comparable to each other. Therefore, only a few of the Armington elasticities used in previous modeling efforts were updated. The elasticities are between 2 and 3 for agricultural and manufacturing sectors, and around 1 for most of the other sectors of the economy (Armington elasticities of substitution above 1.0 indicate that it is relatively costless to substitute imports for goods produced within the region).

For households, calibration of the linear expenditure system requires income elasticities and the Frisch (consumer commodity purchase substitution) parameter. The latter was set to -2.0. Income elasticities from Oladosu (2000) were compared with those in Canning and Tsigas
(2000), Tsigas (1997), and Dixon et al. (2007) elasticities. Most of the income elasticities were based on Oladosu (2000) because the commodity categories used there are more consistent with the model specification for the UCASS project. Most elasticities from the other sources were close to 1. Substitution elasticities among market goods in the household production functions were set to values in the 0.1 – 0.5 range, with most less than 0.3.

For production behavior, it was difficult to find elasticities of substitution that match the detailed nesting scheme illustrated in Figure 8.1 above. Most studies estimate substitution elasticities between labor and capital only (see e.g., Balisteri et al., (2003) and Kemfert (1998)). As a result, most of the production elasticities from the previous modeling efforts (Oladosu, 2000; Rose et al., 2009) were retained. For many of the sub-aggregate inputs on Levels 4 – 6, substitution elasticities were set to low, but non-zero values less than or equal to 0.5.

8.3 Model Application

On the cost side of the model, the various aspects of the costs of implementing security measures can readily be incorporated into the CGE Model. The most fundamental are direct capital and operating costs. The former are entered as an exogenous shift in the demand for the relevant construction activities and capital equipment. However, first an assessment must be made of whether the expenditures are paid to firms within or outside the region, and whether the funds stem entirely from the working capital of businesses within the region or are in part paid for by state or federal subsidies. With regard to expenditures, we found that on average 66% of electronic equipment that would be used for terrorist countermeasures is produced in the region.

Other cost components, such as delay costs, inconvenience costs, and business environment delays can also be modeled. With respect to businesses, vehicle, bicycle and pedestrian delivery delay costs can be added to transportation costs in each economic sector, with the model then determining the extent that these costs can be passed along as price increases down the supply chain. In the case of households, these are “non-market” costs, which affect the household utility functions (functions that measure the satisfaction obtained by consuming various mixes of goods and services). Inconvenience costs are costs that decrease the utility experienced by individuals in society. Business environment delays are included in the model as either upward or
downward shifts in demand for goods and services produced or sold in the affected geographic areas, with the model then estimating the general equilibrium effects.

On the benefits side of the model, the application of CGE analysis to estimating the consequences of terrorist attacks is not straightforward. Although this approach has many advantages relative to others, it is in essence an equilibrium model, meaning it is difficult to constrain (Rose et al., 2007; 2009). Several types of disequilibria have been incorporated into the methodology for prior application to terrorism and other disasters, but reduction in production capacity due to damage to the capital stock or to the output of many sectors simultaneously presents computational challenges to obtaining feasible and meaningful solutions.

### 8.3.1 Ordinary Resource Loss Effects

CGE models can be solved as a set of simultaneous equations, reflecting market equilibria, or as some form of mathematical programming model, reflecting the optimizing behavior of individual producers and consumers. The disequilibrium analysis requires the inclusion of constraints and thus dictates the use of the mathematical programming model. In this study, the general equilibrium effects of output losses are being simulated using the following approach in a non-linear programming format of the General Algebraic Modeling (GAMS) software (Bussieck & Meeraus, 2007).

1. Upper bounds on output of the affected sectors were imposed as the base year level minus estimated direct losses from the 9/11 attack.

2. A slack price variable was introduced into the revenue equation for each sector. This variable is allowed to take on positive, negative or zero values and enables producer’s revenue in these sectors to be greater than, less than or equal to the cost of production (Note that for the U.S. simulations this variable was restricted to be positive or zero in order to obtain a feasible solution).

3. For each sector a complementary equation was introduced that requires the product of the slack price variable from (2) and the gap between actual and upper bound on output to be greater than or equal to zero as:
\[(X_i - X_i^{up}) \times P_{slack} \geq 0 \]
\((-or 0) \ (+,-or 0)\)

a. This equation implies that revenue received by any sector could be greater than its cost (positive \(P_{slack}\)), provided that the upper-bound constraint on output is binding.

b. However, revenues received could also be lower than the cost of production (negative \(P_{slack}\)) when actual production is lower than or equal to the upper-bound constraint.

c. Thus, \(P_{slack}\) represents a shadow price that serves to ration the available output when the upper-bound constraint is binding, but also allows producers to reduce production and/or prices.

4. Extra revenues (or losses) are added to (or subtracted from) the affected sector’s capital returns. This ensures that revenues/losses in the economy are completely distributed.

5. Since the above equation introduces disequilibrium into the model, its value is squeezed towards zero in relation to the objective function of the model (the total utility of consumers to be maximized).

### 8.3.2 Resilience

There are numerous ways that businesses and households can reduce business interruption losses following a terrorist attack. Resilience refers to the ability of an entity or system to maintain function (e.g., continue producing) when shocked (see also Rose, 2007, 2009b). Thus, it is aligned with the fundamental economic problem -- efficient allocation of resources, which is exacerbated in the context of disasters. This aspect is interpreted as static because it can be attained without repair and reconstruction activities, which affect not only the current level of economic activity but also its future time path. Another key feature of static economic resilience is that it is primarily a demand-side phenomenon involving users of inputs (customers) rather than producers (suppliers). Many resilience tactics are inherent in the CGE model (e.g., substitution adjustments to price changes); in fact, that is one of the reasons it was chosen. Others will be factored in following the methodology in Rose et al. (2009).
A more general definition that incorporates dynamic considerations is the speed at which an entity or system recovers from a severe shock to achieve a desired state. This also subsumes the concept of mathematical or system stability because it implies the system is able to bounce back. This version of resilience is relatively more complex because it involves a long-term investment problem associated with repair and reconstruction. This is also more likely to be affected by public policy than is static resilience. However, we address it by performing sensitivity tests on the economic impacts of various lengths of business recovery.

Two other dimensions of resilience can be distinguished. *Inherent* resilience refers to the ordinary ability to deal with crises (e.g., the ability of individual firms to substitute other inputs for those curtailed by an external shock, or the ability of markets to reallocate resources in response to price signals). This is itself a type of resource already in place that can be enhanced prior to a disaster, so that capabilities that are not damaged or eroded can be implemented in the disaster aftermath. *Adaptive* resilience, in contrast, refers to the ability in crisis situations to maintain function on the basis of ingenuity or extra effort (e.g., increasing input substitution possibilities in individual business operations or strengthening the market by providing information to match suppliers with customers). This corresponds to pushing the efficiency frontier outward.

Resilience can take place at three levels: microeconomic level, mesoeconomic level, and macroeconomic level. At the microeconomic level, individual producers and consumers decide to conserve scarce resources, use inventories, or substitute one input or good for another, or use alternative technologies (e.g., distributed power generation), excess capacity, relocation, or make up lost economic activity at a later date. At the mesoeconomic level, resilience occurs when individual markets adjust to price changes in the face of demand and supply changes and improved information flows to compensate for market deficiencies in a crisis (e.g., information clearinghouses that match customers who lost their suppliers with suppliers who have lost their customers). At the macroeconomic level, resilience refers to the ability of an economy to input more goods when there is a shortfall at home, interactions among markets for goods and services through quantity changes (ordinary multiplier impacts) and/or through price changes. Finally, it is important to note the overall ability in the market to provide valuable information to producers and consumers, spur efficiency and innovation, and otherwise maintain organization.
Several studies have found resilience to be sizeable in short-term or limited cases, such as water and electricity outages following the Northridge Earthquake (Tierney, 1997), or simulations of earthquakes (Rose & Liao, 2005) and terrorist attacks (Rose et al., 2007). Conservation input-substitution and inventories were found to be of limited effect. Alternative technologies (e.g., back-up electricity generators) or alternative sources (e.g., well water or riverine water), price adjustments, and production rescheduling were found to be major sources of resilience. In the case of 9/11, Rose et al. (2009) found that the quick action of nearly 1,110 businesses displaced by the World Trade Center attacks reduced business interruption losses by 72%.

Several types of resilience are being modeled and measured as noted in the last column of Table 8-1. The data input is a combination of data obtained from surveys and literature searches associated with the UCASS study, as well as data transferred from other studies, including those discussed above.

**Table 8-1: Resilience in CGE Modeling of Urban Security**

<table>
<thead>
<tr>
<th>Type</th>
<th>Direct Effect</th>
<th>Indirect Effect</th>
<th>How Modeled (Direct/Indirect)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microeconomic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business Relocation</td>
<td>external shock</td>
<td>internal</td>
<td>data compilation/CGE</td>
</tr>
<tr>
<td>Conservation</td>
<td>-a</td>
<td>n.a.</td>
<td>not modeled^a</td>
</tr>
<tr>
<td>Input Substitution</td>
<td>b,c</td>
<td>internal</td>
<td>CGE/CGE</td>
</tr>
<tr>
<td>Inventories</td>
<td>-a</td>
<td>-a</td>
<td>not modeled^a</td>
</tr>
<tr>
<td>Excess Capacity</td>
<td>d</td>
<td>office space</td>
<td>modeled separately</td>
</tr>
<tr>
<td>Macroeconomic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Import Substitution</td>
<td>b</td>
<td>internal</td>
<td>CGE/CGE</td>
</tr>
<tr>
<td>Price Adjustments</td>
<td>c</td>
<td>internal</td>
<td>CGE/CGE</td>
</tr>
</tbody>
</table>

^a Assumed to be minor.
^b Inherent (rather than adaptive) only. Adaptive assumed to be minor.
^c Applies to extended linkages as well.
^d Major example is excess office space, so associated with relocation.
8.3.3 Behavioral Linkages

In the past decade, the major extension of economic consequence analysis has been to include behavioral considerations. Behavioral linkages refer to off-site effects manifesting themselves through changes in risk perceptions that affect the way people react to a terrorist event. A prime example is the “fear factor,” which refers to changes in risk perception that translate into changes in economic behavior. Rose et al. (2009) measured the effect of the nearly 2-year downturn in air travel and related tourism in the U.S. following 9/11 at $85 billion, which accounted for over 80 percent of the estimated business interruption losses stemming from the event. A recent study by Giesecke et al. (2012) of a potential RDD (radiological dispersion device, or “dirty bomb”) attack on the financial district of Los Angeles would lead to social amplification of risk in the short-run and stigma effects in the long run (see Kaspseron et al., 1988; Slovic, 1987) that could exceed conventional “resource loss” effects by several-fold.

For the UCASS study, findings from several previous studies have been adapted to estimate various types of behavioral linkages. The adaptations are based on close analogs for type of attack, magnitude, duration and other factors that have a significant bearing on the size of these linkages (Gordon et al., 2007; Rose, 2013).

8.4 Challenges

While CGE models are the state of the art, they do have their limitations. First, their many strengths come at a cost of high complexity, including sophisticated functional relationships and interdependencies that require thousands of equations for a model like that of the New York Metro Region. The large size imposes a cost of immense data requirements that cannot be readily fulfilled with primary data. CGE models are typically calibrated on the basis of a single year of data rather than being statistically estimated from a large set of time series or cross-sectional data, primarily because such data do not exist. As such, they do not have standard "goodness of fit" measures that are a major form of model validation. Moreover, CGE models for a given region are often constructed by borrowing some key parameters, such as substitution elasticities from studies of other regions, thus increasing uncertainty about model accuracy.

Several other limitations have been noted in the literature, but modelers have worked tirelessly to overcome them. The basic CGE model does center around equilibria in all markets of the
economy, which is a departure from the real world. However, it is possible to build in various
types of disequilibria with respect to major segments of the economy, such as trade imbalances,
fiscal deficits, and frictional unemployment. Moreover, a special concern for studies of
disasters, it is possible to incorporate various types of constraints to reflect shortages of material
inputs or limitations of productive capacity in the aftermath of a terrorist attack. Other
limitations are being overcome as well, as in the implicit consideration of sectors or household
income brackets as "representative” firms and households, respectively. One of the ways of
accomplishing this is to distinguish the firms according to size or technology and to distinguish
households according to socioeconomic status.
9 RISK MODELING: PORTFOLIOS OF SECURITY MEASURES

One of the goals of UCASS is to provide an incisive analysis relating the total costs of security measures to their anticipated benefits. To clarify the comparison, costs and benefits are distinguished by considering the net costs of implementing a set of security measures without considering the risk reduction attributable to those security measures and comparing these net costs to the expected reduction in risk. Table 9-1 displays the relevant costs and benefits of security, absent a terrorist event occurring, and also shows the aspects of risk reduction.

Table 9-1: Costs/Benefits of Security and Expected Risk Reduction

<table>
<thead>
<tr>
<th>Costs and Benefits Absent an Event</th>
<th>Aspects of Risk Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct costs</strong> of security measures including:</td>
<td></td>
</tr>
<tr>
<td>- Capital costs</td>
<td></td>
</tr>
<tr>
<td>- Operating costs</td>
<td></td>
</tr>
<tr>
<td>- Maintenance costs</td>
<td></td>
</tr>
<tr>
<td><strong>Spillover costs</strong> accrued by security measures impinging economic activity</td>
<td>Reduction in threat probability due to deterrence</td>
</tr>
<tr>
<td><strong>Spillover benefits</strong> of security measures enhancing the business environment</td>
<td>Likelihood of the security measures interdicting/foiling a launched attack</td>
</tr>
<tr>
<td><strong>Indirect (multiplier) benefits</strong> of expenditures for security measures (employment, etc.)</td>
<td>Direct consequences of an event including:</td>
</tr>
<tr>
<td>- Deaths</td>
<td></td>
</tr>
<tr>
<td>- Property damage</td>
<td></td>
</tr>
<tr>
<td>- Injuries</td>
<td></td>
</tr>
<tr>
<td>- Economic losses at the site</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect costs</strong> of an event to the regional/national economies</td>
<td>Indirect costs of an event to the regional/national economies</td>
</tr>
<tr>
<td><strong>Reduction in direct and indirect consequences due to mitigation through security measures</strong></td>
<td></td>
</tr>
</tbody>
</table>

A security measure, or countermeasure, works to reduce the risk of a threat by deterring the attack, by thwarting the attack, or by reducing the consequences of a successful attack. The effectiveness of a security measure may be different for one type of attack than for another. Some security measures are designed for a specific attack mode, such as a concealed bomb, while others work more generically against many types of threats. For example, a metal detector (magnetometer) is useful in both deterring and thwarting an attack that employs a metallic weapon, such as a gun. Closed circuit television cameras, on the other hand, can detect
suspicious activities of many kinds and have forensic value that may contribute to deterrence. Neither of these security measures would reduce the severity of a successful attack as would a stockpile of medical supplies in the case of a biological attack or escape ladders and emergency lighting in the case of the bombing of a building.

An example of a security measure considered in the UCASS study is the imposition of random vehicle inspections at entry points into the Lower Manhattan region. Such a security measure would have some effectiveness against a multi-person, low-tech attack reminiscent of the Mumbai attack (on the rail station, synagogue, and Taj Mahal Palace Hotel). The deterrent effect of such random vehicle inspections against such an attack has been estimated by subject matter experts to be nearly 3%, while the likelihood of the security measure interdicting and thwarting the attack once launched was estimated to be nearly 10% (detailed explanation of these estimates is in Chapter 19). Clearly, the ability to stop an attack of this type once launched is thought to be greater than the deterrent effect.

Another security measure is random bag and parcel inspections at subway station stops in the Lower Manhattan area. Such a security measure could deter or thwart an individual attempting to smuggle an explosive device into the area and detonate the device. The deterrent effect of such a security measure for this type of attack has been estimated at 2.5%, while the ability to thwart the attack was put at nearly 1% (detailed explanation of these estimates is in Chapter 19).

A graphical representation of the net costs/benefits to risk reduction provides a convenient way to explain the analysis further (see Figure 9.1 below). Each point in the graph represents a discrete portfolio, or a combination of security measures. The position of a point shows the expected net costs of the portfolio of security measures on the vertical axis (numerated in millions of $) and the expected risk reduction on the horizontal axis (numerated in the equivalent loss of lives or in $). While the minimum net costs and maximum risk reduction is the preferred strategy, it is often the case that tradeoffs must be made. It is obvious, however, that one would not choose a specific portfolio when another portfolio exists with the same risk reduction and a lower net cost, nor would one choose a portfolio that can be bested by another with the same net cost and higher risk reduction.
Figure 9.1: Notional Chart of Net Costs of Security Portfolios related Expected Risk Reduction.

*Note that in this figure risk reduction is shown on the horizontal axis. The line indicates the optimal portfolio for a specific ratio of the value of risk reduction [measured in equivalent lives] and a net cost, measured in dollars.

Those portfolios that are in the lower right corner in the diagram are preferred to others that are dominated- those that can be simultaneously bettered in both dimensions. The curved line that forms the boundary on the lower right edge of the scatterplot highlights the portfolios that are not dominated by better alternatives and, therefore, should be considered as viable alternatives. This boundary is known as the efficient frontier. The choice of a particular place along the efficient frontier depends upon one’s tolerance for risk, which will likely differ among various stakeholder groups. One might anticipate, for example, that the law enforcement community, whose primary responsibility is public safety, would favor portfolios that entail greater risk reduction at higher net costs, while stakeholders in business and commercial sectors, such as real estate developers, might be willing to accept more risk in exchange for lower cost.

The straight dotted line illustrates how one person or stakeholder group might evaluate the tradeoff between risk and net costs. This is a line (not necessarily straight) on which points have the same attractiveness or utility in terms of the risk reduction-cost combination, thus portfolios falling on this line are equally attractive. Portfolios above and to the left are less attractive than those below and to the right, although the line has been positioned so that no portfolios lie below or to the right. Two portfolios do fall on the line and, for this particular “indifference line” (line of equal utility), they are equal in attractiveness and, moreover, preferred to all other portfolios because there is no other portfolio that produces higher risk reduction at a lower net cost.
9.1 Computing Risk for Security Portfolios

Computation of the net costs of a portfolio of security measures is conceptually straightforward but difficult to accomplish in practice. In the simplest case, the costs and benefits of the security measures in the portfolio can be summed across the security measures for each of the categories shown in the table, and then the costs and benefits can be summed across the categories yielding the total portfolio net cost.

While costs are largely additive, this is not the case for risk reduction probabilities, which are inherently sub-additive. This becomes obvious when one considers two security measures, each of which independently provides a 60% reduction in risk. It is impossible that they would together produce a 120% reduction in risk. Rather, the correct value is found through the well-known formula for the probability of unions of events. The total risk reduction is therefore calculated as \( 100\% - (100\% - 60\%)(100\% - 60\%) = 84\% \), assuming independence. In the following explanations of this and more general results, probabilities rather than percentages are used, resulting in a more compact notation.

Next, consider a portfolio with a number, \( m \), of security measures used against \( n \) scenarios. A particular security measure may be useful against a particular scenario by either deterring an attack or successfully interdicting or foiling an attack once launched. Denote the deterrence effect of the \( i^{th} \) security measure against the \( j^{th} \) scenario by \( d_{ij} \) and the interdiction/foiling effect by \( e_{ij} \). The interpretation of these factors is that given the security measure is in place, the threat frequency (i.e., expected attacks per unit of time) of the \( j^{th} \) kind of attack is reduced by a factor of \( d_{ij} \), and the success probability of such an attack once launched is reduced by \( e_{ij} \). Taking the two effects to be independent, for the \( i^{th} \) scenario, the frequency of successful attacks will be reduced by the factor

\[
1 - \prod_{j=1}^{m} (1 - d_{ij}) \prod_{j=1}^{m} (1 - e_{ij})
\]

For scenarios having threat frequencies of \( t_i \) and consequences, if an attack is successful, of \( c_i \), the aggregate risk reduction (R) of the portfolio is given by
Data for quantification of the probabilistic values in the model are obtained from terrorism databases and interviews with expert security personnel.

We anticipate that the analysis described here will facilitate collaboration among diverse stakeholder groups and exploration of possible security solutions. The tool is intended to promote interaction and discussion among stakeholder groups with the goals of better understanding one another’s needs and developing a path to participative security solutions.

9.2 Challenges

A major challenge to analyzing the economic costs of security is obtaining useful estimates of the component costs for each security measure. This is particularly true of spillover costs, such as changes in the business climate. Spillover costs can only be inferred and not directly measured as capital and operating costs can be measured. Another potential difficulty arises when two or more security measures have costs that are not additive. This could occur, for example, when two security measures share resources or have a countervailing impact on the business environment. In such situations, the acquisition of estimates of security measure costs was a major challenge for UCASS.

Second, the set of scenarios to be considered is inherently incomplete. We consider the selected scenarios as a representative set of all scenarios (similar to a sample) and allocate a total threat frequency across the included scenarios so that the sum of threat frequencies is equal to the overall threat frequency.

Finally, the risk reduction, R, calculated above, is shown as a single value. However, the quantities from which it is calculated are, in reality, uncertain and, therefore, correctly represented by uncertainty distributions (or probability densities that are functions that describe the relative likelihood of a quantity taking on a given value). This will result in R being represented as a random variable. The same is true for the costs that are somewhat uncertain. By moving to this level of representation, the portfolios will be depicted by an area, such as an ellipsoid, in the diagram rather than points. Propagation of the uncertainty to the risk and cost
estimates can be accomplished through Monte Carlo simulation -- a computerized mathematical technique to account for risk in quantitative analysis and decision making-- or analytically.
10 SIMULATION OF THE IMPACT OF COUNTERMEASURES ON THE LOCAL ECONOMY: OMNeT++

10.1 Economic Impact of Countermeasures
We assess the economic impact of various portfolios of countermeasures using discrete event simulation, to model the movement and behavior of pedestrians in a specified small area. By running the simulation first without countermeasures and then with them, we can estimate the behavioral and economic impact of the selected countermeasures.

10.2 Countermeasures
The security countermeasures implemented in the model include: temporary perimeter and access control, random bag and parcel inspection on subway, X-rays and magnetometers in building lobbies, increased visible presence of police, and increased use of CCTV cameras. The countermeasures are summarized in Table 10-1.

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary Perimeter and Access Control (sm3)</td>
<td>This countermeasure involves putting street restrictions and security checkpoints at which pedestrians would be subject to a “stop and search” before proceeding down the street.</td>
</tr>
<tr>
<td>Random Bag and Parcel Inspection on Subway (sm4)</td>
<td>This countermeasure involves the inspections of bags at subway stations, which may modify subway use by people entering or leaving the area.</td>
</tr>
<tr>
<td>X-rays and Magnetometers in Building Lobbies (sm5)</td>
<td>This countermeasure involves implementing security checkpoints in front of businesses, which may impact the likelihood that people enter the stores and make purchases.</td>
</tr>
<tr>
<td>Increased Visible Presence of Police (sm6)</td>
<td>This countermeasure involves increasing police presence at certain locations and may have an effect on pedestrian behavior on streets. In this mode, the police do not conduct any “stop and search” of pedestrians.</td>
</tr>
<tr>
<td>CCTV Cameras (sm7)</td>
<td>This countermeasure involves placing security CCTV cameras at certain locations on the streets, which may also affect pedestrian behavior on entering these streets.</td>
</tr>
</tbody>
</table>

To evaluate the tradeoff between commerce and security, we model the flow of pedestrians on a selected region, specifically a 2-by-2 city block area. Within the four-block region, we include
15 generic retail shops, 5 restaurants, 4 convenience stores, 3 bookstores, and 1 subway station. Each type of establishment has its own profile representing the probability that people will enter the store, the (random) distribution of the time that they spend in the store, the probability of spending various amounts of money, and the range of prices for goods available in the store.

10.3 OMNeT++ Model
The model presented here is constructed using OMNeT++ modules and components from the OMNeT++ queuing library. Modules called “sources” and “sinks” serve as arrival and departure points for pedestrian traffic. Modules called “classifiers” model street intersections and encode the direction(s) an entity takes at each intersection according to suitable programmed rules. In the current implementation, when an entity reaches an intersection, it will randomly proceed in one of three directions, forward, left, or right, with equal probability. “Delay” modules on the streets simulate the time spent moving along a street. Establishments, such as the stores, and security countermeasures are implemented with combinations of several modules, called: classifiers and single server queues. Classifiers inside establishments or associated with countermeasures are used as decision points to model whether a person will enter an establishment or proceed through a countermeasure. Classifiers are also used to set entity movement behavior after exiting the establishment or exiting a countermeasure.

The OMNeT++ model requires as input a model topology file (extension: .ned) and a configuration file (named: omnetpp.ini) specifying the simulation parameters. Figure 10.1 shows the 2-by-2 city block area (CityRegion.ned) that is modeled, along with the locations of the establishments and the subway station. Countermeasures can be placed near the corner on each street (at locations indicated by a red dot on the map) and are assumed to affect pedestrian traffic both entering and leaving the block.

---

80 These establishments are of the sort found in Lower Manhattan, but the model does not represent the actual businesses on any particular block in the Lower Manhattan area.
81 We refer to the simulated pedestrians as “entities.”
82 The data here are not representative of any specific block or any establishments. However, the ranges used for the establishments, and for pedestrian behavior are informed by a survey of businesses completed in connection with the development of the ARENA model, and as reported in Chapter 13.
10.4 Modules of the Simulation

10.4.1 Basic Modules

Pedestrians enter or leave the 2-by-2 city block area either through the arrival (source) and leave (sink) modules at the perimeters of the area, or through the subway station. The inter-arrival rates of people entering the region are based on the assigned parameter values. When pedestrians reach an intersection module (classifier), they will proceed either forward, left, or right, with equal probability. When they reach an intersection module on the perimeter, they may depart the region.

10.4.2 Countermeasure Module

The countermeasure module is a generic module, with the following parameters:

- A Service time distribution
- A Capacity
- A Probability that a person will join the queue at the countermeasure, which can be conditioned on the number of people in the queue
- A Probability that a person will continue in the same direction, after being processed at the countermeasure
Depending on the kind of countermeasure represented, the parameter values will vary. For temporary perimeter and access control, there is a queue capacity and service time distribution, which represents the inspection time. These modules also allow for the possibility that a new pedestrian arrival will see the length of the queue, and only enter the countermeasure if the wait time is within a tolerable length. Otherwise the person will avoid the countermeasure and turn around instead of walking further down the street\(^8^3\). The maximum length of the queue that the person would tolerate is specified in the configuration file.

For the increased visible presence of police and CCTV cameras, the person will enter the street, with some probability, which is set in the configuration file. These measures have neither queue capacity nor service time distribution. The Countermeasure Module consists of classifiers and a queue. The classifiers determine the conditions in which a person will proceed to the countermeasure. The queue is used to represent the countermeasure process and associated delays (see Figure 10.2).

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\(^8^3\) It is important to note that the present model does not assign to each entity a destination which would lead to complex behavior as the agent seeks another path to the destination.
10.4.3 Establishments

Person behavior:
When an entity arrives in front of an establishment, it enters the establishment, with some probability, which is set in the configuration file. When an entity enters a store, the module keeps track of whether it arrived from the left or the right. When it leaves the store, it may continue to travel in the same direction or return in the opposite direction. In the current implementation, an entity will always continue to travel in the same direction after leaving a store.

Establishment Characteristics:
In addition, each establishment also has the following parameters:

- Service time distribution, which determines (randomly) how long a person will be in the store
- Capacity, which defines how many people the store can hold
- Spending distribution, which determines (randomly) how much a person will spend in the store

A countermeasure queue is available to be activated at each establishment and is used to represent X-rays and magnetometers at the building lobby at which the establishment is located. The Establishment Module consists of two queues in addition to the classifiers. One queue represents a countermeasure at the establishment while the other queue represents the establishment itself.

Figure 10.3: The Components of an Establishment Module
10.4.4 Subway Station
The subway station serves as another possible arrival and departure point for pedestrians. The arrival rate of pedestrians [from outside the 2-by-2 city block area] is set in the configuration file, along with the probability that a person might enter the subway station to depart from the region. By default, a person passing the subway station will enter with probability 0.50.

The random bag and parcel inspection on subway countermeasure is modeled using classifiers and a queue. In the current implementation, the inspection process only affects pedestrians entering the subway station. Figure 10.4 shows the components that make up a subway station. If the random bag and parcel inspection on subway countermeasure is inactive, the person will go directly to the sink module and leave the system. If the countermeasure is active, the person may enter the countermeasure queue with a specified probability. If the entity turns away from the countermeasure, it is returned to the streets via the router module.

![Figure 10.4: The Components Inside the Subway Module (these include classifiers, a queue, a router, as well as a source and a sink)](image)

10.5 Cumulated Data
At the end of each simulation run, the following outputs are collected:

- Number of customers who entered each establishment
- Number of customers who entered and made a transaction
- Amount of spending at establishments
10.6 Net Cost and Risk Reduction Calculations
The UCASS approach considers that one or more countermeasures may be put in place to protect an area. The array of countermeasures in place is called a portfolio.

The total net cost for a selected portfolio of countermeasures includes the direct costs of implementing each of the countermeasures in the portfolio and also the loss of business that is predicted to occur as a result of the countermeasures. The loss of business is calculated by the OMNeT++ simulation. Our analysis is limited to short term interventions, for which the behavioral data obtained from the survey (See Chapter 13) may be expected to hold. If a countermeasure were to be in place for a long period of time (weeks) then both the consumers and the businesses will change their behavior to adapt to the constraints in ways that we cannot predict.

10.7 Cost Estimation Calculations
Direct cost includes the amortized capital cost and the operating and maintenance (O&M) cost of the countermeasure $c$.

$$DirectCost_c = CapitalCost_c + OperatingCost_c$$

Capital costs and operating costs in turn are estimated based on the annual cost estimates presented in Chapter 4 Section 4.2.4 of this report, together with information obtained from the USDOT ITS Cost Databases (USDOT, 2008; USDOT, 2010). For personnel wages, the hourly mean wages for civilian police officers (Level 6) and security guards (Level 4) are used (USBLS, 2009).

10.7.1 Temporary Perimeter and Access Control
Table 10-2 shows the annual cost estimates for temporary perimeter and access control to certain restricted areas of the Lower Manhattan in 2009$ as presented in Chapter 4 Section 4.2.4. Table 4.11
These cost estimates are for approximately 100 intersections or tactical checkpoints operating 7 days a week. Each checkpoint includes temporary barricades, and people traveling into or within the area would be subject to a “stop and search” by police personnel. There are two police personnel at each checkpoint.

To obtain cost estimates for one intersection, we divide the capital cost and O&M cost of each component by 100, giving the annual cost per intersection. Since capital cost is a fixed, initial, one-time expense, we divide the capital cost of each component by its estimated lifetime and further divide by 365 days/year and by 24 hours/day to get its capital cost per hour.

The estimated lifetime for checkpoint equipment is 10 years, and 14 years for a portable dynamic message sign (USDOT, 2010). For the O&M cost, we divide the dynamic message sign component by the number of hours for which it is operated, or 365 days * 8 hours, since the sign is operated 7 days a week but only for 8-hour shifts. To determine the hourly wage of police personnel, we use the reported mean hourly earnings for civilian police officers (Level 6), which is $30.12 (USBLS, 2009).

Table 10-3 summarizes the estimated hourly costs for the countermeasure of temporary perimeter and access control.

The resulting estimate for the total cost per hour is $60.74, which is the average of $60.66 (low) and $60.82 (high).

---

84 This assumes a 24-hour duty cycle or 168 hours per week. A higher estimate of the unit cost would be obtained with cycles such as 60 business hours per week.
Table 10-3: Costs for Temporary Perimeter and Access Control (Hourly)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($/hour)</th>
<th>O&amp;M Cost ($/hour)</th>
<th>Total Cost ($/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Checkpoint Equipment</td>
<td>0.23</td>
<td>0.23</td>
<td>n.a.</td>
</tr>
<tr>
<td>Wages and Benefits (2 persons)</td>
<td>n.a.</td>
<td>n.a.</td>
<td>60.24</td>
</tr>
<tr>
<td>Dynamic Message Sign – Portable</td>
<td>0.13</td>
<td>0.17</td>
<td>0.06</td>
</tr>
<tr>
<td>Total</td>
<td>0.36</td>
<td>0.40</td>
<td>60.30</td>
</tr>
</tbody>
</table>

10.7.2 Random Bag and Parcel Inspection on Subway

Table 10-4 shows the annual cost estimates for random bag and parcel inspection on subway in 2009$, as presented in Chapter 4 Section 4.2.4, Table 4.12.

Table 10-4: Costs for Random Bag and Parcel Inspection on Subway (Annual)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($K)</th>
<th>O&amp;M Cost ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Bomb-Sniffing Dogs (100 dogs)</td>
<td>2,743.51</td>
<td>2,743.51</td>
</tr>
<tr>
<td>Wages and Benefits (500 persons)</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Bomb Detection Equipment (1000 detectors)</td>
<td>21,220.00</td>
<td>21,220.00</td>
</tr>
<tr>
<td>Total</td>
<td>23,963.51</td>
<td>23,963.51</td>
</tr>
</tbody>
</table>

The cost estimates assume approximately 50 subway stations, 10 police personnel per station operating 7 days a week, 2 dogs per station, and 20 detectors per station. The inspections are carried out 24 hours a day, 7 days a week.

To get the cost estimates for one subway station, we divide the capital cost and operating and maintenance cost by 50, which gives the annual cost estimates for one station. To get capital cost per hour, we divide by estimated lifetime, by 365 days/year, and by 24 hours/day.

The estimated lifetime for the bomb detection equipment is 10 years. We assume that the bomb-sniffing dogs will be in service for up to 10 years. To get the operating and maintenance cost for the canines, we divide the O&M cost by 365 days/year and by 24 hours/day. For the wages of the
10 police personnel, we use the reported mean hourly earnings for civilian police officers, which is $30.12 (USBLS, 2009).

Table 10-5 summarizes the estimated hourly costs for random bag and parcel inspection on subway.

**Table 10-5: Costs for Random Bag and Parcel Inspection on Subway (Hourly)**

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($/hour)</th>
<th>O&amp;M Cost ($/hour)</th>
<th>Total Cost ($/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bomb-Sniffing Dogs (2 dogs)</td>
<td>0.63</td>
<td>0.19</td>
<td>1.21</td>
</tr>
<tr>
<td>Wages and Benefits (10 persons)</td>
<td>n.a.</td>
<td>301.20</td>
<td>301.20</td>
</tr>
<tr>
<td>Bomb Detection Equipment (20 detectors)</td>
<td>4.84</td>
<td>n.a.</td>
<td>4.84</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5.47</strong></td>
<td><strong>301.39</strong></td>
<td><strong>306.86</strong></td>
</tr>
</tbody>
</table>

**10.7.3X-rays and Magnetometers in Building Lobbies**

Table 10-6 shows the annual cost estimates in 2009$ as presented in Chapter 4 Section 4.2.4. Table 4.13.

**Table 10-6: Costs for X-rays and Magnetometers in Building Lobbies (Annual)**

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($K)</th>
<th>O&amp;M Cost ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Magnetometer (50)</td>
<td>750.00</td>
<td>750.00</td>
</tr>
<tr>
<td>Wages and Benefits (assuming 100 persons)</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>X-ray Scanner (50)</td>
<td>1,611.66</td>
<td>1,611.66</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2,361.66</td>
<td>2,361.66</td>
</tr>
</tbody>
</table>

This cost estimate assumes one magnetometer and one X-ray scanner each is placed in the lobbies of each of 50 major, large buildings in Lower Manhattan. There are 2 police personnel present at each building entrance. We divide the values by 50 to obtain the cost estimate for each building.
To get capital costs per hour, we divide the annual capital costs by the estimated lifetime by 365 days/year and by 24 hours/day. The estimated lifetime for the magnetometer and X-ray scanner is 10 years.

For the wages of the police personnel, we use the reported mean hourly earnings for civilian security officers (Level 4), which is $17.98 (USBLS, 2009)\(^8\).

Table 10-7 summarizes the estimated hourly costs for placing both an X-ray and a magnetometer in a building lobby, with necessary police personnel.

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($/hour)</th>
<th>O&amp;M Cost ($/hour)</th>
<th>Total Cost ($/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetometer (1)</td>
<td>0.34</td>
<td>n.a.</td>
<td>0.34</td>
</tr>
<tr>
<td>Wages and Benefits (assuming 2 persons)</td>
<td>n.a.</td>
<td>35.96</td>
<td>35.96</td>
</tr>
<tr>
<td>X-ray Scanner (1)</td>
<td>0.74</td>
<td>n.a.</td>
<td>0.74</td>
</tr>
<tr>
<td>Total</td>
<td>1.08</td>
<td>35.96</td>
<td>37.04</td>
</tr>
</tbody>
</table>

10.7.4 Increased Visible Presence of Police

To estimate the cost of increased visible presence of police, we assume that 2 police personnel are added to the specified location of the countermeasure. We use the reported mean hourly earnings for civilian police officers (Level 6), which is $30.12 (USBLS, 2009).

Table 10-8: Costs for Increased Visible Presence of Police (Hourly)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($/hour)</th>
<th>O&amp;M Cost ($/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages and Benefits (assuming 2 persons)</td>
<td>n.a.</td>
<td>60.24</td>
</tr>
</tbody>
</table>

10.7.5 CCTV Cameras

Table 10-9 shows the annual cost estimates of 3,000 CCTV video cameras and towers in 2009$ for Lower Manhattan, as described in Chapter 4 Section 4.2.4. Table 4.15. The low range

---

\(^8\) The salary scales can be used with more precision, depending on the level of worker required.
estimate assumes that there are 3,000 video cameras and 1000 video towers, while the high range assumes that are 3,000 video cameras and 2000 video towers.

Table 10-9: Costs for CCTV Cameras (Annual)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($K)</th>
<th>O&amp;M Cost ($K/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>CCTV Video Camera (3,000)</td>
<td>23400.00</td>
<td>76500.00</td>
</tr>
<tr>
<td>CCTV Video Tower (low 1,000; high 2,000)</td>
<td>4530.00</td>
<td>38280.00</td>
</tr>
<tr>
<td>Total</td>
<td>27930.00</td>
<td>114780.00</td>
</tr>
</tbody>
</table>

CCTV cameras can be placed near the street corners. We assume that 3 CCTV video cameras are used along with either 1 or 2 video towers, for low and high, respectively. In other words, placing CCTV cameras at a location would involve 3 CCTV video cameras and either 1 or 2 video towers. The estimated lifetime for a CCTV video camera is 10 years and 20 years for a tower (USDOT, 2010).

To get capital costs per hour, we divide the annual capital costs by estimated lifetime by 365 days/year and by 24 hours/day. To get the operating costs per hour, we divide by the hours of operation, which is 365 days/year and by 24 hours/day. Table 10.10 summarizes the resulting cost estimates for the installation and use of CCTV cameras. Note that we do not include the costs of labor or smart software. This corresponds to using the cameras only after an incident for the purpose of forensic investigation.

Table 10-10: Costs for CCTV Cameras (Hourly)

<table>
<thead>
<tr>
<th>Subsystem/Unit Cost Element</th>
<th>Capital Cost ($/hour)</th>
<th>O&amp;M Cost ($/hour)</th>
<th>Total Cost ($/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>CCTV Video Camera (3)</td>
<td>0.27</td>
<td>0.87</td>
<td>0.29</td>
</tr>
<tr>
<td>CCTV Video Towers (1,2)</td>
<td>0.03</td>
<td>0.22</td>
<td>n.a.</td>
</tr>
<tr>
<td>Total</td>
<td>0.29</td>
<td>1.09</td>
<td>0.29</td>
</tr>
</tbody>
</table>

10.8 Costs for Portfolios of Countermeasures

Table 10-11 summarizes the total direct costs of each of the countermeasures.
### Table 10-11: Total Direct Cost Of Each Countermeasure

<table>
<thead>
<tr>
<th>Cost Element</th>
<th>Total Capital Cost ($/hour)</th>
<th>Total O&amp;M Cost ($/hour)</th>
<th>Total Cost ($/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary Perimeters and Access Control (2 personnel)</td>
<td>0.38</td>
<td>60.36</td>
<td>60.74</td>
</tr>
<tr>
<td>Random Bag and Parcel Inspection on Subways (2 dogs, 10 personnel, 20 detector equipment)</td>
<td>5.47</td>
<td>301.39</td>
<td>306.86</td>
</tr>
<tr>
<td>X-rays and Magnetometers in Building Lobbies (1 magnetometer, 1 X-ray scanner, 2 personnel)</td>
<td>1.08</td>
<td>35.96</td>
<td>37.04</td>
</tr>
<tr>
<td>Increased Visible Presence of Police (2 personnel)</td>
<td>0.00</td>
<td>60.24</td>
<td>60.24</td>
</tr>
<tr>
<td>CCTV Cameras (3 cameras)</td>
<td>0.69</td>
<td>0.48</td>
<td>1.17</td>
</tr>
</tbody>
</table>

The total direct cost of a countermeasure portfolio \( p \) is taken to be the sum of the direct costs of each of the countermeasures in \( p \).

\[
DirectCostPerHour_p = \sum_{c \in p} DirectCostPerHour_c
\]

Lastly, the total net cost of a countermeasure portfolio is the sum of the direct cost and the loss of business obtained from the OMNeT++ simulation.

\[
TotalNetCost_p = (DirectCostPerHour_p \times SimulatedTime) + SimulatedBusinessLoss
\]

### 10.9 Risk Reduction Calculations

As a measure of benefit, we compute the estimated fractional risk reduction for a selected portfolio of countermeasures using information on the five attack scenarios: Mumbai, Tokyo, Madrid, London, and Israel.

The estimated fractional risk reduction (EFRR) attributed to a portfolio \( p \) for a specific attack scenario \( S \) is the expected annual risk reduction in dollars (EARR$) of that portfolio divided by the cost of the scenario \( S \$\).

\[
EFRR(S)_p = \frac{EARR(S)_p}{Cost(S)}
\]
Using the EFRR of the five attack scenarios, we obtain an overall estimated fractional risk reduction value by computing the reduction in the probability that \textit{at least one attack scenario succeeds}, given that the countermeasure portfolio is in effect.

Table 10-12 shows the total cost of each of the attack scenarios.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total (M2009$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mumbai</td>
<td>877.371</td>
</tr>
<tr>
<td>Tokyo</td>
<td>15772.781</td>
</tr>
<tr>
<td>Madrid</td>
<td>4907.201</td>
</tr>
<tr>
<td>London</td>
<td>992.306</td>
</tr>
<tr>
<td>Israel</td>
<td>921.669</td>
</tr>
</tbody>
</table>

The probabilities of the attack scenarios are given in Chapter 19 Table 19.1. Likelihood of attack scenarios (per year) and repeated below in Table 10-13.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Annual Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mumbai</td>
<td>0.14</td>
</tr>
<tr>
<td>Tokyo</td>
<td>0.09</td>
</tr>
<tr>
<td>Madrid</td>
<td>0.10</td>
</tr>
<tr>
<td>London</td>
<td>0.21</td>
</tr>
<tr>
<td>Israel</td>
<td>0.16</td>
</tr>
</tbody>
</table>

The probability that no attack scenario $S$ occurs is the product of the probabilities that each does not occur.

\[
\Pr\{\text{no scenario } S \text{ occurs}\} = \prod_{S}(1-\Pr\{S\}) = 0.4674
\]

The probability that at least one attack scenario $S$ occurs is the complement of this number:
\[ \Pr\{\text{at least one scenario } S \text{ occurs}\} = 1 - \prod_s (1 - \Pr\{S\}) = 0.5326 \]

The probabilities in Table 10.13 are for the whole of Lower Manhattan, for a full year. We scale these probabilities to fit our 2-by-2 city block model, for a single hour of exposure, as follows:

\[
\Pr\{S\}_{\text{scaled}} = \frac{\Pr\{S\}}{365 \text{ days} \times 24 \text{ hours} \times \frac{N\text{blocks}}{4\text{blocks}}} \cdot \text{SimulationTime}
\]

where \( N = 81 \) is the estimated number of city blocks in the whole of Lower Manhattan.

The probability of at least one attack scenario \( S \) occurring given that the portfolio of countermeasures \( p \) is implemented, is related to the probabilities of the individual threats by the equation\(^86\) (see also\(^87\)):

\[
\Pr\{\text{at least one scenario } S \text{ occurs } | \ p\} = 1 - \prod_s [1 - \Pr\{S\}(1 - \text{EFRR}(S)_{p})]
\]

The Estimated Fractional Risk Reduction (Overall)\(^88\) is then computed as:

\[
\text{EFRR}_{\text{overall}} = \frac{\Pr\{\text{at least one scenario } S \text{ occurs}\} - \Pr\{\text{at least one scenario } S \text{ occurs } | \ p\}}{\Pr\{\text{at least one scenario } S \text{ occurs}\}}
\]

### 10.10 The Precision Information Environment (PIE)

A key goal of the project was to construct a Precision Information Environment (PIE), an analysis system that couples behavioral, risk and economic models, thereby supporting tactical evaluations and decision making either for strategic planning, or in the tactical stages of recovery from an attack.

\(^86\) The overall risk reduction is computed as a weighted sum of the risk reduction for each of the scenario. To compute the overall risk reduction, we could weight it according to the damage costs of the scenario. However, since there is much uncertainty on the estimating the damage costs of each scenario, we chose to use the scenario probabilities as weights instead. This is the effect of the more complex calculation detailed here, when the probability of an attack for the time and space being considered is very, very small.

\(^87\) See Appendix 6 for analysis of the limit of the ratio, \( \Pr\{\text{at least one scenario } S \text{ occurs } | \ p\} \) to \( \Pr\{\text{at least one scenario } S \text{ occurs}\} \)

\(^88\) The EFRR values for all combinations of security measures, along with values for direct costs of countermeasures, are stored in an XML file, which is read by the PIE during runtime.
An early prototype of a UCASS decision support tool was implemented with three steps: (a) pre-processing step; (b) simulation input and execution step; (c) and a post-processing step. In the pre-processing step, the user builds a portfolio of countermeasures from an available list and assigns the countermeasures to specified locations. The user is also provided, as reference, a list of security events/scenarios, along with suggested countermeasures for each event. In the simulation input and execution step, the user is prompted to define specific input parameters and then executes the simulation model to produce the economic activity outputs. The post-processing step is used to view the economic impact. This impact is a combination of the individual costs described previously in this report, which are obtained from the UCASS models, and the impact on commerce produced by the discrete event simulation.

This section provides a description of the precision information environment (PIE), with a working example. The PIE provides a graphical interface between the user and the OMNeT++ simulation model. Through the interface, the user may experiment with constructing countermeasure portfolios, varying model parameters, and perform “what-if” analyses.

When the PIE is launched, the users are brought to a “Welcome” page where they may select the model layout to use.

![Figure 10.5: Welcome Page](image)

Users are provided with a short description and a screen shot of the selected model.
Once the model is selected, they can examine the topology of the layout, and assign security countermeasures to specified locations. A list of the attack scenarios and their associated countermeasures is provided on the left of the screen and serves as guidance on the types of countermeasures the users may want to include in their portfolios. The countermeasures that have been selected appear in the box on the right. Users are provided with a larger view of the model topology and may assign available countermeasures to appropriate locations.
In this demonstration, we place X-rays and magnetometers in front of the four convenience stores. The locations of the convenience stores are shown in Figure 10.8.

**Figure 10.8: Location of Convenience Stores**

For demonstration purposes, the locations of the 4 convenience stores are circled in blue. The locations are as follows: north side of Block 1, west side of Block 2, south side of Block 3, and east side of Block 4.

When the users choose a countermeasure to add, a window pops up with a dropdown list of possible locations to place the countermeasure. This countermeasure, X-rays and magnetometers can only be placed at establishments. Therefore, a list of the four available types of establishments (bookstores, restaurants, convenience stores, and shops) is presented. In this formulation, either all or none of the establishments of a given type are protected.

Once the countermeasure portfolio is complete, users can adjust the values for the parameters of each countermeasure, such as inspection times, and visitor behavioral parameters, such as the probability of entering inspection queues. Users can specify or modify the expected business transaction values for various establishments such as bookstores, convenience stores, restaurants and retail shops. Finally, users can also adjust the duration of the proposed interventions, which
by default is 4 hours, as well as the inter-arrival times for visitors entering the 2-by-2 city block area, from the street and from the subway station.

**Figure 10.9: Window for Adding Countermeasures**

Users can assign parameter values for countermeasures, visitor behaviors, along with business transaction values for the different types of establishments. See Appendix 6 for details on the parameters for the establishments.

**Figure 10.10: Assigning Parameter Values for Countermeasures**
Finally, the users can review all the selections, and run the simulation model. When the simulation is complete, they can proceed to view the economic impact analysis.

Prior to running the model, the users can name the run for the specific portfolio in the text box on the top bar. The run name will be used as a prefix for the output files. When the user clicks on “Run Model,” the PIE will invoke OMNeT++ and the simulation will run. Once the run is completed, the “Economic Impact Analysis” button on the top bar will become enabled and the users may proceed to the simulation results.

The economic impact analysis view displays the total net cost (direct cost of countermeasures and loss of business) in dollars, and also the expected risk reduction for the selected portfolio of countermeasures as a percentage. The analysis view further breaks down the information on the overall impact on businesses to report on the number of customers entering establishments, and the amount of business transacted (in dollars). The loss of customers and business transactions is also displayed by individual establishments, and by type of shop, as well as by block.

In addition, there are three main output files that retain the results of each simulation run, for further analysis and study. Several .xml files contain the detailed results from the simulation, i.e., the number of customers that entered each establishment, the number of customers who made a
purchase, and the amount spent, for the baseline case and for the case where the countermeasures are in place. The results are also organized by store type. A copy of the OMNeT++ configuration file is also saved. A sample of the OMNeT++ configuration can be found in Appendix 7.

Table 10-14 summarizes the details of the output files, where run_name is the name provided by the users in the text box found on the top bar in the PIE.

<table>
<thead>
<tr>
<th>Output Files</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>run_name_outputByStore.xml</td>
<td>Contains data on the number of customers that entered the establishment, number of customers who made a purchase, and amount of spending at the establishment, for the baseline case and the countermeasure case.</td>
</tr>
<tr>
<td>run_name_outputByStoreType.xml</td>
<td>Contains the same data as observe, but organized by store type, i.e., bookstore, convenience store, restaurant, and shop.</td>
</tr>
<tr>
<td>run_name_omnetpp.ini</td>
<td>A copy of the OMNeT++ configuration file used for this run.</td>
</tr>
</tbody>
</table>

In this example, the total net cost of putting X-ray and magnetometers in front of the four convenience stores for 4 hours is $2,022.63. This cost includes the direct costs of the equipment and operating expenses ($592.64), and its effect on businesses in the area ($1430.00). The estimated fractional risk reduction is quite low: 1.15%.
The overall loss of customers and business transactions is displayed cumulatively for the 2-by-2 city block area. In this example, the region incurred a business loss of $1,430 in 4 hours.

**Figure 10.13: Economic Impact Analysis View: Overall Impact on Business**

![Economic Impact Analysis View: Overall Impact on Business](image1)

The loss of customers and business transactions is also displayed for each individual establishment. The user may examine and sort the data by clicking on the columns. The impact on customers and businesses is also presented by type of store. The bar chart shows the number of customers that entered the establishments for the baseline (no countermeasures) and also in the case of the countermeasures. The table in Figure 10.15 shows the loss in the number of customers visiting the establishments, and the loss in business revenue.

**Figure 10.14: Economic Impact Analysis View: Impact by Establishments**

![Economic Impact Analysis View: Impact by Establishments](image2)

The loss of customers and business transactions is also displayed for each individual establishment. The user may examine and sort the data by clicking on the columns. The impact on customers and businesses is also presented by type of store. The bar chart shows the number of customers that entered the establishments for the baseline (no countermeasures) and also in the case of the countermeasures. The table in Figure 10.15 shows the loss in the number of customers visiting the establishments, and the loss in business revenue.

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The impact on customers and business activities is presented by block. In this example, the establishments on the south side of Block 3 experience the largest total business loss of $1,783. Establishments on most of the streets in the region also experienced business losses, while establishments on a few streets experienced revenue gains. This is likely due to the fact that the placement of the countermeasures and the establishment will influence the movement and behavior of the pedestrians.
10.11 Challenges of Simulation

There are several challenges in this study related to modeling and simulation. It is important to understand individuals’ buying behavior for a given area in order to thoroughly understand what attracts different people to the area. In addition, it is important to understand individuals’ attitudes towards security, as well as safety procedures for transportation and other infrastructure. Similarly, it is important to understand commercial stakeholders’ views, such as shop owners, of a high-security area in order to build good models.

There are unique challenges when modeling urban areas. Economic activity stems from commerce on the streets and in offices, shops and restaurants, all of which are embedded in an interconnected network of transportation routes frequented by large numbers of people making transactions. Clearly, there are modeling decisions to be made, such as the appropriate boundary or scale of the area, which includes both the size of the area to be covered and the number of people to be included in the model. Moreover, these chosen areas may be neighboring national landmarks, such as the World Trade Center site, which require intense levels of security around the area. Decision-makers are therefore challenged to find the right balance between security and the free flow of people - an issue very similar to container inspection in port security (Altiok, 2009; Yi, Salehi, & Wang, 2011), another area to which simulation modeling methodology has been extensively applied.
11 ECONOMIC PROFILE OF LOWER MANHATTAN

11.1 New York City and New York Metropolitan Area Economies
The New York City (NYC) economy is the largest among municipalities in the United States and second largest in the world after Tokyo (USBEA, 2011). The Gross City Product (GCP) in 2009 was $602 billion, 4.2% of the nation’s total economic output (Comptroller, 2010). The unemployment rate declined from 10.5% to 10.2% during that year (Comptroller, 2010). Per capita income is above the national average, but the poverty rate is 5% above the national average as well (Miller & Smith, 2010). Income is less evenly distributed in NYC than in other cities in the U.S. The Gini coefficient measure of income inequality for New York City was 0.6 according to 2005-2007 estimates, compared to about 0.45 for the U.S. as a whole (Census, 2009).89

11.2 New York City’s Major Economic Sectors

11.2.1 Finance and Insurance
The top two stock exchanges in the world are located in NYC: The New York Stock Exchange (NYSE) and NASDAQ. Four other exchanges are also located there as well: American Stock Exchange, International Securities Exchange, New York Board of Trade and the New York Mercantile Exchange. Wall Street, NYC’s financial services district, accounts for nearly 25% of all income produced in the city and 10% of the city’s tax revenue (Comptroller, 2008). The Federal Reserve Bank of New York, the largest of the U.S. regional banks, implements monetary policy decided in Washington, DC. Finance and insurance account for nearly 10% of New York City’s employment (Census, 2011) and over 35% of wage and salary income (Orr & Topa, 2006). Over 60% of statewide employment in finance is concentrated in NYC (ESD, 2006). The Securities sub-cluster within the Finance sector is also concentrated in NYC and employs over 20% of the nation’s securities workforce (ESD, 2006). In the aftermath of 9/11, finance sector employment decreased by over 10% (Parrott & Cooke, 2005) and still has not returned to pre-9/11 levels (NYS Department of Labor, 2011).

89 See Appendix 2 for New York demographic and economic statistics. Note that a higher Gini coefficient means less even distribution.
11.2.2 Real Estate
Real estate plays a large role in New York City’s economy. In fiscal year 2011 (FY2011), the total value of property in NYC was over $823 billion (NYC Finance, 2011). Despite this large valuation, real estate values have dropped 20% since the 2007 peak (Miller & Smith, 2010). In 2009, real estate employed 137,626 people, totaling 3.8% of the city’s total employment. The office vacancy rate in the first quarter of 2010 (1Q2010) was 11.6%. Apartments sold in 1Q2010 numbered 2,384, an increase of almost 100% over 4Q2009, but the average price was down 18.3% (Comptroller, 2010).

11.2.3 Information Technology
New York City is a hotbed of information technology (IT) employment, with six of nine IT industry clusters showing spatial employment concentration (ESD, 2005). Information technology employs almost 5% of the NYC workforce (Census, 2011). Half of all IT employment in New York State is located in NYC (ESD, 2005). In 2006, Google moved into the second largest office building in New York City, which also houses the digital advertising giant, Doubleclick (NY Times, 2008). NYC is also the terminus of the transatlantic fiber optic trunk line, making it the primary international internet gateway into the U.S. (NYCEDC, 2005).

11.2.4 Health
Healthcare is the largest employer in NYC, accounting for over 15% of total employment (Census, 2011). It is also among the fastest growing sectors in NYC, expanding by more than 50 percent from 1990-2008, a growth rate more than double all other industries combined (USBLS, 2009). Fundamental drivers of this growth include population growth in the area combined with an aging population, as well as pharmaceutical and biotechnology research associated with educational institutions (USBLS, 2009). Major pharmaceutical companies located in NYC include Bristol-Meyers Squibb, Pfizer and OSI.

11.2.5 Educational Services
The Education sector is another one of the largest employers in NYC, accounting for nearly 10% of employment (Census, 2011). Higher education in NYC in particular is a major industry, and New York State ranks third among states in enrollment in higher education (State Comptroller, 2010). NYC also has one of the highest educational levels in the United States (State
Comptroller, 2010). Higher education institutions also have important second-order impacts on the construction, high tech, and health care industries through supply chain multiplier and productivity effects (State Comptroller, 2010).

11.3 New York City’s Tax Revenues & Expenses

11.4 New York City’s Economic Growth
In FY2010, the growth of the NYC economy (measured in terms of gross city product, GCP) declined to 1.2%, following a contraction to 2.1% in FY2009 (Comptroller, 2010b). A time series of economic growth rates is presented in Figure 11.1.

Figure 11.1: NYC Economic Growth 2001-2010 (GCP)
11.5 Metropolitan New York Economy

The Metropolitan New York area (MNY, formally designated as the New York-Northern New Jersey-Long Island Metro Region) is the largest economic metro area (in population) in the United States. It spans four states (New York, New Jersey, Connecticut, and Pennsylvania), 23 counties and 15 cities (including NYC, Newark NJ, and Bridgeport CT). The total labor force was 9,376,500, and employment was at 8,617,400 resulting in an unemployment rate of approximately 8% (US BLS, 2011). It ranks first in metropolitan areas in the country, with a Gross Regional Product of over $1.2 trillion (BEA, 2011). The Gini coefficient of MNY is .504, making it the fourth most unequal metro area in terms of income in the U.S. (Census, 2009). The region’s economy has proven to be remarkably “resilient” in terms of growth and stability. Orr and Topa (2006) attribute this to a migration from a manufacturing base to a service base and to large investments in human capital.

The Metropolitan New York area, excluding the NYC portion, places second to NYC proper in many industry categories. For instance, it is the second largest in Financial Services and Insurance, Information Technology and Education Services (EDC, 2005; EDC 2006; State Comptroller, 2008). Educational services accounts for over 10% of all employment. Like NYC, Health Services is the largest single employment sector. Finance and Insurance accounts for nearly 10% of employment (Census, 2011). The Metropolitan New York economy is first in the nation as a high-tech cyber center (TechAmerica, 2008). Biotechnology is also a rapidly growing industry in MNY, with MNY ranking 6th among metropolitan areas (Orr & Topa, 2006).

The GDP for MNY in 2009 was $1.21 trillion, which ranks it first in the nation, even higher than the entire state of California, which ranked second (USBEA, 2011). A time series of MNY GDP in other years is presented in Figure 11.2.

Interestingly, in both New York City and New York State, there is a strong private sector consensus that the business climate is unfavorable. In a ranking by CEOs, New York City ranked worst in the nation for business climate based on taxation, workforce quality, living environment and regulation (Donlon, 2011). A study by the Tax Foundation noted that New York City has one of the highest local sales tax rates, property taxes and gasoline taxes (Tax Foundation, 2011). New York State also lost the most residents of any state from 2000 to 2008,
with the exit of more than 1.5 million people (Reisman, 2011). These factors accompany a generally bleak outlook for business in New York City, although this was found to be heavily influenced by the national economic climate (Rummel & Szczerbacki, 2011). Sixty-five percent of businesses surveyed indicated a favorable opinion of state economic policies; however, the same proportion indicated the future would be less favorable.

Figure 11.2: MNY Regional GDP 2001-2009 (in 2009 dollars)
12  LOWER MANHATTAN STAKEHOLDER INTERVIEWS

Lower Manhattan is an exceptional area in which to examine the relationship between security and economic activity for a number of reasons. Not only is the district rich with iconic buildings and history, but it also holds a critical position in both national and global economies (as a key part of New York City’s economy that was discussed in Chapter 11). While geographically an area less than two square miles, Lower Manhattan is home to over 28,000 households, up from 7,000 since 1993 (Downtown Alliance, 2011). The Lower Manhattan market has an estimated annual spending power of $4.6 billion, with approximately 1,085 retailers and restaurants, and 18 hotels conducting business with its residents and visitors. It also has over 308,000 workers and over 9 million tourists who visit the area annually (Downtown Alliance, 2011).

Lower Manhattan has had a number of substantial urban renewal and revitalization projects and initiatives in both the commercial and residential sectors since the 9/11 terrorist attacks. The public transportation system includes the World Trade Center transportation hub and the Fulton Street Transit Center. A number of large chain retailers have moved into the area, such as Sprint, Whole Foods and Sephora. However, many of the area’s smaller merchants have been forced to close or relocate since 2001, their closures or relocations can be attributed largely to the initial damage caused by the 2001 attacks, economic strain inflicted by the heavy construction, and subsequent street closures and restrictions resulting from the ambitious renewal and revitalization projects implemented since 2001. The growing popularity of the area also resulted in increasing rents, and the most recent economic recession has forced small businesses and residents to leave the area. Nevertheless, there have been coordinated campaigns to draw the retail establishments and service industries into the area by both the city and Downtown Alliance, the group that manages the Downtown-Lower Manhattan Business Improvement District. While the revitalization of Lower Manhattan has been considered largely successful, the construction necessary for such redevelopment has proved disruptive for the area’s commercial residents and residential inhabitants.

In addition, Lower Manhattan is the only district in NYC with a multi-modal regional transportation network that includes 12 subway lines, 30 bus routes, the PATH train to New Jersey, six ferry landings, a heliport, and vehicular access to the Brooklyn Battery Tunnel, Holland Tunnel and Brooklyn and Manhattan bridges (Downtown Alliance, 2011). As the
nation’s fourth largest business district, it houses some of the world’s most prestigious firms and corporations. Furthermore, since terrorists have successfully attacked the World Trade Center complex on two occasions, both the New York Police Department and private security contractors have implemented some of the country’s most ambitious security initiatives, most notably the Lower Manhattan Security Initiative (LMSI). This means that a greater range of responses are available to first responders, and with this expanded range of responses comes the need to understand what their indirect impacts will be on businesses, visitors and residents.

12.1 Lower Manhattan Security Initiative

In 2005, the New York Police Department (NYPD) began developing the Lower Manhattan Security Initiative (LMSI), a concept and applied strategy of counterterrorism security modeled after London’s “Ring of Steel” (Buckley, 2007). The NYPD security strategy is a combination of police presence, domain awareness, contingency planning, and a strategic deployment of police resources. The LMSI was designed to ensure the public safety and security of NYC’s people and assets and to detect, deter and prevent potential terrorist attacks.\(^9\) The LMSI is an integrated security strategy that combines the presence of police officers and an extensive network of counterterrorism technologies, including a heavy reliance on closed-circuit television (CCTV) cameras, license plate readers, and chemical, biological, radiological and nuclear detectors. Since 2008, the LMSI has been managed from the Lower Manhattan Coordination Center, and since 2010 has been extended into Midtown Manhattan, incorporating approximately 500 subway cameras in Times Square, Penn Station, and Grand Central Station.

The CCTV cameras associated with the LMSI are connected to a single network and are intended to help the NYPD identify and observe terrorists’ pre-planning and preparing for an attack, assess suspicious activities, reduce incident response time, and create a common technological infrastructure for security surveillance. There are reportedly over 1,300 CCTV cameras operating in the area, and there are plans for a total of 3,000 operational CCTV cameras to be located throughout Lower and Midtown Manhattan by 2013. Moreover, select cameras are fitted with advanced video analytic software. When fully configured, the analytics will provide a number of advanced capabilities, such as the capability to alert police in real-time to potentially

suspicious objects or activities, including suspicious parcels, movement in restricted areas, and unusual loitering, and it enables investigators to search multiple cameras simultaneously to retrieve incidents of concern. The NYPD, other public agencies and the private sector share ownership of and/or access to the camera network, as well as oversight of the cameras' operations and monitoring. It is estimated that approximately two-thirds of the cameras tied into the LMSI program are owned by the private sector. The LMSI also employs the use of license plate readers and air quality monitors that are both mobile and stationary. These devices are also placed at vehicle crossings, including the Brooklyn-Battery, Holland, Lincoln and Queens-Midtown Tunnels. The LMSI cost has been estimated at $90 million dollars, funded largely through federal funding streams (Baker, 2008).

Figure 12.1: Map of CCTV Cameras in Lower Manhattan as of 2005

Source: New York Civil Liberties Union, 2006

12.2 Perceptions of Safety and Security in Lower Manhattan

One goal of the UCASS study was to engage the various stakeholder communities in Lower Manhattan to ensure that the research team conducted the study aware of the realities that people who live, work and otherwise visit the area face routinely. As discussed in Chapter 6, stakeholders have been engaged in two ways. First, one-on-one interviews were conducted with both stakeholders and experts. Second, an online survey was administered to four target groups: people who live in Lower Manhattan, people who work in Lower Manhattan, people who visit Lower Manhattan and people who own and operate businesses in Lower Manhattan. Using both methods, the UCASS team collected both qualitative and quantitative data about the perceptions
of safety and security in Lower Manhattan in general and with respect to particular security measures. This chapter provides the results from the UCASS interviews.

A diverse sample of stakeholders and expert informants participated in semi-structured interviews, including individuals experienced in or familiar with Lower Manhattan’s law enforcement community, business community and residential community. The purpose of the interviews, in part, was to learn about people’s perceptions of safety and security in Lower Manhattan by asking about three primary areas. First, the UCASS research team was interested in learning more about how the security landscape of Lower Manhattan has changed since 9/11. Second, it was important to understand whether different stakeholder groups currently perceive Lower Manhattan as safe, and third, if they think there is the right amount of security currently in place in Lower Manhattan. These three topics were used as general guidelines for the questions in the one-to-one interviews.

12.2.1 Sample

While there have been a number of informal meetings with persons at various city and state agencies, twenty-four (N=24) subjects participated in formal, semi-structured interviews with a UCASS researcher. Of the 24 subjects, 19 were male and five were female. The subjects were sampled using purposive sampling techniques, primarily snowball sampling and expert sampling, to generate a sample that reflects the heterogeneity of Lower Manhattan; therefore, the sample is small but diverse. The subjects belong to five general subgroups: workers, residents, individuals with a security background, individuals with a community development background and “other” experts (see Table 12-1). However, it is important to note that the five subgroups are not mutually exclusive and not all participants were asked all available questions on the different topics studied. The interviews were conducted between November of 2010 and June of 2011.

Table 12-1: Interviewed UCASS Subjects (N=24)*

<table>
<thead>
<tr>
<th>Workers (past or current)</th>
<th>15</th>
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<tbody>
<tr>
<td>Residents</td>
<td>6</td>
</tr>
<tr>
<td>Security Background</td>
<td>8</td>
</tr>
<tr>
<td>Community Leaders</td>
<td>2</td>
</tr>
<tr>
<td>“Other” Experts</td>
<td>5</td>
</tr>
</tbody>
</table>

*Not mutually exclusive groups
Of the 15 subjects classified as workers, two were contractors in the construction sector, of the 12 worked in an office setting, and one worked in a large regional public agency. Of the 6 subjects classified as residents, all but one had lived in Lower Manhattan since before the 9/11 terrorist attacks. Of the 8 individuals with a security background, two had a background in corporate security, three were former New York police officers, one had a career in law enforcement in the New York-New Jersey area as a policing executive and one had an extensive career in the intelligence community. The two individuals with community development positions also lived in Lower Manhattan. One of the subjects represented both the business and residential community of Lower Manhattan, while the other individual was heavily involved in the redevelopment of Lower Manhattan’s business community. The “other” experts included an individual in the private security sector with over 20 years experience in the commercial sector, an urban architect who was heavily involved in the design of Battery Park City and various environmental security features in Lower Manhattan, and three individuals from a marketing, tourism and partnership agency focused on the New York City tourism industry.

Unfortunately, an important subgroup not represented is the area’s commercial business community, both large and small; thus, inferences or conclusions regarding how security in Lower Manhattan is perceived by different sectors, such as the retail industry, food industry, or hotel and guest services community is not possible from the interview data.

12.2.2 Findings

Several interesting insights emerged from the one-on-one interviews. Below are the general themes that emerged from the interviews along the three primary research questions outlined above. Generally, the securitization of Lower Manhattan has substantially increased since the 9/11 terrorist attacks, having evolved through three distinguishable “eras” over the past decade. In addition, while Lower Manhattan is perceived as safe in general, there is not a clear consensus from the interviewees whether they perceive that there is enough security in Lower Manhattan.

91 One of the general contractors had an office located in Lower Manhattan.
92 One of these men was former military as well.
93 One of these individuals lived in Lower Manhattan.
12.2.2.1 How has Lower Manhattan’s Security Landscape Changed?
The Lower Manhattan security environment has changed substantially in the decade since the 9/11 terrorist attacks as layers of security have been added. Not only is there a distinction between pre-9/11 Lower Manhattan and post-9/11 Lower Manhattan, but interviewees say the decade since 9/11 can be divided into three different “eras.” The “eras” (as detailed below) demarcate how the NYPD’s security strategies have evolved in response to political and other social changes, including the renewal and revitalization of Lower Manhattan’s commercial and residential markets, and the 2008 economic recession.

12.2.2.2 Description of the Lower Manhattan Security Environment
All of Lower Manhattan is safeguarded with layers of both overt and covert security measures. Overt security measures in place include uniformed patrol officers, heavily armed police officers in tactical gear and heavy artillery, vehicular security checkpoints (primarily for large vehicles such as delivery trucks), various physical security structures, such as bollards, and fencing and road closures or restrictions. Covert security strategies include the Lower Manhattan Security Initiative, as described previously, and a heavy reliance on undercover, plain-clothed officers who serve within the NYPD’s counterterrorism and intelligence programs.

While security has increased generally in Lower Manhattan since 9/11, there are particular areas around which there are many layers of heavy security. These areas are the WTC site, Wall Street and Centre Street Courthouse. The WTC site is secured with a variety of security measures, including fencing, cameras, private security guards, New York City police officers, and access restrictions to both pedestrians and vehicles. Security measures around Wall Street consist of tactical police presence, CCTV cameras, and various target hardening measures, such as fencing, bollards, traffic restrictions to vehicles, including a state of the art, in-ground turnstile. In addition, the many financial firms housed on or near Wall Street have implemented various private security measures, and these security management teams work in coordination with each other and the NYPD. The area around the Centre Street Courthouse is also heavily guarded, primarily by police officers, and is a restricted zone to vehicles.
12.2.2.3 Post 9/11 Policing in Lower Manhattan: Three “Eras” of Security

Prior to the 9/11 terrorist attacks, traditional policing strategies that focused on crime prevention and deterrence dominated security practices in downtown Manhattan. Although the WTC towers were successfully attacked in 1993, traditional policing strategies still prevailed within Lower Manhattan. However, after the 9/11 attacks, policing practices began to shift. While traditional policing practices and strategies were never abandoned after 2001, the NYPD’s policing practices not only expanded to include a counterterrorism focus, but also included additional priorities of crisis mitigation and recovery.

Since 9/11, the NYPD has assumed an integrated security strategy that combines police presence, situational awareness, contingency planning, and the strategic deployment of police resources for deterrence purposes. The NYPD strategically positions uniformed officers (both in standard patrol uniform and heavily dressed in tactical gear) and plain clothes police officers throughout Lower Manhattan, focusing on the highly vulnerable areas near the WTC site, Wall Street and Centre Street Courthouse. The uniformed officers not only demonstrate a visible presence of security in the area, but the undercover officers and the uniformed officers also gather intelligence for the NYPD’s Intelligence Division and Counterterrorism Bureau. Together with the extensive CCTV camera system, which is a primary component of LMSI, these strategies allow the NYPD to deter both traditional criminal threats and potential terrorist activities and increase their situational awareness throughout the downtown area.

Over the years, the security environment has changed from an ad hoc, militaristic and highly visible strategy into a more technologically focused and aesthetically pleasing strategy. The adjectives that subjects used to describe the security environment in Lower Manhattan immediately after the 9/11 terrorist attacks include unattractive, rigid and restrictive. The reliance on visible presence is still key to the NYPD’s security strategy; however, it has become less intrusive and more streamlined and integrated into the environmental fabric of Lower Manhattan. As noted earlier, since the 9/11 terrorist attacks, the area can be described as having evolved along three “eras” of security. The first era lasted from approximately 2001 to 2004. The second era lasted from approximately 2004 to 2008, and the third era began to emerge in 2008 and continues to the present day.
For the first twelve to eighteen months after the 9/11 attacks, Lower Manhattan was a disaster zone. Immediate clean up and recovery efforts were prioritized as the community was covered in dust and debris. Few businesses could operate, and residents initially were unable to return to their homes until the roads were cleared and buildings tested and determined to be structurally sound. Once they could return to their homes and places of employment, residents and workers had to demonstrate to authorities that they in fact lived or worked in the area. During this period, the city was in “recovery mode,” exploring what the appropriate security responses should be for the downtown area.

Initially, security was very rigid and militaristic. Respondents indicated that the security responses during this period more closely resembled security in a military camp rather than an American city. Security measures included heavily armed officers, chain link fencing, trucks parked in the middle of the road serving as roadblocks, and concrete jersey barriers used to restrict movement of people or vehicles. Interviewees who saw security in Lower Manhattan during this time described it as off-putting and aesthetically unappealing. As a prominent community leader and 30 year resident recounted:

In the year following the 9/11 attack, the barricades at that point were large trucks parked sideways across the street to prevent anything from getting in and they were surrounded by guys with assault rifles and all that, so it did look very militaristic. There were jersey barriers, and it was very unattractive and off-putting, and that had an impact as well on local merchants because many of the people doing business in that area depend pretty heavily on tourism.

As New York City recovered from the initial damage caused by the 9/11 attacks, security remained visible and rudimentary. During this time, New York City and the country as a whole struggled to understand the new threat environment and establish plans on how to best address the threat.

During this time, there was a paradigm shift occurring within the law enforcement community. Prior to 9/11, law enforcement focused on crime prevention and deterrence. The threat of
terrorism was not a focus, even though the WTC had been bombed in 1993. As an interviewee explained:

The first bombing did not receive much attention, and it fizzled rather quickly. Terrorism was not our main focus. After 9/11, it forced law enforcement to understand the threat of terrorism and learn ways to protect against it. When the planes hit the WTC, so much was affected and law enforcement realized that they were to some part responsible for the prevention of terrorism and to look at the scope the threat encapsulated.

As another policing executive who worked near the WTC site during both the 1993 bombing and the 2001 attacks explained:

In law enforcement, when an event occurs [now], I assume it’s terrorism until someone proves to me it’s not. On 9/11, that first plane hit and nobody thought it was terrorism. Everyone thought it was an accident. But from that point forward, everyone will always think terrorism first.

In addition to reprioritizing their responsibilities, the law enforcement community came to realize the importance of developing partnerships with the private sector. Since beginning the security planning and rebuilding efforts in Lower Manhattan, the NYPD has met with the business sector to discuss how their security initiatives would impact business in the area. This is a drastic change historically as law enforcement typically has not considered such matters when planning for security measures. Moreover, corporate security officers, particularly from the financial sector, communicate and coordinate more with the NYPD now than they have in the past.

12.2.2.3.2 Second Era: 2004-2008
During this period, concerted efforts were underway to make security in the area less intrusive and militaristic and more attractive. It was recognized that for the area’s successful economic recovery, the area must be accessible and the environment must be more maneuverable and attractive to businesses and people (i.e., residents, tourists, and workers) alike. The federal and
municipal government dispersed substantial funds throughout New York City through these years, which largely supported the ongoing securitization of Lower Manhattan.

Between 2004 and 2008, the NYPD’s security strategy became heavily counterterrorism focused. One interviewee described the security strategy in New York City almost as a separate mission from the traditional public safety and crime prevention missions. During this time, the NYPD revamped its Intelligence Bureau and focused on developing the Counterterrorism Bureau, which was created post 9/11. The NYPD’s counterterrorism activities became very ambitious during this period, including the deployment of NYPD officers overseas to act as intelligence officers, the hiring of linguists, and the creation of various counterterrorism initiatives. One of these counterterrorism initiatives, NYPD Shield, was created as an umbrella program created to foster collaboration with New York City’s private sector and their security managers largely for information sharing purposes.\(^{94}\) Around 2005, the Lower Manhattan Security Initiative, the most ambitious law enforcement surveillance system in the U.S., was also publicly announced, and the program has continued to grow over the years since.

From 2004 to 2008, the securitization of Lower Manhattan continued to develop as did the push for economic revitalization of the district. As the NYPD further developed their counterterrorism security strategies, there was a hard push for economic renewal in both the residential and commercial sectors located in Lower Manhattan. Lower Manhattan’s residential population has doubled since the 9/11 terrorist attacks (Wichert, 2011) and its office and retail markets have steadily improved due to a combination of commercial and residential incentives, grants and tax credits, as well other local amenities (NYC Economic Development Corporation, 2011). To coordinate and manage the area’s redevelopment process, the Lower Manhattan Development Corporation and the Lower Manhattan Construction Command Center were created in 2002 and 2004, respectively.

12.2.2.3.3 Third Era: 2008-Present
The third era of security in the Lower Manhattan environment is defined by two characteristics. First is the implementation of less intrusive security measures, particularly around the Wall Street area. Up to this point, not only was security visually unappealing and hastily erected, but

\(^{94}\) NYPD Shield was modeled after a similar counterterrorism security program created in London in 2004. See http://www.nypdshield.org/public/ for more information.
it made navigating the area burdensome. Acknowledging the militaristic and crude nature of the different security measures, New York City’s leadership went to great lengths to alleviate the navigation and aesthetic problems. For example, immediately after 9/11, jersey barriers and barricades were set up to control traffic. These gave away to large planters and other temporary solutions. Finally, an architectural firm was hired to redesign the physical security landscape on Wall Street and Broadway. They replaced the temporary solutions with anchored and freestanding sculptural bollards that are not only visually pleasing but also serve a utilitarian purpose as seating. They also created an innovative turntable device with LED lights that can be rotated to allow for a wider street passage. Reflecting on this, a community leader stated:

To the City’s credit, they really bent over backwards to accommodate what we wanted, and hired architectural firms and really worked hard to mitigate some of the impacts that these security arrangements cause. And the final results, I think everyone is extremely pleased with. It cost a lot of money, and I think it was a very shrewd investment on the City’s part because the security arrangements now are a lovely stretch of street ... I think they have done a great job mitigating the visual impact as much as possible.

While these security initiatives were started in the years prior, it took many years to fully implement the measures, as many lead stakeholders had to come to an agreement on the changes and coordinate their implementation. In addition to being more utilitarian and appealing, New York City’s security has become more sophisticated technologically as the LMSI program has expanded and technology itself has become more refined to include analytic software.

However, during this era the U.S. economic recession hit and funding sources began to dry up. Due to limited funding streams, it has become widely recognized that security must achieve collateral benefits of both crime reduction and counterterrorism; a “do more with less” view has became the new operational reality for law enforcement. While counterterrorism was approached as a separate mission from crime control in prior years, during the recent economically lean years the same security measures are being used to fulfill multiple functions. As an intelligence specialist explained:
In the 2008-2009 time frame with the drop in the economy, people started realizing that there is not an endless source of funding [for security, and that] we are going to have to absorb these types of missions … The idea that you can compartmentalize everything doesn’t make sense.

On a broader scale, it is important to note the events that were occurring nationally and internationally during this ten-year period. In 2001, former President Bush declared War on Terrorism in response to the 9/11 terrorist attacks. In 2002, the Homeland Security Act was passed establishing the permanent, cabinet-level Department of Homeland Security (DHS). As a new organization, DHS struggled to define its mission, organizational structure, and place within the national security infrastructure. In 2003, the U.S. invaded both Afghanistan and Iraq. Between 2003 and 2008, the country was fighting a protracted war abroad with no end in sight, while trying to adapt domestically to the “new reality” of a post-9/11 world. Finally, in 2008 the recession hit the world economy, forcing local, state and federal governments to adapt once more to fiscally leaner public safety strategies.

12.2.2.4 Perceived Safety of Lower Manhattan
Not all participants were asked directly whether Lower Manhattan is perceived as safe. Of the ten participants who were directly asked whether Lower Manhattan is safe, only one individual, a general contractor who often has clients in Lower Manhattan, responded that Lower Manhattan is not safe, stating, “It’s difficult to police and secure New York City. There are too many people, too many different opportunities. The population is overwhelming.” The remaining participants who directly indicated that they think that Lower Manhattan is safe pointed out that they live and have raised their children there and work in the area. One participant mentioned that Lower Manhattan has low crime rates, particularly compared to the remainder of the city, and that the residential population is booming. A security consultant (and a retired NYPD officer) said, “It’s as safe as any other place in New York, maybe a bit more.” A chief engineer working for a prominent property developer in Lower Manhattan stated, “It’s as safe as an open society can be.”

When asked whether there is *enough* security in Lower Manhattan, participants’ answers were not consistent, even within response groups. Out of the 17 participants who addressed the
current level of security in Lower Manhattan, nine felt that there is enough security, four felt there is not enough security, three felt that they do not know if there is enough security, and one participant answered, “It depends.”

Of the nine individuals who responded that there is enough security in Lower Manhattan, they framed their responses in various ways. A community leader reported that he does feel that there is plenty of security in Lower Manhattan, but his concern was over the purpose of the implemented security measures. The NYPD had discussed with the neighborhood’s commercial and residential leadership that there would be a significant and permanent police presence in Lower Manhattan. He said they were “delighted” with the news, until they were notified that the new officers would be assigned to counterterrorism duties. He felt that, “This was an example of the City spending money to enhance the neighborhood, but not really enhancing the quality of life” for those in the neighborhood. He further explained:

We are in desperate need of all kinds of residential infrastructure that was never anticipated—things that most urban neighborhoods take for granted, like schools, parks, playgrounds, community centers, libraries, we need everything. I would love for some of this tremendous amount of money being put towards security to be put towards some of those needs. I think it’s a question of priorities. I don’t have any objection to security measures being put into place; I just think it’s a matter of proportion. Some of that money could be diverted without any tangible harm to the community or any diminishment of readiness but could better serve the community.

Other participants expressed their opinion that there was enough security in Lower Manhattan. As a property manager stated:

I can’t say less would be appropriate. I think there is the right amount now because of our lifestyles, we expect a certain amount of freedom to come and go … If someone is going to blow up a commuter train, its going to happen. I’m not willing to trade an hour of my day for additional security measures to be put in place to prevent that from happening.
A resident from Battery Park City similarly stated, “I would not say more is needed. Absolutely not. I think it’s adequate; I think the level is fine. The police presence from what I observe is more than adequate.” Another resident from Battery Park City commented, “I think [security] appears sufficient. Particularly with the Ring of Steel and the ancillary security, I think it is fairly tight. My sense is that there is not so much a need for overt security but a need for covert security.” While these participants were comfortable with the amount of security, a resident of Lower Manhattan heavily involved with the area’s commercial revitalization summarized it best, stating, “People have made a decision not regarding whether its actually safe or not, but that it is safe enough.”

Conversely, of the four individuals who felt there is not enough security in Lower Manhattan, two reported that they think there should be a greater visible presence of police officers. A Battery Park City resident stated:

I think there is not enough and there should be more … To see an armed officer every block or two, which I know is a lot, provides a certain level of comfort. There is so much going on in Manhattan, so many different walks of life. It would personally make me feel a little bit better.

A general contractor who often works in Lower Manhattan explained:

I feel there should be a greater presence of police, which is becoming invisible again. They are not there. It is impossible to totally protect an area, but at least if there is a presence of the police … You can go in and out of Manhattan with almost anything you want; nobody checks anymore.

Another participant similarly expressed his concern over the absence or minimal checking of bags on transportation systems. He explained, “When they do bag checks on the subway and trains, it’s hit-or-miss. It’s pathetic…It’s still too open if you ask me. It’s not standardized.” Finally, as a construction site safety expert who often works in Lower Manhattan stated, “Yea, we are more secure, but are we doing it to full capacity? I don’t think so.”
Three participants indicated that they did not know whether there is enough security in Lower Manhattan. As a person publicly involved in the redevelopment of Lower Manhattan’s business district expressed:

It’s hard to know [if there is enough security]. Living and working in Lower Manhattan, some may say that there is too much security around the New York Stock Exchange, but maybe there is not. That [amount of security] may be absolutely necessary.

A seasoned law enforcement executive similarly stated:

What is enough? I don’t know. And at what point is the tipping point? By tipping point I mean an economic tipping point where we know our enemies are trying to destroy our country. One of the ways they have identified is through our economy, and that may happen if we go on a path where more and more [security] is better no matter what the cost… So, when you ask me if there is enough being done, I don’t know if there will ever be enough. But I guess the question is are we being smart enough? Are we taking reasonable precautions? Are we looking at it from a cost-benefit point of view?

The one participant who indicated “it depends” when asked if there is enough security in Lower Manhattan explained that “enough” is dependent on having the proper people in place. He explained:

There is a lot of security and people there, [but] it’s a matter of getting the right people there … People who are properly trained. I think they [i.e., NYPD] train their people fairly well, well the higher end people, JTTF [i.e., Joint Terrorism Task Force], but I don’t think the uniformed patrol on the street is properly trained in what to do and how to go about it.

A point that many interviewees raised when addressing the level of security in Lower Manhattan was the ancillary benefits of counterterrorism security measures. While a community leader criticized the plan that the increased number of police officers in the area would be assigned counterterrorism functions only and would do little to enhance the quality of life for people who
live and work in the neighborhood, another participant with a career in the intelligence field explained that the area would receive the collateral benefits of having an increased presence of police such as the reduction of traditional crime. As he explained:

I think a lot of that has to do with the grant funding process because a lot of the overtime of those officers and salaries are driven out of DHS grants, and the stipulations within those grants are that they are used for counterterrorism purposes. And they certainly are being used; [however], that does not mean to discount that ancillary benefit on criminal activity … At the end of the day, they are still police officers and you are not going to commit a crime in front of a police officer, especially when they are heavily armed tactical officers. If anything, that is going to have a greater effect on driving down that crime rate. So, their focus and mission may solely be counterterrorism, but that doesn’t mean that still doesn’t have an impact on crime.

12.2.2.5 Additional Themes That Emerged
Two additional themes emerged from the interviews that are relevant to the larger discussion of security and its relationship to economic activity: the issue of adaptation and the influence of leadership. Several participants acknowledged that people have continued to adapt to both the post-9/11 threat environment in Lower Manhattan and to the changing security landscape of Lower Manhattan over the past decade. Moreover, the role leadership has played in Lower Manhattan’s security transformation was recognized as critical by several interviewees.

As the years have passed since the 9/11 terrorist attacks, the Lower Manhattan community has adapted to the ongoing changes of Lower Manhattan’s security environment. Moreover, as the 2001 terrorist attacks become more distant, and in the absence of another successful attack, people become less focused on security in their daily lives. As a community leader heavily invested in the revitalization of Lower Manhattan (and a longtime resident) stated:

I think people have contextualized the risk. They have decided that it is what it is, and they will continue with their daily lives and activities. Maybe people base that on the credibility of NYPD and the periodic visible cues that the NYPD is sophisticated, excellent, and doing a good job. Maybe they don’t and maybe they
just don’t want to sit around and wait to die … Who knows? There is a kind of battle fatigue… People who live and work in the area have become immune to it [i.e., security]. Not that they do not feel it, but in a way they do not see it. Visitors [i.e., tourists or others who come to the area irregularly] are shocked at acknowledging it.

Another way that the community has adapted to the changing threat environment is that they are more likely to self-evacuate from buildings. Prior to 9/11, people were more likely to wait for instructions regarding building evacuations. Since the WTC towers fell, this is no longer the case. People in New York City are substantially more sensitive to the possibility of terrorist activity and building collapse and therefore will more readily evacuate buildings without instruction.

In addition to adapting to their environment, several participants addressed the role that New York City’s leadership, and the trust the community has in them, has played in the transformation of the area’s security environment. Respondents used adjectives like *progressive, enlightened,* and *innovative* to describe the City’s leadership. The same community leader further explained:

> Security is all mental. New Yorkers believe in New York and believe New York City has smart, sophisticated team of people. It doesn’t matter who is in charge in Washington, D.C. or on state level. We believe in current local leadership, even to the point we are willing to let go of the civil liberties New Yorkers fought for … we now have license plate readers, cameras, intolerance for civil disobedience at political conventions that in the past New Yorkers would never have allowed prior to 9/11. Now it’s allowed, because we trust the leadership. It’s all about trust, knowing that security will not be used for other purposes, but of course, it is used for other purposes. The Police Commissioner is trusted. If we trust our leaders are doing a good job, people feel safer. If trust in leadership is absent, then we feel less safe.

Similarly, an architect heavily involved in the design of the New York Stock Exchange security landscape explained:
I think New York City is under an enlightened administration at this point in time … The investment in time, innovation, sticking with it when some agencies didn’t immediately accept it. Also, to implement unused, and thus tested and verified, measures as primary security element, that took real will in time and money on part of the higher ups to stay with it and say, ‘We need a better solution for the big picture and not just security now.’ That was critical.

Finally, a resident of Lower Manhattan’s Battery Park City expressed his support for the NYPD stating:

I think the NYPD is doing a spectacular job. I think they are being very proactive, very overt, and very forceful. They recognize the threat. They have instituted and implemented a whole range of trip wires and mechanisms to identify and deter terrorist activity as well as other criminal acts, so there is an ancillary benefit to that.

12.2.3 Limitations of the Research
While the data that emerged from the one-on-one interviews was informative and helped develop a context around the larger UCASS study, there are limitations to the method used that should be addressed. First, the sample size was small; thus, the findings cannot be generalized to the larger community of Lower Manhattan. However, there is little reason to believe that the findings grossly misrepresent the perceptions of the different stakeholder groups if a larger sample had been interviewed. While the sample size was small, the sample was diverse, including people who live and work in Lower Manhattan, people who have expert knowledge of security and law enforcement, and people who were heavily involved with both the residential and commercial redevelopment of the area.

The diversity among the stakeholders in Lower Manhattan is substantial, and this diversity has proved to be exceptionally challenging from a research standpoint. Identifying and capturing the various stakeholders’ perceptions was difficult, and ensuring that all stakeholder perspectives were captured was impossible. Moreover, the greatest challenge encountered was gaining access to different stakeholders, as access often required third party introductions, the pursuit of informal relationships, or explicitly stated support from DHS or other prominent organizations.
Even with such assistance, interviewees from both the public and private sectors were reluctant to meet with a researcher. A considerable amount of time was invested by the interviewer in establishing relationships, building trust, rapport and credibility within the stakeholder communities to gain enough trust to get interviewees to agree to discuss the issues.

While the research team fully expected to confront challenges in recruiting the stakeholder groups, this task was substantially more challenging than anticipated, and this may be due to several factors. Culturally, Manhattan is a fast-paced, highly politicized environment where personal relationships are important in gaining access to certain persons in highly placed positions; hence the heavy reliance on informal networks. It is part of the New York psyche and reputation to be skeptical of “outsiders.” Individuals’ time is limited, and oftentimes, unless those contacted viewed there to be a direct benefit for their contribution to the research, they often declined participation. In addition, due to the sensitive nature of security and the politically complex environment of New York City, people and organizations were less inclined to participate in the research out of concern for backlash, even though the researchers promised confidentiality for participants. Finally, the stakeholder community in Lower Manhattan is extremely large and diverse. We have sorted the larger stakeholder community into three general categories (i.e., public sector, business and residential); however, there is substantial variation both between and within each category, which made the task of soliciting stakeholders extremely difficult.

12.2.4 Discussion
A qualitative research strategy was incorporated into the largely technical and quantitative UCASS study for linking the research to reality. Doing so not only helped the research team better understand stakeholders’ unique needs and concerns regarding security so that models developed as part of the UCASS effort are realistic and useful to users, but it also gave the stakeholders themselves the ability to influence the overall direction of the project and the end-products.

Several major themes emerged from the interviews. First, the security environment of Lower Manhattan has undergone substantial changes over the past decade in order to improve New York City’s ability to protect its people and infrastructure from future terrorist attacks.
Moreover, Lower Manhattan is perceived as safe in general; however, based on the subjects’ responses it is difficult to ascertain if there is the proper amount or the proper types of security measures in place in Lower Manhattan. This is not surprising since security is a subjective concept that changes over time, from place to place, and depends on context.

It is challenging as a practical, psychological and economic matter to determine how much actual security is needed to protect various assets. To identify the proper balance is an elusive task, particularly since the environment is always evolving. Practically, absolute security is unrealistic, just as an absence of security is unacceptable. Therefore, the question becomes how much risk is a person, company, city, or government willing to accept? The greater the amount of risk one is willing to accept, the less investment in security is needed and vice-versa.

Psychologically, determining the appropriate amount, type and combination of security measures that is necessary to make people feel safe, comfortable, unrestricted or not inconvenienced is difficult. For example, as it emerged in the interviews, some people felt that they would prefer to see more (or less) police officers or that while they like the idea of CCTV cameras, they do not see them; thus, they do not have much of an opinion about the effectiveness of the security strategy. The challenge for law enforcement and other security officials is to find the proper balance of security. Too much (or too little) security creates fear within the populace, which is then counterproductive to a healthy society. Instead, psychologically the purpose of security measures is to create a feeling of safety.

Economically, security providers must balance the monetary cost of implementing and maintaining security measures and practices with other fiscal needs, otherwise they will reach the economic tipping point where the money invested in security is grossly disproportionate to the total amount of money available to invest. Moreover, money budgeted for security is as a result not invested in other needed areas and services, which are equally important to the functioning of a healthy society. As a community leader stated:

   I know security is always necessary, and it’s a prudent thing to do and one should always be vigilant. But I think it’s time someone sits down and does some cost-
benefit analysis and figure out if there is not a better way to spend that money.
For example, we need schools and residential amenities.

Finally, as we move farther away from the 9/11 terrorist attacks, and as security becomes less intrusive and more streamlined into the fabric of society, as a result people adapt. Individuals’ threshold for what is acceptable fluctuates, as does how the changing security environment affects their perceptions of safety. As the security environment continues to change in Lower Manhattan, people will continue to adjust to those changes. The city’s leadership also has an impact on both the changing security environment and how people perceive this environment. When the people trust their leadership and view their leaders as highly capable of ensuring the community’s safety, their perceptions of and tolerance for security will change accordingly.
13 LOWER MANHATTAN ONLINE SURVEY

The UCASS study used an online survey to provide data for the simulation modeling and economic modeling activities. The survey sought four primary stakeholder groups: people who live in Lower Manhattan (residents), people who work in Lower Manhattan (workers), people who visit Lower Manhattan either as a tourist or to socialize (visitors), and businesses, which operate in Lower Manhattan, represented by “business owners.”

Survey subjects were to be drawn from a sampling pool using seven zip codes within Lower Manhattan. However, since the number of people in Lower Manhattan satisfying the stakeholder group criteria was small, it was extremely difficult to solicit a large sample size directly from the region. Thus, the geographic area from which a survey sample was drawn was expanded to include all five boroughs of New York City, five counties in northern New Jersey, and one county in Connecticut. Since the sampling pool was expanded into all five New York City boroughs, New Jersey and Connecticut, subjects who did not fall into one of the four targeted stakeholder groups were asked to respond to the survey questions “as if” they lived, worked or owned a business in Lower Manhattan. The sampling pool was extended to these areas outside of Lower Manhattan because many people residing in these areas are not only familiar with Lower Manhattan, but they travel to the area to work, socialize, and visit tourist attractions. The total sample size was N=1016. Of the 1016 subjects, 425 subjects (41.8%) belonged to one of the four targeted stakeholder groups within Lower Manhattan. The remaining 591 subjects (58.2%) were drawn from the expanded sampling pool (see Table 13-1).

As discussed in Chapter 6, the survey was programmed using Qualtrics, an online survey software provider and administered via Amazon’s Mechanical Turk, a crowdsourcing Internet marketplace. Using zip codes as the primary filter, survey respondents were required to meet relevant qualifications, specific to the targeted group they belonged to, prior to accessing the survey site. It is important to note that not all survey subjects were recruited from Lower Manhattan, as many reported being from the surrounding New York area. This limits the validity of some of the data. The reader is reminded that a survey subject may not, in fact, have lived,

95 Manhattan, Brooklyn, Queens, the Bronx and Staten Island.
96 Hudson, Bergen, Passaic, Union and Essex Counties
97 Fairfield County
worked, or owned a business in Lower Manhattan. Rather, these individuals were asked to imagine they did so, and to answer the survey questions as hypothetical situations. For simplicity, hereafter we refer to such respondents as “workers,” “residents,” etc.

Table 13-1: Distribution of Survey Sample (N=1016)

<table>
<thead>
<tr>
<th></th>
<th>Lower Manhattan</th>
<th>Outside Lower Manhattan</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residents</td>
<td>29</td>
<td>263</td>
<td>292</td>
</tr>
<tr>
<td>Workers</td>
<td>56</td>
<td>184</td>
<td>240</td>
</tr>
<tr>
<td>Visitors</td>
<td>246</td>
<td>--</td>
<td>246</td>
</tr>
<tr>
<td>Businesses</td>
<td>94</td>
<td>144</td>
<td>238</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>425</strong></td>
<td><strong>591</strong></td>
<td><strong>1016</strong></td>
</tr>
</tbody>
</table>

The survey was designed to assess three security measures: temporary street closures with “stop and search” security checkpoints, extensive use of CCTV camera surveillance system, and 100% baggage and parcel inspections in subways and trains stations. Each measure was presented in a long paragraph and was followed by a series of questions. The questions were designed to capture the subjects’ attitudes about the measure and to elicit the value they placed on the security measure. The security checkpoint questions were also designed assess how the subjects’ daily routines would change in response to the security measure. Each subject was presented with two of the three security measures (randomly) to minimize the time required to complete the survey (see Table 13-2).

Table 13-2: Frequency and Distribution of Security Measure Combinations

<table>
<thead>
<tr>
<th>Security Measure Combinations</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop &amp; Search Checkpoint &amp; CCTV surveillance</td>
<td>321</td>
<td>31.6</td>
</tr>
<tr>
<td>Stop &amp; Search Checkpoint &amp; Bag and Parcel Inspections</td>
<td>325</td>
<td>32.0</td>
</tr>
<tr>
<td>CCTV Surveillance &amp; Bag and Parcel Inspections</td>
<td>370</td>
<td>36.4</td>
</tr>
</tbody>
</table>

98 See Appendix 4 for a complete copy of the survey.

13-191
13.1 Sample Description

The survey sample was 56.8% male (see Figure 13.1) and 64.2% were 30 years old or younger (see Table 13-3). A majority of the sample (62.2%) was single, never having married; married individuals were 30.3% (see Table 13-4). Approximately half of the subjects were employed full-time, while 19.6% were employed part-time and 16.8% were students (see Table 13-5). Approximately 33.5% of the sample reported annual household income between $10,000 and $49,000 and 26.9% of the sample reported a household income between $50,000 and $99,999 per year (see Table 13-6).

Figure 13.1: Gender by Stakeholder Group (N=1016)

Table 13-3: Age Ranges by Stakeholder Group (N=1016)

| Age Range | Businesses | | Residents | | Workers | | Visitors | | TOTAL |
|-----------|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|           | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % |
| 18-21     | 5    | .5 | 72   | 7.1 | 35   | 3.4 | 38   | 3.7 | 150  | 14.7 |
| 22-25     | 33   | 3.2| 97   | 9.5 | 72   | 7.1 | 53   | 5.2 | 255  | 25.0 |
| 26-30     | 52   | 5.1| 70   | 6.9 | 62   | 6.1 | 65   | 6.4 | 249  | 24.5 |
| 31-40     | 50   | 4.9| 46   | 4.5 | 36   | 3.5 | 66   | 6.5 | 198  | 19.4 |
| 41-50     | 45   | 4.4| 16   | 1.6 | 14   | 1.4 | 35   | 3.4 | 110  | 10.8 |
| 51-60     | 17   | 1.7| 4    | .4  | 4    | .4  | 13   | 1.3 | 38   | 3.8 |
| 60+       | 3    | .3 | 7    | .7  | 0    | 0   | 5    | .5  | 15   | 1.5 |
| **TOTAL** | **205** | **20.0** | **312** | **30.7** | **223** | **21.9** | **275** | **27.1** | **1015** | **99.7** |

*1 missing case
Table 13-4: Marital Status by Stakeholder Group (N=1016)

<table>
<thead>
<tr>
<th></th>
<th>Businesses</th>
<th>Residents</th>
<th>Workers</th>
<th>Visitors</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Freq  %</td>
<td>Freq  %</td>
<td>Freq  %</td>
<td>Freq  %</td>
<td>Freq  %</td>
</tr>
<tr>
<td>Single, Never Married</td>
<td>94 9.2</td>
<td>235 23.1</td>
<td>169 16.6</td>
<td>135 13.3</td>
<td>633 62.2</td>
</tr>
<tr>
<td>Married</td>
<td>88 8.7</td>
<td>68 6.7</td>
<td>53 5.2</td>
<td>99 9.7</td>
<td>308 30.3</td>
</tr>
<tr>
<td>Divorced/Separated</td>
<td>21 2.2</td>
<td>11 1.1</td>
<td>5  .5</td>
<td>27 2.7</td>
<td>64  6.5</td>
</tr>
<tr>
<td>Widowed</td>
<td>1  .1</td>
<td>1  .1</td>
<td>0  0</td>
<td>4  .4</td>
<td>6   .6</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>204 20.2</strong></td>
<td><strong>315 31.0</strong></td>
<td><strong>227 22.3</strong></td>
<td><strong>265 26.1</strong></td>
<td><strong>1011 99.6</strong></td>
</tr>
</tbody>
</table>

*5 missing cases

Table 13-5: Employment Status by Stakeholder Group (N=1016)

<table>
<thead>
<tr>
<th></th>
<th>Businesses</th>
<th>Residents</th>
<th>Workers</th>
<th>Visitors</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time</td>
<td>162</td>
<td>142</td>
<td>151</td>
<td>144</td>
<td>599</td>
</tr>
<tr>
<td>Part-time</td>
<td>24</td>
<td>75</td>
<td>68</td>
<td>66</td>
<td>233</td>
</tr>
<tr>
<td>Student</td>
<td>12</td>
<td>93</td>
<td>47</td>
<td>47</td>
<td>199</td>
</tr>
<tr>
<td>Homemaker</td>
<td>3</td>
<td>14</td>
<td>26</td>
<td>10</td>
<td>53</td>
</tr>
<tr>
<td>Unemployed</td>
<td>2</td>
<td>28</td>
<td>5</td>
<td>12</td>
<td>47</td>
</tr>
<tr>
<td>Retired</td>
<td>6</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>19</td>
</tr>
<tr>
<td>Disability</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Other</td>
<td>21</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 13-6: Annual Household Income by Stakeholder Group (N=1016)

<table>
<thead>
<tr>
<th></th>
<th>Residents</th>
<th>Workers</th>
<th>Visitors</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freq  %</td>
<td>Freq  %</td>
<td>Freq  %</td>
<td>Freq  %</td>
<td>Freq  %</td>
</tr>
<tr>
<td>Less than 10,000</td>
<td>20 2.0</td>
<td>8  .8</td>
<td>8  .8</td>
<td>36  3.6</td>
</tr>
<tr>
<td>$10,000 to $49,999</td>
<td>128 12.5</td>
<td>89  8.9</td>
<td>123 12.1</td>
<td>340 33.5</td>
</tr>
<tr>
<td>$50,000 to $99,999</td>
<td>102 10.2</td>
<td>82  8.2</td>
<td>85  8.5</td>
<td>269 26.9</td>
</tr>
<tr>
<td>$100,000 to $149,999</td>
<td>37 3.6</td>
<td>31  3.1</td>
<td>23  2.3</td>
<td>91   9.0</td>
</tr>
<tr>
<td>More than $150,000</td>
<td>19 1.9</td>
<td>13  1.3</td>
<td>6   .6</td>
<td>38   3.8</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>306 30.2</strong></td>
<td><strong>223 22.3</strong></td>
<td><strong>245 24.3</strong></td>
<td><strong>774 76.8</strong></td>
</tr>
</tbody>
</table>

*242 missing cases, including the business subjects
In addition to the general demographic variables above, specific data were collected for each stakeholder group.

Of the 203 business owners who responded, 78.3% indicated that they had been open since 2000, 14.8% indicated they opened between 1990-1999, and the remaining 6.9% of businesses indicated that they had opened prior to 1990. Over half of the business owners (55.4%) indicated that they belonged to one of three industry areas: retail trade (29.9%), arts, entertainment or recreation (13.2%), and professional, scientific, or technical services (12.3%), and the majority (68.4%) had between one and five employees (see Figure 13.2).

Figure 13.2: Reported Number of Employees by Business (n=206)

![Pie chart showing distribution of employees](image)

Approximately half (54.7%) of the businesses (n=204) indicated monthly gross operating revenues between $10,000 and $100,000 (see Table 13-7). Among those respondents (n=218) who responded when asked why they chose a Lower Manhattan location, the “commercial environment” was indicated 97, “rent” 44 times, “security in the area” 14 times, and “government incentive, stimulus program or grants” 12 times.

Table 13-7: Reported Gross Monthly Operating Revenue for Businesses

<table>
<thead>
<tr>
<th>Revenue Range</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $10,000</td>
<td>69</td>
<td>33.8</td>
</tr>
<tr>
<td>$10,000 to $25,000</td>
<td>56</td>
<td>27.5</td>
</tr>
<tr>
<td>$25,000 to $100,000</td>
<td>55</td>
<td>27.0</td>
</tr>
<tr>
<td>$100,000 to $1,000,000</td>
<td>19</td>
<td>9.3</td>
</tr>
<tr>
<td>More than $1,000,000</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>204</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>
Residents reported that they had lived in Lower Manhattan an average of 4.9 consecutive years (SD=6.47) and paid $1,344 per month on average (SD=$2199) on housing expenses. The majority of residents (64.8%) indicated that they rent, while 19% indicated that they live with friends, family or others free of charge, and 12.6% own their homes. On average, residents traveled 7 times per week (SD=5.8) by subway or rail.

Approximately 39.5% of workers indicated that they commute to work in Lower Manhattan from other parts of Manhattan, and another 31.6% commute to Lower Manhattan from New York’s outer boroughs (i.e., Bronx, Brooklyn, Queens, Staten Island). Only 12.2% reported that they commute from New Jersey and 8% commute from Connecticut. Another 8.7% indicated that they commute from “other” places, mostly elsewhere in New York State. Workers indicated that they have worked in Lower Manhattan 4.23 consecutive years, on average, and spend, on average, $14.36 per day (SD=13.24) on commuting costs.

A majority of the visitors (60.2%) indicated that they had last been in Lower Manhattan within the past six months; 27.9% indicated their last visit had been not in the past 6, but in the past twelve months, and 11.9% indicated it had been over one year since they were last in Lower Manhattan. The majority (59.7%) of visitors go to Lower Manhattan either as tourists or to socialize (see Figure 13.3)

**Figure 13.3: Reasons Visitors Go To Lower Manhattan (n=245)**

Finally, respondents also reported how often they visit Lower Manhattan for recreational purposes, such as to socialize, shop, dine or visit tourist attractions (see Table 13-8) and the
typical modes of transportation used most often, when traveling to and from or within Lower Manhattan (see Figure 13.4).

Table 13-8: Frequency of Visits to Lower Manhattan for Recreational Purposes (N=1016)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>31 3.1</td>
</tr>
<tr>
<td>Once</td>
<td>198 19.5</td>
</tr>
<tr>
<td>A Few Time</td>
<td>366 36.0</td>
</tr>
<tr>
<td>Once a month</td>
<td>146 14.4</td>
</tr>
<tr>
<td>Once a week</td>
<td>111 10.9</td>
</tr>
<tr>
<td>2-3 times a week</td>
<td>89  8.8</td>
</tr>
<tr>
<td>Daily</td>
<td>75  7.4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1016 100.0</strong></td>
</tr>
</tbody>
</table>

Survey subjects (n=1015) were asked about the modes of transportation they most often used when traveling to and from or within Lower Manhattan. Approximately 44% of respondents indicated that they use mass transit (i.e., subway, bus, PATH train, or ferry), 18% indicated they use taxis, 12% indicated they use a personal vehicle, 20% indicated they walk and 5% indicated they use a bike. When asked if they have a usual route when traveling into and out of Lower Manhattan (n=623), 63.7% of the subjects indicated that they do have usual routes.

Figure 13.4: Usual Mode of Transportation to and from Lower Manhattan
13.2 Perceptions of Safety & Security in Lower Manhattan

The UCASS survey solicited stakeholder groups’ perceptions of safety and security in Lower Manhattan with regard both to terrorism and common crime. Their attitudes towards all three security measures were measured. Six-point Likert scales were used to measure stakeholders’ perceptions of crime, safety, terrorism and to capture a range of attitudes about each of the three security measures (i.e., security checkpoints, CCTVs cameras and random bag inspections in transit stations).

Subjects (n=689) were asked “how scared” they were that a terrorist attack will occur in Lower Manhattan over the next year (see Figure 13.5). Approximately 34.2% indicated that they were “very scared,” “somewhat scared,” or “scared.” Comparably, subjects (n=690) were asked “how scared” they were that they will be victims of common crime in Lower Manhattan over the next year (see Figure 13.5). Approximately 39.5% indicated that they were “very scared,” “somewhat scared,” or “scared.”

Figure 13.5: Fear of Terrorism & Crime in Lower Manhattan

Subjects (n=690) were then asked “how likely” they thought it was that a terrorist attack will occur in Lower Manhattan over the next year (see Figure 13.6). Approximately 23.5% indicated that a terrorist attack within the next year is “very likely,” “somewhat likely,” or “likely.”

99 It must be noted that the objective chance that a person in Lower Manhattan will be the victim of a crime is enormously larger than the chance of being a victim of terrorism.
Similarly, subjects (n=690) were then asked “how likely” they thought it was that they will be a victim of a common crime in Lower Manhattan over the next year (see Figure 13.6). Approximately 24.0% indicated they thought that their being victims of a common crime in Lower Manhattan over the next year is “very likely,” “somewhat likely,” or “likely.”

Figure 13.6: Attitudes Regarding Likelihood of Terrorist Attack & Crime Victimization in Lower Manhattan

Subjects (n=1014) were also asked how scared they were that a terrorist attack will occur on the local subway or rail systems over the next year. Approximately 27.0% indicated that they were “very scared,” “somewhat scared,” or “scared.” Subjects (n=674) were then asked how likely they thought it was that there will be a terrorist attack on the New York City subway or rail systems over the next year. Approximately 58.6% indicated that they feel a terrorist attack on the New York subway or rail systems over the next year is “very likely,” “somewhat likely,” or “likely.”

13.3 Stakeholders’ Attitudes about Security Checkpoints

Survey subjects were asked about their attitudes regarding random security checkpoints (referred to here as a “stop and search” (see Figure 13.7). Approximately 68.0% of subjects indicated that they “strongly agree,” “agree” or “somewhat agree” that “stop and search” inspections are a violation of their privacy, and 61.5% reported that a “stop and search” inspection program is an

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100 Note that this question does not ask whether the respondent anticipates being among the victims of the hypothesized terrorist attack.
unacceptable breach of their freedom. Approximately 86.8% indicated that they “strongly agree,” “agree” or “somewhat agree” that the delays caused by “stop and search” inspections would be frustrating. Approximately 73.5% indicated that they “strongly agree,” “agree” or “somewhat agree” that being randomly stopped and searched by a police officer while walking in Lower Manhattan makes them uncomfortable, while 63.5% similarly reported that a “stop and search” inspection would make them feel anxious and stressed.

Approximately 60.9% indicated that they “strongly agree,” “agree” or “somewhat agree” that random security checkpoints would help keep contraband and other hazardous materials, such as bombs, from being brought into Lower Manhattan. Approximately 47.0% indicated that they “strongly agree,” “agree” or “somewhat agree” that they would be more willing to live, work, visit or operate a business in Lower Manhattan knowing that enhanced security measures are being implemented.

**Figure 13.7: Stakeholders’ Attitudes Regarding Security Checkpoints in Lower Manhattan**

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13.4 Stakeholders’ Attitudes About CCTV Cameras

Respondents were first asked if they were aware of the extensive camera network in Lower Manhattan. Of the 658 subjects who responded to the question of whether they were aware that
there are over 1,000 cameras located in Lower Manhattan, approximately 53.2% of subjects indicated that they were aware of the cameras, while the remaining 48.6% indicated they were not aware of the cameras. Subjects were then asked their attitudes regarding the extensive presence and operation of CCTV camera systems in Lower Manhattan.

Subjects in all four targeted stakeholder groups were asked to indicate their level of agreement with ten value statements about the presence and use of CCTV cameras in Lower Manhattan, using the six-point Likert scale (see Figure 13.8). Approximately 56.4% of residents, 69.8% of workers, 64.1% of visitors, and 69.5% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that CCTV cameras in Lower Manhattan help prevent terrorist attacks. Approximately 75.0% of residents, 80.7% of workers, 87.7% of visitors, and 81.9% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that CCTV cameras make Lower Manhattan a safer place to live, work, visit, or operate a business. Approximately 38.8% of residents, 49.9% of workers, 53.6% of visitors, and 68% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that CCTV cameras make Lower Manhattan a more attractive place to live, work, visit or operate a business. Approximately 62.1% of residents, 67.3% of workers, and 33.2% of visitors indicated that they “strongly agree,” “agree” or “somewhat agree” that CCTVs make them feel safer when walking around Lower Manhattan. The business owners group was not presented with this value statement, but were asked to assess the impact of CCTV cameras on their monthly revenue. Approximately 34.8% of the business group indicated that they “strongly agree,” “agree” or “somewhat agree” that since the CCTV system has been installed, their monthly revenue has increased.

Approximately 42.2% of residents, 36.6% of workers, 34.6% of visitors, and 42.1% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that the presence of CCTV cameras makes them feel uncomfortable. Approximately 50.8% of residents, 41.1% of workers, 25.3% of visitors, and 47.9% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that CCTV cameras infringe on their right to privacy.
Approximately 48% of residents, 42.8% of workers, 33.2% of visitors, and 41.1% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that they are uncomfortable knowing that the CCTV cameras are monitored by law enforcement, public agencies and private sector companies. Moreover, approximately 37.2% of residents, 34.4% of workers, 29.5% of visitors, and 35.3% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that knowing that the footage captured by the CCTV cameras is maintained for 30 days before being deleted makes them feel uncomfortable.
Approximately 56.7% of residents, 48.9% of workers, 41% of visitors, and 41.8% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that too much money has been invested in Lower Manhattan’s CCTV system. On the other hand, approximately 49.7% of residents, 55.6% of workers, 60.8% of visitors, and 59.3% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that the amount of money invested in Lower Manhattan’s CCTV system is necessary.

13.5 Stakeholders’ Attitudes about Random Bag & Parcel Inspections

Using a six-point Likert scale, survey subjects were asked to rate their attitudes regarding inspections of all bags and parcels at rail and subway stations heading into or out of Lower Manhattan. Subjects were informed that such a program would increase the level of security to keep transportation systems safe; however, as a result there would be longer delays as passengers wait to undergo the screening process.

The survey subjects were asked a series of general questions regarding their experiences with bag and parcel inspections at transit stations (see Figure 13.9). Approximately 74% of those

Figure 13.9: Stakeholders’ Attitudes Regarding Bag & Parcel Inspections in Lower Manhattan Transit Stations
asked indicated that they “strongly agree,” “agree” or “somewhat agree” that they feel safer knowing that the bag and parcel inspections program is in place. A majority (67.6%) of those asked indicated that they “strongly agree,” “agree” or “somewhat agree” that the inspections program prevents and deters terrorist attacks.

Approximately 95.3% of residents, 90.5% of workers, 91.0% of visitors, and 84.4% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that the inconvenience created by 100% inspection would be frustrating (see Figure 13.10). Approximately 76.4% of residents, 59.1% of workers, 58.0% of visitors, and 64.0% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that searching their bags is a violation of their privacy.

**Figure 13.10: Stakeholders’ Attitudes of Bag & Parcel Inspections in Transit Stations**

Approximately 65.9% of residents, 60.6% of workers, 52.3% of visitors, and 54.4% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that they would avoid traveling by subway or rail to Lower Manhattan because of the 100% inspections program. Approximately 81.5% of residents, 73.9% of workers, 79.7% of visitors, and 76.5% of business owners indicated that they “strongly agree,” “agree” or “somewhat agree” that they would avoid bringing a bag or parcel when commuting by train or rail to Lower Manhattan.
The residents group was presented with two additional value statements regarding bag and parcel inspections in rail and subways stations. Approximately 82.5% of residents indicated that they “strongly agree,” “agree” or “somewhat agree” that they would prefer to walk or take a cab if traveling within a mile from their home if there were a 100% inspections program. Moreover, approximately 74.0% of residents indicated that they “strongly agree,” “agree” or “somewhat agree” that if they have many bags after running errands (e.g., after going to the grocery store or clothing shopping), they would not take the subway because of the 100% inspections program.

13.6 Value Placed on Security “Stop and Search” Checkpoints
Each of the four respondent groups was presented with a brief vignette describing a situation in which a street block has a security checkpoint at both ends. To access the street, an individual would have to pass through a security checkpoint. At the checkpoint a police officer would search bags and check identification. The vignette proposed that the only way to avoid the checkpoint would be to wait a few hours for it to be removed. A series of questions tailored to each stakeholder group was presented after the vignette. These questions were intended to capture the value each stakeholder group places on the security checkpoints and to gather data on how security checkpoints influence people’s routines and decision-making.

13.6.1 Businesses
For the security “stop and search” checkpoint portion of the survey, 138 business owners responded. Of these, 11.6% stated they run a restaurant, 34.1% classified their business as a retail store, and 54.3% classified their business as neither a restaurant nor a retail store (see Figure 13.11). Of the 16 businesses identified as a restaurant, 13 were described as an average eatery. Of the 47 businesses identified as a retail store, 34 were described as an average goods and/or service provider.

Figure 13.11: Business Classification (n=138)
Business owners were asked whether, if a security checkpoint were to be routinely implemented on the street on which their business is located, their businesses’ monthly revenue be affected (see Figure 13.12). Approximately 72.0% of business owners responded that a security checkpoint would decrease their monthly revenue, 7.0% indicated that it would increase their monthly revenue, and 21.0% indicated that it would have no impact on their monthly revenue. Of the 99 business subjects who indicated that it would decrease their monthly revenue, 66 subjects estimated that it would decrease their monthly revenue by 5% - 25%. The 10 subjects who indicated that it would increase their monthly revenue estimated that the security checkpoint would increase their monthly revenue by 5% - 25%.

**Figure 13.12: Impact of Security Checkpoint on Businesses Monthly Revenue (n=138)**

![Chart showing the impact on businesses monthly revenue](image)

Business owners were then asked if they would be willing to offer their customers/clients a discount to offset any inconvenience because of the security checkpoint. Eighty-two subjects responded “Yes” while 56 subjects responded “No.” Of the 82 business owners who reported that they were willing to offer clients/customers a discount, 83.0% indicated they would be willing to give clients/customers as much as a $10 discount, and of these, only 36.0% reported that they would be willing to give their customers/clients a $15 discount. Of the 17.0% of subjects who indicated they would not be willing to give their customers/clients a $10 discount, 79.0% indicated they would, however, be willing to offer a $5 discount. When asked to propose the maximum discount they would be willing to offer their customers/clients to offset their inconvenience, the average discount was $14.01 (SD=10.16).

When asked if they would continue to operate their business from their current address if a security checkpoint were to be routinely implemented several times a week on the street on which their business is located, half indicated they would keep their businesses open at that location. Approximately 3.6% indicated they would relocate their businesses to new locations.
within Lower Manhattan, 18.8% indicated they would relocate their businesses to new locations outside Lower Manhattan, and 27.5% indicated they would close their businesses.

13.6.2 Residents
If presented with a security checkpoint on the street on which their home is located, 72.4% of residents (n=192) indicated that they would go through the checkpoint. Of these subjects, only four indicated that they would not be willing to wait even three minutes if there were a line. The majority (82%) indicated that they would be willing to wait as much as 10 minutes to pass through the security line. Of the residents who indicated that they would not be willing to pass through the security checkpoint, 38% indicated they would go to a restaurant, bar or coffee shop, 20% would go to a friend’s house, 10.7% would go to the park, 9.8% would wait around and use their cell phones, 9.3% would go shopping, 7.8% would go to their office, and 4.4% indicated “other.”

Residents (n=190) were also asked to imagine that a “security” tax to fund the security checkpoints would be added to the ballot in the next election. If approved, this tax would increase the monthly cost of living. Approximately 18.9% of residents indicated that they would be supportive of the “security” tax. Those who indicated they would be supportive of the “security tax,” were asked to report the most (in dollars per month) they would be Willing To Pay (WTP) a “security tax” to fund the operation of random checkpoints. The average reported value was $31.34 (SD=66.52) per month.

Residents were also asked how much they would be willing to pay for an improved security checkpoint program that reduces their wait time by one minute. Table 13-9 displays the results.

Table 13-9: Residents’ Willingness to Pay (WTP) to Reduce Wait Time (in dollars)

<table>
<thead>
<tr>
<th>Residents’ WTP to reduce wait time from:</th>
<th>n</th>
<th>Mean $</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 minutes to 4 minutes</td>
<td>23</td>
<td>27.74</td>
<td>84.90</td>
</tr>
<tr>
<td>10 minutes to 9 minutes</td>
<td>98</td>
<td>19.01</td>
<td>101.88</td>
</tr>
<tr>
<td>3 minutes to 2 minutes</td>
<td>7</td>
<td>6.57</td>
<td>8.97</td>
</tr>
</tbody>
</table>
When asked if they would continue to live at their current addresses if a security checkpoint were to be routinely implemented several times a week where their homes are located, 22.8% of residents indicated they would continue to live at that address. Approximately 22.2% indicated they would look for another place to live within Lower Manhattan, 55% indicated they would move out of Lower Manhattan.

### 13.6.3 Workers

If presented with a security checkpoint on the street on which their place of employment is located (n=164), 90.3% of workers indicated that they would go through the checkpoint. Of these subjects, only fourteen indicated that they would not be willing to wait even three minutes if there were a line. The majority (80.3%) indicated that they would be willing to wait as much as 10 minutes to pass through the security line. Of the workers who indicated that they would not be willing to pass through the security checkpoint, twelve indicated they would contact work and tell them they could not get to the office, six would go home to work, five would go home and take the day off, seven would go to another office branch, twelve would go to another location to work remotely, such as a restaurant, coffee shop, or library, and three indicated “other.”

Workers (n=148) were then asked to assume that New York City would increase transportation costs to support the implementation of these security checkpoints, thus increasing the subject’s monthly commuting costs. The fare increase would apply to all modes of transportation (i.e., train, subway, bus, ferry, taxis, and tolls) traveling into, out of, and within Lower Manhattan. Approximately 29.8% of workers indicated that they would be willing to pay the additional monthly fare increase. Those who did indicate they would be willing to pay additional monthly transportation costs were asked the maximum they would be willing to pay to support the implementation of security checkpoints in Lower Manhattan. The average maximum value was $25.58 (SD=21.39) per month.

Workers were also asked how much they would be willing to pay for an improved security checkpoint program that reduces the wait time by one minute. Table 13-10 displays the results.
Table 13-10: Workers’ Willingness to Pay (WTP) to Reduce Wait Time (in dollars)

<table>
<thead>
<tr>
<th>Workers’ WTP to reduce wait time from:</th>
<th>n</th>
<th>Mean $</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 minutes to 4 minutes</td>
<td>33</td>
<td>14.65</td>
<td>24.49</td>
</tr>
<tr>
<td>10 minutes to 9 minutes</td>
<td>87</td>
<td>9.43</td>
<td>16.00</td>
</tr>
<tr>
<td>3 minutes to 2 minutes</td>
<td>14</td>
<td>12.81</td>
<td>28.19</td>
</tr>
</tbody>
</table>

When asked if they would continue to work at their current addresses if a security checkpoint were to be routinely implemented several times a week on the street on which their place of employment is located, 64.4% indicated they would continue to work from that address, 21.2% indicated that they would request or find a new address within Lower Manhattan from which to work, 9.6% indicated they would look for a new job and 4.8% indicated “other.”

13.6.4 Visitors

Visitors were asked to imagine a security checkpoint on the street on which the visitor was walking to meet some friends. Some 93.4% of subjects indicated they would go through the security checkpoint. Of these, only two indicated that they would not be willing to wait even three minutes if there were a line. The majority (72.2%) indicated that they would be willing to wait as much as 10 minutes to pass through the security line. Of the 10 visitors who indicated that they would not go through the security checkpoint, 45.5% indicated they would call their friends and establish a new place to meet, 36.4% indicated they would meet their friends at a nearby restaurant, deli, or coffee shop to eat, 13.6% indicated they would look on the Internet to find another fun site to visit in Lower Manhattan, and 4.5% indicated they would go home.

Visitors were then asked to suppose that New York City would increase transportation costs to support the implementation of these security checkpoints, thus increasing monthly commuting costs. The fare increase would apply to all modes of transportation (i.e., train, subway, bus, ferry, taxis, and tolls) traveling into, out of, and within Lower Manhattan. Approximately 38.8% of visitors indicated that they would be willing to pay the additional monthly fare increase. For those visitors who did indicate they would be willing to pay additional monthly transportation costs, they were asked the maximum they would be willing to pay to support the implementation
of security checkpoints in Lower Manhattan. The average value was $17.76 (SD=12.85) per month.

Visitors were also asked how much they would be willing to pay for an improved security checkpoint program that reduces the wait time by one minute. Table 13-11 displays the results.

Table 13-11: Visitors’ Willingness to Pay (WTP) to Reduce Wait Time (in dollars)

<table>
<thead>
<tr>
<th>Visitors’ WTP to reduce wait time from:</th>
<th>n</th>
<th>Mean $</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 minutes to 4 minutes</td>
<td>37</td>
<td>2.97</td>
<td>5.37</td>
</tr>
<tr>
<td>10 minutes to 9 minutes</td>
<td>93</td>
<td>11.33</td>
<td>19.64</td>
</tr>
<tr>
<td>3 minutes to 2 minutes</td>
<td>4</td>
<td>9.25</td>
<td>10.63</td>
</tr>
</tbody>
</table>

When asked if they would continue to visit stores and restaurants on a street where a security checkpoint were to be routinely implemented several times a week, 62.5% of subjects indicated that they would not, but rather they would find other stores or restaurants to frequent.

Table 13-12: Summary Table of Residents, Workers & Visitor “Stop & Search” Checkpoints Data

<table>
<thead>
<tr>
<th></th>
<th>Residents</th>
<th>Workers</th>
<th>Visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willing to pass through security checkpoint (%)</td>
<td>72.4</td>
<td>90.3</td>
<td>93.4</td>
</tr>
<tr>
<td>Willing to wait up to 10 minutes (%)</td>
<td>82</td>
<td>80.3</td>
<td>72.2</td>
</tr>
<tr>
<td>WTP additional per month (%)</td>
<td>18.9</td>
<td>29.8</td>
<td>38.8</td>
</tr>
<tr>
<td>*in the form of “security” tax or transportation costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount willing to pay in add’l costs [Mean (SD)]</td>
<td>31.34 (SD=66.52)</td>
<td>25.58 (SD=21.39)</td>
<td>17.76 (SD=12.85)</td>
</tr>
<tr>
<td>*in the form of “security” tax or transportation costs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13.7 Value Placed on CCTV Camera System in Lower Manhattan

13.7.1 Businesses

Business owners (n=140) were asked to assume that New York City is considering raising property taxes for all properties located south of Canal Street to support the existing 1,300 CCTV
security cameras in Lower Manhattan, thus causing an increase in monthly business expenses to cover this cost. Approximately 35.6% of business owners indicated that they would be willing to pay the additional monthly expenses. Those business owners who indicated they would be willing to pay more were asked the maximum amount that they would be willing to pay extra in business expenses per month to support the existing 1,300 CCTV security cameras in Lower Manhattan. The average value was $231.80 (SD=132.35) per month.

Business owners (n=140) were then asked to assume that New York City is considering raising property taxes for all properties located south of Canal Street to support the addition of 1,700 CCTV security cameras in Lower Manhattan (for a total of 3,000 cameras), thus causing an increase in the business’ monthly business expenses to cover this cost. Approximately 36.4% of business owners indicated that they would be willing to pay the additional monthly expenses. Those business owners who indicated they would be willing to pay more were asked the maximum extra amount that they would be willing to pay in business expenses per month to support the addition of 1,700 CCTV security cameras in Lower Manhattan. The average value was $262.86 (SD=285.26) per month.

Business owners (n=51) were then asked what effect an expansion from 1,700 CCTV cameras to 3,000 CCTV cameras would have on their businesses’ monthly revenue (see Figure 13.13). Approximately 41.2% of business owners indicated the expansion would increase their monthly revenue, 3.9% indicated it would decrease their monthly revenue, and 54.9% indicated it would have no effect on their monthly revenue. Of those who indicated it would increase their monthly revenue, 33.4% indicated it would increase their monthly revenue by 5%, 28.6% indicated it would increase their monthly revenue by 5%-10%, 33.3% indicated it would increase their monthly revenue by 10%-25%, and 4.8% indicated it would increase their monthly revenue by more than 25%. Of the two subjects who indicated the expansion would decrease their monthly revenue, one business owner indicated it would decrease it by 1%-5% and another indicated it would decrease it by 5%-10%.

Conversely, business owners (n=51) were asked what effect the discontinuance of Lower Manhattan’s CCTV security system would have on their businesses’ monthly revenue (see Figure 13.13). Approximately 2% indicated it would increase their monthly revenue, 49% indicated
that it would decrease their monthly revenue and 49% indicated the discontinuance would have no impact on their businesses’ monthly revenue. Only one business owner indicated that the discontinuance would increase their monthly revenue by 5-10%. Of those who indicated the discontinuance would decrease their monthly revenue, 33.4% indicated that it would decrease their monthly revenue by 5%, 25% indicated it would decrease their monthly revenue by 5%-10%, 41.7% indicated it would decrease their monthly revenue by 10%-25%.

Figure 13.13: Expected Effect of CCTV Cameras on Monthly Business Revenue (n=51)

Business owners (n=140) were then asked to suppose that, rather than increasing property taxes, the Lower Manhattan business district has proposed the addition of a “security” tax on goods and services offered throughout Lower Manhattan. The “security” tax would support the entire CCTV security system (a total of 3,000 cameras by 2013) in Lower Manhattan. Approximately 37.9% indicated that they would be willing to increase their annual cost of doing business to cover the expense of the “security” tax. When asked the maximum extra amount they would be willing to pay per year in business costs to support the CCTV “security” tax in Lower Manhattan, the average amount was $281.53 (SD=810.15).

13.7.2 Residents

Residents (n=203) were asked to assume that New York City is considering raising property taxes for all properties located south of Canal Street to support the existing 1,300 CCTV security cameras in Lower Manhattan. Approximately 18.2% of residents indicated that they would be willing to increase their monthly living expenses to cover this cost. Of the residents who
indicated they would be willing to pay, the maximum extra amount they would be willing to pay in living expenses \textit{per month} to support the existing 1,300 CCTV security cameras, on average, was $41.81 (SD=27.91).

Residents (n=201) were then asked to assume that New York City would be raising property taxes for all properties located south of Canal Street to support \textit{the addition of 1,700 CCTV security cameras} in Lower Manhattan (resulting in 3,000 cameras total in Lower Manhattan). Approximately 18.4\% of residents indicated that they would be willing to pay to cover this cost. Of the residents who indicated they would be willing to pay, the maximum extra amount they would be willing to pay in living expenses \textit{per month} to support the additional 1,700 CCTV security cameras in Lower Manhattan, on average, was $38.47 (SD=28.05).

Finally, residents (n=201) were asked to suppose that, rather than increasing property taxes, the Lower Manhattan business district had proposed the addition of a “security” tax on goods and services offered throughout Lower Manhattan. The “security” tax would support the entire CCTV security system (3,000 cameras total by 2013) in Lower Manhattan. Approximately 26.9\% of residents indicated that they would be willing pay to cover the expense of the “security” tax. When asked the maximum extra amount \textit{per year} they would be willing to pay in living costs to support the CCTV “security” tax in Lower Manhattan, the average amount was $99.81 (SD=96.18).

\textbf{13.7.3 Workers}

Workers (n=180) were asked to assume that New York City would increase transportation costs to support the \textit{existing 1,300 CCTV security cameras} in Lower Manhattan. The fare increase would apply to all modes of transportation (i.e., train, subway, bus, ferry, taxis, and tolls) within the New York City metro region traveling into and out of New York City. Without the fare increase, the CCTV camera program would be eliminated. Approximately 43.9\% of workers indicated that they would be willing to pay to cover this cost. Of the workers who indicated they would be willing to pay, the maximum amount in living expenses extra \textit{per month} they would be willing to pay to support the existing 1,300 CCTV security cameras, on average, was $64.82 (SD=225.37).
Workers (n=162) were then asked to assume that New York City is increasing transportation costs to support the additional 1,700 CCTV security cameras (resulting in 3,000 cameras total) in Lower Manhattan. The fare increase would apply to all modes of transportation (i.e., train, subway, bus, ferry, taxis, and tolls) within the New York City metro region traveling into and out of New York City. Without the fare increase, the CCTV program of adding 1700 cameras would be eliminated. Approximately 33.3% of workers indicated that they would be willing to pay to cover this cost. Of the workers who indicated they would be willing to pay, the maximum extra amount in living expenses per month they would be willing to pay to support the additional 1,700 CCTV security cameras in Lower Manhattan, on average, was $42.09 (SD=49.03).

Finally, workers (n=160) were then asked to suppose that, rather than increasing property taxes, the Lower Manhattan business district has proposed the addition of a “security” tax on goods and services offered throughout Lower Manhattan. The “security” tax would support the entire CCTV security system (3,000 cameras total by 2013) in Lower Manhattan. Approximately 41.8% of workers indicated that they would be willing to pay to cover the expense of the "security" tax. When asked the maximum extra amount per year in living costs they would be willing to pay to support the CCTV "security" tax, the average amount was $114.97 (SD=200.50).

13.7.4 Visitors

Visitors (n=166) were asked to assume that New York City is increasing transportation costs to support the existing 1,300 CCTV security cameras in Lower Manhattan. The fare increase would apply to all modes of transportation (i.e., train, subway, bus, ferry, taxis, and tolls) within the New York City metro region traveling into and out of New York City. Without the fare increase, the CCTV camera program would be eliminated. Approximately 56% of visitors indicated they would be willing to pay to cover this cost. Of the visitors who indicated they would be willing to pay, the maximum extra amount in living expenses per month they would be willing to pay to support the existing 1,300 CCTV security cameras, on average, was $29.60 (SD=23.93).

Visitors (n=166) were then asked to assume that New York City is increasing transportation costs to support an additional 1,700 CCTV security cameras (resulting in 3,000 cameras total) in Lower Manhattan. The fare increase would apply to all modes of transportation (i.e., train,
subway, bus, ferry, taxis, and tolls) within the New York City metro region traveling into and out of New York City. Without the fare increase, the CCTV program of adding 1,700 cameras would be eliminated. Approximately 30.7% of visitors indicated they would be willing to pay to cover this cost. Of the visitors who indicated they would be willing to pay, the maximum extra amount in living expenses *per month* they would be willing to pay to support the additional 1,700 CCTV security cameras in Lower Manhattan, on average, was $33.94 (SD=25.81).

Finally, visitors (n=166) were then asked to suppose that, rather than increasing transportation costs, the Lower Manhattan business district has proposed the addition of a “security” tax on goods and services offered throughout Lower Manhattan. The “security” tax would support the entire CCTV security system (3,000 cameras total by 2013) in Lower Manhattan. Approximately 50% of visitors indicated that they would be willing to pay the “security” tax. When asked the maximum extra amount *per year* in living costs they would be willing to pay to support the CCTV “security” tax in Lower Manhattan, the average amount was $121.80 (SD=157.67).

**Table 13-13: Summary of Stakeholders’ Willingness to Pay (WTP) for CCTV System**

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Description</th>
<th>n</th>
<th>% WTP</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Businesses</strong></td>
<td>Property Tax Increase (1,300 cameras, monthly)</td>
<td>140</td>
<td>35.6</td>
<td>$23.80 (132.35)</td>
</tr>
<tr>
<td></td>
<td>Property Tax Increase (3,000 cameras, monthly)</td>
<td>140</td>
<td>36.4</td>
<td>$262.86 (285.26)</td>
</tr>
<tr>
<td></td>
<td>Security Tax (3,000 cameras, annually)</td>
<td>140</td>
<td>37.9</td>
<td>$281.53 (810.15)</td>
</tr>
<tr>
<td><strong>Residents</strong></td>
<td>Property Tax Increase (1,300 cameras, monthly)</td>
<td>203</td>
<td>18.2</td>
<td>$41.81 (27.91)</td>
</tr>
<tr>
<td></td>
<td>Property Tax Increase (3,000 cameras, monthly)</td>
<td>201</td>
<td>18.4</td>
<td>$38.47 (28.05)</td>
</tr>
<tr>
<td></td>
<td>Security Tax (3,000 cameras, annually)</td>
<td>201</td>
<td>26.9</td>
<td>$99.81 (96.18)</td>
</tr>
<tr>
<td><strong>Workers</strong></td>
<td>Transportation Tax Increase (1,300 cameras, monthly)</td>
<td>180</td>
<td>43.9</td>
<td>$64.82 (225.37)</td>
</tr>
<tr>
<td></td>
<td>Transportation Tax Increase (3,000 cameras, monthly)</td>
<td>162</td>
<td>33.3</td>
<td>$42.09 (49.03)</td>
</tr>
<tr>
<td></td>
<td>Security Tax (3,000 cameras, annually)</td>
<td>160</td>
<td>41.8</td>
<td>$114.97 (200.50)</td>
</tr>
</tbody>
</table>
Table 13-13 - continued -

<table>
<thead>
<tr>
<th>Visitors</th>
<th>n</th>
<th>% WTP</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation Tax Increase (1,300 cameras, monthly)</td>
<td>166</td>
<td>56.0</td>
<td>$29.60 (23.93)</td>
</tr>
<tr>
<td>Transportation Tax Increase (3,000 cameras, monthly)</td>
<td>166</td>
<td>30.7</td>
<td>$33.94 (25.81)</td>
</tr>
<tr>
<td>Security Tax (3,000 cameras, annually)</td>
<td>166</td>
<td>50.0</td>
<td>$121.80 (157.67)</td>
</tr>
</tbody>
</table>

13.8 Value Placed on Baggage & Parcel Inspections in Transit Stations

Prior to assessing subjects’ attitudes, the survey collected information regarding subjects’ experiences with baggage and parcel inspections within transit stations (see Figure 13.14). Approximately 84.9% of subjects indicated that they have never had their bag or parcel inspected when traveling by subway or rail to or within Lower Manhattan; however, slightly less than half of the subjects (45.7%) indicated that they had seen someone else’s bag or parcel searched when traveling by subway or rail to or within Lower Manhattan. Moreover, approximately 36% of subjects indicated that they had heard about friends or family having had their bag or parcel searched when traveling by subway or rail to or within Lower Manhattan. Only 8.1% of the subjects indicated that they had changed their commute to avoid the possibility of having their
bag or parcel searched when riding the subway or rail to Lower Manhattan. The reasons given by this group as to why they had changed their commuting patterns include: to maintain their feelings of privacy from having their personal items searched, to avoid being uncomfortable or uneasy about being searched, to avoid delays caused by searches, and the belief the searches are inconvenient, annoying and/or believed to be unconstitutional.

13.8.1 Businesses
When asked if they would continue to travel by rail or subway knowing that their bags and parcels would be inspected (n=136), 70.6% of business owners answered, “Yes.” Of these subjects, only 13 indicated that they would not be willing to wait even three minutes if there were a line. Approximately 45.9% indicated that they would be willing to wait as much as 10 minutes to pass through the inspection line.

Approximately 66% of business owners indicated that they would be willing to pay to be pre-screened (one-time iris scan, fingerprinting and background check) for one year’s access to a faster security screening line that cuts their wait time in half whenever they travel by rail or subway within Lower Manhattan. Those subjects who indicated they would be willing to pay to be pre-screened for one year's access to the faster security screening line whenever they traveled by rail or subway in the Lower Manhattan area, would be willing to pay a maximum, on average, of $73.39 (SD=65.73) per year.

Business owners were asked if bag and parcel inspections in subway and train stations would affect their monthly revenue (see Figure 13.15). Approximately 62.5% responded that a security checkpoint would decrease their monthly revenue, 5.9% indicated that it would increase their monthly revenue, and 31.6% indicated that it would have no impact on their monthly revenue. Of the 85 subjects that indicated that it would decrease their monthly revenue, 18.8% estimated that it would decrease their monthly revenue by 5%, 36.5% estimated that it would decrease their monthly revenue by 5% - 10%, 29.4% estimated that it would decrease their monthly revenue by 10% - 25%, and 15.3% estimated that it would decrease their monthly revenue by 25% - 50%. Of the 10 subjects that indicated that it would increase their monthly revenue, they estimated that the security checkpoint would increase their monthly revenue by more than 25%. 
Business owners were then asked if they would be willing to offer their customers/clients a $12 discount to help draw people back to the area. Approximately 36% indicated, “Yes.” When asked if they would offer a $5 discount, approximately half (56%) indicated, “Yes.” Only fourteen subjects indicated that they would be willing to offer a $20 discount and only five subjects indicated they would be willing to offer a $25 discount. The average discount on all purchases that business owners (n=136) reported they would be willing to offer to help draw people back to the area was $9.14 (SD=9.16).

### 13.8.2 Residents

When asked if they would continue to travel by rail or subway knowing that their bags and parcels would be inspected (n=193), 63.7% of residents answered, “Yes.” Approximately 45.5% indicated that they would be willing to wait as much as 10 minutes to pass through the inspection line.

Approximately 55.4% of residents indicated that they would be willing to pay to be pre-screened (one-time iris scan, fingerprinting and background check) for one year’s access to a faster security screening line that cuts their wait time in half whenever they traveled by rail or subway in Lower Manhattan. For those subjects who indicated they would be willing to pay to be pre-screened for one year's access to the faster security screening line whenever they travel by rail or subway in the Lower Manhattan area, the maximum they would be willing to pay was, on average $61.53 (SD=52.92) per year.

### 13.8.3 Workers

When asked if they would continue to travel by rail or subway knowing that their bags and parcels would be inspected (n=176), 71% of workers answered, “Yes.” Approximately 46.1%
indicated that they would be willing to wait as much as 10 minutes to pass through the inspection line.

Approximately 69.8% of workers indicated that they would be willing to pay to be pre-screened (one-time iris scan, fingerprinting and background check) for one year’s access to a faster security screening line that would cut their wait time in half whenever they traveled by rail or subway. Those subjects who indicated they would be willing to pay to be pre-screened for one year's access to the faster security screening line whenever they traveled by rail or subway in the Lower Manhattan area, were asked the maximum they would be willing to pay. The average was $69.94 (SD=73.51) per year.

13.8.4 Visitors
When asked if they would continue to travel by rail or subway knowing that their bags and parcels would be inspected (n=174), 73.6% of visitors answered, “Yes.” Of these subjects, only nine indicated that they would not be willing to wait even three minutes if there were a line. Approximately 51.8% indicated that they would be willing to wait as much as 10 minutes to pass through the inspection line.

Approximately 58% of visitors indicated that they would be willing to pay to be pre-screened (one-time iris scan, fingerprinting and background check) for one year’s access to a faster security screening line that would cut their wait time in half whenever they traveled by rail or subway. Those subjects who indicated they would be willing to pay to be pre-screened for one year's access to the faster security screening line whenever they traveled by rail or subway in the Lower Manhattan area were asked the maximum they would be willing to pay. The average was $65.03 (SD=68.75) per year.

Visitors (n=174) were asked whether their favorite store or restaurant in Lower Manhattan had a second location elsewhere in Manhattan, and if they would go there instead because of the 100% inspection program. Approximately 75.3% of subjects indicated “Yes.” When asked if a $7 discount on their total purchase would lead them to go to Lower Manhattan despite the subway inspections, approximately 69% indicated “Yes.” When asked the minimum discount in dollars they would need on all purchases to visit a store/restaurant in Lower Manhattan instead of the
same store or restaurant at another location in Manhattan, the average amount was $10.79 (SD=15.93).

**Table 13-14: Summary Table of Data on Bag & Parcel Inspections by Stakeholder Group**

<table>
<thead>
<tr>
<th></th>
<th>Businesses</th>
<th>Residents</th>
<th>Workers</th>
<th>Visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willing to continue travel on</td>
<td>70.6</td>
<td>63.7</td>
<td>71.0</td>
<td>73.6</td>
</tr>
<tr>
<td>subway/rail (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willing to wait up to 10</td>
<td>45.9</td>
<td>45.5</td>
<td>46.1</td>
<td>51.8</td>
</tr>
<tr>
<td>minutes (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WTP annually to be pre-screened</td>
<td>66.0</td>
<td>55.4</td>
<td>69.8</td>
<td>58</td>
</tr>
<tr>
<td>(%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WTP annually to be pre-screened</td>
<td>73.39</td>
<td>61.53</td>
<td>69.93</td>
<td>65.03</td>
</tr>
<tr>
<td>($) [Mean (SD)]</td>
<td>(SD=65.73)</td>
<td>(SD=52.92)</td>
<td>(SD=73.51)</td>
<td>(SD=68.75)</td>
</tr>
</tbody>
</table>

Those individuals who indicated that they would not be willing to wait to have their bags and parcels inspected in train and subway stations were asked what alternative form of transportation they would use. Across all four stakeholder groups (n=547), approximately 23.4% indicated they would use the bus, 25% indicated they would use a taxi, 27.8% indicated they would walk, 19% indicated they would carpool, and 4.8% indicated they would use the railway systems to travel (see Table 13-15).

**Table 13-15: Frequency Distribution of Alternative Forms of Transportation by Stakeholder Group**

<table>
<thead>
<tr>
<th></th>
<th>Businesses</th>
<th>Residents</th>
<th>Workers</th>
<th>Visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>24</td>
<td>45</td>
<td>34</td>
<td>25</td>
</tr>
<tr>
<td>Taxi</td>
<td>30</td>
<td>44</td>
<td>34</td>
<td>29</td>
</tr>
<tr>
<td>Walk</td>
<td>24</td>
<td>58</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Carpool</td>
<td>21</td>
<td>40</td>
<td>19</td>
<td>24</td>
</tr>
<tr>
<td>Rail</td>
<td>6</td>
<td>10</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>105</td>
<td>197</td>
<td>129</td>
<td>116</td>
</tr>
</tbody>
</table>

The survey solicited information from business owners regarding the expected effect of each security measure on their businesses’ monthly revenue. As shown in Table 13-16 the expected effect of each security measure varies greatly, with the weekly “stop and search” checkpoints being most disruptive, followed by the 100% bag and parcel inspections in subway and train

13-219
stations. An expansion of Lower Manhattan’s CCTV camera system, however, was expected to substantially increase businesses’ monthly revenues.

Table 13-16: Summary of the Expected Effect of Security Measures on Business Monthly Revenue

<table>
<thead>
<tr>
<th></th>
<th>Weekly Stop &amp; Search Checkpoint (n=138)</th>
<th>CCTV System Expansion (n=51)</th>
<th>100% Bag &amp; Parcel Inspections in Transit stations (n=136)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase (%)</td>
<td>7</td>
<td>41.2</td>
<td>5.9</td>
</tr>
<tr>
<td>Decrease (%)</td>
<td>72</td>
<td>3.9</td>
<td>62.5</td>
</tr>
<tr>
<td>No Change (%)</td>
<td>21</td>
<td>54.9</td>
<td>31.6</td>
</tr>
</tbody>
</table>
14 GENERAL EQUILIBRIUM IMPACTS OF INCREASED SECURITY IN THE NEW YORK METROPOLITAN REGION

Most security measures used to protect society against terrorism involve both capital and operating expenditures. These direct purchases of equipment and of labor, electricity, and various overhead items to operate and maintain it, in turn, stimulate the demand for additional goods and services. Manufacturers of surveillance equipment, for example, purchase fabricated metals, electronic components, and transportation needed to deliver these inputs to their factory, as well as management, labor and electricity to operate the production lines. The production of supplies for the office where surveillance monitoring takes place requires inputs of pulp for paper, ink for pens, and foam for seat cushions among others. Each of these various inputs sets off a further chain reaction for still more inputs. In addition, payments of wages and dividends are transformed into direct purchases of consumer goods, which, in turn, stimulate further rounds of spending. The sum total of all of these indirect demands is some multiple of the direct expenditures, hence the use of the common term "multiplier" effect. More advanced models also estimate an even broader set of effects of these successive rounds of demand shifts, typically resulting in price increases that can partially or more than offset some of the positive gains (i.e., cause them to be negative) because higher prices reduce purchasing power throughout the economy. The combination of quantity and price effects is termed "general equilibrium effects" in these more advanced models.

The analysis must also consider the origin of the funds for the initial expenditure. If these stem from the attraction of outside investment or federal subsidies into the region, it will promote a net expansionary effect. If the funds are derived from tax increases or decreases of other spending, then the outcome is unknown, and depends a great deal on the general equilibrium effects. For example, the production of surveillance equipment might have either higher or lower quantity multiplier effects than the goods whose expenditures have been displaced.

In this chapter, the total (direct plus indirect) economic impacts of capital and operating expenditures for terrorism countermeasures are estimated. A computable general equilibrium (CGE) model is utilized. A CGE model is the state of the art approach to economic consequence analysis in general (Dixon & Rimmer, 2002) and to terrorism in particular (Rose, 2013). CGE is a multi-market model of the behavioral responses of individual producers and consumers to
changes in prices and other conditions, within the constraints of the availability of labor, capital, and natural resources. CGE models can be constructed for any region of interest. This chapter, a uses a CGE model for the New York City Metropolitan Region which consists of 23 counties in the states of New York, New Jersey, and Pennsylvania. The vast majority of the multiplier, or general equilibrium effects will be contained within the Region. This model was successfully applied in a major study of the economic impacts of the September 11, 2001 World Trade Center Attacks (Rose et al., 2009). For more details about CGE modeling, see Chapter 8.

While the UCASS project has defined and studied rather general descriptions of selected countermeasures first introduced in Chapter 4, this chapter uses very specific versions of these countermeasures as also defined in that chapter and does not address the many variations pursued in our study, and in particular in the discrete event simulations. This chapter is thus illustrative of the calculation of the kind of multiplier effects resulting from countermeasures. The countermeasure versions studied here typically consider implementations at every street, every subway stop, or every building (rather than just some of these) and for application 24/7 (rather than periodically for possibly part of a day). It is not necessarily the case that the general equilibrium effect of a partial closure can be simply estimated from the effect of a full one, because the CGE model is inherently non-linear. Illustrative calculations of more limited countermeasures are given in Chapter 10.

General equilibrium experiments for terrorism countermeasures were run to determine the multiplier effects, as explained below. The simulation of the installation of CCTV cameras in the Lower Manhattan Area, was conducted in two parts using the capital and operating cost estimates of installing 1700 CCTV cameras (see Chapter 4). In the first part, the regional economic impacts of additional investment in equipment produced by the Electronics sector were simulated. In the second, the increased electricity and labor costs in the sectors using this equipment were simulated. In a similar manner the general equilibrium effects of both capital and operating costs for the other discrete event simulation countermeasures in the Lower

101 Bergen County, NJ; Essex County, NJ; Hudson County, NJ; Hunterdon County, NJ; Middlesex County, NJ; Monmouth County, NJ; Morris County, NJ; Ocean County, NJ; Passaic County, NJ; Somerset County, NJ; Sussex County, NJ; Union County, NJ; Bronx County, NY; Kings County, NY; Nassau County, NY; New York County, NY; Putnam County, NY; Queens County, NY; Richmond County, NY; Rockland County, NY; Suffolk County, NY; Westchester County, NY; Pike County, PA;
Manhattan Area, namely street closure and subway bag checking were calculated. Finally, multipliers derived from these three sets of simulations were used to estimate the total economic impacts for the seven security measures used in the UCASS project.

14.1 The New York CGE Model
Computable general equilibrium (CGE) model refers to a multi-market model of behavioral responses of firms and households to price changes and external shocks subject to constraints on available labor, capital and natural resources. CGE models are becoming increasingly prevalent in the estimation of the consequences of terrorist attacks because of several attractive features: behavioral content, price/market responsiveness, incorporation of supply chain interdependencies and explicit constraints (see, e.g., Rose, 2005; Rose et al., 2009; Dixon et al., 2007; Giesecke et al., 2012).

In the New York Metro Region CGE model, the following assumptions and conditions hold. A modified Keynesian closure rule is used in the model allowing for flexible wages, which in turn, generate additional savings necessary to finance the increased investment (Lofgren et al., 2002). The typical Keynesian closure allows for an unemployment equilibrium in the labor market, which means eliminating the total labor supply constraint. In contrast, the Neoclassical closure rule always generates full employment in equilibrium. The results are generated in real terms, since the consumer price index, which is the numeraire (reference, or base, price level) in the model, is at unity before all CGE experiments. In the New York Metro Region CGE Model, total investment is equal to net savings, capital endowments are fixed to reflect the short-run nature of the simulation, and the price of labor or wage rate is allowed to change. In addition, there is no change in export and import prices of all commodities except for those that are exogenously modified in model simulations. Particularly, the prices of imports and exports for both the rest of the U.S. and the rest of the world are fixed in the closure rule, but we modify these conditions based on the following assumption. Although the New York Metro Region is a small open economy relative to the rest of the regions of the world, it can be assumed to be a large open economy with respect to the regions of the rest of the U.S. Therefore, the New York Metro Region will have no impact on world prices of imports and exports, but will affect the export and import prices of some commodities in the U.S.
In terms of the computer code, using GAMS (Rosenthal et al., 2011), the following program statements specify the base case closure rules in the model:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDEX1.fx = 1 ;</td>
<td>normalized consumer price index</td>
</tr>
<tr>
<td>FCU.fx(“k”,i) = FCU0(“k”,i);</td>
<td>fixed capital (short term)</td>
</tr>
<tr>
<td>PWM.fx(gi) = PWM0(gi);</td>
<td>fixed Rest of World import price</td>
</tr>
<tr>
<td>PWE.fx(i) = PWE0(i);</td>
<td>fixed Rest of World export price</td>
</tr>
<tr>
<td>PIU.fx(gi) = PIU0(gi);</td>
<td>fixed Rest of the United States import price</td>
</tr>
<tr>
<td>PEU.fx(i) = PEU0(i);</td>
<td>fixed Rest of the United States export price</td>
</tr>
<tr>
<td>tsav.fx = invest0;</td>
<td>fixed total investment and net savings</td>
</tr>
</tbody>
</table>

14.2 Regional Economic Impacts of CCTV Cameras in Lower Manhattan

14.2.1 Base Case
The total regional economic impacts of the capital and operating costs of installing 1,700 CCTV cameras in the Lower Manhattan are estimated based on the alignment of detailed cost estimates with the sectors of the New York CGE model (see Chapter 4). The first part of the intervention is treated as an autonomous investment in the Electronics sector. The second involves increased electricity and labor costs. In the simulations, it is assumed that the installation of CCTV cameras is funded by additive government investment (i.e., it does not displace any other investment in the region). The analysis also assumes expenditures for the operation and maintenance of these cameras in Lower Manhattan are additive (i.e., they do not directly displace other expenditures but do increase the cost of doing business). The results of these experiments are summarized in Table 14-1.

Simulation Case 1 reveals that an increase in capital (autonomous investment) costs due to the additional 1,700 CCTV cameras installed in Lower Manhattan generates an increase in the regional GDP of $81.85 million. Whereas in simulation Case 2, the increase in labor and electricity costs alone yields a reduction in GDP of $2.66 million. The aggregate effect of investment, labor and electricity shocks on the regional GDP is illustrated in Case 3. As can be observed from Table 14-1, the additional investment in the Electronics sector generates a
relatively larger net multiplier compared to the combined increase in capital and operating costs, which is a weighted average of higher and lower multiplier effects.\textsuperscript{102}

Table 14-1: Impact of Capital and Operating Costs of CCTV Cameras on the New York Metro Economy (in millions of dollars)

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Gross Stimulus / Expenditure Assumption</th>
<th>Net Direct Expenditure\textsuperscript{a} ($US M)</th>
<th>Net Change in GDP ($US M)</th>
<th>Adjusted Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Investment</td>
<td>$76.34 M / additive</td>
<td>41.99</td>
<td>81.85</td>
<td>1.95</td>
</tr>
<tr>
<td>2. ΔC (Price increase for labor &amp; electricity)</td>
<td>LAB = $2.74 M / add.</td>
<td>1.57</td>
<td>-2.66</td>
<td>-1.70</td>
</tr>
<tr>
<td></td>
<td>PELE = $0.389 M / add.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Investment + ΔC (Price increase for labor &amp; electricity)</td>
<td>INV + (LAB + PELE)</td>
<td>43.55</td>
<td>75.24</td>
<td>1.06</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Refers to portion of operating expenditure that calls forth production within the region.

Although the total investment for 1,700 CCTV cameras is $76.34 million, the regional economy receives only $41.99 million as a direct investment stimulus, since the regional self-sufficiency ratio of the Electronics sector is only 0.55 (i.e., $41.99 = $76.34 * 0.55). Note the following two aspects of the multiplier values. First, the CGE multipliers for investment are larger than the corresponding input-output (I-O) multipliers. The reason is that the latter are unidirectional (i.e., do not include any offsetting factors, such as price increases that mute positive impacts in CGE modeling of these impacts).

Second, note that the result of the operation of the CCTV equipment has a negative impact on the economy. Although there is an expenditure for additional resources, this translates first to an increase in direct operating costs in each sector using CCTV, which is then passed forward in

\textsuperscript{102} In our simulations, we invoke two procedures common to models of this type. First, since both experiments assume relatively small changes in costs, we use a scaling factor of 100 to increase the size of the shocks and then appropriately scale down their economic effects (change in GDP) by this same factor. This approach helps us obtain an accurate estimate of the effects of relatively small changes in capital and operating costs in the New York City Metro economy. Second, we make a further equilibrium adjustment of the initial changes in GDP to adjust for rounding error. This adjustment makes the dampening effect of increased operating and maintenance costs become positive because it offsets the small initial effects. In the case of larger price increase scenarios, the dampening effect of increased labor costs remains negative after the equilibrium adjustment of the model solution, because large price increases significantly reduce purchasing power and result in fewer goods being demanded.
part to customers (in a form of “cost-push” inflation). The proportion of costs passed along as price increases depends on the price elasticity of demand for each product. Moreover, these price increases ripple through the economy in successive waves as a type of price-multiplier effect, further magnifying the price shock. Higher prices reduce purchasing power, which reduces economic activity. It is assumed that 50% of the newly installed CCTV cameras are privately operated, while the other 50% are maintained and operated by the government. Therefore, the estimate of $1.57 million represents only direct operating costs related to the operation of CCTV cameras by private companies in Lower Manhattan.

14.2.2 Regional Economic Impacts of Street Closures

Similar to the CCTV experiments, CGE simulations of impacts of the countermeasures used in the Street Closure simulations were based on the alignment of detailed cost estimates with the sectors of the New York CGE model. To undertake these simulations, we first considered the multiplier effects of various capital and operating and maintenance costs.

In this case as well, the additional investment is funded by additive government investment, without displacing any other investment in the region. The results of these experiments are summarized in Table 14-2. The increase in the regional GDP due to an increase in capital (autonomous investment) expenditures in the Electronics and Construction sectors is $75.24 million. Note that the discrete event simulation countermeasures do not increase the operating costs because the government shifts labor from its other activities. We also show that, due to some interaction effects, the multiplier value for the investment in the Electronics and Construction sectors combined is larger than in the case of CCTV cameras, which includes autonomous investment only in the former sector.

Although total investment for the specific version of the Street Closure simulation countermeasures as described in Chapter 4 is $49.97 million, the regional economy receives only $31.80 million as a direct investment stimulus, since the regional self-sufficiency ratios of the Electronics and Construction sectors are only 0.55 and 0.98, respectively ($31.80 = $39.93 * 0.55 + $10.04 * 0.98).
Table 14-2: Impact of Capital Costs of Discrete Event Simulation Countermeasures on the New York Metro Economy

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Gross Stimulus / Expenditure Assumption</th>
<th>Net Direct Expenditure(^a) ($US M)</th>
<th>Net Change in GDP ($US M)</th>
<th>Adjusted Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>CNSR = $10.04 M / add. \nMSEM = $39.93 M / add.</td>
<td>31.80</td>
<td>75.24</td>
<td>2.37</td>
</tr>
</tbody>
</table>

\(^a\)Refers to portion of operating expenditure that calls forth production within the region.
CNSR: Construction
MSEM: Electronic Equipment Manufacturing

14.2.3 Sensitivity Analysis\(^{103}\)

In this section, the choice of how an investment-funding source can affect the direct and indirect economic impacts of an additional 1,700 CCTV cameras installed in Lower Manhattan is analyzed. First, the experiment that autonomously increases the New York Metro Region investment in the Electronics sector by $76.34 million is repeated and the New York Metro Region CGE Model is used to estimate the direct and indirect effects of this shock throughout the regional economy. In the second experiment, the additional investment in CCTV equipment in that sector simply displaces other types of investment. JW - No reference to the Table in the text.

Table 14-3: Sensitivity Analysis of Capital Costs of CCTV Cameras in the New York Metro Economy

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Gross Stimulus / Expenditure Assumption</th>
<th>Net Direct Expenditure(^a) ($US M)</th>
<th>Net Change in GDP ($US M)</th>
<th>Adjusted Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Capital Cost: Base Case(^b)</td>
<td>1. Investment $76.34 M / additive</td>
<td>41.99</td>
<td>81.85</td>
<td>1.95</td>
</tr>
<tr>
<td>B. Capital Cost: Full Displacement Case(^c)</td>
<td>2. Investment $0 additive / $76.34 M displaced</td>
<td>-19.09</td>
<td>14.86</td>
<td>-0.78</td>
</tr>
</tbody>
</table>

\(^a\)Refers to portion of operating expenditure that calls forth production within the region.
\(^b\)Base case assumes: No subsidy & Armington elasticities.
\(^c\)Stimulus to the electronic equipment produced within the region is $41.99 M, but the portion of net direct expenditure due to displaced investment in other sectors needs to be subtracted, which yields an even lower net direct investment expenditure of -$19 M = $42 M - $76 M * 0.8 (where 0.8 is the self-sufficiency ratio for a mix of all investment goods).

\(^{103}\)Sensitivity analysis is the study of how the uncertainty in the output of a model (numerical or otherwise) can be apportioned to different sources of uncertainty in the model input.
In contrast to the autonomous investment, the displaced investment generates a smaller increase in GDP ($14.86 million vs. $81.85 million) and a negative adjusted multiplier because of the displacement effect.

### 14.3 Regional Economic Impacts for UCASS Countermeasures on Lower Manhattan

The total economic impacts of the particular versions of the UCASS countermeasures as defined in Chapter 4 are summarized here. This calculation is illustrative and would change if, for example, we only closed certain streets or instituted bag checks or magnetometers only at selected locations, or if we made any of these changes for shorter periods of time. Examples are given in Chapter 10. Additional CGE experiments were conducted to compute a set of average economic multipliers associated with increased capital and operating costs for various input sectors, such as Electronics, Construction, Other Business Services, Electricity and Labor (see Table 14-4).

#### Table 14-4: Economic Multipliers of Increased Capital and Operating Costs in the New York Metro Economy

<table>
<thead>
<tr>
<th>Cost Element</th>
<th>Capital Cost</th>
<th>O&amp;M Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Description</td>
<td>Average Multiplier</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>NYCGE code</td>
</tr>
<tr>
<td>Barriers</td>
<td>Other</td>
<td>MOND</td>
</tr>
<tr>
<td></td>
<td>Non-Durable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturing</td>
<td></td>
</tr>
<tr>
<td>Construction of Shelter</td>
<td>Construction</td>
<td>CNSR</td>
</tr>
<tr>
<td>Bomb Detection Equipment</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>Electronic Toll Collection Structure</td>
<td>Construction</td>
<td>CNSR</td>
</tr>
<tr>
<td>Hardware, Software for Traffic Surveillance</td>
<td>Information</td>
<td>INFO</td>
</tr>
<tr>
<td></td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
</tbody>
</table>

104 This multiplier is defined as the ratio of total net output/GDP/value added divided by direct gross output. The ratio of total gross output to direct gross output will be approximately 50% higher. The reason we have expressed the multipliers in a mix of gross and net terms, is because, (1) gross output is more consistent with total direct cost estimates, and (2) it is preferable to express overall impact in net/GDP terms.
Table 14-4 – continued -

<table>
<thead>
<tr>
<th>Cost Element</th>
<th>Capital Cost</th>
<th>O&amp;M Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>NYCGE code</td>
<td>Average Multiplier(^{105})</td>
</tr>
<tr>
<td>Cargo Monitoring Sensors and Gauges</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>Portable Traffic Management System</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>X-ray Scanners</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>Magnetometers</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>Bomb-Sniffing Dogs</td>
<td>Other Business Services</td>
<td>OBSV</td>
</tr>
<tr>
<td>Checkpoint Equipment</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>Dynamic Message Sign – Portable</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>CCTV Video Camera/Towers</td>
<td>Electronics</td>
<td>MSEM</td>
</tr>
<tr>
<td>Maintenance of the Checkpoint Structure</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Inspector Training</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Wages and Benefits</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

MOND: Other Non-Durable Manufacturing  
CNSR: Construction  
MSEM: Electronic Equipment Manufacturing  
INFO: Information  
OBSV: Other Business Services

To repeat, in calculating Table 14-5, a number of assumptions were made for each of the seven security measures defined in Chapter 4. For example, it was assumed that random vehicle inspections include permanent checkpoints on each of the 26 entry/exit points around Lower Manhattan (rather than introducing such checkpoints on selected entry/exit points). It was

\(^{105}\) This multiplier is defined as the ratio of total net output/GDP/value added divided by direct gross output. The ratio of total gross output to direct gross output will be approximately 50% higher. The reason we have expressed the multipliers in a mix of gross and net terms, is because, (1) gross output is more consistent with total direct cost estimates, and (2) it is preferable to express overall impact in net/GDP terms.
assumed that the permanent closure of certain streets to traffic was a partial street closure on Broad Street in front of the New York Stock Exchange and Federal Hall. It was assumed that the temporary perimeters and access controlled areas to certain restricted areas of Lower Manhattan was to areas surrounding the World Trade Center site and the Financial District, assuming approximately 30 intersections bounded by West Street, Barclay Street, Church Street/Trinity Place, and Rector Street (i.e., the World Trade Center area), and approximately 70 intersections bounded by Broadway, Fulton Street, and Water Street (rather than some intersections). It was assumed that random bag and parcel inspection on subways included about 50 subway stations in Lower Manhattan (rather than some of them). It was assumed that there were X-rays and magnetometers in the building lobbies of approximately 50 major/large buildings in Lower Manhattan (rather than some of them). It was assumed that an increased visible presence of police officers included an additional 200 police officers in the areas surrounding the World Trade Center site and the Financial District. Finally, CCTV cameras were assumed to be located throughout Lower Manhattan. More detailed information on the UCASS security measures and underlying assumptions for these special cases is available in Chapter 4.

Note that the annualized capital costs are determined for a 10-year time horizon by applying a factor of 0.1 to total capital costs of each countermeasure. This approach is utilized rather than the standard amortization formula that is used to estimate levelized annual costs to differentiate between the annual stimulus injected to the regional economy for the averaged annual production of capital equipment and the interest paid for that amount in every period of the considered time interval. The interest payment stimulus is not included because it was not clear that the financing would have come from inside the region or that it was not covered by retained earnings, thereby not representing an explicit cost captured in macroeconomic accounts.

As shown in Table 14-6, the largest operating costs are associated with our specific versions of random vehicle inspections, followed by our specific versions of random bag and parcel inspection on subways and then by installation of CCTV cameras. There are some security measures operated by the government, some are maintained and operated by private companies, and there may be countermeasures representing a mix of the two. It is assumed that operating costs in the private
sector are an added cost of doing business, and the CGE model determines any substitutions with respect to other inputs. On the other hand, it is assumed that operating costs for government in this era of tight budgets will simply displace other government expenditures, resulting in no net expenditure increase (see the last column of

Table 14-6 for this adjustment).

**Table 14-5: Total Capital Cost and Annualized Capital Cost of UCASS Security Measures under Special Assumptions as detailed in the text (in thousand 2009$)**

<table>
<thead>
<tr>
<th>Countermeasure Type</th>
<th>Total Capital Cost</th>
<th>Annualized Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random Vehicle Inspections</td>
<td>44,039</td>
<td>4,404</td>
</tr>
<tr>
<td>Permanent Closure of Certain Streets to Traffic</td>
<td>116</td>
<td>12</td>
</tr>
<tr>
<td>Temporary Perimeters and Access Control to Certain Restricted Areas of the City</td>
<td>3,826</td>
<td>383</td>
</tr>
<tr>
<td>Random Bag and Parcel Inspection on Subways</td>
<td>23,964</td>
<td>2,396</td>
</tr>
<tr>
<td>X-rays and Magnetometers in Building Lobbies</td>
<td>2,362</td>
<td>236</td>
</tr>
<tr>
<td>Increased Visible Presence of Police</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>CCTV Cameras</td>
<td>40,435</td>
<td>4,044</td>
</tr>
</tbody>
</table>

**Table 14-6: Total Annual Operating Cost of UCASS Security Measures under Special Assumptions of Chapter 4: Basic and Adjusted for Public Sector Spending (in thousand 2009$)**

<table>
<thead>
<tr>
<th>Countermeasure Type</th>
<th>Operating Cost</th>
<th>Operating Cost Public Sector Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random Vehicle Inspections</td>
<td>67,881</td>
<td>0</td>
</tr>
<tr>
<td>Permanent Closure of Certain Streets to Traffic</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Temporary Perimeters and Access Control to Certain Restricted Areas of the City</td>
<td>1,987</td>
<td>0</td>
</tr>
<tr>
<td>Random Bag and Parcel Inspection on Subways</td>
<td>4,792</td>
<td>0</td>
</tr>
<tr>
<td>X-rays and Magnetometers in Building Lobbies</td>
<td>942</td>
<td>942</td>
</tr>
<tr>
<td>Increased Visible Presence of Police</td>
<td>1,883</td>
<td>0</td>
</tr>
<tr>
<td>CCTV Cameras</td>
<td>2,385</td>
<td>1,193</td>
</tr>
</tbody>
</table>
Finally, in Table 14-7 the GDP impacts of capital and operating expenditures of the UCASS countermeasures are presented. These estimates include the direct impacts just discussed, including the adjustment for government spending displacement, as well as indirect impacts calculated with the use of the New York Metro CGE Model for the case of the CCTV countermeasure and the use of approximate multipliers derived from the model for the other countermeasures. While the direct expenditure impacts pertain to the countermeasures themselves, the indirect cost impacts refer to backward and forward quantity linkages to all sectors, which affect their production, as well as input choice and production responses in all sectors to price changes.

Table 14-7: GDP Impacts of the UCASS Security Measures under Special Assumptions of Chapter 4 (in thousand 2009$)

<table>
<thead>
<tr>
<th>Countermeasure Type</th>
<th>Annualized Capital Expenditure Impacts</th>
<th>Adjusted Annual Operating Expenditure Impacts</th>
<th>Grand Total GDP Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Direct</td>
<td>Indirect</td>
<td>Total</td>
</tr>
<tr>
<td>Random Vehicle Inspections</td>
<td>4,404</td>
<td>8,808</td>
<td>13,212</td>
</tr>
<tr>
<td>Permanent Closure of Certain Streets to Traffic</td>
<td>12</td>
<td>23</td>
<td>35</td>
</tr>
<tr>
<td>Temporary Perimeters and Access Control to Certain Restricted Areas of Lower Manhattan</td>
<td>383</td>
<td>765</td>
<td>1,148</td>
</tr>
<tr>
<td>Random Bag and Parcel Inspection on Subways</td>
<td>2,396</td>
<td>4,656</td>
<td>7,052</td>
</tr>
<tr>
<td>X-rays and Magnetometers in Building Lobbies</td>
<td>236</td>
<td>472</td>
<td>708</td>
</tr>
<tr>
<td>Increased Visible Presence of Police</td>
<td>n.a.</td>
<td>n.a.</td>
<td>0</td>
</tr>
<tr>
<td>CCTV Cameras</td>
<td>4,044</td>
<td>8,087</td>
<td>12,131</td>
</tr>
</tbody>
</table>

The results in Table 14-7 show that security measures such as our specific version of random vehicle inspections ($13.21 million) and CCTV cameras ($12.13 million) have the highest total capital expenditure impacts, while our specific version of permanent closure of selected streets to traffic ($0.04 [.035] million) has the lowest capital expenditure effect. Assuming our version of
private operation of X-rays and magnetometers in building lobbies, the impact of their operating expenditure on GDP is found to be a negative -$0.66 million/year, while for CCTV cameras, operated by both the government (50%) and the private sector (50%), the GDP impact of their operating expenditures is a negative -$0.72 million/year. The negative operating impacts stem from the fact that operating cost increases translate into direct price increases, which in turn result in a price multiplier process that magnifies the price increases. These in turn stunt demand and lead to a decrease in production in the region. Overall, the largest impacts on GDP will stem from countermeasures with the largest capital costs, while the lowest, and potentially negative GDP impacts, will stem from countermeasures that have the lowest capital cost and that are operated by the private sector.

The difference in an economic consequence (impact) analysis (ECA), such as the one performed above, and a benefit-cost (BCA) analysis is an important distinction. In the former, only market goods and services are included. Even in the simulation of general equilibrium effects of spillovers in Chapter 18 are confined to those that can be translated into production impacts. A BCA would include all non-market impacts for producers and consumers, such as the value of time of a person who encountered delays at a traffic checkpoint (the value of time for trucking companies is in fact included because it relates to market transactions). It would also include the interest charge on the levelized annual capital cost. All general equilibrium effects on production stemming from the implementation of countermeasures are included in an economic consequence analysis. However, there is some debate about the extent of the general equilibrium effects that should be included in a BCA. On the cost side, it is suggested all impacts are legitimate, but they need to be interpreted properly in a BCA. For example, while the capital and operating expenditures promote an increase in GDP in the consequence analysis, they should be included only in the cost side in a BCA—they are not benefits in and of themselves. The benefits from the security measures are the risk reduction they provide. The reader should keep in mind that the security benefits of each countermeasure must be estimated separately and need not correspond to the cost rankings just summarized. The CGE model can be used to estimate the indirect benefits of this risk reduction.
14.4 Conclusions

This section has briefly introduced a computable general equilibrium model for the New York Metropolitan Region, and has applied it to analyzing the total economic impacts of capital and operating expenditures of specific terrorism security measures. Note that the results are somewhat sensitive to assumptions regarding the extent to which funds for capital equipment purchases are generated from within the region, thereby displacing other investments, or are attracted from outside the region in the form of externally financed investment or federal subsidies. The results are also sensitive to the extent to which cost increases can be passed along to consumers. The overall findings suggest that the general equilibrium effects accentuate the positive effects of capital investment on countermeasures on the regional economy but that general equilibrium effects of operating expenditures may have a dampening effect. The analysis has illustrated the usefulness of CGE modeling for this portion of an economic consequence analysis and a benefit-cost analysis of security measure implementation.

Again, we emphasize that the countermeasure versions studied here typically consider implementations at every street, every subway stop, or every building (rather than just some of these) and for application 24/7 (rather than periodically for possibly part of a day). It is not necessarily the case that the general equilibrium effect of a partial closure can be simply estimated from the effect of a full one, because the CGE model is inherently non-linear.
15 SUMMARY OF ATTACK SCENARIO DIRECT CONSEQUENCE COSTS

15.1 Introduction

The purpose of this chapter is to estimate the direct consequence costs, including property damage, casualties (that is, fatalities), and injuries, from five terrorist attack scenarios in the Lower Manhattan area (see Chapter 4). This is a key input in analyzing tradeoffs between urban security and its broader costs in the UCASS Project.

The methodology builds on statistical analysis of historical terrorism incident data in the Global Terrorism Database (GTD) maintained by the START Homeland Security Center (National Consortium for the Study of Terrorism and Responses to Terrorism, 2012). The direct loss data analysis is limited to incidents that occurred between January 1, 1970 and December 31, 2010 and to the information pertaining to the 17 countries shown in Figure 15.1.

Figure 15.1: Countries Chosen for Direct Loss Data Analysis

The definitions of the attack scenarios from Chapter 4 are repeated below:

**Mumbai Scenario:**
Several small teams of attackers shoot their way into a number of large office buildings and hotels surrounding the World Trade Center construction site and begin a killing rampage.

**Tokyo Scenario:**
In five coordinated attacks, perpetrators release a chemical agent on several lines of the New York City Metro and PATH (The Port Authority of New York and New Jersey) trains passing through Lower Manhattan and the World Trade Center Station.

**Madrid Scenario:**
During the peak of New York City rush hour, multiple explosions occur aboard New York Metro subway trains heading into Lower Manhattan. These include the 7th Avenue express and local, Lexington Avenue express and local, 8th Avenue express and local, Queens/Broadway/Brooklyn express and local, and Nassau Street express and local.

**London Scenario:**
Terrorists detonate a large bomb aboard a Manhattan express bus heading into Lower Manhattan, targeting civilians using New York’s public transportation system during the morning rush hour.

**Israel Scenario:**
A terrorist with explosives strapped to his chest detonates a bomb at a checkpoint at an entrance outside of the New York Stock Exchange.

An important step in this analysis is the mapping of the five chosen attack scenarios to the combinations of attack and target type characteristics of historical incidents in the GTD for the countries of interest. This mapping structure is presented in Figure 15.2. These characteristics formed the criteria for querying the GTD for this analysis.
Figure 15.2: Mapping Attack Scenarios to Combinations of Attack Types and Target Types from the GTD

15.2 Property Damage from Attack Scenarios in UCASS

The property damage loss estimates in GTD are reported in U.S. dollar amounts at the time of the incident (GTD, START, 2012). Incidents with a blank entry for property damage loss estimate were not included in the analysis. The remaining property damage loss estimates (for 2,854 incidents) were converted to millions of 2009 U.S. dollars using Gross Domestic Product (GDP) deflators for the countries where the incidents occurred (The World Bank, 2012), using an Excel Visual Basic for Applications (VBA) code.

The Kaplan-Meier estimate (Kaplan & Meier, 1958) of the cumulative distribution function (CDF) or the empirical CDF of property damage losses corresponding to the five attack scenarios (mapped to GTD) were generated in a Matrix Laboratory (MATLAB) environment. Figure 15.3 presents the result of this effort. Note that the horizontal axis is logarithmic, so that the unit represents a ten-fold increase in cost.
The expected property damage loss estimates for each attack scenario were computed (numerically in MATLAB) as the area above the empirical CDF curves in Figure 15.3. Table 15-1 presents the expected property damage loss estimates in millions of 2009 U.S. dollars for each attack scenario.

Table 15-1: Estimates of Property Damage Losses from the UCASS Attack Scenarios

<table>
<thead>
<tr>
<th>Attack Scenario</th>
<th>Expected Property Damage (M2009$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mumbai</td>
<td>3.351</td>
</tr>
<tr>
<td>Tokyo</td>
<td>0.021</td>
</tr>
<tr>
<td>Madrid</td>
<td>0.220</td>
</tr>
<tr>
<td>London</td>
<td>1.386</td>
</tr>
<tr>
<td>Israel</td>
<td>41.555</td>
</tr>
</tbody>
</table>

15.3 Casualties from Attack Scenarios in UCASS

The number of casualties for an incident is reported in the GTD. The incidents with a blank entry for the number of casualties were not included in the analysis. The remaining casualty numbers (corresponding to 15,306 incidents) were used in this study.
The Kaplan-Meier estimate of the CDF or the empirical CDF of number of casualties corresponding to the five attack scenarios (mapped to GTD) were generated in MATLAB. Figure 15.4 presents the result of this effort. Note that there is more than 50% probability of having no casualties for the different scenarios in Figure 15.4. This is because of the relatively high number of incidents with no casualties.

**Figure 15.4: Empirical CDF of Casualties from Attack Scenarios**

The expected number of casualties for each attack scenario was computed (numerically in MATLAB) as the area above the empirical CDF curves in Figure 15.4. According to the U.S. Department of Transportation (U.S. DOT, 2011) guidelines, the value of a statistical life (VSL) is 6.2 million in 2011 U.S. dollars. The expected casualty numbers for each attack scenario were multiplied by the VSL to generate expected casualty loss in 2011 U.S. dollars.

The expected casualty loss estimates were converted to 2009 U.S. dollars using the consumer price index (CPI) (U.S. Department of Labor, 2012). Table 15-2 presents the expected casualty losses in millions of 2009 U.S. dollars for each attack scenario.
Table 15-2: Estimates of Casualty Losses from the UCASS Attack Scenarios

<table>
<thead>
<tr>
<th>Attack Scenario</th>
<th>Expected Casualty Loss (M2009$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mumbai</td>
<td>2.996</td>
</tr>
<tr>
<td>Tokyo</td>
<td>6.451</td>
</tr>
<tr>
<td>Madrid</td>
<td>5.491</td>
</tr>
<tr>
<td>London</td>
<td>4.357</td>
</tr>
<tr>
<td>Israel</td>
<td>3.973</td>
</tr>
</tbody>
</table>

15.4 Injuries from Attack Scenarios in UCASS

The number of injuries for an incident is also reported in the GTD. Incidents with a blank entry for the number of injuries were not included in the analysis. The remaining injury numbers (corresponding to 13,700 incidents) were used in this study.

The Kaplan-Meier estimate of the CDF or the empirical CDF of number of injuries corresponding to the five attack scenarios (mapped to GTD) were generated in MATLAB. Figure 15.5 presents the result of this effort. The reason for more than 50% probability of no injuries for the different scenarios in Figure 15.5 is the inclusion of incidents with zero injuries in our dataset and a relatively high number of such incidents. Note that, like the property loss graph, the horizontal axis here is logarithmic.
The expected number of injuries for each attack scenario was computed (numerically in MATLAB) as the area above the empirical CDF curves in Figure 15.5. According to the U.S. Department of Transportation (U.S. DOT, 2011) guidelines, the expected injury value (computed as 20.28% of VSL) is 1.3 million in 2011 U.S. dollars. The expected injury numbers for each attack scenario were multiplied by the expected injury value to generate expected injury loss in 2011 U.S. dollars.

The expected injury loss estimates were converted to 2009 U.S. dollars using the consumer price index (CPI) (U.S. Department of Labor, 2012). Table 15-3 presents the expected injury losses in millions of 2009 U.S. dollars for each attack scenario.

Table 15-3: Estimates of Injury Losses from the UCASS Attack Scenarios

<table>
<thead>
<tr>
<th>Attack Scenario</th>
<th>Expected Injury Loss (M2009$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mumbai</td>
<td>1.024</td>
</tr>
<tr>
<td>Tokyo</td>
<td>700.309</td>
</tr>
<tr>
<td>Madrid</td>
<td>10.490</td>
</tr>
<tr>
<td>London</td>
<td>7.563</td>
</tr>
<tr>
<td>Israel</td>
<td>6.141</td>
</tr>
</tbody>
</table>
15.5 Summary

We summarize the estimates of direct consequence costs from attack scenarios in the Lower Manhattan area in Table 15-4. These estimates are based on statistical analysis of historical terrorism incident data in the GTD. The casualty and injury losses were monetized using U.S. DOT guidelines on VSL. As observed from the table, the highest total direct consequence cost is associated with the Tokyo scenario, followed by the Israel and Madrid scenarios.

Table 15-4: Estimates of Direct Consequence Costs from the UCASS Attack Scenarios

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mumbai</td>
<td>3.351</td>
<td>2.996</td>
<td>1.024</td>
<td>7.371</td>
</tr>
<tr>
<td>Tokyo</td>
<td>0.021</td>
<td>6.451</td>
<td>700.309</td>
<td>706.781</td>
</tr>
<tr>
<td>Madrid</td>
<td>0.220</td>
<td>5.491</td>
<td>10.490</td>
<td>16.202</td>
</tr>
<tr>
<td>London</td>
<td>1.386</td>
<td>4.357</td>
<td>7.563</td>
<td>13.306</td>
</tr>
<tr>
<td>Israel</td>
<td>41.555</td>
<td>3.973</td>
<td>6.141</td>
<td>51.668</td>
</tr>
</tbody>
</table>
16 BUSINESS INTERRUPTION IMPACTS OF TERRORIST ATTACKS ON THE NEW YORK METROPOLITAN REGION ECONOMY

This section presents the estimates of the total (direct and indirect) business interruption impacts for two terrorist attack scenarios on the New York Metro Economy. This is a key input in analyzing tradeoffs between urban security benefits and costs in the UCASS study. The economic consequences of a Mumbai-style scenario and a Tokyo-style scenario are analyzed in this chapter. These scenarios are defined in Chapter 4.

A computable general equilibrium (CGE) model, the state of the art approach to economic consequence analysis in general (Dixon & Rimmer, 2002) and to terrorism in particular (Rose, 2013), was employed for this analysis. CGE is a multi-market model of the behavioral responses of individual producers and consumers to changes in prices and other conditions, within the constraints of the availability of labor, capital, and natural resources. CGE models can be constructed for any region of interest. In this section, a model for the New York City Metropolitan Region, which consists of 14 counties in the states of New York, New Jersey, and Pennsylvania, is formulated. The vast majority of the multiplier, or general equilibrium, effects are contained within the New York Metro Region. This model was successfully applied in a major study of the economic impacts of the 9/11 World Trade Center attacks (Rose et al., 2009). For more on CGE, see Chapter 8.

The production loss estimates were computed for both partially (single building) and totally (entire blocks) affected areas.

16.1 Partially Affected Area: A Mumbai-Style Terrorist Attack

In this scenario, separate attacks on an office building, hotel, and financial institution are simulated. For the office, a building located on Greenwich Street, New York, NY 10007 was randomly chosen. Using information from Google Maps and Daftlogic.com, the number of floors and square footage for the building were estimated (see Figure 16.1).
Figure 16.1 Office Building Loss Area

Source: Daftlogic.com (2012).

It was assumed that in the office building the first six floors are occupied by offices from retail trade firms, and the rest of the 48 floors are shared equally between financial institutions and professional services firms. Thus, the area estimates for the office building are as follows:

**Office Building:**
Number of floors = 54
Area per floor = 38,395 ft²
Total area for the office building = 2,073,338.64 ft²

**Part 1 (Retail trade):**
Number of floors = 6
Area = 38395 ft²
Total area = 230,370.96 ft²

**Part 2 (Banks):**
Number of floors = 24
Area = 38395 ft²
Total area = 921,483.84 ft²

**Part 3 (Professional services):**
Number of floors = 24
Area = 38395 ft²
Total area = 921,483.84 ft²
For the case of the hotel, a Lower Manhattan hotel (West Street, New York, NY 10006), which is located close to the World Trade Center area, was randomly chosen. Google Maps and Daftlogic.com were used to estimate the number of floors and square footage for the hotel (see Figure 16.2).

**Figure 16.2: Hotel Loss Area**

![Hotel Loss Area](source.png)

Source: Daftlogic.com (2012).

The area estimates for the hotel building are as follows:

**Hotel:**
- Number of floors = 34
- Area per floor = 8,660 ft²
- Total area = 294,437.96 ft²

Finally, a large bank corporation building (Wall Street, New York, NY 10005) was randomly chosen as the financial institution for this analysis. The building has two parts – the first part has 20 floors, and the second one includes 25 floors. Google Maps and Daftlogic.com were used to estimate the number of floors and square footage for the bank as well (see Figure 16.3 and Figure 16.4).

**Figure 16.3: Financial Institution Area Loss for First Part of Bank**

![Financial Institution Area Loss for First Part of Bank](source.png)

Source: Daftlogic.com (2012).
Using this information, the area estimates for the financial institution are as follows:

**Office Building:**
Number of floors = 45
Total area for the office building = 498,440.9 ft²

**Part 1 (Bank):**
Number of floors = 20
Area = 18,917.43 ft²
Total area = 378,348.6 ft²

**Part 2 (Bank):**
Number of floors = 25
Area = 4,803.69 ft²
Total area = 120,092.3 ft²

For each building, the output loss in each of the economic sectors was computed by combining the estimates of affected areas with the per square foot output data available from HAZUS MH2.1 and MR4 (FEMA, 2012) (see Table 16-1). Since the latter are available in 1990 US dollars, the Producer Price Index was used to adjust it to 2006 US dollars. A four-month repair and reconstruction period following the terrorist attacks was assumed, during which the entire building is shut down. This was implemented by dividing the model’s standard annual loss estimates by a factor of 3.

---

106 As in the other chapters of this report, a single year was selected for reporting of aggregate costs. The results can be rescaled to other years, if desired.
Table 16-1: Direct Output Loss for Mumbai-Style Terrorist Attacks on the New York Metro Economy

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hotel</td>
<td>294,438</td>
<td>0.460</td>
<td>0.651</td>
<td>237.78</td>
<td>23,337,151</td>
</tr>
<tr>
<td>2. Bank</td>
<td>498,441</td>
<td>2.912</td>
<td>4.124</td>
<td>1505.25</td>
<td>250,092,831</td>
</tr>
<tr>
<td>3. Office building</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Retail trade</td>
<td>230,371</td>
<td>0.401</td>
<td>0.568</td>
<td>207.28</td>
<td>15,917,260</td>
</tr>
<tr>
<td>b. Banks</td>
<td>921,484</td>
<td>2.912</td>
<td>4.124</td>
<td>1505.25</td>
<td>462,354,718</td>
</tr>
<tr>
<td>c. Professional services</td>
<td>921,484</td>
<td>0.897</td>
<td>1.270</td>
<td>463.67</td>
<td>142,421,766</td>
</tr>
<tr>
<td>Total</td>
<td>2,073,339</td>
<td></td>
<td></td>
<td></td>
<td>620,693,744</td>
</tr>
</tbody>
</table>

The New York Metro Region computable general equilibrium model was employed to estimate the economic consequences of the Mumbai-style terrorist attack on the New York Metro Region economy. Simulation results of impacts on the New York Metro Region economy are summarized in Table 16-2.

In the first case, the direct impact of a terrorist attack on a large hotel in Lower Manhattan is simulated. The estimated direct loss in gross output is about $23 million. As shown in the table, the value added (net output) impact of a hotel attack has the smallest negative impact on the GDP of the Metro Region of the three scenarios. The effect of a terrorist attack on a financial institution in Lower Manhattan generates a reduction in gross output of $250 million. The GDP impacts of $216 million for this case are larger than in the hotel attack. Finally, in the multiple-use office building case, most sectors of the economy experience a general equilibrium output reduction, but the largest impacts are observed for the directly affected sectors. The total GDP reduction in the office building scenario is about twice as large as the total negative change in GDP in the bank case.

Similar multipliers for the bank and office building cases are observed, on the order of 1.19 and 1.23, respectively. These multipliers are computed as a ratio of the general equilibrium (total) change in net output (GDP, or value-added) and the direct loss in net output (GDP). It is interesting that in the hotel case the multiplier is much larger than in the other two cases. One
explanation is that the hotel sector price increases, while the bank sector price decreases. Price increases have the effect of exacerbating losses.

The reader should keep in mind that these economic loss estimates are the basis of the estimate of the benefits of a countermeasure’s ability to prevent these losses. However, for an accurate benefit estimate in a cost-benefit analysis or an economic consequence analysis, one must multiply the avoided losses by the probability of a successful attack. For a cost-benefit analysis, one juxtaposes these benefits against the various direct and indirect capital, operating and spillover costs of the countermeasure. For the economic consequence analysis, one simply adds these various components to yield a net impact on GDP.

**Table 16-2: Total Economic Consequences of Mumbai-Style Terrorist Attacks on the New York Metro Economy**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hotel</td>
<td>-23.34</td>
<td>-12.90</td>
<td>-89.37</td>
<td>6.93</td>
</tr>
<tr>
<td>2. Banking</td>
<td>-250.00</td>
<td>-181.41</td>
<td>-216.31</td>
<td>1.19</td>
</tr>
<tr>
<td>3. Office building (mix of sectors)*</td>
<td>-15.92</td>
<td>-11.67</td>
<td>-512.58</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td>-462.35</td>
<td>-335.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-142.42</td>
<td>-77.50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The mix is a combination of retail trade, banking, and professional services.

**16.2 Totally Affected Area: Tokyo-Style Terrorist Attack**

This scenario assumes a simultaneous release of chemical agent Sarin at five different locations in the area surrounding the World Trade Center. Five subway stations were randomly chosen and the Sarin threat zone estimates from Chapter 15 were used to define the total affected area for a Tokyo-style terrorist attack scenario. The radius for each location is determined from the affected region estimate of 0.179 km$^2$, which also accounts for possible changes in wind direction$^{107}$.

---

$^{107}$ The available models used in Chapter 15 do not include the complexities of wind-driven dispersal among large buildings, so that these estimates are illustrative, but not determinative.
A map of the affected region was then generated using the Geographic Information System (GIS tool available from the U.S. Census Bureau. As shown in Figure 16.5, the affected areas partially overlap. Therefore, the loss in employment will be less than it would be with more distant (distinct) attack locations. OnTheMap was also used to determine the number of jobs corresponding to the total affected area by 2-digit North American Industrial Classification System (NAICS) sectors.

**Figure 16.5: Affected Area for the Sarin Attack**

![Affected Area for the Sarin Attack](image)


Using the employment data from the OnTheMap tool (which are only available for an aggregated set of sectors), the output loss in each of the sectors was computed by combining the estimates of affected labor with the employment/output ratios available from the IMPLAN database (MIG, 2012) (see Table 16-3). A four-month decontamination/quarantine\(^{108}\) period following the terrorist attacks is assumed, thus requiring that the model’s standard annual loss estimates be divided by a factor of 3.

\(^{108}\) Sarin actually disperses and/or degrades quite rapidly. This period is an estimate of the reduction in productivity due to loss of workers or unwillingness to return to work. It can be scaled based on variant estimates of that impact.
Table 16-3: Direct Output Loss for Tokyo-Style Terrorist Attack Combinations on the New York Metro Economy

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Share</td>
<td>Total Employment Loss</td>
<td>Employment/Output</td>
</tr>
<tr>
<td>1. Agriculture, Forestry, Fishing and Hunting</td>
<td>4</td>
<td>0.00%</td>
<td>1.3</td>
<td>0.0000173</td>
</tr>
<tr>
<td>2. Mining, Quarrying, and Oil and Gas Extraction</td>
<td>0</td>
<td>0.00%</td>
<td>0.0</td>
<td>0.000021</td>
</tr>
<tr>
<td>3. Utilities</td>
<td>2</td>
<td>0.00%</td>
<td>0.7</td>
<td>0.000012</td>
</tr>
<tr>
<td>4. Construction</td>
<td>563</td>
<td>0.50%</td>
<td>187.7</td>
<td>0.000070</td>
</tr>
<tr>
<td>5. Manufacturing</td>
<td>265</td>
<td>0.20%</td>
<td>88.3</td>
<td>0.000019</td>
</tr>
<tr>
<td>6. Wholesale Trade</td>
<td>902</td>
<td>0.80%</td>
<td>300.7</td>
<td>0.000041</td>
</tr>
<tr>
<td>7. Retail Trade</td>
<td>3,479</td>
<td>3.20%</td>
<td>1159.7</td>
<td>0.000132</td>
</tr>
<tr>
<td>8. Transportation and Warehousing</td>
<td>738</td>
<td>0.70%</td>
<td>246.0</td>
<td>0.000081</td>
</tr>
<tr>
<td>9. Information</td>
<td>5,134</td>
<td>4.70%</td>
<td>1711.3</td>
<td>0.000026</td>
</tr>
<tr>
<td>10. Finance and Insurance</td>
<td>32,359</td>
<td>29.80%</td>
<td>10786.3</td>
<td>0.000029</td>
</tr>
<tr>
<td>11. Real Estate and Rental and Leasing</td>
<td>13,386</td>
<td>12.30%</td>
<td>4462.0</td>
<td>0.000026</td>
</tr>
<tr>
<td>12. Professional, Scientific, and Technical Services</td>
<td>13,967</td>
<td>12.90%</td>
<td>4655.7</td>
<td>0.000058</td>
</tr>
<tr>
<td>13. Management of Companies and Enterprises</td>
<td>5,048</td>
<td>4.70%</td>
<td>1682.7</td>
<td>0.000036</td>
</tr>
<tr>
<td>14. Administration &amp; Support, Waste Management</td>
<td>6,198</td>
<td>5.70%</td>
<td>2066.0</td>
<td>0.000123</td>
</tr>
<tr>
<td>15. Educational Services</td>
<td>671</td>
<td>0.60%</td>
<td>223.7</td>
<td>0.000144</td>
</tr>
<tr>
<td>16. Health Care and Social Assistance</td>
<td>5,112</td>
<td>4.70%</td>
<td>1704.0</td>
<td>0.000102</td>
</tr>
<tr>
<td>16. Arts, Entertainment, and Recreation</td>
<td>211</td>
<td>0.20%</td>
<td>70.3</td>
<td>0.000130</td>
</tr>
<tr>
<td>18. Accommodation and Food Services</td>
<td>2,207</td>
<td>2.00%</td>
<td>735.7</td>
<td>0.000129</td>
</tr>
<tr>
<td>19. Other Services (excluding Public Admin)</td>
<td>2,578</td>
<td>2.40%</td>
<td>859.3</td>
<td>0.000130</td>
</tr>
<tr>
<td>20. Public Administration</td>
<td>15,712</td>
<td>14.50%</td>
<td>5237.3</td>
<td>0.000105</td>
</tr>
</tbody>
</table>

a Economic activity for sectors such as Agriculture and Mining in New York City pertain to headquarters operations.

b The employment/output ratio is computed from the IMPLAN database.

The New York Metro Region computable general equilibrium model was used to estimate the economic consequences of the Tokyo-style terrorist attack on the New York Metro Region economy, as summarized in Table 16-4. The largest loss of output is in the Real Estate, Finance, Insurance, and Other Business Services sectors. The results also demonstrate that a Tokyo-style attack scenario will have a larger negative total impact on the Metro Region economy than any of the Mumbai-style scenarios. As shown in the table, the direct loss in gross output in 44 aggregated sectors of the New York Metro Region CGE model generates a $14.2 billion negative impact on the GDP of the Metro Region. Note that in this case the implicit multiplier value is 2.5.

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109 See also footnote 108.
Table 16-4: Total Economic Consequences of Tokyo-Style Terrorist Attacks on the New York Metro Economy

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agriculture</td>
<td>-0.08</td>
<td>-0.03</td>
<td>0.57</td>
</tr>
<tr>
<td>2. Other Mining</td>
<td>-0.08</td>
<td>-0.05</td>
<td>8.04</td>
</tr>
<tr>
<td>4. Food Processing</td>
<td>-2.78</td>
<td>-0.96</td>
<td>-5.54</td>
</tr>
<tr>
<td>5. Chemicals</td>
<td>-16.64</td>
<td>-3.82</td>
<td>-13.86</td>
</tr>
<tr>
<td>6. Petroleum Refining</td>
<td>-1.73</td>
<td>-0.10</td>
<td>-0.92</td>
</tr>
<tr>
<td>7. Other Non-Durable Manufacturing</td>
<td>-6.87</td>
<td>-2.35</td>
<td>39.27</td>
</tr>
<tr>
<td>8. Primary Metals</td>
<td>-0.89</td>
<td>-0.17</td>
<td>1.62</td>
</tr>
<tr>
<td>9. Ordnance</td>
<td>-0.02</td>
<td>-0.01</td>
<td>0.26</td>
</tr>
<tr>
<td>10. Electronics</td>
<td>-4.97</td>
<td>-0.53</td>
<td>-1.19</td>
</tr>
<tr>
<td>11. Other Durable Manufacturing</td>
<td>-12.43</td>
<td>-5.70</td>
<td>13.46</td>
</tr>
<tr>
<td>12. Air Transport</td>
<td>-6.24</td>
<td>-2.86</td>
<td>9.35</td>
</tr>
<tr>
<td>14. Water Transport</td>
<td>-1.90</td>
<td>-0.46</td>
<td>-4.10</td>
</tr>
<tr>
<td>15. Rail Transport</td>
<td>-0.49</td>
<td>-0.22</td>
<td>-0.46</td>
</tr>
<tr>
<td>16. Other Transport</td>
<td>-11.65</td>
<td>-9.24</td>
<td>-188.41</td>
</tr>
<tr>
<td>17. Private Transit</td>
<td>-4.23</td>
<td>-2.75</td>
<td>-3.56</td>
</tr>
<tr>
<td>18. Communications</td>
<td>-379.55</td>
<td>-148.76</td>
<td>-265.78</td>
</tr>
<tr>
<td>20. Private Electric Utilities</td>
<td>-0.42</td>
<td>-0.35</td>
<td>182.13</td>
</tr>
<tr>
<td>21. Gas Utilities</td>
<td>-0.11</td>
<td>-0.03</td>
<td>33.56</td>
</tr>
<tr>
<td>22. Private Water Utilities (Retail)</td>
<td>-0.01</td>
<td>-0.01</td>
<td>4.19</td>
</tr>
<tr>
<td>23. Sanitary Services</td>
<td>-0.02</td>
<td>-0.01</td>
<td>5.48</td>
</tr>
<tr>
<td>24. Wholesale Trade</td>
<td>-72.71</td>
<td>-36.78</td>
<td>1,508.40</td>
</tr>
<tr>
<td>25. Retail Trade</td>
<td>-87.91</td>
<td>-64.46</td>
<td>1,210.79</td>
</tr>
<tr>
<td>26. Real Estate</td>
<td>-1,741.70</td>
<td>-1,318.48</td>
<td>-8,367.52</td>
</tr>
<tr>
<td>27. Finance Banking and Credit</td>
<td>-1,224.32</td>
<td>-888.40</td>
<td>-2,144.11</td>
</tr>
<tr>
<td>29. Insurance</td>
<td>-776.21</td>
<td>-355.54</td>
<td>-600.53</td>
</tr>
<tr>
<td>30. Owner Occupied Dwellings</td>
<td>0.00</td>
<td>0.00</td>
<td>354.77</td>
</tr>
<tr>
<td>31. Hotel and Restaurants</td>
<td>-57.24</td>
<td>-31.64</td>
<td>-36.91</td>
</tr>
<tr>
<td>32. Personal Services</td>
<td>-65.92</td>
<td>-39.82</td>
<td>-43.08</td>
</tr>
<tr>
<td>33. Veterinary Services</td>
<td>-4.47</td>
<td>-1.63</td>
<td>-1.96</td>
</tr>
<tr>
<td>34. Waste Management Remediation</td>
<td>-167.67</td>
<td>-68.60</td>
<td>-156.21</td>
</tr>
<tr>
<td>35. Other Business Services</td>
<td>-1,257.45</td>
<td>-684.21</td>
<td>-1,687.88</td>
</tr>
<tr>
<td>38. Medical Services</td>
<td>-137.02</td>
<td>-93.40</td>
<td>-110.81</td>
</tr>
<tr>
<td>39. Other Health &amp; Social Services</td>
<td>-29.92</td>
<td>-21.16</td>
<td>-1,217.08</td>
</tr>
<tr>
<td>40. Federal State Local Electric Utilities</td>
<td>-5.78</td>
<td>-3.31</td>
<td>-15.25</td>
</tr>
<tr>
<td>41. Local Public Transportation</td>
<td>-4.28</td>
<td>-1.88</td>
<td>-1.89</td>
</tr>
<tr>
<td>42. Federal State Local Water Utilities (Wholesale)</td>
<td>-21.84</td>
<td>-7.55</td>
<td>-23.94</td>
</tr>
<tr>
<td>43. Federal Military</td>
<td>-20.36</td>
<td>-20.36</td>
<td>-23.13</td>
</tr>
<tr>
<td>44. Other Government</td>
<td>-140.97</td>
<td>-103.60</td>
<td>-126.35</td>
</tr>
<tr>
<td>45. State-Local Government</td>
<td>-304.80</td>
<td>-304.80</td>
<td>-555.55</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>-8,580.15</strong></td>
<td><strong>-5,769.18</strong></td>
<td><strong>-14,173.99</strong></td>
</tr>
</tbody>
</table>
16.3 Conclusion

This chapter has briefly analyzed the total economic impacts of Mumbai and Tokyo style terrorist attacks on the New York Metro Region Economy. The analysis has shown that, out of the three Mumbai-style attacks, the scenario attack on a general-purpose office building had the largest negative impact on the GDP of the Metro Region. This can be explained by the following factors. First, the area occupied by the hotel and bank is about 15% and 25%, respectively, of the area of the general purpose office building. Second, the annual output per square foot is larger for office buildings than for the other two types of buildings. Accordingly, the total output loss is the largest in the office building scenario.

It was also found that a Tokyo-style attack scenario would have a larger negative impact on the Metro Region economy than any of the Mumbai-style scenarios, primarily because it involves a large land area\textsuperscript{110}. The analysis has also indicated that the largest share of this negative GDP impact will be generated by the most directly affected sectors, such as the real estate, finance, insurance, and other business services sectors.

This analysis has demonstrated the usefulness of CGE modeling for the analysis of direct and indirect business interruption impacts of a terrorist attack on the Metro Region economy. As we have noted, these economic loss estimates are the basis of the estimate of the benefits of a countermeasure’s ability to prevent these losses. However, for an accurate benefit estimate in a cost-benefit analysis or an economic consequence analysis, one must multiply the avoided losses by the probability of the occurrence of a successful attack. These estimates are discussed in Chapter 19. The reader is reminded that the specific estimates made here, for each type of attack, will be influenced by many factors not considered here, such as the effect of the urban landscape on sarin dispersal, and, most importantly, the human behavior of leaders and citizens whose lives are disrupted by the attacks.

\textsuperscript{110} See also footnote 108
17 PRESERVATION VALUE OF FOUR ICONIC NEW YORK CITY BUILDINGS

This chapter estimates the iconic or preservation value, a non-market value, of four iconic buildings in New York City: the New York Stock Exchange, Trinity Church, New York City Hall, and the South Street Seaport. The major methods for determining non-market values are outlined, the benefit transfer method is detailed and applied to these buildings. The results are discussed in a concluding section.

17.1 Methods of Non-Market Valuation

Non-market valuation involves estimating the values of goods and/or services that are not commonly traded in markets. While well-functioning markets give clear signals as to the value of goods and services, some goods and services, or aspects of goods and services, are not readily priced in conventional ways. Traditionally, non-market valuation has been used to determine the values of environmental goods and services for which there are no markets (e.g., clean air, scenic views, national parks). More recently, the method has been applied to the built environment, in cases where market prices do not capture the entirety of the building’s value. Some examples include cultural values for museums (Boter et al., 2005) and heritage houses (Deodhar, 2004) and historic values for very old buildings (Grosclaude & Sogel, 1993). There are several major methods for determining non-market values: contingent valuation, choice models, hedonics and travel costs. Contingent valuation and choice modeling are examples of stated preference methods, which rely on surveys in which respondents are asked to state their willingness to pay for a non-market good or service. Hedonics and travel costs are examples of revealed preference methods, which rely on statistical inferences about actual purchases people have made within markets.

Contingent valuation relies on surveys that directly ask participants for their willingness to pay for a non-market good or service (Boyle, 2003; NOAA, 1993). Surveys are carefully constructed to clearly define the good or service in question and to identify a relevant physical change (qualitative or quantitative) in the good or service. For example, a survey may ask respondents how much they would pay for a specific increase in the quality of a recreational site in a state park. While the validity and reliability of contingent valuation is sometimes debated in academic literature (cf., Andreoni, 1989), it is currently an accepted technique among practitioners,
including US government agencies conducting cost-benefit analysis. The primary limitations of a contingent valuation study are the time and costs of developing and pre-testing a survey, and the costs of collecting and analyzing data.

Choice modeling was developed more recently and allows for estimation of economic values for individual attributes of a good or service (Ben-Akiva & Lerman, 1989). Like contingent valuation, it relies on surveys in which participants are directly asked about their preferences. Unlike contingent valuation, however, choice modeling asks individuals to choose between different bundles of attributes, including a price\textsuperscript{111}. Through econometric techniques (usually conditional logit analysis, a form of discrete choice modeling), a willingness to pay for each attribute is determined, based on survey responses. Choice modeling is considered a more reliable technique than contingent valuation in terms of controlling for strategic behavior or hypothetical bias by survey respondents (Carlsson & Martinsson, 2001). Like contingent valuation, however, the primary limitations are the time and costs associated with survey design, testing, and with data analysis.

The hedonic method takes advantage of heterogeneous goods whose characteristics differ in distinct ways even though they are sold in the same market (Taylor, 2003; Boyle et al., 1999). The variation in product characteristics is associated with variations in prices in the market. These variations can be used to determine the value of a particular characteristic by examining the price differences between products differing only by that characteristic. For instance, in a single housing market, some houses may be closer to parks or other open space. The value of proximity to open space can be estimated by examining many houses that are similar in all other attributes (square feet, number of rooms, etc.) and differ only in their proximity to parks. This allows one to calculate the indirect value of parks or open space. The primary limitation of a hedonic study is the availability of data on a wide enough variety of the heterogeneous goods in question. To apply this method to iconic buildings would require real estate values for buildings that were very similar to each other in every way except for their iconic nature. For the buildings in this study, such data are not likely to be available because each is somewhat unique in more than one attribute above and beyond its iconic nature and therefore it would be difficult to isolate the non-market value associated with the iconicity.

\textsuperscript{111} A related technique used in market analysis is called conjoint analysis.
The travel cost method is a demand-based model for determining non-market values that is primarily applied to the valuation of recreation sites (Parsons, 2003; Ward & Beal, 2000). The basic premise is that peoples’ willingness to pay for a recreation site can be correlated to the expenses they incur in order to visit that site. These data are gathered via on-site or off-site surveys. Some limitations of the travel cost method include difficulties in apportioning travel costs for multi-purpose trips, and difficulties in determining the value of travel time (it is conventional to use a person’s wage rate, but if he or she enjoys the trip then travel time becomes a benefit rather than a cost). Additionally, like the stated preference methods, the travel cost method requires time consuming and potentially extensive survey development and implementation.

Given the time, costs and data limitations of the methods described above, the analysis in this chapter uses a benefit transfer method of evaluating non-market values. This method circumvents the expenses of data collection by transferring data from other studies to the site, entity, or policy being evaluated, and applying corrections for socio-demographic differences between the two sites. The following section describes the method in detail.

17.2 The Benefit Transfer Method

Benefit transfer is the transposition of monetary values, calculated at a study site through market or non-market based economic valuation techniques, to a policy site (Brouwer, 2000). This involves transferring information and assumptions from one context to address policy questions in another. Information transfer is not new to economics or many other disciplines, but what is considered unique about benefit transfers is that it uses data that it claims are sensitive to changes in the context under which they were collected (Morrison et al., 2002). Benefit transfer is considered to be valid in theory, as long as site characteristics are reasonably similar and adjustments for aspects such as socioeconomic characteristics and geographic distribution of the population are taken into account (Leon et al., 2003). Benefit transfers are generally used because they are less expensive in time and money than empirical studies.

There are three types of benefit transfer: direct benefit transfers (or value transfers), function transfers and meta-analysis. Benefit function transfer involves transfer of the demand function or value (of the object of study) function obtained from a valuation study, while direct benefit
transfer involves the transfer of average unit values from one or more studies to a policy site. Meta-analysis involves using multiple demand functions from several studies, which are then fitted to characteristics of a policy site. Although most authors agree that benefit function transfer and meta-analysis are preferred to direct benefit transfer, the latter is often used because in many cases the benefit function is not available for the policy site (Kirchoff et al., 1996; Loomis, 1992).

There is no consensus in the literature as to the validity of benefit transfers. Several studies have explored the validity of benefit transfers. Kirchoff et al. (1996) test the performance of two types of benefit transfer: benefit function transfer and direct benefit transfer and draw conclusions on the validity and usefulness of each. They found that transfer errors ranged from a very acceptable 2% to a high of 224%. Barton (2002) examined coastal water quality improvements in Costa Rica and tested several hypotheses for benefit transfer reliability. He found that transfer errors converged around the plus or minus 30%, which is within the generally accepted level of error for policy makers (plus or minus 50%). Brouwer (2000) examined the validity of environmental benefit transfer as a decision support tool. He surveyed seven benefit transfer studies, finding errors ranging from 1% to 475%.

There are several steps involved in conducting a benefit function transfer analysis. The first involves identifying the policy context, including the attributes of the policy site. The second step is to identify other research that is potentially relevant to the policy site and identify a value function to be used for the benefit transfer. The third step is to gather data on the policy site for as many of the variables in the value function as possible. The fourth step is to predict the policy site benefits by multiplying the regression coefficients from the value function by the summary statistics collected for the policy site. The final step is to aggregate the new estimate by multiplying it by the total population.

**17.3 Data and Analysis**

For this analysis, a benefit function transfer was conducted because transfer errors by this method are generally smaller. There were not enough candidate studies identified to support a meta-analysis. Almost 20 valuation studies were identified, which involved cultural, historic or preservation values of buildings. When analyzed as candidate transfer studies; however, many of
these were eliminated because the good in question was too different from the iconic buildings used for this study (for instance, one study calculated the preservation values of submerged shipwrecks), and/or the demographic and cultural characteristics were too different (for instance, many studies were valuations of very old and culturally significant buildings in Eastern and Western Europe).

Ultimately, a study by Chambers et al. (1998) was selected as most suitable given the nature of the non-market value used in the study and some demographic similarities. The primary drawback to using this study was that the value function only allows for correction for demographic differences and not for heterogeneity in the buildings themselves. Even though the two buildings are very different, the same willingness to pay estimates will be used for each.

The Chambers study was a contingent valuation study of a historic academy in Missouri. The authors surveyed both urban and rural residents who might potentially visit the academy, which was built in 1810, or who would at least be aware of its existence. The survey included a willingness to pay question, several demographic questions and questions about the respondents’ interest, visits to, knowledge of, and concern for the academy. They found a mean willingness to pay of $6.48 per person. When aggregated up to the entire population, the total willingness to pay ranged from $560,000 to $1,270,000 (based on 95% confidence intervals). The market value of the building is just $55,000, making the non-market value at least 10 times greater than the market value.

Using the estimated coefficients from the Chambers value function, the values were first corrected for inflation, and then a policy site multiplier was applied (see Table 17-1). The policy site multiplier is the demographic correction of the study site estimates for our policy site. In the Chambers value function the meaning of the variables is: income means median income; sex is the male percentage of the population; age is the mean age of the population; education is the mean number of years of education, and family size is the mean number of people in the household. The variable called concern represents the level of concern for the preservation of the building, asked as a three-level Likert scale question (not concerned, somewhat concerned and very concerned). The mean value of this variable in the Chambers study was 1.53. For
UCASS, a value of 1.5 was used, as the data are not available, and this is a plausible lower bound.

The mean values of these variables for the policy site (New York) are multiplied by the inflation corrected transfer site coefficients. This calculation delivers a partial willingness to pay (WTP) for each variable in the value function. When summed, they yield a mean WTP for preserving one of the four iconic buildings in New York City. In Table 17-1, the population of interest is New York City. Demographic data are drawn from the 2010 Census. The mean willingness to pay for preserving one of the four iconic buildings in New York City is $21.86 per person. Aggregating this value to the entire population of New York City results in $178,724,475 for total willingness to pay for a single building. Multiplying this by all four buildings yields $714,897,900.

Table 17-1: NYC Mean Willingness to Pay for Preserving an Iconic Building

<table>
<thead>
<tr>
<th>Variable</th>
<th>Transfer Site Regression Coefficient</th>
<th>Inflation Correction</th>
<th>Policy Site Multiplier</th>
<th>Partial WTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-27.27</td>
<td>-40.621392</td>
<td>1</td>
<td>-40.621392</td>
</tr>
<tr>
<td>Income</td>
<td>0.00024</td>
<td>0.000357504</td>
<td>48743</td>
<td>17.42581747</td>
</tr>
<tr>
<td>Sex</td>
<td>-11.75</td>
<td>-17.5028</td>
<td>0.475</td>
<td>-8.31383</td>
</tr>
<tr>
<td>Age</td>
<td>0.0051</td>
<td>0.00759696</td>
<td>35.5</td>
<td>0.26969208</td>
</tr>
<tr>
<td>Education</td>
<td>1.26</td>
<td>1.876896</td>
<td>13.183</td>
<td>24.74311997</td>
</tr>
<tr>
<td>Concern</td>
<td>19.63</td>
<td>29.240848</td>
<td>1.5</td>
<td>43.861272</td>
</tr>
</tbody>
</table>

| WTP       | $21.86 |

Some assumptions are adjusted to create low- and high-end estimates of willingness to pay. For instance, it is assumed that the population of interest consists only of those over the age of 16 (those potentially in the work force). The level of concern is also adjusted to 2.5, because it is reasonable that the level of concern for these iconic buildings in New York City is higher than the concern for a historic academy in Missouri. Table 17-2 provides a summary of the range of values obtained by adjusting these assumptions. The low-end estimate, therefore, for one building is $144,625,842 or $578,503,368 for all four. The high-end estimate is $417,772,296 for one building or $1,671,089,184 for all four.
Table 17-2: NYC Sensitivity Analysis

<table>
<thead>
<tr>
<th>Concern</th>
<th>Total Population</th>
<th>Over 16 YOA only</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>$178,724,475</td>
<td>$144,625,842</td>
</tr>
<tr>
<td>x4 buildings</td>
<td>$714,897,900</td>
<td>$578,503,368</td>
</tr>
<tr>
<td>2.5</td>
<td>$417,772,296</td>
<td>$338,066,011</td>
</tr>
<tr>
<td>x4 buildings</td>
<td>$1,671,089,184</td>
<td>$1,352,264,044</td>
</tr>
</tbody>
</table>

We note that although the method is a sound and established one, the magnitude of the result is astonishingly high. It is not, for example, proposed that “the population of New York City would be willing to pay nearly 150 million dollars to remediate the loss of these four buildings.”

Using only New York City as the population of concern may be an underestimate. The Chambers study included the population of St. Louis (64 miles from the site of the historic academy), as well as the population local to the site. In the same spirit, the population for this analysis can be expanded to include the New York-New Jersey-Pennsylvania Metropolitan area, and the willingness to pay re-estimated using this region. Table 17-3 shows the willingness to pay estimates for this “New York Metro Region” Area. Mean willingness to pay for preserving one of the four iconic buildings is $28.54. Aggregating this value up to the whole population results in $539,605,941 for total willingness to pay for a single building. Multiplying this by all four buildings gives $2,158,423,767. Of course the caveat mentioned above applies with even greater force to this extended conclusion.

Table 17-3: NY-NJ-PA Metro Region Mean Willingness to Pay for Preserving an Iconic Building

<table>
<thead>
<tr>
<th>Variable</th>
<th>Transfer Site Regression Coefficient</th>
<th>Inflation Correction</th>
<th>Policy Site Multiplier</th>
<th>Partial WTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-27.27</td>
<td>-40.621392</td>
<td>1</td>
<td>-40.621392</td>
</tr>
<tr>
<td>Income</td>
<td>0.00024</td>
<td>0.000357504</td>
<td>50795</td>
<td>18.15941568</td>
</tr>
<tr>
<td>Sex</td>
<td>-11.75</td>
<td>-17.5028</td>
<td>0.483</td>
<td>-8.4538524</td>
</tr>
<tr>
<td>Age</td>
<td>0.0051</td>
<td>0.00759696</td>
<td>37.9</td>
<td>0.287924784</td>
</tr>
<tr>
<td>Education</td>
<td>1.26</td>
<td>1.876896</td>
<td>14.62</td>
<td>27.44021952</td>
</tr>
<tr>
<td>Family Size</td>
<td>-3.07</td>
<td>-4.573072</td>
<td>2.65</td>
<td>-12.1186408</td>
</tr>
<tr>
<td>Concern</td>
<td>19.63</td>
<td>29.240848</td>
<td>1.5</td>
<td>43.861272</td>
</tr>
</tbody>
</table>

WTP $28.55
Table 17-4 shows the results of the sensitivity analysis for the NY-NJ-PA Metropolitan Area. Our low-end estimate, therefore, for one building is $455,967,018 or $1,823,868,072 for all four. Our high-end estimate is $1,092,173,433 for one building or $4,368,693,735 for all four.

**Table 17-4: NY-NJ-PA Metro Region Sensitivity Analysis**

<table>
<thead>
<tr>
<th>Concern = 1.5</th>
<th>Total Population</th>
<th>Over 16 YOA only</th>
</tr>
</thead>
<tbody>
<tr>
<td>x4 buildings</td>
<td>$2,158,423,767</td>
<td>$1,823,868,072</td>
</tr>
<tr>
<td>Concern = 2.5</td>
<td>$1,092,173,433</td>
<td>$922,886,545</td>
</tr>
<tr>
<td>x4 buildings</td>
<td>$4,368,693,735</td>
<td>$3,691,546,182</td>
</tr>
</tbody>
</table>

**17.4 Conclusion**

The analysis above arrives at a range of possible non-market values for iconic buildings in New York City. The low end is $144.6 million and the high end is $1,092.2 million for a single building. To put this in the context of the market values of these buildings, the market values for two buildings, Trinity Church and the New York Stock Exchange, were estimated based on their total square footage, which was calculated using Daftlogic (2012) and mean price per square foot of commercial space in Manhattan. The mean price per square foot, according to an industry report is $431 for the first half of 2012 (RPG, 2012). The resulting market value of Trinity Church was estimated to be $7,917,780, and the New York Stock Exchange building’s market value was estimated to be $135,638,588. Like the Chambers study, this analysis shows the non-market value of these four iconic buildings to be higher than the market value of these buildings, (in the case of the New York Stock Exchange and our low-end estimate for New York City residents) and possibly much higher if high-end estimates are used (up to 138 times larger than the market value in the case of Trinity Church using our high-end estimates).

While these analyses show that iconic values are estimated to be “of the same order of magnitude” as the market value of the land on which the buildings stand (assuming it were to be exploited for commercial use), it is not recommended that these iconic values be summed with other estimates of loss.
18 IMPACTS OF COUNTERMEASURE SPILLOVERS ON THE NEW YORK METROPOLITAN REGION ECONOMY

Terrorism countermeasures have several direct and indirect costs and benefits, as analyzed in the previous chapters of this report. However, their implementation also generates complicated “spillover effects,” both positive and negative. These include adverse impacts stemming from traffic delays, inconvenience, and invasion of privacy. It is also possible that security measures could improve the general business environment, apart from the above, if people feel safer from terrorism or criminal activity. It is also possible, however, that the change in the business environment might be negative if the personal spillover effects discourage sightseeing, shopping, job seeking, or other investments in the affected areas.

In this chapter, the direct and indirect impacts of spillover effects on the New York Metro Region Economy are examined. This is a key input in analyzing tradeoffs between urban security benefits and costs in the UCASS study. In this chapter, we select three security measures (i.e., random vehicle inspections, CCTV, and subway bag and parcel searches) in Lower Manhattan, and analyze the impacts of their spillover effects using the computable general equilibrium (CGE) model described in Chapter 8. As described in Chapters 4 and 14, we consider very specific versions of the countermeasures considered in UCASS, to illustrate the method.

The direct effects of countermeasure spillovers are calculated using the data collected from the online survey, which was described in Chapter 6 and analyzed in Chapter 13. Specifically, these relate to changes in the business environment, inconvenience/delay, and invasion of privacy. The results are then incorporated into the computable general equilibrium (CGE) model to determine the broader economic impacts of these three types of spillover effects.

Changes in the business environment are measured in terms of increases or decreases in business activity in a selected set of sectors, which stimulate various quantity and price interactive multiplier effects. Delays in relation to business activity are entered into the CGE model as increases in transportation costs, which also have general equilibrium impacts, as these cost increases are passed along as a set of successive rounds of price increases. Inconvenience and
invasion of privacy are incorporated into the model’s individual utility functions. This does not have an effect on GDP, but it does have an effect on measures of economic welfare (i.e., well-being) that include non-market considerations. Note that the results presented below are, intended to demonstrate the methodology rather than to provide definitive estimates of spillover effects.

The analysis of spillover effects considers three countermeasures:

1. Random Vehicle Inspections: This involves a perimeter of entry/exit checkpoints around Lower Manhattan for random searches. This countermeasure is likely to cause inconvenience, invasion of privacy, and delays.

2. Closed-Circuit Television (CCTV) Cameras: An additional 1,700 CCTV to be installed throughout Lower Manhattan to monitor suspicious activity or actual events, and improve incident response. In general, this countermeasure should not cause delays or inconvenience, but may represent an invasion of privacy to some people.

3. Subway Bag and Parcel Searches: This involves random inspections at rail and subway stations heading in and out of Lower Manhattan. It also involves the use of bomb-sniffing dogs and explosive detection technology. This countermeasure is likely to cause inconvenience, invasion of privacy, and delays.

18.1 Total Economic Impacts of Business Environment Spillover Effects

Table 18.1 repeats the results of the survey analysis of business owners regarding their estimate of likely direct changes in the business environment for three countermeasures: random vehicle inspections, closed-circuit television cameras (CCTV), and subway bag and parcel searches. Overall, these data indicate that random vehicle inspections and subway bag and parcel searches have a negative direct effect on the business environment, while CCTV has a positive direct effect.¹¹² These results are not surprising. The searches are obtrusive and invasive. Any feelings of greater safety are apparently more than offset by the negative side effects. On the

¹¹² One control question relating to CCTV was also included in the questionnaire. This asked respondents about the likely impact on the business environment of removal of existing CCTV. The overall result for this question was, as expected, that it would detract from the business environment.
other hand, CCTV is non-obtrusive, and it appears that invasion of privacy is minimal, in part perhaps because surveillance cameras are now so commonplace and because, in this case, they are placed in public areas. Hence, there is little offset to the feeling of enhanced security for the CCTV countermeasure.

The estimated mean fractional change in business revenue stemming from the change in the business environment for each countermeasure is based on effects on the following sectors: Retail and Wholesale Trade, Finance, Education, and Service. These are the only sectors related to street traffic in Lower Manhattan.\textsuperscript{113} For each countermeasure we compute a weighted average effect using the mean percentage estimated change in business revenue, with the weights derived from the number of respondents\textsuperscript{114} (see Table 18-1).

<table>
<thead>
<tr>
<th>Countermeasure: Random Vehicle Inspections</th>
<th>Min</th>
<th>Median</th>
<th>Mean</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase (N=10)</td>
<td>0.05%</td>
<td>7.50%</td>
<td>12.75%</td>
<td>37.50%</td>
</tr>
<tr>
<td>No Change (N=29)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Decrease (N=99)</td>
<td>-3%</td>
<td>-17.50%</td>
<td>-19.61%</td>
<td>-50%</td>
</tr>
<tr>
<td>Weighted Average</td>
<td>-</td>
<td>-</td>
<td>-13.14%</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Countermeasure: CCTV</th>
<th>Min</th>
<th>Median</th>
<th>Mean</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase (N=21)</td>
<td>0.05%</td>
<td>7.50%</td>
<td>10.60%</td>
<td>37.50%</td>
</tr>
<tr>
<td>No Change (N=28)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Decrease (N=2)</td>
<td>-3.00%</td>
<td>-5.25%</td>
<td>-5.25%</td>
<td>-7.50%</td>
</tr>
<tr>
<td>Weighted Average</td>
<td>-</td>
<td>-</td>
<td>4.16%</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Countermeasure: Subway Bag and Parcel Searches</th>
<th>Min</th>
<th>Median</th>
<th>Mean</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase (N=8)</td>
<td>3.00%</td>
<td>7.50%</td>
<td>12.06%</td>
<td>37.50%</td>
</tr>
<tr>
<td>No Change (N=43)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Decrease (N=85)</td>
<td>-0.05%</td>
<td>-7.50%</td>
<td>-14.70%</td>
<td>-50.00%</td>
</tr>
<tr>
<td>Weighted Average</td>
<td>-</td>
<td>-</td>
<td>-8.48%</td>
<td>-</td>
</tr>
</tbody>
</table>

*Source: Chapter 13*

\textsuperscript{a}Pertains only to Retail and Wholesale Trade, Education, and Service sectors.

\textsuperscript{113} We exclude activity of the Finance, Insurance and Real Estate sectors because, while many offices are located in this area, the prevalence of internet transactions on the one hand, and the importance of Lower Manhattan locations for high-level meetings on the other, suggest that the business environment for these sectors will not be affected.

\textsuperscript{114} A more accurate estimate would weight the sectors according to their contribution to the economy of Lower Manhattan.
The direct changes in spending shown in the final columns of Table 18-2 to Table 18-4 are entered into the CGE model as changes in the household final demand (increased personal consumption expenditures) to determine the indirect, or general equilibrium, economic impacts. For the case of random vehicle inspections, the weighted average direct percentage decrease of 13.14% in demand leads to -$1.7 billion per year (see Table 18-2). This leads to a total (direct plus indirect) impact of -$2.9 billion per year on the GDP of the New York Metro Region (See Table 18-5). Note that the multiplier value in the right-hand column of Table 18-5 is on the order of 2.6. As in other estimating simulations, CGE multipliers are lower than the corresponding input-output model multipliers, in this case because decreased business activity also has the effect of lowering prices, which, in turn offsets some of the drop in demand.

For the CCTV countermeasure, the weighted average direct percentage increase of 4.16% in demand amounts to $545 million per year (see Table 18-3). This leads to a total GDP impact of $1.1 billion per year (see Table 18-5). The corresponding multiplier is on the order of 3.2. As for the preceding simulation, the CGE multiplier differs from the I-O multiplier, in this case due to increased business activity and its effect on prices. These results are not surprising, because CCTV is not intrusive in the ordinary sense of affecting everyday activities of the average citizen. At the same time this surveillance service is likely to decrease terrorism and crime.

Table 18-2: Direct Impacts of Random Vehicle Inspection Spillover Effects on Business Revenue of the New York Metro Region Economy

<table>
<thead>
<tr>
<th>NYCGE Sectors</th>
<th>NAICS Sectors</th>
<th>Percent Change in LM Demand by NAICS</th>
<th>Percent Change in LM Demand by NYCGE</th>
<th>Percent of LM Employment in NY Metro Employment</th>
<th>Percent Change in NYCGE Demand</th>
<th>Level of Change (in million 2006 dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Retail Trade</td>
<td>44-45</td>
<td>-13.14</td>
<td>-13.14</td>
<td>2.23</td>
<td>-0.29</td>
<td>-327</td>
</tr>
<tr>
<td>5. Veterinary Services</td>
<td>54</td>
<td>-13.14</td>
<td>-13.14</td>
<td>2.07</td>
<td>-0.27</td>
<td>-6</td>
</tr>
<tr>
<td>11. Social Services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>-13.14</td>
<td>-13.14</td>
<td>3.02</td>
<td>-0.40</td>
<td>-1,720</td>
</tr>
</tbody>
</table>
### Table 18-3: Direct Impacts of CCTV Spillover Effects on Business Revenue of the New York Metro Region Economy

<table>
<thead>
<tr>
<th>NYCGE Sectors</th>
<th>NAICS Sectors</th>
<th>Percent Change in LM Demand by NAICS</th>
<th>Percent Change in LM Demand by NYCGE</th>
<th>Percent of LM Employment in NY Metro Employment</th>
<th>Percent Change in NYCGE Demand</th>
<th>Level of Change (in million 2006 dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wholesale Trade</td>
<td>42</td>
<td>4.16</td>
<td>4.16</td>
<td>1.59</td>
<td>0.07</td>
<td>39</td>
</tr>
<tr>
<td>2. Retail Trade</td>
<td>44-45</td>
<td>4.16</td>
<td>4.16</td>
<td>2.23</td>
<td>0.09</td>
<td>103</td>
</tr>
<tr>
<td>3. Hotel and Restaurants</td>
<td>72</td>
<td>4.16</td>
<td>4.16</td>
<td>4.98</td>
<td>0.21</td>
<td>102</td>
</tr>
<tr>
<td>4. Personal Services</td>
<td>81</td>
<td>4.16</td>
<td>4.16</td>
<td>8.64</td>
<td>0.36</td>
<td>48</td>
</tr>
<tr>
<td>5. Veterinary Services</td>
<td>54</td>
<td>4.16</td>
<td>4.16</td>
<td>2.07</td>
<td>0.09</td>
<td>2</td>
</tr>
<tr>
<td>6. Waste Management</td>
<td>56</td>
<td>4.16</td>
<td>4.16</td>
<td>1.27</td>
<td>0.05</td>
<td>0</td>
</tr>
<tr>
<td>7. Other Business Services</td>
<td>54, 55, 56</td>
<td>4.16</td>
<td>4.16</td>
<td>3.68</td>
<td>0.15</td>
<td>49</td>
</tr>
<tr>
<td>8. Entertainment</td>
<td>71</td>
<td>4.16</td>
<td>4.16</td>
<td>1.40</td>
<td>0.06</td>
<td>6</td>
</tr>
<tr>
<td>9. Education</td>
<td>61</td>
<td>4.16</td>
<td>4.16</td>
<td>1.58</td>
<td>0.07</td>
<td>12</td>
</tr>
<tr>
<td>10. Medical Services</td>
<td>62</td>
<td>4.16</td>
<td>4.16</td>
<td>3.09</td>
<td>0.13</td>
<td>165</td>
</tr>
<tr>
<td>11. Social Services</td>
<td>61</td>
<td>4.16</td>
<td>4.16</td>
<td>3.09</td>
<td>0.13</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4.16</strong></td>
<td><strong>4.16</strong></td>
<td><strong>3.02</strong></td>
<td><strong>0.13</strong></td>
<td><strong>545</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Table 18-4: Direct Impacts of Subway Bag and Parcel Searches Spillover Effects on Business Revenue of the New York Metro Region Economy

<table>
<thead>
<tr>
<th>NYCGE Sectors</th>
<th>NAICS Sectors</th>
<th>Percent Change in LM Demand by NAICS</th>
<th>Percent Change in LM Demand by NYCGE</th>
<th>Percent of LM Employment in NY Metro Employment</th>
<th>Percent Change in NYCGE Demand</th>
<th>Level of Change (in million 2006 dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wholesale Trade</td>
<td>42</td>
<td>-8.48</td>
<td>-8.48</td>
<td>1.59</td>
<td>-0.13</td>
<td>-80</td>
</tr>
<tr>
<td>2. Retail Trade</td>
<td>44-45</td>
<td>-8.48</td>
<td>-8.48</td>
<td>2.23</td>
<td>-0.19</td>
<td>-211</td>
</tr>
<tr>
<td>3. Hotel and Restaurants</td>
<td>72</td>
<td>-8.48</td>
<td>-8.48</td>
<td>4.98</td>
<td>-0.42</td>
<td>-207</td>
</tr>
<tr>
<td>4. Personal Services</td>
<td>81</td>
<td>-8.48</td>
<td>-8.48</td>
<td>8.64</td>
<td>-0.73</td>
<td>-97</td>
</tr>
<tr>
<td>5. Veterinary Services</td>
<td>54</td>
<td>-8.48</td>
<td>-8.48</td>
<td>2.07</td>
<td>-0.18</td>
<td>-4</td>
</tr>
<tr>
<td>6. Waste Management</td>
<td>56</td>
<td>-8.48</td>
<td>-8.48</td>
<td>1.27</td>
<td>-0.11</td>
<td>0</td>
</tr>
<tr>
<td>7. Other Business Services</td>
<td>54, 55, 56</td>
<td>-8.48</td>
<td>-8.48</td>
<td>3.68</td>
<td>-0.31</td>
<td>-100</td>
</tr>
<tr>
<td>8. Entertainment</td>
<td>71</td>
<td>-8.48</td>
<td>-8.48</td>
<td>1.40</td>
<td>-0.12</td>
<td>-13</td>
</tr>
<tr>
<td>9. Education</td>
<td>61</td>
<td>-8.48</td>
<td>-8.48</td>
<td>1.58</td>
<td>-0.13</td>
<td>-25</td>
</tr>
<tr>
<td>10. Medical Services</td>
<td>62</td>
<td>-8.48</td>
<td>-8.48</td>
<td>3.09</td>
<td>-0.26</td>
<td>-336</td>
</tr>
<tr>
<td>11. Social Services</td>
<td>61</td>
<td>-8.48</td>
<td>-8.48</td>
<td>3.09</td>
<td>-0.26</td>
<td>-37</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>-8.48</strong></td>
<td><strong>-8.48</strong></td>
<td><strong>3.02</strong></td>
<td><strong>-0.26</strong></td>
<td><strong>-1,110</strong></td>
<td></td>
</tr>
</tbody>
</table>
Table 18-5: Total Impacts of Business Environment Spillovers from Terrorism Countermeasures on New York Metro Region GDP

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>Direct Impact on Business Revenue ($US B)</th>
<th>Direct Impact on Net Output ($US B)</th>
<th>Change in GDP ($US B)</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Random Vehicle Inspections</td>
<td>-1.72045</td>
<td>-1.10181</td>
<td>-2.914</td>
<td>2.64</td>
</tr>
<tr>
<td>2. CCTV</td>
<td>0.54468</td>
<td>0.34882</td>
<td>1.134</td>
<td>3.25</td>
</tr>
<tr>
<td>3. Subway Bag and Parcel Searches</td>
<td>-1.11031</td>
<td>-0.71106</td>
<td>-1.857</td>
<td>2.61</td>
</tr>
</tbody>
</table>

For the case of subway bag and parcel searches, the weighted average direct percentage decrease of 8.48% in demand corresponds to $1.1 billion per year in lost business revenue (see Table 18-4). This leads to a total GDP impact of -$1.9 billion per year (see Table 18-5). The multiplier in this case is also on the order of 2.6. Searches are viewed by many as obtrusive and thus have a dampening effect on the ambiance of an area, and hence its business environment.

The effect of the three countermeasures on economic activity, acting through changes in the business environment, should not be summed. This is because they represent alternatives, and they are likely to be used in tandem only under extreme security situations. If the survey responses accurately represent the general population’s reaction to the CCTV measure, compared to the other measures, it is the best alternative, which results in positive impacts on GDP from its installation and operation, as well as improvement of the business environment, in addition to the intended benefits of reducing losses from terrorism. There may still be some negative spillover impacts because of privacy concerns, but these are likely to be outweighed by the expected positive spillover impacts measured here.

Random vehicle inspections and subway bag and parcel searches do involve tradeoffs because of the negative spillover effects. Positive impacts of capital and operation on GDP (see Chapter 14) for these two countermeasures (in the specific version of them described in Chapters 4 and 14) are very minor—only several million dollars. However, the benefits of avoiding a sarin attack, for example, are estimated at $14.2 billion. This exceeds the negative spillover effects of $2.9 and $1.9 billion from random vehicle inspections and subway bag and parcel searches,
respectively. Still, the latter needs to be adjusted by the probability of occurrence of the sarin attack. This probability would have to be greater than 20% for the random vehicle inspections countermeasure to pass the simple benefit-cost test, taking into account the fact that such an attack is not very likely.

Of course, the above BCA example takes the perspective of Lower Manhattan. If the reduced business from the implementation of the random vehicle inspections countermeasure, for example, simply shifts to other parts of the New York Metro Region, then the spillover costs from this broader geographic perspective is much reduced. However, the benefits will also be reduced if potential business losses due to the sarin attack itself are also offset by explicit business relocation or customers shopping elsewhere in the New York Metro Region. These likelihoods would have to be assessed in making a determination of the BCA balance for the broader region.

18.2 Total Economic Impacts of Inconvenience

The inconvenience costs of two of the countermeasures were also examined: random vehicle inspections and subway bag and parcel searches (inconvenience is deemed not a factor for CCTV). Inconvenience can be measured in a number of ways, but we choose two proxies that were included in the survey presented in Chapters 6 and 13.

Two questions were used for the random vehicle inspection security measure: 1) a question relating to willingness to pay (WTP) of Lower Manhattan residents for a security tax to reduce waiting time and 2) a question pertaining to WTP for additional costs for transportation-related services that would reduce waiting time through checkpoints for non-residents. The analysis is presented in Table 18-6, where, in row three, we note that the mean WTP of residents is higher than that of workers or visitors, in part because the former are likely to have to pass through these checkpoints more often. Also, note that the figures in row three pertain to a per-minute charge. Combining these data suggests that the WTP pertains to an average reduction of waiting time by three minutes. These figures are presented in row four, and are multiplied by the population in each category. They are also multiplied by the percentage of the population that is willing to pay the security tax or incur the higher transportation cost. The results are then adjusted for overlaps in the population groups (e.g., some fraction of the residents are also
employed in Lower Manhattan). The results indicate that the cost of inconvenience, for this countermeasure, is more than $125 million per year. More than 90 percent of this total is attributable to inconvenience attributed to visitors, primarily because this group is so much larger than the other two.

Table 18-6: Inconvenience Costs of Random Vehicle Inspections in Lower Manhattan

<table>
<thead>
<tr>
<th></th>
<th>Residents</th>
<th>Workers</th>
<th>Visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of people</td>
<td>330,807</td>
<td>301,000</td>
<td>7,900,000</td>
</tr>
<tr>
<td>Population willing to pay security tax or increased transportation costs per minute (decimal %)</td>
<td>0.12</td>
<td>0.18</td>
<td>0.24</td>
</tr>
<tr>
<td>Mean WTP security tax per minute ($)</td>
<td>31.34</td>
<td>25.77</td>
<td>17.76</td>
</tr>
<tr>
<td>Mean WTP security tax for 3 minutes ($)</td>
<td>94.02</td>
<td>77.31</td>
<td>53.28</td>
</tr>
<tr>
<td>Total inconvenience cost ($)</td>
<td>3,726,076</td>
<td>4,258,467</td>
<td>100,934,698</td>
</tr>
<tr>
<td>Number of people adjusted for double counting</td>
<td>276,462</td>
<td>251,552</td>
<td>7,900,000</td>
</tr>
<tr>
<td>Total adjusted for double counting ($)</td>
<td>3,113,957</td>
<td>3,558,887</td>
<td>100,934,698</td>
</tr>
</tbody>
</table>

a Source: U.S. Census Bureau (2012).

The results for the subway bag and parcel searches countermeasure are presented in Table 18-7. In this analysis, we measure inconvenience in terms of the amount people are willing to pay to be pre-screened to avoid the search line. This has the benefit of not requiring an estimate on the number of minutes that are saved, which is implicit in the response. Also, in this case we include the category of business owners. The initial results are again adjusted for double-counting because there are overlaps between workers and residents, and between business owners and residents. The final results are presented in the bottom row of Table 18-7, and the total costs amount to over $225 million per year. Again, the inconvenience cost of visitors dominates because of the very high proportion of this population category as respondents in the survey.

Note that adding this category would not have made much difference in the random vehicle inspections case, since this population sub-group is such a very minor part of the total population.
Of the two countermeasures examined in this section, it appears that the subway bag and parcel searches generates much larger negative spillover effects if used in the specific version described in Chapter 4. However, this large effect could be decreased, if we have underestimated the number of waiting time minutes that people would be willing to pay to avoid random vehicle inspections.

Finally, note that our estimates of inconvenience represent “non-market” costs, i.e., they are not part of the GDP accounts. These are expressed as dollar values, and do not necessarily represent the true effect on the well-being of individuals, conceptualized as the “utility” that people gain from the consumption of goods and services. The effect on utility is computed using a consumer welfare measure known as equivalent variation – defined as how much money a consumer would be willing to pay before an event to avoid it. This measure has different meanings for consumers with different incomes, so we analyzed it in terms of 9 income brackets in our CGE model database, and using constant elasticity in the model’s utility functions. The results, presented in Table 18-8, indicate that the total utility value of avoiding the measured inconvenience of the two countermeasures examined is more than double the direct dollar values (compare with Table 18-6 and Table 18-7).

**Table 18-7: Inconvenience Costs of Subway Bag and Parcel Searches in Lower Manhattan**

<table>
<thead>
<tr>
<th></th>
<th>Business Owners</th>
<th>Residents</th>
<th>Workers</th>
<th>Visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of people</td>
<td>8,100(^a)</td>
<td>330,807(^b)</td>
<td>301,000(^c)</td>
<td>7,900,000(^d)</td>
</tr>
<tr>
<td>Population willing to be pre-screened (decimal %)</td>
<td>0.38</td>
<td>0.36</td>
<td>0.50</td>
<td>0.41</td>
</tr>
<tr>
<td>Mean WTP annually to be pre-screened ($)</td>
<td>73.39</td>
<td>62.09</td>
<td>69.37</td>
<td>65.03</td>
</tr>
<tr>
<td>Total inconvenience cost ($)</td>
<td>224,824</td>
<td>7,455,950</td>
<td>10,440,185</td>
<td>210,940,412</td>
</tr>
<tr>
<td>Number of people adjusted for double-counting</td>
<td>8,067</td>
<td>275,116</td>
<td>251,552</td>
<td>7,900,000</td>
</tr>
<tr>
<td>Total adjusted for double-counting ($)</td>
<td>223,910</td>
<td>6,200,756</td>
<td>8,725,074</td>
<td>210,940,412</td>
</tr>
</tbody>
</table>

\(^a\) Source: Downtown Alliance (2011).  
\(^b\) Source: U.S. Census Bureau (2012).  
Table 18-8: Welfare Effects of Inconvenience Costs of UCASS Countermeasures in the New York Metro Region Economy (in million 2006 dollars)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Random Vehicle Inspections</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equivalent Variation</td>
<td>-8.30</td>
<td>-4.92</td>
<td>-9.87</td>
<td>-10.85</td>
<td>-20.20</td>
<td>-44.05</td>
<td>-37.18</td>
<td>-39.75</td>
<td>-40.10</td>
<td>-215.21</td>
</tr>
<tr>
<td><strong>Subway Bag and Parcel Searches</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equivalent Variation</td>
<td>-17.43</td>
<td>-10.34</td>
<td>-20.74</td>
<td>-22.79</td>
<td>-42.43</td>
<td>-92.55</td>
<td>-78.12</td>
<td>-83.52</td>
<td>-84.25</td>
<td>-452.18</td>
</tr>
</tbody>
</table>

18.3 Total Economic Impacts of Delays

Our survey was not able to include questions about exact delay times for businesses, residents, employees, or tourists. Moreover the simulations did address vehicular traffic. To illustrate the remaining steps of the analysis, we hypothesize that delays can be represented by a fractional increase in transportation costs.

We estimate a transport delay scenario to increase the total cost of truck transport by 1.0%, based on an informal analysis of the survey described in Chapters 6 and 13. We, therefore, adjust the aggregate Transportation sector of our model by the share of trucks (40%) in its gross output. We also apply the share of the Lower Manhattan population in the New York Metro Region population (1.75%) to compute the corresponding changes in transport costs in the New York Metro Region.

The direct impact on transportation costs of 0.007% in the New York Metro Region Economy translates into $84 million in terms of GDP (see Table 18-9). This leads to a total GDP impact of $93 million per year. In this case the multiplier is on the order of 1.1. It is low primarily because most of the inputs into transportation are produced outside the region (e.g., gasoline may be sold in the New York Metro Region, but only the service station mark-up is included; the gasoline is imported from elsewhere and thus does not produce multiplier effects within our study region).
Table 18-9: Impacts of Increased Transport Costs on the New York Metro Region GDP

<table>
<thead>
<tr>
<th>Change in Total Transport Costs in Lower Manhattan</th>
<th>Direct Impact on Transportation Cost (decimal fraction)</th>
<th>Direct Impact on Net Output (2006$ M)</th>
<th>Total Change in GDP (2006$ M)</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in Transportation Costs by 1%</td>
<td>0.00007</td>
<td>-83.93</td>
<td>-93.00</td>
<td>1.11</td>
</tr>
</tbody>
</table>

18.4 Conclusion

In this chapter, we have estimated the total (direct and indirect) economic impacts of some major spillover effects, for each of three countermeasures in Lower Manhattan. The estimates are based on responses from a first-of-its-kind survey. The direct spillover cost estimates do involve interpretations of the responses. The indirect cost estimates are based on a concrete model but are only as accurate as the data on which it is built. For this reason, it is recommended that the reader exercise great caution in evaluating the presentation in this chapter as anything other than indicative of general qualitative directions of a specific set of spillover impacts, for a subset of the countermeasures examined in this study.
19 EXPERT ELICITATION: THREAT, DETERRENCE AND INTERDICTION PROBABILITIES

19.1 Introduction
In UCASS, we needed to estimate the probability of different scenarios and the reduction in the probability of a successful attack brought about by different countermeasures. To do so, we employed expert judgments. Experts are often used to provide uncertainty distributions in risk analyses. They play an important role when insufficient data exist for quantification or when the available data or models are conflicting. Multiple steps are required in constructing a successful expert judgment process. These steps include selecting and framing the issues, identifying the experts, deciding upon an organizational structure, and possibly combining the distributions from multiple experts.

Expert judgments are normally given as probabilities or probability distributions that express the uncertainty about future events or unmeasured quantities. Often multiple experts are employed to answer the same questions. This is done to ensure inclusion of diverse points of view and to gain a better representation of the uncertainty. It is usually desirable to combine the judgments of the various experts to obtain a single value or distribution to use in the analysis.

Judgment involves the weighing of available evidence and reaching a balanced conclusion from that evidence. We consult with experts to provide these judgments because they have developed the mental tools needed to make sound evaluations. These mental tools include knowledge of what evidence can be brought to bear on the question, the ability to weigh the validity of various pieces of evidence and to interpret the relative importance of various facts or assertions, and to craft a view from an ensemble of information that may be inherently limited or conflicting. In risk analysis these judgments nearly always entail uncertainty so that the judgments are not definitive, but reflect what we know and what we know we do not know.

The quantification of uncertainty is probability, it provides a precise way to encode knowledge that is inherently imprecise. Probability mathematically encodes expert judgments in a form where they can be manipulated mathematically and thereby integrated with other pieces of information and used in models to assess risks. These expert judgments are essential in many
analyses of risk, for example, see Harper et al., (1994), Hora and Jensen (2002), Bonano et al., (1989), Keeney and Winterfeldt (1991), and Spetzler and von Holstein (1975).

When we set about to acquire expert judgments for an analysis, there are a number of decisions that must be made about how to proceed. These include:

- Selecting the issues to be addressed by the experts
- Selecting the experts
- Organizing the effort
- Choosing a method for combining multiple judgments if needed.

**19.1.1 Posing Questions To The Experts**

The first stage of developing an expert judgment process is to determine the objectives and desired products. Judgments can be made about a number of different things. Moreover, not all questions are of equal importance in quantifying risk. There will normally be a few major questions that drive the uncertainty about the risk. These questions are candidates for a more structured expert judgment activity. Other issues – those that play a minor role – can often be treated less formally or through sensitivity analysis,\(^{116}\) saving the consultation with experts for the more important issues. A sensitivity analysis using initial estimates of probabilities and probability distributions may be performed after an initial risk model has been structured. The sensitivity analysis identifies those questions deserving of a more in depth study. In risk studies of terrorism events, there are two entities that drive the analysis and require special attention. They are threat probabilities and consequence distributions.

But not all issues lend themselves to quantification through expert judgment. In addition to expert judgments being important contributors to estimating uncertainty and risk, an issue that is a candidate for expert judgment analysis should:

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\(^{116}\) Sensitivity analysis is the study of how the uncertainty in the output of a model (numerical or otherwise) can be apportioned to different sources of uncertainty in the model input.
• Be resolvable in that given sufficient time and/or resources, one could conceivably learn whether the event has occurred or learn the value of the quantity in question. Hence, the issue concerns a fact or set of facts.

• Have a basis upon which judgments can be made and can be justified.

The requirement of resolvability means that the event or quantity is knowable and physically measurable. The second requirement is that there is some knowledge that can be brought to bear on the event or quantity. For many issues, there is no directly applicable data so that data from analogues, such as models using social, medical or physical principles, etc., may form the basis for the judgments. If the basis for judgments is incomplete or sketchy, the experts should reflect this by expressing greater uncertainty in their judgments.

Once the issues have been identified, it is necessary to develop a statement that presents the issue to the experts in a manner that will not influence their responses. This is called framing the issue. Part of framing is creating an unbiased presentation that is free of preconceived notions, political overtones, and discussions of consequences that might affect the response. Framing also provides a background for the question. Sometimes there are choices about whether certain conditions should be included or withheld from the analysis and whether the experts are to integrate the uncertainty about the conditions into their responses. The experts should be informed about those factors that are considered to be known, those that are constrained in value, those that are uncertain, and, perhaps, those that should be excluded from their analyses.

Finally, once an issue has been framed and put in the form of a statement to be submitted to the experts, it should be tested. The best way to do this testing is through a dry-run with stand-in experts who have not been participants in the framing process. Although this seems like a lot of extra work, experience has shown that getting the issue right is both critical and difficult (Hora & Jensen, 2002). All too often, the expert’s understanding of the question differs from what was intended by the analyst who drafted the question. It is also possible that the question being asked appears to be resolvable to the person who framed the question, but not to the expert who must respond.
19.1.2 The Quality of Judgments

Because subjective assessments of the probabilities of an event occurring are personal, and vary from individual to individual, and from time to time, there is no “true” number that one might use as a measure of the accuracy of a single elicited probability. For example, consider the question “what is the probability the next elected president of the United States is a woman?” Individuals may hold a different sense of the odds or degree of belief about this event occurring. The event will resolve as occurring or not, but will not resolve to a frequency or probability.

It is possible to address the goodness of probabilities, however. There are two properties that are desirable to have in probabilities:

- Probabilities should be informative
- Probabilities should authentically represent uncertainty.

The first property, being informative, means that probabilities closer to 0.0 or 1.0 should be preferred to those closer to .5, as the more extreme probabilities provide greater certainty about the outcome of an event. In a like manner, continuous probability distributions that are narrower or tighter convey more information than those that are more widely spread. The second property, the appropriate representation of uncertainty, requires consideration of a set of assessed probabilities. For those events that are given an assessed probability of \( p \), the relative frequency of occurrence of those events should approach \( p \).

19.1.3 Combining Expert Judgments

Judgments may also be combined across multiple experts. While using multiple experts to address a single question allows for a greater diversity of approaches and often provides a better representation of the inherent uncertainty, doing so creates the problem of having multiple answers when it would be convenient to have a single answer. If one decides to evaluate the risk model separately using the judgments of each individual expert and there are multiple points in the model where different experts have given their judgments, the number of separate evaluations of the model is the product of the number of experts used at each place in the model and can be very large. Aggregation of the judgments into a single probability or distribution avoids this problem.
There are two classes of aggregation methods, behavioral and mathematical. Behavioral approaches entail negotiation among the experts to reach a representative or consensus distribution. Mathematical methods, in contrast, are based on a rule or formula. The approaches are not entirely exclusive however, as they may both be used to a greater or lesser degree to perform an aggregation.

19.1.4 Expert Judgment Designs

In addition to defining issues and selecting and training the expert(s), there are a number of questions that must be addressed concerning the format for a probability elicitation. These include:

- The amount of interaction and exchange of information among experts
- The type and amount of preliminary information to be provided to the experts
- The time and resources that will be allocated to preparation of responses
- Venue – the expert’s place of work, the project’s home, or elsewhere
- Will there be training, what kind, and how will it be accomplished?
- Are the names of the experts to be associated with their judgments and will individual judgments be preserved and made available?

These choices result in the creation of a design for elicitation of expert judgments that has been termed a protocol. Some protocols are discussed in Cooke (1991), Merkhofer (1987) and Morgan and Henrion (1990).

19.2 The UCASS Design

The UCASS expert elicitation process focused only on acquiring information about the relative likelihoods of various attack scenarios being launched, the effectiveness of various countermeasures in deterring various attacks, and the effectiveness of the countermeasures in interdicting and terminating an attack before damage occurs. In addition to the relative likelihood judgments, questions were also asked about the collective effectiveness of the entire set of countermeasures under consideration, both in terms of deterrence and interdiction. These
questions were of the ilk “given the set of security measures, what is the probability that their presence would result in the attack of type A being interdicted?” In contrast, distributions for consequences were estimated using statistical analysis of terrorism databases as described in Chapter 15. The desired information was collected from five experts who were recruited to participate in the UCASS expert elicitation process. The selected experts were identified because of their experience in law enforcement and homeland security in the New York and New Jersey regions.

Several difficulties were encountered in designing the process:

1. Experts were scarce, difficult to schedule, and sometimes unable to participate without anonymity due to current employment.
2. The number of target elicitation quantities was large: (5 threats) x (7 countermeasures) x (3 questions = threat frequency + deterrence + interdiction) = 105 individual values
3. The experts, who were sophisticated with respect to terrorist threats, were not accustomed to providing judgments as probabilities.

The above concerns led the UCASS team to develop an elicitation methodology that was unique and well suited to the study at hand.

19.2.1 Training
Given the scarcity of experts and the difficulty of scheduling time with them, training for UCASS was kept to a minimum with a customized two-hour training module delivered to the subject matter experts in small groups (not more than three at any one time). The training was focused on understanding the meaning and role of subjective probabilities, practice with answering questions about uncertainties, and feedback on the performance of their probability estimates in terms of calibration (meaning the proportion of the events judged at a certain probability and that actually occur is equal to that probability) and sharpness (accuracy of estimates).
A collection of 77 training slides and an associated calibration debiasing quiz (a training quiz used to educate experts on probability estimation) were developed as training materials. The training and elicitation sometimes took place at Rutgers University and sometimes at the offices of the experts or at a site convenient to all parties.

**19.2.2 Elicitations**

While the design of an elicitation protocol provides the needed structure to ensure the process meets “best practice” requirements, there is a need to provide a good deal of latitude in the actual elicitation so that differences in how experts think about a problem and how they are able to express their views are not sacrificed to holding to a narrow and rigid script. With this in mind, and knowing that every elicitation session is unique and follows a somewhat variant path, an example of how an elicitation session might proceed is offered as an illustration rather than a record.

_Elicitor:_ We are going to spend a couple of hours discussing security measures and their relative effectiveness against various threats. In our discussions, we will attempt to separate two different components of effectiveness: deterrence and the detection/interdiction of an attack. The first type of effectiveness relates to preventing an attack from ever being launched by discouraging the potential attackers. The second concept deals with the ability of a countermeasure/security tool to thwart an attack that is in progress. Of course the two concepts are related, but in our modeling of terrorist attacks, each type of effectiveness is relevant at a different point in the attack path – one at the beginning and the other closer to the end. Are you ready to go?

_Subject Matter Expert (SME):_ Sure.

_Elicitor:_ We will start by considering just one type of attack – one scenario. The first scenario entails a Mumbai-style attack: Several small teams of attackers shoot their way into a number of large office buildings and hotels and begin killing people at random. Are you familiar with what happened in Mumbai at the train station and the Taj Mahal Palace Hotel?

_SME:_ Yes
Elicitor: Now suppose that a group such as Al Qaeda is in the planning stages for such an attack and is casing Lower Manhattan as the target. I’m going to give you a list of seven countermeasures that might be in place. I would like you to identify the countermeasures that you believe would have the greatest deterrent effect.

List:

1. Random vehicle inspection at entrances into the Lower Manhattan Security Zone.
2. Permanent closure of portions of certain streets to traffic (e.g., Park Hill Road in New York, Pennsylvania Avenue in Washington).
3. Establishment of temporary perimeters and access control (potentially) to certain restricted areas of the city (e.g., during national political conventions).
4. Random voluntary inspections of bags and parcels at rail and subway stations.
5. X-rays and magnetometers in building lobbies (e.g., Congressional office buildings, Federal Reserve, sporting events, etc., and during emergencies at hotels, department stores, etc.).
6. Increased visible presence of police.
7. High concentration of monitored CCTV cameras.

SME: This is already pretty difficult. How about I tell you whether there is a lot or a little deterrence provided by the measures?

Elicitor: OK.

SME: If #3 were in effect, it would have the greatest impact. Countermeasures #1 and #6 would provide some deterrence. #2 and #7 would at least be considered by the terrorist, while #4 and #5 would do little to deter the attack. Voluntary inspections would just be circumvented, while
detectors in building lobbies would be too late in the attack sequence and the terrorists would just blast their way in.

_Elicitor:_ That’s great. Just the kind of info we need. Now, the next question will really require you to dig deep into your knowledge base. Imagine two situations. One where all of the listed security measures are simultaneously in place and another where all the security measures are absent. Suppose that the terrorist would launch the attack if *none* of the countermeasures were in place. How much less likely are they to launch that attack if they knew that *all* the countermeasures were in place? I’ll try to help you think through this.

[After some back and forth discussion…].

_SME:_ I guess the terrorist might just find another venue for their attack. Maybe they would be only half as likely to continue with their plans to attack the secure Lower Manhattan area.

_Elicitor:_ We are ready to move on to the second type of effectiveness – detection and interdiction.

_SME:_ I’m ready.

_Elicitor:_ Suppose that the Al Qaeda teams have positioned themselves to enter the secure area. The attack is launched. Which of the proposed countermeasures is most likely to play a role in defeating the attack and by what means and to what degree would it stop the attack?

_SME:_ The most likely scenario is that one or more teams of terrorists are detected at an access control point. The attack could still be successful if after detection there is insufficient time to intercept the other teams.

_Elicitor:_ What about the other security measures? Which ones might be effective?

_SME:_ I think that the effectiveness in stopping an attack pretty much mirrors the effectiveness of a deterrent with the exception of the CCTV cameras. They might deter because of forensic value
if the terrorist plans to escape. But if it is a suicide mission, they will have little deterrent value. Also, the CCTVs have no effectiveness in [this] second sense. Their only value is in deterrence. 

*Elicitor:* OK. We are almost through with the Mumbai-style attack. Just one more question. Suppose that without the countermeasures, a terrorist has a 50-50 chance of entering and controlling one or more of the multiple targets. With all the countermeasures in place, how much less would be the probability of success? A little less, like 40%. A lot less, such as 25% or one-in-ten?

*SME:* I think it would cut the chance of success by a factor of 2. That seems reasonable. But it could be anywhere from a 50% success rate to maybe 10%.

*Elicitor:* That’s good. Let’s move on to the next scenario which is a chemical attack in an underground station.

### 19.2.3 Analysis

The UCASS elicitation process was designed to acquire information about a wide variety of attacks and countermeasures. The emphasis was on obtaining reasonable representations of the various risks rather than attempting to be precise about facts where precision is an illusion. These judgments about the relative effectiveness of individual countermeasures and the relative frequencies of various attack scenarios were acquired as ordinal information—in other words, a ranking. For example, each expert was asked to rank the scenarios in terms of their relative frequency from most likely, or frequent, to least likely. Similarly, ordinal judgments about the deterrent potential of individual countermeasures and the likelihood that a countermeasure could interdict and foil an attack once undertaken were obtained.

The rank order assessments and the absolute probability and frequency assessments for total threat, total deterrence, and total interdiction were used to infer the individual scenario frequencies, the deterrent effect of each countermeasure separately, and the interdiction probability for each countermeasure separately. One of the five experts, however, was unable or unwilling to address some of the tasks and this expert’s data has not, at this time, been integrated.
into the analysis for technical reasons. It may be possible in the future, however, to include some partial results from this expert into the ensemble of judgments.

In order to obtain absolute probabilities from the relative judgments, the method of rank order centroid weights (ROC) as described in Goodwin and Wright (2010) was used. The ROC method takes advantage of the rank order and the natural tendency to have ordered quantities that diminish at a less than linear rate as one moves from the largest to the smallest of the quantities.

As an example, suppose that an event can happen \( n \) distinct ways corresponding to the scenarios that result in the event occurring. Suppose the total probability of the event, \( P \), is known while the constituents going into \( P \) denoted by \( P_1, \ldots, P_n \) are not known. What is known is the relation between \( P \) and its constituents given by

\[
P = 1 - \prod_{i=1}^{n} (1 - P_i)
\]

Denote the ROC weights associated with \( n \) quantities by \( r_{in} > \ldots > r_{nn} \) where the double subcripting is needed as the ROC weights vary with both the rank of a quantity (first subscript) and the total number of quantities (second subscript) and these weights for a given \( n \) sum to 1. For example, with three quantities, the ROC weights\(^{117} \) are .611, .278, .111, while with four quantities the weights are .521, .271, .146, .063. The important properties of the weights are the preservation of the rank order information and the representation of declining values where the rate of decrease is itself decreasing. Next we replace the component probabilities with their respective ROC weight times and a constant whose value is to be determined. Specifically, if \( P_i = 1 - r_{in} c \), we get

\[
P = 1 - \prod_{i=1}^{n} (1 - r_{in} c)
\]

Suppose the total probability of an attack is .1 and there are four scenarios leading to an attack and suppose the scenarios are ordered from most likely to least likely by \( i = 1, \ldots, 4 \). Then,

\(^{117}\) The algorithm for computing weights is given in Goodwin and Wright (2010)
which yields $c = .103$ and $P = (.521)(.103) = .0538$, etc. Thus we obtain the component probabilities in a manner that the overall probability is preserved. While the use of ROC weights sacrifices some information that might be obtained from more extensive probability elicitation, it does allow the assessment of a relatively large number of values in a compressed period of time. In this case, the two hour elicitation of each expert resulted in over 100 probabilities being assessed. Moreover, the technique allows the experts, who are not experts in probability, to make judgments in a form that they are comfortable with and believe accurately reflects their judgments without overstating their knowledge.

For each expert, the seventy-eight assessed frequencies, probabilities and rank orders produced seventy-five frequencies and probabilities. These values have been aggregated through simple averaging which is known to be a robust method for combining probability judgments (Hora, 2010).

### 19.3 Results
The UCASS expert elicitations involved the ranking of the relative annual frequencies of various attack scenarios, and the relative effectiveness of individual security measures in deterring and interdicting the same set of attack scenarios. Elicited values were aggregated as described in the previous section, and the results of the analysis are reported herein.

The estimates of annual attack likelihood in Table 19-1 represent the four experts’ aggregated relative likelihood estimates for the five attack scenarios. Estimates are rank ordered from most to least likely. None of the attacks are estimated to have a greater annual probability of occurrence than 0.21. The London-style scenario was estimated to be the attack most likely to occur (at 0.21), followed somewhat closely by the Israel and Mumbai-style scenarios (0.16 and 0.14, respectively). Two times less likely than the London-style attack were the Tokyo and Madrid-style scenarios at 0.09 and 0.10, respectively.

### Table 19-1: Probability of Attack Scenarios (Per Year)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>London</th>
<th>Israel</th>
<th>Mumbai</th>
<th>Madrid</th>
<th>Tokyo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Frequency</td>
<td>0.21</td>
<td>0.16</td>
<td>0.14</td>
<td>0.10</td>
<td>0.09</td>
</tr>
</tbody>
</table>
Results in Table 19-2 are the aggregated estimates of the deterrence probabilities for each of the seven countermeasures across the five attack scenarios. The attack scenario experts believed the countermeasures would most likely deter was the London-style event. Of greatest estimated value were the increased visibility of police (0.181) and random bag and parcel searches on the subway (0.083) countermeasures. High concentration of CCTV cameras (0.058) and the set up of temporary perimeters and access control (0.050) were estimated as less likely to effectively deter the attack. For the remaining two countermeasures, X-rays and magnetometers in building lobbies, and the permanent closure of certain streets to traffic, estimated deterrent value was relatively low at 0.009, likely due to the lack of relevance to the attack scenario. For the Mumbai-style attack, estimates indicate that the set of countermeasures believed to be the most effective in deterring the event were increased visibility of police (0.031), X-rays and magnetometers in building lobbies (0.027), permanent closure of certain streets to traffic (0.024), and random vehicle inspections (0.029). Estimated to be less useful in preventing such an attack were random bag and parcel searches on the subway (0.018), high concentrations of CCTV cameras (0.011), and temporary perimeters and access control (0.009). For the Tokyo-style scenario, increased visibility of police (0.024) and random bag and parcel searches on subways (0.026) were estimated to most likely deter the attack. Less likely, but still estimated to have some deterrent value, were the high concentration of CCTV cameras (0.011) and random vehicle inspections at Lower Manhattan entrances (0.009) countermeasures. The remaining three countermeasures’ deterrent value was negligible. For the Israel-like scenario, increased visibility of police (0.085) was estimated to have the greatest deterrent value, followed by the temporary set up of perimeters and access control (0.044) and high concentrations of CCTV cameras (0.036). Less likely to have a deterrent effect was the random bag and parcel searches on subways (0.025), random vehicle inspections at Lower Manhattan entrances (0.023), X-rays and magnetometers in building lobbies (0.022), and the permanent closure of certain streets to traffic (0.018). Compared to the other four attacks, the countermeasures were not believed to be very effective in deterring a Madrid-style attack, with all probability estimates equal to or less than 0.012. The countermeasure estimated to have the highest deterrent effect was random bag and parcel inspections on subways (0.012) and increased visibility of police (0.011). The remaining five countermeasures’ estimated deterrent value was negligible.
Table 19-2: Probability that Each of 7 Countermeasures Deters Each of 5 Attack Scenarios

<table>
<thead>
<tr>
<th>Security Measure</th>
<th>Mumbai</th>
<th>Tokyo</th>
<th>Madrid</th>
<th>London</th>
<th>Israel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random vehicle inspections at LM entrances</td>
<td>0.029</td>
<td>0.011</td>
<td>0.003</td>
<td>0.103</td>
<td>0.023</td>
</tr>
<tr>
<td>Permanent closure of certain streets to traffic</td>
<td>0.024</td>
<td>0.003</td>
<td>0.001</td>
<td>0.009</td>
<td>0.018</td>
</tr>
<tr>
<td>Temp perimeters and access control</td>
<td>0.009</td>
<td>0.006</td>
<td>0.003</td>
<td>0.050</td>
<td>0.044</td>
</tr>
<tr>
<td>Random bag and parcel inspection on subways</td>
<td>0.018</td>
<td>0.026</td>
<td>0.012</td>
<td>0.083</td>
<td>0.025</td>
</tr>
<tr>
<td>X-rays and magnetometers in building lobbies</td>
<td>0.027</td>
<td>0.003</td>
<td>0.001</td>
<td>0.009</td>
<td>0.022</td>
</tr>
<tr>
<td>Increased visible presence of police</td>
<td>0.031</td>
<td>0.024</td>
<td>0.011</td>
<td>0.181</td>
<td>0.085</td>
</tr>
<tr>
<td>High concentration of CCTV cameras</td>
<td>0.011</td>
<td>0.009</td>
<td>0.004</td>
<td>0.058</td>
<td>0.036</td>
</tr>
</tbody>
</table>

Results in Table 19-3 are the aggregated estimates of the interdiction effect of the seven countermeasures across the five attack scenarios. The scenario for which the countermeasures were estimated to be most effective in interdicting an attack was the Mumbai-style scenario. Of greatest estimated value were the X-rays and magnetometers in building lobbies (.331) and temporary perimeters and access control (.201). Less likely to be effective were the random bag and parcel inspections on subways (.158) and the increased visible presence of police (.140) countermeasures. Estimated to have the smallest interdiction effect on the Mumbai-style attack were high concentrations of CCTV cameras (.016) and the permanent closure of certain streets to traffic (.013). For the Tokyo-style attack, the countermeasures estimated to effectively interdict the attack were random bag and parcel searches on subways (.070), increased visible presence of police (.043), and temporary perimeters and access controls (.042). Less likely to be effective were random vehicle inspections at Lower Manhattan entrances (.025), high concentrations of CCTV cameras (.004), X-rays and magnetometers in building lobbies (.002) and permanent street closures to traffic (.002). For the London-style attack the countermeasures were not estimated to have high interdiction values. Two of the countermeasures, random vehicle inspections at Lower Manhattan entrances (.014) and increased police presence (.013) have a minimal interdiction effect. The remaining five countermeasures’ interdiction potential was negligible. Similar to the London-style attack, for the Israel scenario the countermeasures were not estimated as having a high likelihood of interdicting the attack. Temporary perimeters and access control (.029), increased visible presence of police (.028), random vehicle inspections at Lower Manhattan entrances (.015) and permanent closure of certain streets to traffic (.010) had
some interdiction potential. The remaining two countermeasures’ interdiction effect was negligible.

Table 19-3: Probability that Each of 7 Countermeasures Interdicts Each of 5 Attack Scenarios

<table>
<thead>
<tr>
<th>Security Measure</th>
<th>Mumbai</th>
<th>Tokyo</th>
<th>Madrid</th>
<th>London</th>
<th>Israel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random vehicle inspections at LM entrances</td>
<td>0.099</td>
<td>0.025</td>
<td>0.047</td>
<td>0.014</td>
<td>0.015</td>
</tr>
<tr>
<td>Permanent closure of certain streets to traffic</td>
<td>0.013</td>
<td>0.002</td>
<td>0.004</td>
<td>0.006</td>
<td>0.010</td>
</tr>
<tr>
<td>Temp perimeters and access control</td>
<td>0.201</td>
<td>0.042</td>
<td>0.081</td>
<td>0.005</td>
<td>0.029</td>
</tr>
<tr>
<td>Random bag and parcel inspection on subways</td>
<td>0.158</td>
<td>0.070</td>
<td>0.136</td>
<td>0.002</td>
<td>0.009</td>
</tr>
<tr>
<td>X-rays and magnetometers in building lobbies</td>
<td>0.331</td>
<td>0.002</td>
<td>0.004</td>
<td>0.001</td>
<td>0.005</td>
</tr>
<tr>
<td>Increased visible presence of police</td>
<td>0.140</td>
<td>0.043</td>
<td>0.080</td>
<td>0.013</td>
<td>0.028</td>
</tr>
<tr>
<td>High concentration of CCTV cameras</td>
<td>0.016</td>
<td>0.004</td>
<td>0.007</td>
<td>0.001</td>
<td>0.005</td>
</tr>
</tbody>
</table>

19.4 Discussion

The results suggest that our experts believe the likelihood of a terrorist attack taking place in Lower Manhattan over the next year is relatively small. Of the five attack scenarios, the London-style attack was estimated to be the most likely to take place. When assuming that an attack is either being planned or has been launched, the elicitation results found that the countermeasures are not likely to deter or interdict any of the attack scenarios. As suggested by several of our experts, if a terrorist, or group of terrorists, intends to prepare for and execute an attack, the United States has options, but is limited in what the country can do from a defensive standpoint. The country has made great strides in creating an environment where the homeland is more secure, both domestically and overseas. However, in the case of terrorism, if the terrorist has a desire to carry out an attack, s/he will likely find a way to do so. There are innumerable attack types, vulnerable targets and an endless amount of time available to terrorists for attack development. Coupled with the fact that they value their political ends above anything, constrains the United States in its defensive efforts. To set up an effective system of deterrence and interdiction, the experts are suggesting that the United States needs to find a balance between maximizing security against our enemies and concerns over compromising our privacy and civil liberties.
20 ANALYZING PORTFOLIOS OF SECURITY MEASURES

20.1 Introduction

In this chapter, we report on a spreadsheet-based application and a Tableau-based data visualization to facilitate the evaluation of security portfolio risks and costs. The portfolio analysis concentrates on five terrorist attack scenarios (Jenkins, 2011a) and seven security measures (Jenkins, 2011b) in the Lower Manhattan area as defined in Chapter 4. From these seven, a total of 27 or 128 security portfolios may be generated\(^{118}\).

This chapter combines risk estimates and economic estimates to compute the expected annual risk reduction and the resulting “net cost” for various security portfolios. The information needed to generate risks and costs for the security portfolios under different scenarios is suggested in Figure 20.1.

Figure 20.1: Information for Analyzing Security Portfolios

![Diagram](image)

Notes:
- (1) Risk Assessment: Expert Elicitation, Statistical Analysis, Excel VBA Macro
- (2) Economic Analysis: COE, Survey, Simulation, Statistical Data Analysis, Literature Synthesis
- (3) Portfolio Analysis: Excel VBA Macro, Tableau Public View
- Sm3*: Temporary perimeters and access control to certain restricted areas of the city
- Sm3**: X-rays and magnetometers in building lobbies

Figure 20.1 presents a notional risk reduction versus cost plot and notional pie charts to indicate scenario- and portfolio-related computation elements. The information required to compute risk

\(^{118}\) One of these is “do nothing new.” The situation is more complex since the scenarios specify a level for each type of intervention, and other levels are surely possible.
reduction includes the scenario likelihood, the total scenario cost or consequence, and the
deterrence and interdiction effects of the portfolio for the specific scenario. The total cost of
mitigation is taken, in this chapter, to be the net cost of a portfolio\textsuperscript{119}. Business interruption costs
were estimated for two of the five scenarios and the spillover costs were estimated for three of
the seven security measures. Business interruption and spillover costs for the remaining
combinations were extrapolated from the estimates for the analyzed cases by discussions among
the risk and economic analysis teams at CREATE.

For a given set of scenario \( \{1,\ldots, i\} \) and a given set of security portfolio options \( \{1,\ldots, j\} \), the
expected annual risk reduction \( R_{\{1,\ldots, i\}, \{1,\ldots, j\}} \) and net cost \( C_{\{1,\ldots, j\}} \) are computed as in Eq. 20.1
below. The expected annual risk reduction formulation is based on fundamental concepts of
probability theory (Ross, 2004).

\[
R_{S,P} = \sum_{i \in S} t_i c_i \left[ 1 - \prod_{j \in P} (1 - d_{ij}) \prod_{j \in P} (1 - e_{ij}) \right] \quad (20.1)
\]

The notation is:

\( R_{S,P} \) is the expected annual risk reduction for scenario set \( S \) and security portfolio set \( P \);

\( t_i \) is the probability of scenario \( i \);

\( c_i \) is the total cost or consequence of scenario \( i \) if the attack is successful;

\( d_{ij} \) is the deterrence effect against scenario \( i \) of security measure \( j \);

\( e_{ij} \) is the interdiction effect against scenario \( i \) of security measure \( j \).

\textsuperscript{119} Note that if the estimated reduction in loss exceeds the direct capital and operating cost of the countermeasure,
the countermeasure will have a negative net cost. That is, it will appear as if it were income. This notion is
discussed in detail in Chapter 1. In other parts of this report we have separated costs of the countermeasure from the
estimated reduction in losses.
This formula can be applied for a subset of the scenarios, and any subset of the full set of countermeasures.

Similarly, the net cost of any set $P$ of countermeasures is given in Eq. 20.2

$$C_P = \sum_{j \in P} (k_j + o_j + s_j)$$

(20.2)

where:

$C_p$ is the net cost for security portfolio set $P$;

$k_j$ is the amortized capital cost of security measure $j$;

$o_j$ is the operating cost of security measure $j$; and

$s_j$ is the spillover cost of security measure $j$ (which may be positive or negative).

The scenario probabilities, $t_i$, are determined by allocating the total estimated annual threat frequency against the five included scenarios. This was done so that the sum of the probabilities of the five threat scenarios across all scenarios (whether or not included in this analysis) would be equal to the total threat annual frequency. This results in a plausible estimate of the chance for each threat, and justifies balancing the avoided cost against the direct cost. The five included scenarios are representative of the set of all possible scenarios which cannot be enumerated.\(^{120}\)

In this analysis, the expected reduction in risk (annually) and combined net cost in the equations above are given as point estimates. In reality, these estimates have uncertainty and can be represented as random variables.

The technology used in this analysis: a portfolio analysis framework, Excel VBA code to implement the above formulae, and a Tableau data visualization to display the computational results are discussed briefly in the following sections.

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\(^{120}\) This analysis presumes that the experts’ estimation of total risk is correct, even if the expert has not been able to think of all the possible modalities of attack, or of all threat scenarios. It is an expert opinion usually grounded in recent experience.
20.2 Portfolio Analysis Framework

The notional risk reduction versus cost plot in Figure 20.1 describes a multi-objective decision problem. The decision making objectives are to minimize the net cost $C$ while maximizing the reduction in risk, $R$. The analysis will generate an efficient frontier of non-dominated solutions as shown in the notional risk reduction versus cost plot below (see Figure 20.2). In this figure, for a given level of net cost or risk reduction, the optimal security portfolio falls on the efficient frontier. The efficient frontier consists of those portfolios that cannot be bested simultaneously in both a lower cost and greater annual risk reduction.\textsuperscript{121}

![Figure 20.2: Portfolio Analysis Framework](image)

20.3 Spreadsheet-Based Portfolio Application

The pseudocode for a spreadsheet-based portfolio application is presented in Figure 20.3.

\textsuperscript{121} Economic analysis usually considers mixed policies, so that the frontier is convex. In reality it may have an uneven edge, depending on how the costs and risk reductions turn out.
Figure 20.3: Pseudocode for Spreadsheet-based Portfolio Application

| For each scenario
| likelihood
| consequence = casualty + injury + property damage + business interruption
| For each portfolio
| deterrence = 1 - \( \Pi \) (1 - deterrence of security measure)
| interdiction = 1 - \( \Pi \) (1 - interdiction of security measure)
| expected annual risk reduction = likelihood \( \times \) consequence
| return expected annual risk reduction
| expected annual risk reduction across all scenarios = \( \Sigma \) expected annual risk reduction

The portfolio application (an Excel VBA code) in Figure 20.2 is a direct implementation of equations (20.1) and (20.2). It computes all of the subset of scenarios and countermeasures. The risk and cost parameters were determined by methods described elsewhere in this report. Table 20-1 presents the format of the results from the portfolio spreadsheet application for given scenarios and portfolios. Expected annual risk reduction results (in dollar terms) were generated for the individual scenarios and also summed across all scenarios.

Table 20-1: Portfolio Spreadsheet Application Results Format

<table>
<thead>
<tr>
<th>Security Portfolio</th>
<th>Expected Annual Risk Reduction ($) for scenario set {1}</th>
<th>...</th>
<th>Expected Annual Risk Reduction ($) for scenario set {\ldots}</th>
<th>Expected Annual Risk Reduction ($) for scenario set {1,2,3,4,5}</th>
<th>Net Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>{}</td>
<td>( R_{1}{} )</td>
<td>...</td>
<td>( R_{\ldots}{} )</td>
<td>( R_{1,2,3,4,5}{} )</td>
<td>( C_{{} } )</td>
</tr>
<tr>
<td>{1,2,3,4,5,6,7}</td>
<td>( R_{1}{1,2,3,4,5,6,7} )</td>
<td>...</td>
<td>( R_{\ldots}{1,2,3,4,5,6,7} )</td>
<td>( R_{1,2,3,4,5}{1,2,3,4,5,6,7} )</td>
<td>( C_{1,2,3,4,5,6,7} )</td>
</tr>
</tbody>
</table>

20.4 Tableau-Based Portfolio Visualization

Tableau Public is a freely available data visualization tool with which data can be uploaded to a server and can be shared via a link to the webpage. Users can interact with the visualization, selecting the options to be displayed, and varying the kind of presentation. (Tableau Software, 2012). A Tableau-based data visualization was developed to display the portfolio spreadsheet
application results (expected annual risk reduction versus net cost plot) from Table 20-1 above. The web link to the portfolio visualization is\textsuperscript{122}:

\texttt{http://public.tableausoftware.com/views/SecurityPortfolios/Latest?:embed=y}  
A screenshot is presented in Figure 20.4. Note that the user has here selected all of the countermeasures.

**Figure 20.4: Screenshot of the Tableau Portfolio Visualization**

![Screenshot of the Tableau Portfolio Visualization](image)


The portfolio visualization in Figure 20.4 presents a decision-making framework where security portfolios can be compared for a given scenario and across multiple scenarios. Portfolio selection may be achieved at different net cost or risk reduction levels. The portfolio viz allows the user to select different scenarios and portfolios via menu boxes. The user may also filter portfolios by the magnitude of risk reduction and net cost via sliding scales. Placing the screen pointer on a portfolio opens up a dialog box with information pertaining to the chosen portfolio. The user can

\textsuperscript{122} This link may yield the most recent modification of the choice of countermeasures, rather than the one shown in the Figure. The online display supports any number of users.
zoom in or out of different regions within the portfolio diagram, select multiple portfolios at one time, and retain or discard a particular portfolio from the plot.

As an example, Figure 20.5 shows the benefits of increased police presence. This countermeasure is shown as having a negative net cost. The cost includes a notional cost of zero for the police presence (considered to be the result of reallocating time already paid for) and a negative cost resulting from the fact that customers are more likely to conduct business in the region, whether or not the threat is actually reduced. All of the points have (of course) the same net cost. But the benefit depends on which threat is being considered.

Figure 20.5: The Effect of Increased Police Presence Throughout Lower Manhattan

Figure 20.6 presents an example of an efficient frontier when the risk reduction is aggregated across all scenarios. The portfolios on the efficient frontier represent non-dominated solutions (i.e., those that cannot be simultaneously bettered in both dimensions). In all of these “best solutions” either increased visible presence of police or high concentration of CCTV cameras or both appears in the non-dominated portfolio sets.
Figure 20.6: An Example Efficient Frontier for Overall Scenario Case
21 CONCLUSIONS

The UCASS project represents a new paradigm for Homeland Security research. Until now, research on economic activity and research on security practices, policies and measures has been conducted independently. However, few would deny that the complex relationships between these considerations are important, and are viewed very differently by distinct stakeholders.

The research reported here is intended to provide pilot research designs and technologies which will be of value to the practitioner communities, and it is hoped that they may be applied and adapted to other urban environments other settings/venues. In this section we present some recommendations for accomplishing this transition, and some recommendations for future research. In addition, we summarize a number of observations or “lessons learned” during the course of this innovative collaborative project. We hope that these observations will smooth the path for other cross-center collaborations among the DHS Centers of Excellence.

21.1 Transferring the UCASS Methods to Other Environments

The following recommendations may be useful to interested parties when transferring the methods developed in the UCASS study to other environments and venues.

- **Identify project objectives, stakeholders, ultimate users and beneficiaries, and end-products.**

  A large scale project with multiple participants requires focus. Various participants will have their own ideas about the project and variations in these ideas may not be clearly communicated among team members. Written objectives and articulated end-products will facilitate the project planning process and cohesion.

- **Use a project kickoff retreat meeting, face to face, to build cross disciplinary trust.**

  Researchers in each of the several disciplines are accustomed to working independently, finding the needed information available to other disciplines either from the literature, or by making “reasonable estimates” for unknown but important parameters of the problem. It takes more than one day of discussion for the team to learn which of that information is
available from the research of the diverse specialists, and to begin to learn how concepts are named in the several disciplines.\textsuperscript{123}

- **Clearly articulate a research plan.**

Drawing on both this report and on team experience, develop a clear research plan, identifying the key players, expectations, and responsibilities. Doing so will not only help all interested parties specify their goals, objectives and commitments, but it will help all parties involved identify potential challenges before they arise and design solutions or alternatives to address or minimize obstacles. The plan should clearly identify and describe linkages between the work to be done by the various team members including where the transfer of information, models, data, etc. must occur. As much as possible the nature of the hand-offs should be described detailing the form of the information (qualitative, estimates, density functions, models, equations etc.) and the conditions or assumptions underlying the information.

- **Develop and implement a project management plan.**

To ensure continuity and to safeguard progress and outcomes throughout the project, a management plan should be developed, implemented, shared and followed. The plan should: a) clearly outline participant roles, expectations and deliverables; b) set guidelines for regular meetings and discussions; c) provide standards for documentation sharing and storing and d) outline consequences for failure to meet the timeline for checkpoints and major milestones\textsuperscript{124}.

- **Engage stakeholder leaders early in the planning process.**

Stakeholder participation is critical, not least because stakeholders’ mission priorities are

\textsuperscript{123} The real costs of such a meeting are substantial. The UCASS project team included three center directors, and six other senior faculty members, together with four post-doctoral researchers and an equal number of graduate students. Using GSA scale rates for comparison, a 2-day (including travel time) meeting of these personnel represents an expense of around $15,000 not including travel costs.

\textsuperscript{124} Academic researchers are accustomed to “pull an all-nighter” in order to close out research projects. Because of the complex interdependencies among the components of this kind of project, that kind of approach cannot succeed. It will result in conversations and iterations continuing beyond the end of project funding.
distinct from those of the research, and stakeholder resources are limited. Stakeholders will look to their leaders for guidance on whether it is worthwhile to commit time to working with (and educating) the researchers. Stakeholder commitment not only facilitates the planning and design process, it also improves the strength of interagency and inter-institutional partnerships and helps ensure that the research efforts address diverse stakeholders’ needs. Stakeholder involvement cannot be taken for granted. The stakeholders must see clear benefits to their participation and cooperation. Researchers should anticipate that political considerations may impact the willingness of various stakeholders to participate. They may also have expectations for the project that are inconsistent with stated project objectives.

- **Agree on the goals for the deliverables.**

  It is important to agree in advance not only what the deliverables will be and who will be responsible for developing them, but on their general nature. In the case of UCASS, there was an emphasis on developing a methodology that could be exhibited through pilot models and software tools and illustrated with realistic data. However, there was also the realization that the problems were complex, the data was often very subjective and subject to considerable uncertainty, and therefore the specific numerical conclusions were not as important as the methodologies and concepts.

- **Identify context-specific data needs and sources.**

  During the planning process, careful consideration should be given to identifying the data needed to adapt the study to another environment. Early conversations with contract researchers, and stakeholder groups will define a set of realistic options, and may lead to changes in method.\(^\text{125}\)

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\(^\text{125}\) As an example, the UCASS project originally intended to use contract telephone survey researchers to gather information about citizen response to countermeasures, and citizen assessment of the non-monetary (spillover) effects of countermeasures. Although a contract was written, the contractor found that the task could not be accomplished, and returned the funds.
21.2 Extending UCASS to Other Urban Areas

The methods for UCASS were motivated by the relationships between commerce and security in a specific urban area, namely the area around the World Trade Center site in Lower Manhattan. However, from the beginning it was the intention of the project to develop a methodology that could be generalized and made useful to other urban areas as well. We are confident that the UCASS methodology will generalize to other urban areas.

As it turned out, the amount of effort required to gather the data to build the UCASS models was very significant, the data was both hard and expensive to obtain, and the data was in many cases very special to the particular geographical area being studied. Thus, while the cost of purchasing a CCTV camera might not differ dramatically from New York City to Los Angeles to Chicago, the estimates of probability of entering a restaurant with a metal detector depend to a large extent upon local cultures, biases, and attitudes that could differ greatly from city to city. Thus, when we presented our methodology to the New Jersey Office of Homeland Security and Preparedness, they expressed concern that no urban areas would be able to invest the resources needed to obtain the data needed to populate the UCASS models. Instead, NJ OHSP leaders suggested that we consider extending UCASS by building say half a dozen representative hypothetical urban area models, populated by data relevant to those models. Then a user could start the use of UCASS by choosing a model to work with, rather than gathering data from scratch.

The UCASS model for Lower Manhattan was designed to cover a small area around the WTC site. Completing the details of that model and being able to demonstrate it effectively would have required significantly greater data-gathering and also more powerful computing capability than we put to work. Indeed, to demonstrate UCASS to the user community, we actually developed a hypothetical smaller area that was 2 blocks by 2 blocks. A small area such as that in our study or even the smaller hypothetical area supports “what-if” experiments that will educate decision makers about the interface between commerce and security.

21.3 Extending UCASS to Other Settings/Venues

While the methods of the UCASS study were developed in the context of a specific urban business environment, Lower Manhattan, they are transferable to a variety of geographical and
commercial settings, particularly those in which the nexus between commerce and security is paramount.

Other settings to which the methods will apply include sports and entertainment venues and large retail shopping centers. These enterprises are not only dependent on commercial activity and commerce, but they are also highly attractive terrorist targets. One such setting is the Staples Center, a multi-purpose sports arena in downtown Los Angeles. Hosting a variety of professional sports games and music concerts, the Staples Center seats approximately 20,000 people. It is surrounded by L.A. Live, an entertainment and sports district including clubs, restaurants, hotels and other entertainment features. Transferring the UCASS methods to this section of downtown Los Angeles would provide a comparable, though not identical, test site to be compared to the analysis of Lower Manhattan.

Another suitable setting would be a very large shopping venue, such as the Mall of America. Shopping malls are crucially dependent on the balance between security and economic activity, managing the need for safety and security for both their retailers and their customers, while maximizing sales and the consumer shopping experience. While such centers have a more limited range of stakeholders, the UCASS methods could be adapted to help those stakeholders assess the costs and other impacts of feasible security countermeasures. As part of the UCASS project, and again with the assistance of the NJ Office of Homeland Security and Preparedness, we have visited a number of malls, interacted with mall security directors and mall management, and obtained insight into how they view the interface between security and commerce.

Sports stadiums provide another example where UCASS methods could be useful. These venues want to keep spectators safe but also want security measures that minimize the economic impact on sporting venues and the economic and “spillover” effects that may detract from the fan experience.

In addition to such “brick and mortar” venues, the methods developed here can apply to large-scale special events, where strategic planning and preparation are essential. Examples would include the National Football League’s (NFL) Super Bowl game. Each year, the NFL championship game is hosted in a major U.S. city, attracting an influx of visitors and, thus, a
combination of economic spending and heightened security threats. Other such events would be the quadrennial Democratic and Republican National Convention. There are also city-wide events, such as the NYC and Boston Marathons, NYC Macy’s Thanksgiving Day, St. Patrick’s Day, and Gay Pride Parades. A city preparing for such an event would benefit from the ability to explore and investigate the likely effects of specific measures on both security and commerce.

The area around a port is also a complex mix of businesses, transportation corridors, and living environments. Decisions made at the port can have significant economic impact on this important area. Studies similar to UCASS can be designed to address questions such as “If the Captain of Port changes the Maritime Security level, what is the economic impact on the surrounding area?” and “What is the impact of implementing Transportation worker identification credentialing?”

We have also learned, in conversations with the NYC OEM, that the UCASS approach may be useful in the recovery period following a disruptive event (such as an attack, or a gas leak, or a fuel spill). Effective simulation (see Chapter 10), which takes only a few minutes\textsuperscript{126}, could help to prioritize restoration of services, so as to minimize the impact on commerce. Such work can answer questions such as “What is the economic impact of opening up runway 3 first as opposed to opening up runway 2 first?” and “What is the economic impact of providing power back to one neighborhood rather than another?”.

21.4 Comments on a Multi-Center Project: “Lessons Learned”

In collaborative projects where expertise differs markedly among partners, labor is divided almost wholly according to discipline. The resulting danger is that the final product may become a “stapled together” assembly of loosely related studies, rather than a truly integrated whole. In contrast, true collaboration among the UCASS research team members was a primary goal from the outset, integrating disciplines, theoretical backgrounds, analyses and technical expertise. The research team learned what worked and saw what challenges had to be overcome along the way.

\textsuperscript{126}It takes only a few minutes to “run” the alternatives. Developing usable models of the blocks that are likely to be affected takes considerably more effort, and requires estimates of the total daily commercial activity on each affected block.
The greatest lesson learned is that multi-center and multi-disciplinary collaboration can be not only successful, but it can also be more efficient. The UCASS research team was able to address a very wide range of issues and topics, and to accelerate the research process by sharing work in progress. Thus parts of the team influenced each other’s research decisions *as the project progressed*. Work proceeded in parallel, as the UCASS team was able to manage multiple activities (i.e., stakeholder engagement, an extensive online survey, economic and risk analyses, and simulation model development) simultaneously, as the various tasks were assigned by expertise within centers, and to different team members within each center. It would be very difficult, if not impossible for any single center to manage the range of concurrent tasks required.

There are, it must be noted, social and communicative challenges when scholars from multiple disciplines work intimately together. The UCASS research team includes mathematicians, social scientists, computer scientists, engineers, economists, and experts in risk assessment and terrorism. In practice, these disciplines each have their own customary research practices and expectations. Recognizing and negotiating these differences can be challenging. Similarly, it is challenging to translate members’ different theoretical models and assumptions into a joint technological reality and an integrated tool. We believe that this report, and integrated environment demonstrated in Chapter 10, show that the multi-center collaboration has been both efficient and effective.
1 APPENDICES

1.1 Appendix 1: Summary of Data Sources Used in UCASS

1.1.1 Capital and Operating Cost Estimations (in Chapter 4)

A combination of literature synthesis and cost engineering techniques were used to estimate the capital and operating costs for the seven security measures used in the UCASS study. The cost estimates for these measures can be scaled up or down to generate estimates for similar security measures of different sizes in other areas. The data used was sourced from the following resources:

- Stevens et al. (2004)
  - used to estimate costs for cost estimates for security checkpoints
- Pacific Institute for Research and Evaluation Study (2005)
  - used to estimate total costs of security checkpoint
- U.S. Department of Transportation’s Research and Innovative Technology Administration (RITA) Office maintains Intelligent Transportation Systems (ITS) costs databases
  - used to estimate costs of various components of a security checkpoint and CCTV camera surveillance system, the databases include detailed descriptions of different elements and equipment
- Idaho State Police Study (Wing, 2004)
  - used to estimate canine costs
  - used to estimate costs of X-rays and magnetometers in building lobbies
1.1.2 Modeling in ARENA® Simulation Software

The data required for the ARENA model were obtained in several ways, including the UCASS survey, estimations from direct observation in the area and existing commercial and economic data. For example, data was collected on the number of residential and office buildings, shops, restaurants in the modeled area, as well as data on subway ridership and schedules.

The ARENA model is sophisticated, involving many streets, many residential buildings and many office buildings involving thousands of people passing through for various reasons at different times of a given day. Furthermore, no formal data is available regarding the implementation of the security measures employed in this study, although law enforcement authorities have implemented similar security measures in various parts of Manhattan. Therefore, validation of such a complex model is an extremely challenging process. The model was verified using multiple methods, such as model walkthroughs, observation of people’s behavior over different times of the day, observations of the impact of security measures on the movement of people and estimations of its effect on the daily economic activity of the area.

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127 The ARENA simulation software application was directed by Tayfur Altiok, and was programmed by Selim Bora.
1.2 Appendix 2: New York City Economic Facts and Figures

This appendix supplements Chapter 12 of this technical report. The information provided is a collection of statistics on the New York City economy and population. The data was compiled from three sources: the Census Bureau, the Bureau of Labor Statistics, and a report prepared for the Association for Budgeting and Financial Management 22\textsuperscript{nd} Annual Conference.

Table 1-1 : NYC Social and Demographic Characteristics in 2000 and 2009

<table>
<thead>
<tr>
<th>New York City’s Social and Demographic Characteristics in 2000 and 2009</th>
<th>New York City</th>
<th>New York MSA</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (thousands)(^1)</td>
<td>8,008</td>
<td>8,392</td>
<td>18,333</td>
</tr>
<tr>
<td>Median age</td>
<td>34.2</td>
<td>35.8</td>
<td>35.9</td>
</tr>
<tr>
<td>Less than 18 yrs old (pct) (^2)</td>
<td>24.2</td>
<td>22.5</td>
<td>24.8</td>
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<tr>
<td>Older than 65 yrs old (pct)</td>
<td>11.7</td>
<td>12.1</td>
<td>11.7</td>
</tr>
<tr>
<td>White (pct)(^3)</td>
<td>44.7</td>
<td>48.2</td>
<td>64.1</td>
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<tr>
<td>Black (pct)(^4)</td>
<td>26.6</td>
<td>26.3</td>
<td>17.2</td>
</tr>
<tr>
<td>Asian (pct)(^5)</td>
<td>9.8</td>
<td>12.6</td>
<td>6.8</td>
</tr>
<tr>
<td>Other race (pct)(^6)</td>
<td>13.4</td>
<td>14.3</td>
<td>8.2</td>
</tr>
<tr>
<td>Hispanic (pct)(^7)</td>
<td>27.0</td>
<td>27.6</td>
<td>18.2</td>
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<tr>
<td>Foreign born (pct)</td>
<td>35.9</td>
<td>35.7</td>
<td>24.4</td>
</tr>
<tr>
<td>Per capita income(^8)</td>
<td>28,848</td>
<td>30,885</td>
<td>34,259</td>
</tr>
<tr>
<td>Median household income(^9)</td>
<td>49,311</td>
<td>50,033</td>
<td>65,411</td>
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<tr>
<td>Poverty (pct)</td>
<td>21.2</td>
<td>18.7</td>
<td>16.9</td>
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<tr>
<td>Unemployment rate (pct)(^a)</td>
<td>3.8</td>
<td>9.3</td>
<td>4.4</td>
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<tr>
<td>High school degree (pct)</td>
<td>72.3</td>
<td>79.2</td>
<td>79.4</td>
</tr>
<tr>
<td>Bachelor’s degree (pct)</td>
<td>27.4</td>
<td>34.0</td>
<td>30.5</td>
</tr>
<tr>
<td>Homes owner occupied (pct)</td>
<td>30.2</td>
<td>33.6</td>
<td>53.0</td>
</tr>
<tr>
<td>Median value owner occupied</td>
<td>211,500</td>
<td>217,900</td>
<td>203,100</td>
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<td>Vacant housing (pct)</td>
<td>5.6</td>
<td>8.5</td>
<td>5.8</td>
</tr>
<tr>
<td>Violent crime rate(^b)</td>
<td>946</td>
<td>552</td>
<td>417</td>
</tr>
<tr>
<td>Property crime rate(^c)</td>
<td>2,655</td>
<td>1,692</td>
<td>1,274</td>
</tr>
</tbody>
</table>

\(^1\)The metropolitan statistical area, as defined by the U.S. Census Bureau.
\(^2\)All population figures reported in thousands.
\(^3\)Race statistics do not sum to 100 percent, they sum to the percentage of residents who identify themselves by a single race.
\(^4\)Percent Hispanic, according to the U.S. Census, is a separate category from race.
\(^5\)All figures reported in 2009 CPI inflation-adjusted dollars.
\(^6\)Represents the unemployment rate defined as the ratio of unemployed to the civilian labor force expressed as a percent (i.e., 100 times (unemployed/labor force)).
\(^7\)Represents the crime rate per 100,000 residents.

Source: Miller & Smith (2010)
Figure 1.2.1: Gross City Product, 1993-2009

Table 1-2: 2009 Census Employment Data for NYC

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total All Jobs</td>
<td>3,584,878</td>
<td>100.0%</td>
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<td><strong>Jobs by Worker Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 29 or younger</td>
<td>828,232</td>
<td>23.1</td>
</tr>
<tr>
<td>Age 30 to 54</td>
<td>2,132,725</td>
<td>59.5</td>
</tr>
<tr>
<td>Age 55 or older</td>
<td>623,921</td>
<td>17.4</td>
</tr>
<tr>
<td><strong>Jobs by Earnings</strong></td>
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<tr>
<td>$1,250 per month or less</td>
<td>720,957</td>
<td>20.1</td>
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<tr>
<td>$1,251 to $3,333 per month</td>
<td>1,028,462</td>
<td>28.7</td>
</tr>
<tr>
<td>More than $3,333 per month</td>
<td>1,835,459</td>
<td>51.2</td>
</tr>
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<td><strong>Jobs by NAICS Industry Sector</strong></td>
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<td></td>
</tr>
<tr>
<td>Agriculture, Forestry, Fishing and Hunting</td>
<td>401</td>
<td>0.0</td>
</tr>
<tr>
<td>Mining, Quarrying, and Oil and Gas Extraction</td>
<td>197</td>
<td>0.0</td>
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<tr>
<td>Utilities</td>
<td>17,433</td>
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<tr>
<td>Construction</td>
<td>116,219</td>
<td>3.2</td>
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<tr>
<td>Manufacturing</td>
<td>82,760</td>
<td>2.3</td>
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<tr>
<td>Wholesale Trade</td>
<td>141,944</td>
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<tr>
<td>Retail Trade</td>
<td>283,830</td>
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<tr>
<td>Transportation and Warehousing</td>
<td>160,872</td>
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<tr>
<td>Industry, Sector</td>
<td>Frequency</td>
<td>%</td>
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<tr>
<td>---------------------------------------------------------------------------------</td>
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<tr>
<td>Information</td>
<td>165,136</td>
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<tr>
<td>Finance and Insurance</td>
<td>324,598</td>
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<td>Real Estate and Rental and Leasing</td>
<td>137,626</td>
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<td>Professional, Scientific, and Technical Services</td>
<td>338,523</td>
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<tr>
<td>Management of Companies and Enterprises</td>
<td>66,968</td>
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<tr>
<td>Administration &amp; Support, Waste Management and Remediation</td>
<td>196,887</td>
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<td>Educational Services</td>
<td>345,963</td>
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<td>Health Care and Social Assistance</td>
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<td>Arts, Entertainment, and Recreation</td>
<td>83,171</td>
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<tr>
<td>Accommodation and Food Services</td>
<td>232,262</td>
<td>6.5</td>
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<tr>
<td>Other Services (excluding Public Administration)</td>
<td>148,631</td>
<td>4.1</td>
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<tr>
<td>Public Administration</td>
<td>177,154</td>
<td>4.9</td>
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<table>
<thead>
<tr>
<th>Jobs by Worker Race</th>
<th>Frequency</th>
<th>%</th>
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<tbody>
<tr>
<td>White Alone</td>
<td>2,238,540</td>
<td>62.4</td>
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<tr>
<td>Black or African American Alone</td>
<td>821,803</td>
<td>22.9</td>
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<tr>
<td>American Indian or Alaska Native Alone</td>
<td>22,189</td>
<td>0.6</td>
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<td>Asian Alone</td>
<td>432,081</td>
<td>12.1</td>
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<tr>
<td>Native Hawaiian or Other Pacific Islander Alone</td>
<td>7,421</td>
<td>0.2</td>
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<td>Two or More Race Groups</td>
<td>62,844</td>
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<table>
<thead>
<tr>
<th>Jobs by Worker Ethnicity</th>
<th>Frequency</th>
<th>%</th>
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<td>Not Hispanic or Latino</td>
<td>2,868,412</td>
<td>80.0</td>
</tr>
<tr>
<td>Hispanic or Latino</td>
<td>716,466</td>
<td>20.0</td>
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<table>
<thead>
<tr>
<th>Jobs by Worker Educational Attainment</th>
<th>Frequency</th>
<th>%</th>
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<td>Less than high school</td>
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<tr>
<td>High school or equivalent, no college</td>
<td>510,789</td>
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<tr>
<td>Some college or Associate degree</td>
<td>759,051</td>
<td>21.2</td>
</tr>
<tr>
<td>Bachelor's degree or advanced degree</td>
<td>1,148,943</td>
<td>32.0</td>
</tr>
<tr>
<td>Educational attainment not available (workers aged 29 or younger)</td>
<td>828,232</td>
<td>23.1</td>
</tr>
</tbody>
</table>

Source: Census Bureau (2011)

Table 1-3: 2009 Census Employment Data for MNY

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>%</th>
</tr>
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<tbody>
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<td>Total All Jobs</td>
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<table>
<thead>
<tr>
<th>Jobs by Worker Age</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 29 or younger</td>
<td>1,781,944</td>
<td>22.2</td>
</tr>
<tr>
<td>Age 30 to 54</td>
<td>4,731,087</td>
<td>58.8</td>
</tr>
<tr>
<td>Age 55 or older</td>
<td>1,526,423</td>
<td>19.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Jobs by Earnings</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1,250 per month or less</td>
<td>1,766,753</td>
<td>22.0</td>
</tr>
<tr>
<td>$1,251 to $3,333 per month</td>
<td>2,384,858</td>
<td>29.7</td>
</tr>
<tr>
<td>More than $3,333 per month</td>
<td>3,887,843</td>
<td>48.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Jobs by NAICS Industry Sector</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, Forestry, Fishing and Hunting</td>
<td>7,410</td>
<td>0.1</td>
</tr>
<tr>
<td>Mining, Quarrying, and Oil and Gas Extraction</td>
<td>2,264</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Utilities
Construction
Manufacturing
Wholesale Trade
Retail Trade
Transportation and Warehousing
Information
Finance and Insurance
Real Estate and Rental and Leasing
Professional, Scientific, and Technical Services
Management of Companies and Enterprises
Administration & Support, Waste Management and Remediation
Educational Services
Health Care and Social Assistance
Arts, Entertainment, and Recreation
Accommodation and Food Services
Other Services (excluding Public Administration)
Jobs by Worker Race
White Alone
Black or African American Alone
American Indian or Alaska Native Alone
Asian Alone
Native Hawaiian or Other Pacific Islander Alone
Two or More Race Groups
Jobs by Worker Ethnicity
Not Hispanic or Latino
Hispanic or Latino
Jobs by Worker Educational Attainment
Less than high school
High school or equivalent, no college
Some college or Associate degree
Bachelor's degree or advanced degree
Educational attainment not available (workers aged 29 or younger)
Source: Census Bureau (2011)

Table 1-4: Selected Economic Characteristics, 2005-2009, MNY

<table>
<thead>
<tr>
<th>EMPLOYMENT STATUS</th>
<th>Estimate</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Population 16 years and over</strong></td>
<td>14,959,934</td>
<td>100</td>
</tr>
<tr>
<td>In labor force</td>
<td>9,660,170</td>
<td>64.6</td>
</tr>
<tr>
<td>Civilian labor force</td>
<td>9,651,001</td>
<td>64.5</td>
</tr>
<tr>
<td>Employed</td>
<td>8,972,785</td>
<td>60.0</td>
</tr>
<tr>
<td>Unemployed</td>
<td>678,216</td>
<td>4.5</td>
</tr>
<tr>
<td>Armed Forces</td>
<td>9,169</td>
<td>0.1</td>
</tr>
<tr>
<td>Not in labor force</td>
<td>5,299,764</td>
<td>35.4</td>
</tr>
</tbody>
</table>

Source: Census Bureau (2011)
### OCCUPATION

<table>
<thead>
<tr>
<th>Civilian employed population 16 years and over</th>
<th>8,972,785</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management, professional, and related occupations</td>
<td>3,515,240</td>
<td>39.2</td>
</tr>
<tr>
<td>Service occupations</td>
<td>1,604,039</td>
<td>17.9</td>
</tr>
<tr>
<td>Sales and office occupations</td>
<td>2,349,572</td>
<td>26.2</td>
</tr>
<tr>
<td>Farming, fishing, and forestry occupations</td>
<td>9,276</td>
<td>0.1</td>
</tr>
<tr>
<td>Construction, extraction, maintenance, and repair occupations</td>
<td>673,022</td>
<td>7.5</td>
</tr>
<tr>
<td>Production, transportation, and material moving occupations</td>
<td>821,636</td>
<td>9.2</td>
</tr>
</tbody>
</table>

### CLASS OF WORKER

<table>
<thead>
<tr>
<th>Civilian employed population 16 years and over</th>
<th>8,972,785</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private wage and salary workers</td>
<td>7,081,483</td>
<td>78.9</td>
</tr>
<tr>
<td>Government workers</td>
<td>1,351,162</td>
<td>15.1</td>
</tr>
<tr>
<td>Self-employed in own not incorporated business workers</td>
<td>527,309</td>
<td>5.9</td>
</tr>
<tr>
<td>Unpaid family workers</td>
<td>12,831</td>
<td>0.1</td>
</tr>
</tbody>
</table>

### Income & Benefits (In 2009 Inflation-adjusted Dollars)

<table>
<thead>
<tr>
<th>Total households</th>
<th>6,750,902</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $10,000</td>
<td>513,587</td>
<td>7.6</td>
</tr>
<tr>
<td>$10,000 to $14,999</td>
<td>319,263</td>
<td>4.7</td>
</tr>
<tr>
<td>$15,000 to $24,999</td>
<td>584,263</td>
<td>8.7</td>
</tr>
<tr>
<td>$25,000 to $34,999</td>
<td>554,939</td>
<td>8.2</td>
</tr>
<tr>
<td>$35,000 to $49,999</td>
<td>765,874</td>
<td>11.3</td>
</tr>
<tr>
<td>$50,000 to $74,999</td>
<td>1,107,244</td>
<td>16.4</td>
</tr>
<tr>
<td>$75,000 to $99,999</td>
<td>835,887</td>
<td>12.4</td>
</tr>
<tr>
<td>$100,000 to $149,999</td>
<td>1,038,882</td>
<td>15.4</td>
</tr>
<tr>
<td>$150,000 to $199,999</td>
<td>468,047</td>
<td>6.9</td>
</tr>
<tr>
<td>$200,000 or more</td>
<td>562,916</td>
<td>8.3</td>
</tr>
</tbody>
</table>

**Median household income (dollars)** | 63,553 | -- |

**Mean household income (dollars)** | 91,832 | -- |

<table>
<thead>
<tr>
<th>Families</th>
<th>4,471,071</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $10,000</td>
<td>204,422</td>
<td>4.6</td>
</tr>
<tr>
<td>$10,000 to $14,999</td>
<td>142,970</td>
<td>3.2</td>
</tr>
<tr>
<td>$15,000 to $24,999</td>
<td>311,946</td>
<td>7.0</td>
</tr>
<tr>
<td>$25,000 to $34,999</td>
<td>332,437</td>
<td>7.4</td>
</tr>
<tr>
<td>$35,000 to $49,999</td>
<td>480,286</td>
<td>10.7</td>
</tr>
<tr>
<td>$50,000 to $74,999</td>
<td>728,399</td>
<td>16.3</td>
</tr>
<tr>
<td>$75,000 to $99,999</td>
<td>604,013</td>
<td>13.5</td>
</tr>
<tr>
<td>$100,000 to $149,999</td>
<td>814,727</td>
<td>18.2</td>
</tr>
<tr>
<td>$150,000 to $199,999</td>
<td>385,193</td>
<td>8.6</td>
</tr>
<tr>
<td>$200,000 or more</td>
<td>466,678</td>
<td>10.4</td>
</tr>
</tbody>
</table>

**Median family income (dollars)** | 76,358 | -- |

**Mean family income (dollars)** | 105,906 | -- |

**Per capita income (dollars)** | 34,226 | --

1.3 Appendix 3: UCASS Interviewer Guideline Questions

1. How has the business environment changed over the years since 9/11?

2. Do you feel safe in Lower Manhattan?
   a. Have you ever felt unsafe in the area?

3. How have security practices in Lower Manhattan affected the business environment?
   a. Positive impacts
   b. Negative impacts

4. How do businesses in the neighborhood feel about the current level of security of Lower Manhattan?
   a. How about your customers (if a business)?
   b. How do residents in the neighborhood feel about the current security of Lower Manhattan?

5. Are there any particular security measures that you would like to see in place in Lower Manhattan?
   a. Are there particular security measures you would like to see removed?

6. Do you think there is enough security in Lower Manhattan?
   a. Do you think more or less is needed? Please elaborate.

7. Do you think that the security of Lower Manhattan has affected property values in the area?

8. Do non-invasive or invisible security measures, such as surveillance cameras or the streetscape security measures along Wall Street, have an effect on economic activity in the area?

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This instrument was developed by Renee Graphia-Joyal, with input from Paul Kantor and Fred Roberts.
1.4 Appendix 4: UCASS Survey via Mechanical Turk

Q1.1 How often have you visited Lower Manhattan for recreation (e.g. to visit as a tourist, to shop or dine only) in the last year?
1 Never
2 Once
3 A few times
4 About once a month
5 Once a Week
6 2-3 Times a Week
7 Daily

Q1.2 What is your home Zip Code? (This survey is for specific regions of the country; it is possible that you will not be allowed to complete this survey.)

Q1.3 What is the Zip Code of your workplace? (If this does not apply to you, please enter 00000)

Q2.1 Informed Consent Form

Introduction
This survey is exploring the tradeoffs between economic activity and security by using stated preference approaches for quantifying the indirect costs of security. The survey will also be used to estimate the impact of security practices and policies on stakeholders’ levels of fear, sense of privacy and behavioral choices/daily routines when in Lower Manhattan.

Procedures
The survey opens with a brief series of questions asking about basic demographic information to determine if you qualify as a participant for this study. If you do NOT meet the pre-screening criteria, you will be sent to the end of the survey and we thank you for your time. If you do qualify for this study, you will be presented two hypothetical narratives, each describing the implementation of a security measure in Lower Manhattan. Following each narrative, you will be asked a series of questions about your perceived affective reactions and behavioral decision making to the security measure. The security narratives and questions, while based on security measures that are real, are hypothetical in this survey. Furthermore, some of the countermeasures described may be more familiar as they have been introduced in some form into Lower Manhattan, while others are completely new. Neither the City of New York nor the New York Police Department have reviewed or endorsed the materials presented in this survey; rather these materials have been created by the research team solely for the purposes of this study. The survey is expected to take approximately 20 minutes to complete.

Risks/Discomforts
There are no foreseeable risks to participation in this survey.

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129 This instrument was developed by Renee Graphia-Joyal and Heather Rosoff, with input from Adam Rose, Paul Kantor, and other members of the project team.
Benefits
Once you have fully completed the online survey, and the survey completion has been validated, you will receive $5 in compensation for your time.

Confidentiality
All data obtained from participants will be kept confidential. All questionnaires will be concealed, and no one other than the primary investigator and assistant researchers will have access to them. The data collected will be stored in the HIPPA-compliant, Qualtrics-secure database until it has been deleted by the primary investigator.

Participation
Participation in this research study is completely voluntary. You have the right to withdraw at anytime or refuse to participate entirely without penalty. If you desire to withdraw, please just close your internet browser.

Questions about the Research
If you have questions regarding this study, you may contact DIMACS/CCICADA at Rutgers University at (732) 445-5928. Written correspondence can be sent to Rutgers University, DIMACS/CCICADA, 96 Frelinghuysen Road, Piscataway, NJ 08854

Questions about your Rights as Research Participants
If you have questions you do not feel comfortable asking the researcher, you may contact a Rutgers University IRB Administrator at humansubjects@orsp.rutgers.edu or (732) 932-0150 ext. 2104. Written correspondence can be sent to Rutgers University, Institutional Review Board for the Protection of Human Subjects, Office of Research and Sponsored Programs, 3 Rutgers Plaza, New Brunswick, NJ 07901.

Q2.2  I have read, understood, and printed a copy of, the above consent form and desire of my own free will to participate in this study.
1  Yes
2  No
If No Is Selected, Then Skip To End of Survey

Q3.1 Do you own or operate a business?
1  Yes
2  No
If ‘Yes’ Is Selected

Q3.2 Is the business you own or operate located in Lower Manhattan?
1  Yes
2  No

Q3.6 What modes of transportation do you MOST OFTEN use when traveling to and from or within Lower Manhattan? (Select all that apply.)
1  Personal vehicle
2  Taxi
Q4.1- Q4.4 First, imagine that your business/home/work is located in Lower Manhattan. Please read the following hypothetical situation, and then answer the questions about its effects on your daily routines and habits as if your business/home/work was located in Lower Manhattan. To increase security, suppose the New York Police Department put into place street restrictions and security checkpoints affecting pedestrian traffic. The checkpoints would include temporary barricades at various intersections in the area. Anyone traveling into or within the area would be subject to a “stop and search” by a uniformed New York police officer. The plan is to prevent another terrorist attack within Lower Manhattan (the area south of Canal Street) by increasing the visible presence of law enforcement and to deter a potential suicide bomber by controlling pedestrian traffic. We expect that these enhanced security measures will cause delays.

If Please read the following h... Is Displayed, Then Skip To Do you have a usual route when travel...

Q4.5 Do you have a usual route when traveling to and from Lower Manhattan?
1 Yes
2 No

Read the following statements (Q4.6-Q4.6F) and indicate your level of agreement with each, using the scale below.
1 Strongly Disagree
2 Disagree
3 Somewhat Disagree
4 Somewhat Agree
5 Agree
6 Strongly Agree

Q4.6: I believe random security checks would help keep contraband and hazardous materials (like bombs) from entering Lower Manhattan.
Q4.6A: Knowing I could be randomly stopped and searched by a police officer while walking in Lower Manhattan makes me uncomfortable.
Q4.6B: The delay in my routine created by "stop and search" inspections would be frustrating.
Q4.6C: I would be more willing to visit, work, live and/or own a business in Lower Manhattan knowing that enhanced security measures are implemented.
Q4.6D: The Lower Manhattan "stop and search" inspections program is an unacceptable breach of my freedom.
Q4.6E: I believe “stop and search” inspections are a violation of my privacy.
Q4.6F: Knowing I can be randomly stopped and searched by a police officer while walking in Lower Manhattan makes me stressed and anxious.
Q5.1 Consider the possibility that the only entrance to your business is on a block with security checkpoints at both ends. For customers, clients and employees to get to your business they have to pass through the security checkpoint. Here a police officer will search their bags and ask to see identification. If they do not want to pass through the security checkpoint, their options are to wait a few hours until the checkpoint is removed or leave and come back another time.

Q5.2 If a security checkpoint were to be routinely implemented several times a week on the street which your business is located, do you think your business’ MONTHLY revenue would increase, decrease, or not change?
1 Increase
2 No change
3 Decrease

If ‘Increase’ Is Selected
Q5.3 By how much would your average MONTHLY gross operating revenue increase?
2 1% – 5%
3 5% – 10%
4 10% – 25%
5 25% – 50%
6 More than 50%

If ‘Decrease’ Is Selected
Q5.4 By how much would your average MONTHLY gross operating revenue decrease?
2 1% – 5%
3 5% – 10%
4 10% – 25%
5 25% – 50%
6 More than 50%

Q5.5 Would you be willing to offer your customers/clients a discount to offset any inconvenience they experience because of the security checkpoint?
1 Yes
2 No

If ‘Yes’ Is Selected
Q5.6 Would you be willing to offer your customers/clients a discount valued at $10?
1 Yes
2 No

If ‘Yes’ Is Selected
Q5.7 Since you are willing to offer a $10 discount, would you be willing to offer your customers/clients a $15 discount?
1 Yes
2 No
If ‘No’ Is Selected
Q5.8 Since you are NOT willing to offer a discount valued at $10, would you be willing to offer your customers/clients a $5 discount?
1 Yes
2 No

If ‘Yes’ Is Selected
Q5.9 What is the most you would be willing to offer your customers/clients as a discount to offset their inconvenience? (Please provide a numeric value equal to or greater than 0):

Q5.10 If a security checkpoint were to be routinely implemented several times a week on the street which your business is located, would you continue to operate your business from that address?
1 Yes, I would keep my business open at that location
3 No, I would relocate my business to a new location within Lower Manhattan
5 No, I would relocate my business to a new location outside of Lower Manhattan
2 No, I would close my business

Q5.11 Is your business a restaurant or retail store?
1 Restaurant
2 Retail store
3 Neither

If ‘Restaurant’ Is Selected
Q5.12 How would you best describe your restaurant?
1 High-end eatery
2 Average eatery
3 Low-end eatery

If ‘Retail store’ Is Selected
Q5.13 How would you best describe your retail store?
1 High-end, luxury goods and/or service provider
2 Average goods and/or service provider
3 Low-end, discount goods and/or service provider

Q1161 This section of the survey asked questions about increasing the number of mounted police units in New York City. [Reliability Question]
1 True
2 False

Q6.1 Consider the possibility that upon returning home you find that the block you live on has security checkpoints at both ends. A police officer tells you that to obtain access to your home you must pass through a security checkpoint. Here the officer would search your bags and check
your identification to verify you live on the block. Your only alternative is to wait a few hours for the random security check to be removed.

Q6.2 Would you agree to go through the security checkpoint to get home?
1 Yes
2 No

If ‘Yes’ Is Selected
Q6.3 There is a line to go through the security checkpoint. The officer says the wait is 5 minutes. Would you wait that long?
1 Yes
2 No

If ‘Yes’ Is Selected
Q6.4 Since you agreed to wait 5 minutes, would you be willing to wait 10 minutes?
1 Yes
2 No

If ‘No’ Is Selected
Q6.5 What if you only had to wait 3 minutes?
1 Wait
2 Go Away

If ‘No’ Is Selected
Q6.6 Since you are NOT willing to pass through the security checkpoint, where might you go until the checkpoint is closed for the day? (Check all that apply.)
1 Restaurant
2 Bar
3 Coffee shop
4 Shopping at a store
5 Friend's house
6 Back to your office
7 The park or river front
8 Stand around and use my cell phone
9 Other ____________________

Q6.7 – Q6.9 Keeping in mind that you said you were willing to wait for the security checkpoint, consider the questions below:
OR
Q6.10 Keeping in mind that you said you were NOT willing to wait for the security checkpoint, consider the questions below:
Q6.11 Suppose that a "security" tax to fund these security checkpoints has been added to the New York City ballot. If approved, this tax will increase your monthly cost of living. Would you consider paying for a "security" tax?
1 Yes
2 No

If ‘Yes’ Is Selected
Q6.12 How would you vote on a “security tax” to support random checkpoints if it would cost you $15 each month ($180 a year)?
1 In Favor
2 Against

If ‘In Favor’ Is Selected
Q6.13 Since you were willing to pay $15 per month to support the “security tax,” how would you vote for a "security tax" to support random checkpoints if it would cost you $32 a month ($384 a year)?
1 In Favor
2 Against

If ‘Against’ Is Selected
Q6.14 Since you were NOT willing to pay $15 per month to support the “security tax,” how would you vote for a “security tax” to support random checkpoints if it would cost $7 each month ($84 a year)?
1 In Favor
2 Against

Q6.15 What is the most (in dollars per month) you would be willing to pay for a "security tax" to fund the operation of random checkpoints? (Please provide a numeric value equal to or greater than 0):

Q6.16 You were willing to pay $____ to support a security checkpoint program for which your wait time was 5 minutes. How much would you be willing to pay for an improved security checkpoint program that reduces your wait time to 4 minutes?

Q6.17 You were willing to pay $____ to support a security checkpoint program for which your wait time was 10 minutes. How much would you be willing to pay for an improved security checkpoint program that reduces your wait time to 9 minutes?

Q6.18 You were willing to pay $____ to support a security checkpoint program for which your wait time was 3 minutes. How much would you be willing to pay for an improved security checkpoint program that reduces your wait time to 2 minutes?

Q6.19 If a security checkpoint were to be routinely implemented several times a week on the street you live, would you continue to live at that address?
1 Yes, I would continue to live at that address
3 Yes, but I would look for another place to live within Lower Manhattan
2 Yes, but I would look for another place to live outside of Lower Manhattan
5 No, I would definitely move out of Lower Manhattan

Q7.1 Consider the possibility that the block on which you work has security checkpoints at both ends. A police officer tells you that to obtain access to your office you must pass through the security checkpoints. Here the officer would search your bags and check your identification. Your only alternative is to wait a few hours for the random security check to be removed.

Q7.2 Would you agree to go through the security checkpoint to get to work?
1 Yes
2 No
If Q7.2 ‘Yes’ Is Selected
Q7.3 There is a line to go through the security checkpoint. The officer says the wait is 5 minutes. Would you wait that long?
1 Yes
2 No
If ‘Yes’ Is Selected Q7.4 Since you agreed to wait 5 minutes, would you be willing to wait 10 minutes?
1 Yes
2 No
If ‘No’ Is Selected
Q7.5 Since you were NOT willing to wait 5 minutes, would you be willing to wait 3 minutes?
1 Yes
2 No

Answer If Q7.2 ‘No’ Is Selected
Q7.6 Since you are not willing to pass through the security checkpoint, what might you do next? (Check all that apply.)
1 Contact work and tell them you cannot get to the office
2 Go home to work
3 Go home and take the day off
4 Go to another office branch
5 Go to another location to work remotely, such as a restaurant, coffee shop, or library
6 Other ______________

Q7.7-Q7.9 Keeping in mind that you said you were willing to wait at the security checkpoint, consider the questions below:
OR
Q7.10 Keeping in mind that you said you were NOT willing to wait at the security checkpoint, consider the questions below:

Q7.11 Suppose New York City is increasing transportation costs to support the implementation of these security checkpoints. The fare increase would apply to all modes of transportation (i.e.
train, subway, bus, ferry, taxis, and tolls) traveling into, out of and within Lower Manhattan.

Would you be willing to pay a monthly increase in transportation costs?
1  Yes
2  No

If ‘Yes’ Is Selected
Q7.12 Suppose the fare increase will cost households like yours an additional $15 per month. Would you be willing to pay an additional $15 per month in transportation costs to support the implementation of random checkpoints?
1  Yes
2  No

If ‘Yes’ Is Selected
Q7.13 Since you are willing to pay $15 per month, would you be willing to pay an additional $32 per month in transportation costs to support the implementation of random checkpoints?
1  Yes
2  No

If Q7.12 ‘No’ Is Selected
Q7.14 Since you are NOT willing to pay $15 per month, would you be willing to pay an additional $7 in increased transportation costs for your trip to Lower Manhattan?
1  Yes
2  No

Q7.15 What is the maximum amount you would be willing to pay per month in transportation costs to support the implementation of security checkpoints in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Q7.16 You were willing to pay $____ to support a security checkpoint program that you have to wait 5 minutes to use. How much would you be willing to pay for an improved security checkpoint program that makes you wait only 4 minutes?

Q7.17 You were willing to pay $____ to support a security checkpoint program that you have to wait 10 minutes to use. How much would you be willing to pay for an improved security checkpoint program that makes you wait only 9 minutes?

Q7.18 You were willing to pay $____ to support a security checkpoint program that you have to wait 3 minutes to use. How much would you be willing to pay for an improved security checkpoint program that makes you wait only 2 minutes?

Q7.19 If a security checkpoint were to be routinely implemented several times a week on the street you work, would you continue to work at that address?
1  Yes, I would continue to work at that address
3  No, I would request or find a new address within Lower Manhattan from which to work
2  No, I would look for a new job
Q7.20 When working in Lower Manhattan, do you typically bring your own lunch from home or eat out?
1 Bring lunch and eat in the office building
2 Bring lunch and eat outside the office building
3 Eat out

If ‘Eat’ out Is Selected
Q7.21 What time do you normally go out to lunch?
1 10:30 a.m. to 11:00 a.m.
2 11:00 a.m. to 11:30 a.m.
3 11:30 a.m. to 12:00 p.m.
4 12:00 p.m. to 12:30 p.m.
5 12:30 p.m. to 1:00 p.m.
6 1:00 p.m. to 1:30 p.m.
7 1:30 p.m. to 2:00 p.m.
8 2:00 p.m. to 2:30 p.m.
9 2:30 p.m. to 3:00 p.m.
10 3:00 p.m. to 3:30 p.m.
11 3:30 p.m. to 4:00 p.m.

If ‘Eat out’ Is Selected
Q7.22 How much on average do you spend per person for lunch?
1 $0-$10.00
2 $11.00-$30.00
3 $31.00-$50.00
4 $51.00-$80.00
5 $81.00-$120.00
11 More than $120.00

Q8.1 Consider the possibility that you are walking toward Wall Street to meet some friends and take pictures of the New York Stock Exchange. The block on which you are meeting your friends has security checkpoints at both ends. A police officer tells you that to obtain access to the street you must pass through a security checkpoint. Here the officer would search your bags and check your identification. If you choose not to pass through the security checkpoint, you will not be able to get to the meeting spot you set with your friends until the checkpoint is removed.

Q8.2 Would you agree to go through the security checkpoint to get to your friends?
1 Yes
2 No

If ‘Yes’ Is Selected
Q8.3 There is a line to go through the security checkpoint. The officer says the wait is 5 minutes. Would you be willing to wait that long?
If ‘Yes’ Is Selected
Q8.4 Since you agreed to wait 5 minutes, would you be willing to wait 10 minutes?
1     Yes
2     No

If ‘No’ Is Selected
Q8.5 Since you were NOT willing to wait 5 minutes, would you be willing to wait 3 minutes?
1     Yes
2     No

If Q8.2 ‘No’ Is Selected
Q8.6 Since you are not willing to pass through the security checkpoint, where do you think you
would go? (Check all that apply.)
1     Call my friends to set up a new meeting location
2     Meet my friends at a nearby restaurant, deli, or coffee shop to eat
3     Look on the internet to find another fun site to visit in Lower Manhattan
4     Go shopping
5     Go home
6     Other ___________

Q8.7 – Q9.8 Keeping in mind that you said you were willing to wait for the security checkpoint, consider the questions below:
OR
Q8.10 Keeping in mind that you said you were NOT willing to wait at the security checkpoint, consider the questions below:

Q8.11 Suppose New York City is increasing transportation costs to support the implementation of these security checkpoints. The fare increase would apply to all modes of transportation (i.e. train, subway, bus, ferry, taxis, and tolls) traveling into, out of and within Lower Manhattan. Would you be willing to pay a monthly increase in transportation costs?
1     Yes
2     No

If ‘Yes’ Is Selected
Q8.12 Suppose the fare increase will cost households like yours an additional $15 per month. Would you be willing to pay an additional $15 per month in transportation costs to support the implementation of random checkpoints?
1     Yes
2     No

If ‘Yes’ Is Selected
Q8.13 Since you are willing to pay $15 per month, would you willing to pay an additional $32 per month in transportation costs to support the implementation of random checkpoints?
If Q8.12 ‘No’ Is Selected
Q8.14 Since you are NOT willing to pay $15 per month, would you be willing to pay an additional $7 in increased transportation costs to support the implementation of random checkpoints?
1 Yes
2 No

Q8.15 What is the maximum amount you would be willing to pay per month in transportation costs to support the implementation of security checkpoints in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Q8.16 You were willing to pay $____ to support a security checkpoint program that you have to wait 5 minutes to use. How much would you be willing to pay for an improved security checkpoint program that makes you wait only 4 minutes?

Q8.17 You were willing to pay $____ to support a security checkpoint program that you have to wait 10 minutes to use. How much would you be willing to pay for an improved security checkpoint program that makes you wait only 9 minutes?

Q8.18 You were willing to pay $____ to support a security checkpoint program that you have to wait 3 minutes to use. How much would you be willing to pay for an improved security checkpoint program that makes you wait only 2 minutes?

Q8.19 If a security checkpoint were to be routinely implemented several times a week on the street you often visit to eat and/or shop, would you continue to visit restaurants and stores on that street?
1 Yes, I would continue to eat and/or shop on that street
2 No, I would find other stores to eat and/or shop

Q8.20 Suppose you happened to be in Lower Manhattan in the afternoon. How likely is it that you would stop to eat lunch at a restaurant, bar, deli or street vendor in Lower Manhattan?
1 Very Unlikely
2 Unlikely
3 Undecided
4 Likely
5 Very Likely

Q8.21 If you are a visitor in Lower Manhattan, what time do you think you would stop to eat lunch?
1 10:00 a.m. to 10:30 a.m.
13 10:30 a.m. to 11:00 a.m.
3 11:00 a.m. to 11:30 a.m.
4 11:30 a.m. to 12:00 p.m.
Q8.22 How much on average do you spend per person for lunch?

1. $0-$10.00
2. $11.00-$30.00
3. $31.00-$50.00
4. $51.00-$80.00
5. $81.00-$120.00
6. More than $120.00

Q8.23 Assume you are still in Lower Manhattan as the evening time approaches. How likely is it that you would stop to eat dinner at a restaurant, deli or other eatery in Lower Manhattan?

1. Very Unlikely
2. Unlikely
3. Undecided
4. Likely
5. Very Likely

If ‘Very Likely’, ‘Likely’ or ‘Undecided’ Is Selected

Q8.24 In a circumstance such as this, what time do you normally eat dinner?

1. 4:30 pm to 5:00 pm
2. 5:00 pm to 5:30 pm
3. 5:30 pm to 6:00 pm
4. 6:00 pm to 6:30 pm
5. 6:30 pm to 7:00 pm
6. 7:00 pm to 7:30 pm
7. 7:30 pm to 8:00 pm
8. 8:00 pm to 8:30 pm
9. 8:30 pm to 9:00 pm
10. 9:00 pm to 9:30 pm
11. 9:30 pm to 10:00 pm
12. 10:00 p.m. to 10:30 p.m.
13. later than 10:30 p.m.

If ‘Very Likely’, ‘Likely’ or ‘Undecided’ Is Selected

Q8.25 How much on average do you spend per person for dinner?

1. $0 - $10
2. $11 - $30
Q9.1 First, imagine that your business/home/work is located in Lower Manhattan. Please read the following hypothetical situation, and then answer the questions about its effects on your daily routines and habits as if your business was located in Lower Manhattan.

In 2005, the New York Police Department (NYPD) initiated the Lower Manhattan Security Initiative, which includes the use of close circuit television (CCTV) cameras. By November of 2010, it was reported that approximately 1,300 CCTV cameras were operating in the area. There are plans for a total of 3,000 fully operational CCTV cameras to be located throughout Lower Manhattan by 2013. NYPD, other public agencies and the private sector share ownership of the camera network as well as oversight of the cameras’ operations and monitoring. The Lower Manhattan Coordination Center, which is staffed 24 hours a day, seven days a week by NYPD police officers, serves as the central intake for surveillance captured in Lower Manhattan south of Canal Street. The CCTV cameras support ongoing public safety activities, including the city’s counterterrorism efforts, by increasing the surveillance of the Lower Manhattan area. The cameras are capable of capturing very detailed pictures of people and objects, including license plates. The CCTV cameras will help police identify and observe terrorists’ pre-planning and preparing for an attack, assess suspicious activity or actual events, reduce incident response time, and create a common technological infrastructure for security surveillance. Moreover, research has shown that CCTV cameras moderately reduce common crimes. The cameras currently run 24 hours per day, 7 days a week. The captured footage is being maintained for 30 days before being deleted. Officials insist that cameras are only being used to monitor public spaces where there are no expectations of privacy; however, civil rights groups have argued that the CCTV system is excessive and infringes on the public’s civil liberties. Funding is provided by both the U.S. Department of Homeland Security and New York City. CCTV surveillance systems have been used for decades to successfully reduce terrorist attacks in both London and Belfast.

Q9.5 Are you aware that there are over 1,000 CCTV cameras located throughout Lower Manhattan?
1  Yes
2  No

Q9.6 & Q9.6A Using the scale below, indicate how SCARED you are that:
1  Not Scared at All
2  Not Scared
3  Somewhat Not Scared
4  Somewhat Scared
5  Scared
6  Very Scared
Q9.6 Another terrorist attack will occur in Lower Manhattan over the next year.
Q9.6A You will be a victim of common crime in Lower Manhattan over the next year.
Q9.7 & Q9.7A Using the scale below, indicate how LIKELY:
1 Not Likely at All
2 Unlikely
3 Somewhat Unlikely
4 Somewhat Likely
5 Likely
6 Very Likely
Q9.7: Another terrorist attack in Lower Manhattan is over the next year.
Q9.7A: You will be a victim of a common crime in Lower Manhattan over the next year.

Read the following statements (Q10.1-Q10.1I) and indicate your level of agreement with each, using the scale below.
1 Strongly Disagree
2 Disagree
3 Somewhat Disagree
4 Somewhat Agree
5 Agree
6 Strongly Agree

Q10.1: The CCTV cameras make Lower Manhattan a safer place to operate a business.
Q10.1A: Having CCTV cameras in Lower Manhattan helps prevent terrorist attacks.
Q10.1B: I think that too much money has been invested in Lower Manhattan’s CCTV system.
Q10.1C: The presence of CCTV cameras makes me uncomfortable.
Q10.1D: The CCTV cameras infringe on my right to privacy.
Q10.1E: The presence of CCTV cameras makes having a business in Lower Manhattan more attractive to me.
Q10.1F: Since the CCTV system has been installed, my monthly revenue has increased.
Q10.1G: I am uncomfortable knowing that the CCTV cameras are monitored by law enforcement, public agencies and private sector companies.
Q10.1H: I think that the amount of money invested in Lower Manhattan’s CCTV system is necessary.
Q10.1I: Knowing that the footage captured by the CCTV cameras is maintained for 30 days before being deleted makes me uncomfortable.

Q10.2 Do your customers/clients ever talk about the safety of Lower Manhattan?
1 Yes
2 No

If ‘Ye’ Is Selected
Q10.3 What do they say?

Q10.4 Do your customers/clients ever mention the CCTV security system in Lower Manhattan?
1 Yes
2 No
If ‘Yes’ Is Selected
Q10.5 What do they say?

Q10.12 Assume New York City is considering raising property taxes for all properties located south of Canal Street to support the existing 1,300 CCTV security cameras in Lower Manhattan. Would you be willing to increase your monthly business expenses to cover this cost?
1 Yes
2 No
If No Is Selected, Then Skip To End of Block

Q10.13 To support the existing 1,300 CCTV security cameras in Lower Manhattan, the property tax increase will cost you an additional $250 per month in business expenses. Would you be willing to pay the extra $250 per month in business expenses?
1 Yes
2 No

If ‘Yes’ Is Selected
Q10.14 Since you willing to pay an extra $250 per month, would you be willing to pay an extra $325 per month in business expenses to support the existing 1,300 CCTV security cameras in Lower Manhattan?
1 Yes
2 No

If ‘Yes’ Is Selected
Q10.15 Since you willing to pay an extra $325 per month, would you be willing to pay an extra $425 per month in business expenses to support the existing 1,300 CCTV security cameras in Lower Manhattan?
1 Yes
2 No

If ‘No’ Is Selected
Q10.16 Since you are NOT willing to pay an extra $250 per month, would you be willing to pay an extra $175 per month in business expenses to support the existing 1,300 CCTV security cameras in Lower Manhattan?
1 Yes
2 No

Q10.17 What is the maximum amount you would be willing to pay extra in living expenses per month to support the existing 1,300 CCTV security cameras in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Q11.1 Assume New York City has already managed to fund the existing 1300 CCTV cameras in Lower Manhattan. The city is now considering raising transportation costs to support the addition of 1,700 CCTV security cameras in Lower Manhattan (resulting in a total of 3,000 cameras in Lower Manhattan). Would you be willing to increase your monthly business expenses to cover this cost?
Q11.2 To support the additional 1,700 CCTV security cameras in Lower Manhattan (resulting in a total of 3,000 cameras in Lower Manhattan), the property tax increase will cost you an additional $250 per month in business costs. Would you be willing to pay the extra $250 per month in business costs?
1   Yes
2   No

If ‘Yes’ Is Selected
Q11.3 Since you are willing to pay an extra $250 per month, would you be willing to pay an extra $325 per month in business expenses to support the additional 1,700 CCTV security cameras?
1   Yes
2   No

If ‘Yes’ Is Selected
Q11.4 Since you are willing to pay an extra $325 per month, would you be willing to pay an extra $425 per month in business expenses to support the additional 1,700 CCTV security cameras?
1   Yes
2   No

Answer Q11.2 ‘No’ Is Selected
Q11.5 Since you are NOT willing to pay an extra $250 per month, would you be willing to pay an extra $175 per month in business expenses to support the additional 1,700 CCTV security cameras?
1   Yes
2   No

Q11.6 What is the maximum amount you would be willing to pay extra in business expenses per month to support the additional 1,700 CCTV security cameras in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Q11.7 If Lower Manhattan’s security system were expanded from 1,300 to 3,000 cameras total, do you think your business’ MONTHLY revenue would increase, decrease, or not change?
1   Increase
2   No change
3   Decrease

If ‘Increase’ Is Selected
Q11.8 By how much would your average MONTHLY gross operating revenue increase?
2   1% – 5%
3   5% – 10%
If ‘Decrease’ Is Selected
Q11.9 By how much would your average MONTHLY gross operating revenue decrease?
2 1% – 5%
3 5% – 10%
4 10% – 25%
5 25% – 50%
6 More than 50%

If ‘Increase’ Is Selected
Q1164 By how much would your average MONTHLY gross operating revenue increase?
2 1% – 5%
3 5% – 10%
4 10% – 25%
5 25% – 50%
6 More than 50%

If ‘Decrease’ Is Selected
Q1165 By how much would your average MONTHLY gross operating revenue decrease?
2 1% – 5%
3 5% – 10%
4 10% – 25%
5 25% – 50%
6 More than 50%

Q11.10 Suppose that, rather than increasing property taxes, the Lower Manhattan business district has proposed the addition of a “security” tax on goods and services offered throughout Lower Manhattan. The “security” tax would support the entire CCTV security system (a total of 3,000 cameras by 2013) in Lower Manhattan. Would you be willing to increase your annual cost of living to cover the expense of the "security" tax?
1 Yes
2 No

Q12.1 For households like yours, it is estimated that the "security" tax would increase your annual cost of living by $75. Would you be willing to pay the extra $75 per year in living costs?
1 Yes
2 No
If ‘Yes’ Is Selected
Q12.2 Since you are willing to pay an extra $75 per year, would you be willing to pay an extra $120 per year in living costs for the "security” tax?
1 Yes
2 No

If ‘Yes’ Is Selected
Q12.3 Since you are willing to pay an extra $120 per year, would you be willing to pay an extra $220 per year in living costs for the "security” tax?
1 Yes
2 No

If Q12.2 ‘No’ Is Selected
Q12.4 Since you are NOT willing to pay an extra $75 per year, would you be willing to pay an extra $45 per year in living costs for the "security" tax?
1 Yes
2 No

Q12.5 What is the maximum amount you would be willing to pay extra per year in living costs to support the CCTV "security" tax in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Q1216 This section of the survey asked questions about increasing the number of bomb-sniffing dogs in New York City. [Reliability Check]
1 True
2 False

Read the following statements (Q13.1-Q13.1I) and indicate your level of agreement with each, using the scale below.
1 Strongly Disagree
2 Disagree
3 Somewhat Disagree
4 Somewhat Agree
5 Agree
6 Strongly Agree

Q13.1: The CCTV cameras make Lower Manhattan a safer place to live.
Q13.1A: Having CCTV cameras in Lower Manhattan helps prevent terrorist attacks.
Q13.1 B: I think that too much money has been invested in Lower Manhattan’s CCTV system.
Q13.1 C: The presence of CCTV cameras makes me uncomfortable.
Q13.1 D: The CCTV cameras infringe on my right to privacy.
Q13.1 E: The presence of CCTV cameras makes living in Lower Manhattan more attractive to me.
Q13.1 F: The CCTV cameras make me feel safer walking around Lower Manhattan.
Q13.1 G: I am uncomfortable knowing that the CCTV cameras are monitored by law enforcement, public agencies and private sector companies.
Q13.1 H: I think that the amount of money invested in Lower Manhattan’s CCTV system is necessary.
Q13.1 I: Knowing that the footage captured by the CCTV cameras is maintained for 30 days before being deleted makes me uncomfortable.

Q13.2 Assume New York City is considering raising property taxes for all properties located south of Canal Street to support the existing 1,300 CCTV security cameras in Lower Manhattan. Would you be willing to increase your monthly living expenses to cover this cost?
1. Yes
2. No
If No Is Selected, Then Skip To End of Block

Q13.3 To support the existing 1,300 CCTV security cameras in Lower Manhattan, the property tax increase will cost you an additional $45 per month in living expenses. Would you be willing to pay the extra $45 per month in living expenses?
1. Yes
2. No
If ‘Yes’ Is Selected
Q13.4 Since you willing to pay an extra $45 per month, would you be willing to pay an extra $65 per month in living expenses to support the existing 1,300 CCTV security cameras in Lower Manhattan?
1. Yes
2. No
If ‘Yes’ Is Selected
Q13.5 Since you willing to pay an extra $65 per month, would you be willing to pay an extra $78 per month in living expenses to support the existing 1,300 CCTV security cameras in Lower Manhattan?
1. Yes
2. No
If Q13.3 ‘No’ Is Selected
Q13.6 Since you are NOT willing to pay an extra $45 per month, would you be willing to pay an extra $10 per month in living expenses to support the existing 1,300 CCTV security cameras in Lower Manhattan?
1. Yes
2. No
Q13.7 What is the maximum amount you would be willing to pay extra in living expenses per month to support the existing 1,300 CCTV security cameras in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Q14.1 Assume New York City has already managed to fund the existing 1,300 CCTV cameras in Lower Manhattan. The city is now considering raising property taxes for all properties located south of Canal Street to support the addition of 1,700 CCTV security cameras in Lower
Manhattan (resulting in a total of 3,000 cameras in Lower Manhattan). Would you be willing to increase your monthly living expenses to cover this cost?

1  Yes
2  No

If No Is Selected, Then Skip To Q14.7

Q14.2 To support the additional 1,700 CCTV security cameras in Lower Manhattan (resulting in a total of 3,000 cameras in Lower Manhattan), the property tax increase will cost you an additional $45 per month in living expenses. Would you be willing to pay the extra $45 per month in living expenses?

1  Yes
2  No

If ‘Yes’ Is Selected

Q14.3 Since you are willing to pay an extra $45 per month, would you be willing to pay an extra $65 per month in living expenses to support the additional 1,700 CCTV security cameras?

1  Yes
2  No

If ‘Yes’ Is Selected

Q14.4 Since you are willing to pay an extra $65 per month, would you be willing to pay an extra $78 per month in living expenses to support the additional 1,700 CCTV security cameras?

1  Yes
2  No

If Q14.2 ‘No’ Is Selected

Q14.5 Since you are NOT willing to pay an extra $45 per month, would you be willing to pay an extra $10 per month in living expenses to support the additional 1,700 CCTV security cameras?

1  Yes
2  No

Q14.6 What is the maximum amount you would be willing to pay extra in living expenses per month to support the additional 1,700 CCTV security cameras in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Q14.7 Suppose that, rather than increasing property taxes, the Lower Manhattan business district has proposed the addition of a “security” tax on goods and services offered throughout Lower Manhattan. The “security” tax would support the entire CCTV security system (a total of 3,000 cameras by 2013) in Lower Manhattan. Would you be willing to increase your annual cost of living to cover the expense of the "security" tax?

1  Yes
2  No

Q15.1 For households like yours, it is estimated that the "security" tax would increase your annual cost of living by $75. Would you be willing to pay the extra $75 per year in living costs?

1  Yes
2  No
If ‘Yes’ Is Selected
Q15.2 Since you are willing to pay an extra $75 per year, would you be willing to pay an extra $120 per year in living costs for the "security" tax?
1  Yes
2  No

If ‘Yes’ Is Selected
Q15.3 Since you are willing to pay an extra $120 per year, would you be willing to pay an extra $220 per year in living costs for the "security" tax?
1  Yes
2  No

If Q15.1 ‘No’ Is Selected
Q15.4 Since you are NOT willing to pay an extra $75 per year, would you be willing to pay an extra $45 per year in living costs for the "security" tax?
1  Yes
2  No

Q15.5 What is the maximum amount you would be willing to pay extra per year in living costs to support the CCTV "security" tax in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Read the following statements (Q16.1-Q16.1I) and indicate your level of agreement with each, using the scale below.
1  Strongly Disagree
2  Disagree
3  Somewhat Disagree
4  Somewhat Agree
5  Agree
6  Strongly Agree

Q16.1: The CCTV cameras make Lower Manhattan a safer place to work.
Q16.1A: Having CCTV cameras in Lower Manhattan helps prevent terrorist attacks.
Q16.1 B: I think that too much money has been invested in Lower Manhattan’s CCTV system.
Q16.1 C: The presence of CCTV cameras makes me uncomfortable.
Q16.1 D: The CCTV cameras infringe on my right to privacy.
Q16.1 E: The presence of CCTV cameras makes working in Lower Manhattan more attractive to me.
Q16.1 F: The CCTV cameras make me feel safer walking around Lower Manhattan.
Q16.1 G: I am uncomfortable knowing that the CCTV cameras are monitored by law enforcement, public agencies and private sector companies.
Q16.1 H: I think that the amount of money invested in Lower Manhattan’s CCTV system is necessary.
Q16.1 I: Knowing that the footage captured by the CCTV cameras is maintained for 30 days before being deleted makes me uncomfortable.
Q16.2 Assume that New York City is increasing transportation costs to support the existing 1,300 CCTV security cameras in Lower Manhattan. The fare increase would apply to all modes of transportation (i.e. train, subway, bus, ferry, taxis, and tolls) within the New York City metro region traveling into and out of New York City. Without the fare increase, the CCTV camera program will be eliminated. Would you be willing to pay a monthly increase in transportation costs?
1. Yes
2. No
If No Is Selected, Then Skip To End of Block

Q16.3 To support the existing 1,300 CCTV security cameras in Lower Manhattan, the transportation cost increase will cost you an additional $45 per month in living expenses. Would you be willing to pay the extra $45 per month in living expenses?
1. Yes
2. No
If ‘Yes’ Is Selected

Q16.4 Since you willing to pay an extra $45 per month, would you be willing to pay an extra $65 per month in transportation costs to support the existing 1,300 CCTV security cameras in Lower Manhattan?
1. Yes
2. No
If ‘Yes’ Is Selected

Q16.5 Since you willing to pay an extra $65 per month, would you be willing to pay an extra $78 per month in transportation costs to support the existing 1,300 CCTV security cameras in Lower Manhattan?
1. Yes
2. No
If Q16.3 ‘No’ Is Selected

Q16.6 Since you are NOT willing to pay an extra $45 per month, would you be willing to pay an extra $10 per month in transportation costs to support the existing 1,300 CCTV security cameras in Lower Manhattan?
1. Yes
2. No

Q16.7 What is the maximum amount you would be willing to pay extra in transportation costs per month to support the existing 1,300 CCTV security cameras in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Q17.1 Assume New York City has already managed to fund the existing 1300 CCTV cameras in Lower Manhattan. The city is now considering raising transportation costs to support the addition of 1,700 CCTV security cameras in Lower Manhattan (resulting in a total of 3,000
cameras in Lower Manhattan). Would you be willing to increase your monthly living expenses to cover this cost?
1  Yes
2  No
If No Is Selected, Then Skip To Q17.7

Q17.2 To support the additional 1,700 CCTV security cameras in Lower Manhattan (resulting in a total of 3,000 cameras in Lower Manhattan), the increase in transportation costs will cost you an additional $45 per month. Would you be willing to pay the extra $45 per month in transportation costs?
1  Yes
2  No

If ‘Yes’ Is Selected
Q17.3 Since you are willing to pay an extra $45 per month, would you be willing to pay an extra $65 per month in transportation costs to support the additional 1,700 CCTV security cameras?
1  Yes
2  No

If ‘Yes’ Is Selected
Q17.4 Since you are willing to pay an extra $65 per month, would you be willing to pay an extra $78 per month in transportation costs to support the additional 1,700 CCTV security cameras?
1  Yes
2  No

If Q17.2 ‘No’ Is Selected
Q17.5 Since you are NOT willing to pay an extra $45 per month, would you be willing to pay an extra $10 per month in transportation costs to support the additional 1,700 CCTV security cameras?
1  Yes
2  No

Q17.6 What is the maximum amount you would be willing to pay extra in transportation costs per month to support the additional 1,700 CCTV security cameras in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Q17.7 Suppose that, rather than increasing transportation costs, the Lower Manhattan business district has proposed the addition of a “security” tax on goods and services offered throughout Lower Manhattan. The “security” tax would support the entire CCTV security system (a total of 3,000 cameras by 2013) in Lower Manhattan. Would you be willing to increase your annual cost of living to cover the expense of the "security" tax?
1  Yes
2  No

Q18.1 For households like yours, it is estimated that the "security" tax would increase your annual cost of living by $75. Would you be willing to pay the extra $75 per year in living costs?
1. Yes
2. No

If ‘Yes’ Is Selected
Q18.2 Since you are willing to pay an extra $75 per year, would you be willing to pay an extra $120 per year in living costs for the "security" tax?
1. Yes
2. No

If ‘Yes’ Is Selected
Q18.3 Since you are willing to pay an extra $120 per year, would you be willing to pay an extra $220 per year in living costs for the "security" tax?
1. Yes
2. No

If Q18.1 ‘No’ Is Selected
Q18.4 Since you are NOT willing to pay an extra $75 per year, would you be willing to pay an extra $45 per year in living costs for the "security" tax?
1. Yes
2. No

Q18.5 What is the maximum amount you would be willing to pay extra per year in living costs to support the CCTV "security" tax in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Read the following statements (Q19.1-Q19.1I) and indicate your level of agreement with each, using the scale below.

1. Strongly Disagree
2. Disagree
3. Somewhat Disagree
4. Somewhat Agree
5. Agree
6. Strongly Agree

Q19.1: The CCTV cameras make Lower Manhattan a safer place to visit.
Q19.1A : Having CCTV cameras in Lower Manhattan helps prevent terrorist attacks.
Q19.1 B: I think that too much money has been invested in Lower Manhattan’s CCTV system.
Q19.1 C: The presence of CCTV cameras makes me uncomfortable.
Q19.1 D: The CCTV cameras infringe on my right to privacy.
Q19.1 E: The presence of CCTV cameras makes visiting in Lower Manhattan more attractive to me.
Q19.1 F: The CCTV cameras make me feel safer walking around Lower Manhattan.
Q19.1 G: I am uncomfortable knowing that the CCTV cameras are monitored by law enforcement, public agencies and private sector companies.
Q19.1 H: I think that the amount of money invested in Lower Manhattan’s CCTV system is necessary.
Q19.1 I: Knowing that the footage captured by the CCTV cameras is maintained for 30 days before being deleted makes me uncomfortable.

Q19.2 Assume that New York City is increasing transportation costs to support the existing 1,300 CCTV security cameras in Lower Manhattan. The fare increase would apply to all modes of transportation (i.e. train, subway, bus, ferry, taxis, and tolls) within the New York City metro region traveling into and out of New York City. Without the fare increase, the CCTV camera program will be eliminated. Would you be willing to pay a monthly increase in transportation costs?
1  Yes
2  No
If ‘No’ Is Selected, Then Skip To End of Block

Q19.3 To support the existing 1,300 CCTV security cameras in Lower Manhattan, the transportation cost increase will cost you an additional $45 per month in living expenses. Would you be willing to pay the extra $45 per month in living expenses?
1  Yes
2  No

If ‘Yes’ Is Selected
Q19.4 Since you willing to pay an extra $45 per month, would you be willing to pay an extra $65 per month in transportation costs to support the existing 1,300 CCTV security cameras in Lower Manhattan?
1  Yes
2  No

If ‘Yes’ Is Selected
Q19.5 Since you willing to pay an extra $65 per month, would you be willing to pay an extra $78 per month in transportation costs to support the existing 1,300 CCTV security cameras in Lower Manhattan?
1  Yes
2  No

If Q19.3 ‘No’ Is Selected
Q19.6 Since you are NOT willing to pay an extra $45 per month, would you be willing to pay an extra $10 per month in transportation costs to support the existing 1,300 CCTV security cameras in Lower Manhattan?
1  Yes
2  No

Q19.7 What is the maximum amount you would be willing to pay extra in transportation costs per month to support the existing 1,300 CCTV security cameras in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Q20.1 Assume New York City has already managed to fund the existing 1300 CCTV cameras in Lower Manhattan. The city is now considering raising transportation costs to support the
addition of 1,700 CCTV security cameras in Lower Manhattan (resulting in a total of 3,000 cameras in Lower Manhattan). Would you be willing to increase your monthly living expenses to cover this cost?
1 Yes
2 No
If No Is Selected, Then Skip To Q20.7

Q20.2 To support the additional 1,700 CCTV security cameras in Lower Manhattan (resulting in a total of 3,000 cameras in Lower Manhattan), the property tax increase will cost you an additional $45 per month in transportation costs. Would you be willing to pay the extra $45 per month in transportation costs?
1 Yes
2 No
If ‘Yes’ Is Selected
Q20.3 Since you are willing to pay an extra $45 per month, would you be willing to pay an extra $65 per month in transportation costs to support the additional 1,700 CCTV security cameras?
1 Yes
2 No
If ‘Yes’ Is Selected
Q20.4 Since you are willing to pay an extra $65 per month, would you be willing to pay an extra $78 per month in transportation costs to support the additional 1,700 CCTV security cameras?
1 Yes
2 No
If Q20.2 ‘No’ Is Selected
Q20.5 Since you are NOT willing to pay an extra $45 per month, would you be willing to pay an extra $10 per month in transportation costs to support the additional 1,700 CCTV security cameras?
1 Yes
2 No

Q20.6 What is the maximum amount you would be willing to pay extra in transportation costs per month to support the additional 1,700 CCTV security cameras in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Q20.7 Suppose that, rather than increasing transportation costs, the Lower Manhattan business district has proposed the addition of a “security” tax on goods and services offered throughout Lower Manhattan. The “security” tax would support the entire CCTV security system (a total of 3,000 cameras by 2013) in Lower Manhattan. Would you be willing to increase your annual cost of living to cover the expense of the "security" tax?
1 Yes
2 No
Q21.1 For households like yours, it is estimated that the "security" tax would increase your annual cost of living by $75. Would you be willing to pay the extra $75 per year in living costs?
1 Yes
2 No

If ‘Yes’ Is Selected
Q21.2 Since you are willing to pay an extra $75 per year, would you be willing to pay an extra $120 per year in living costs for the "security" tax?
1 Yes
2 No
If ‘Yes’ Is Selected
Q21.3 Since you are willing to pay an extra $120 per year, would you be willing to pay an extra $220 per year in living costs for the "security" tax?
1 Yes
2 No

If Q21.1 ‘No’ Is Selected
Q21.4 Since you are NOT willing to pay an extra $75 per year, would you be willing to pay an extra $45 per year in living costs for the "security" tax?
1 Yes
2 No

Q21.5 What is the maximum amount you would be willing to pay extra per year in living costs to support the CCTV "security" tax in Lower Manhattan? (Please provide a numeric value equal to or greater than 0)

Q22.1-Q22.4 First, imagine that your business/home/work is located in Lower Manhattan. Please read the following hypothetical situation, and then answer the questions about its effects on your daily routines and habits as if your business was located in Lower Manhattan.

After London’s subway bombs in 2005, the New York Police Department (NYPD) in collaboration with the Mass Transportation Authority (MTA) and New Jersey Transit initiated a program allowing security personnel to conduct random inspections of bags and parcels at rail and subway stations heading to or leaving Lower Manhattan. The program's goal is to provide needed security to keep transportation systems safe, while not being too intrusive and inconvenient to riders. The random searches are carried out 24 hours a day, 7 days a week. Police use bomb-sniffing dogs and explosive detection technology to check the bags for hazardous materials. Items are generally not opened and physically inspected unless the equipment indicates a need for further inspection. Riders can refuse the inspections, but then are prohibited from boarding a train at that station. The inspections take less than a minute to conduct. There are limited reports of passengers missing trains as a result of having to go through the inspection. Critical to the program’s implementation is ensuring that all searches are random. A computer system is used to generate random numbers indicating which rider with a bag should be selected for inspection. This approach is used to protect the rights of riders, as well as prevent anyone surveilling security activity from identifying a search pattern. Those who object to the program either feel it is illegal or just for show and does not
really accomplish anything. Others point out that the program is very visible, effective in adding a layer to transportation security, and introduces an element of uncertainty and unpredictability into the minds of potential terrorists.

Read the following statements (Q22.5-Q22.5A) and indicate your level of agreement with each, using the scale below.

1. Strongly Disagree
2. Disagree
3. Somewhat Disagree
4. Somewhat Agree
5. Agree
6. Strongly Agree

Q22.5 I would feel safer knowing that the bag and parcel inspections program is in place.
Q22.5A I believe the inspections program prevents and deters terrorist attacks.

Q22.6 When traveling by subway or rail to Lower Manhattan, has your bag or parcel ever been searched?
1. Yes
2. No

Q22.7 When traveling by subway or rail to Lower Manhattan, have you ever seen someone get their bag or parcel searched?
1. Yes
2. No

Q22.8 Have you heard from friends or family about having their bag or parcel searched when traveling by subway or rail to Lower Manhattan?
1. Yes
2. No

Q22.9 Have you changed your commute to avoid the chance of having your bag or parcel searched when riding the subway or rail to Lower Manhattan?
1. Yes
2. No

Q22.10 Why have you changed your commute?

Q22.11 Indicate how scared you are that a terrorist attack will occur on the local subway or rail systems over the next year.
1. Not Scared at All
2. Not Scared
3. Somewhat Not Scared
4. Somewhat Scared
5. Scared
6. Very Scared
Q22.12 Indicate the likelihood that there will be a terrorist attack on the New York subway or rail systems over the next year.
1 Not Likely at All
2 Unlikely
3 Somewhat Unlikely
4 Somewhat Likely
5 Likely
6 Very Likely

Q23.1 Assume that the program is revised so that 100% of bags and parcels are inspected at rail and subway stations heading to or leaving Lower Manhattan. This program will increase the level of security employed to keep transportation systems safe. However, there may be longer delays if passengers have to wait to undergo the screening process. Read the following statements and indicate your level of agreement with each, using the scale below.
1 Strongly Disagree
2 Disagree
3 Somewhat Disagree
4 Somewhat Agree
5 Agree
6 Strongly Agree

23.1 The inconvenience created by 100% inspections would be frustrating.
23.1A Searching my bags is a violation of my privacy.
23.1B I would avoid traveling by subway or rail to Lower Manhattan because of the 100% inspections program.
23.1C I would avoid bringing a bag or parcel with me when commuting by train or rail to Lower Manhattan.

Q23.2 Would you continue to travel by rail or subway knowing that you will be stopped and have your bags and parcels inspected?
1 Yes
2 No
If No Is Selected, Then Skip To Q23.6

Q23.3 Suppose upon entering the usual rail or subway station you use for getting to work you are directed to an inspection line where an officer says that there is a 5 minute wait. Would you be willing to wait?
1 Yes
2 No

If ‘Yes’ Is Selected
Q23.4 Since you agreed to wait 5 minutes, would you be willing to wait 10 minutes?
1 Yes
2 No
If ‘No’ Is Selected
Q23.5 Since you were NOT willing to wait 5 minutes, would you be willing to wait 3 minutes?
1 Yes
2 No

If ‘No’ Is Selected
Q23.6 Since you are NOT willing to wait to have your bags inspected, how else might you commute to work (check all that apply)?
1 Bus
2 Taxi
3 Walk
4 Carpool
5 Rail

Q23.7 Would you be willing to pay to be pre-screened (one-time iris scan, fingerprinting and background check) for one year’s access to a faster security screening line that cuts your wait time in half whenever you travel by rail or subway?
1 Yes
2 No

If No Is Selected, Then Skip To End of Block

Q23.8 Would you be willing to pay $60 for one year's access to the faster security screening line that cuts your wait time in half?
1 Yes
2 No

If ‘Yes’ Is Selected
Q23.9 Since you were willing to pay $60, would you be willing to pay $120 for one year’s access to this faster security screening line, cutting your wait time in half?
1 Yes
2 No

If Since ‘Yes’ Is Selected
Q23.10 Since you were willing to pay $120, would you be willing to pay $240 for one year's access to this faster security screening line, cutting your wait time in half?
1 Yes
2 No

If ‘No’ Is Selected
Q23.11 Since you weren't willing to pay $60, would you be willing to pay $30 for one year's access to this faster security screening line, cutting your wait time in half?
1 Yes
2 No

Q23.12 What is the maximum amount in dollars per year you would be willing to pay to be pre-screened for one year's access to the faster security screening line whenever you travel by rail or
subway in the Lower Manhattan area? (Please provide a numeric value equal to or greater than 0)

Q24.1 If 100% of bags and parcels are inspected at rail and subway stations heading to or leaving Lower Manhattan, do you think you business’ MONTHLY revenue would increase, decrease, or not change?
1 Increase
2 No change
3 Decrease

If ‘Increase’ Is Selected
Q24.2 By how much would your average MONTHLY gross operating revenue increase?
1 1% – 5%
2 5% – 10%
3 10% – 25%
4 25% – 50%
5 More than 50%

If ‘Decrease’ Is Selected
Q24.3 By how much would your average MONTHLY gross operating revenue decrease?
1 1% – 5%
2 5% – 10%
3 10% – 25%
4 25% – 50%
5 More than 50%

Q24.4 Assume the number of customers in Lower Manhattan was lower due to the random inspection program. Would you offer a $12 discount on all purchases to help draw people back to the region?
1 Yes
2 No

If ‘Yes’ Is Selected
Q24.5 Since you agreed to offer a $12 discount, would you offer a $20 discount on all purchases to help draw people back to the region?
1 Yes
2 No

If ‘Yes’ Is Selected
Q24.6 Since you agreed to offer a $20 discount, would you offer a $24 discount on all purchases to help draw people back to the region?
1 Yes
2 No

If ‘No’ Is Selected
Q24.7 Since you would not offer a $12 discount, would you offer a $5 discount on all purchases to help draw people back to the region?

1   Yes
2   No

Q24.8 What is the largest discount in dollars on all purchases you would be willing to offer to help draw people back to the region? (Please provide a numeric value equal to or greater than 0)

Q24.9 What else might you do to adapt to the implementation of the 100% inspections program?

Q1217 This section of the survey asked questions about increasing the number random vehicle inspections in New York City. [Reliability Check]

1   True
2   False

Assume the random inspections program is revised so that 100% of bags and parcels are inspected at rail and subway stations heading to or leaving Lower Manhattan. The program would increase the level of security used to keep transportation systems safe. However, there might be longer delays if passengers have to wait to undergo the screening process. Read the following statements and indicate your level of agreement with each, using the scale below.

1   Strongly Disagree
2   Disagree
3   Somewhat Disagree
4   Somewhat Agree
5   Agree
6   Strongly Agree

25.1  The inconvenience created by 100% inspections would be frustrating.
25.1A Searching my bags is a violation of my privacy.
25.1B  I would avoid traveling by subway or rail to Lower Manhattan because of the 100% inspections program.
25.1C I would avoid bringing a bag or parcel with me when commuting by train or rail to and from Lower Manhattan.
25.1D If traveling within a mile of my home, I would prefer to walk or take a cab because of the 100% inspections program.
25.1E After running errands that leave me with many bags (e.g. after going to the grocery store, clothing shopping, etc), I would not take the subway because of the 100% inspections program.

Q25.2 Would you continue to travel by rail or subway knowing that you will be stopped and have your bags and parcels inspected?

1   Yes
2   No
If No Is Selected, Then Skip To Q25.6
Q25.3 Suppose upon entering the usual rail or subway station you use for getting to work you are
directed to an inspection line where an officer says that there is a 5-minute wait. Would you be
willing to wait?
1 Yes
2 No

If ‘Yes’ Is Selected
Q25.4 Since you agreed to wait 5 minutes, would you be willing to wait 10 minutes?
1 Yes
2 No

If ‘No’ Is Selected
Q25.5 Since you were NOT willing to wait 5 minutes, would you be willing to wait 3 minutes?
1 Yes
2 No

If ‘No’ Is Selected
Q25.6 Since you are NOT willing to wait to have your bags inspected, how else might you
commute to work (check all that apply)?
1 Bus
2 Taxi
3 Walk
4 Carpool
5 Rail

Q25.7 Would you be willing to pay to be pre-screened (one-time iris scan, fingerprinting and
background check) for one year’s access to a faster security screening line that cuts your wait
time in half whenever you travel by rail or subway?
1 Yes
2 No
If No Is Selected, Then Skip To End of Block

Q25.8 Would you be willing to pay $60 for one year's access to the faster security screening line
that cuts your wait time in half?
1 Yes
2 No

If ‘Yes’ Is Selected
Q25.9 Since you were willing to pay $60, would you be willing to pay $120 for one year's access
to this faster security screening line, cutting your wait time in half?
1 Yes
2 No

If ‘Yes’ Is Selected
Q25.10 Since you were willing to pay $120, would you be willing to pay $240 for one year's access to this faster security screening line, cutting your wait time in half?
1  Yes
2  No

If ‘No’ Is Selected
Q25.11 Since you weren't willing to pay $60, would you be willing to pay $30 for one year's access to this faster security screening line, cutting your wait time in half?
1  Yes
2  No

Q25.12 What is the maximum amount in dollars per year you would be willing to pay to be pre-screened for one year's access to the faster security screening line whenever you travel by rail or subway in the Lower Manhattan area? (Please provide a numeric value equal to or greater than 0)

Suppose the random inspections program is revised so that 100% of bags and parcels are inspected at rail and subway stations heading to or leaving Lower Manhattan. The program would increase the level of security used to keep transportation systems safe. However, there could be longer delays if passengers have to wait to undergo the screening process. Read the following statements and indicate your level of agreement with each, using the scale below.

1  Strongly Disagree
2  Disagree
3  Somewhat Disagree
4  Somewhat Agree
5  Agree
6  Strongly Agree

26.1: The inconvenience created by 100% inspections would be frustrating.
26.1A: Searching my bags is a violation of my privacy.
26.1B: I would avoid traveling by subway or rail to Lower Manhattan because of the 100% inspections program.
26.1C: I would avoid bringing a bag or parcel with me when commuting by train or rail to and from Lower Manhattan.

Q26.2 Would you continue to travel by rail or subway knowing that you will be stopped and have your bags and parcels inspected?
1  Yes
2  No
If No Is Selected, Then Skip To Q26.6

Q26.3 Suppose upon entering the usual rail or subway station you use for getting to work you are directed to an inspection line where an officer says that there is a 5-minute wait. Would you be willing to wait?
1  Yes
2  No
If ‘Yes’ Is Selected
Q26.4 Since you agreed to wait 5 minutes, would you be willing to wait 10 minutes?
1  Yes
2  No

If ‘No’ Is Selected
Q26.5 Since you were NOT willing to wait 5 minutes, would you be willing to wait 3 minutes?
1  Yes
2  No

If Would ‘ No’ Is Selected
Q26.6 Since you are NOT willing to wait to have your bags inspected, how else might you commute to work (check all that apply)?
1  Bus
2  Taxi
3  Walk
4  Carpool
5  Rail

Q26.7 Would you be willing to pay to be pre-screened (one-time iris scan, fingerprinting and background check) for one year’s access to a faster security screening line that cuts your wait time in half whenever you travel by rail or subway?
1  Yes
2  No
If No Is Selected, Then Skip To End of Block

Q26.8 Would you be willing to pay $60 for one year's access to the faster security screening line that cuts your wait time in half?
1  Yes
2  No

If ‘Yes’ Is Selected
Q26.9 Since you were willing to pay $60, would you be willing to pay $120 for one year's access to this faster security screening line, cutting your wait time in half?
1  Yes
2  No

If ‘Yes’ Is Selected
Q26.10 Since you were willing to pay $120, would you be willing to pay $240 for one year's access to this faster security screening line, cutting your wait time in half?
1  Yes
2  No

If ‘No’ Is Selected
Q26.11 Since you weren't willing to pay $60, would you be willing to pay $30 for one year's access to this faster security screening line, cutting your wait time in half?
Q26.12 What is the maximum amount in dollars per year you would be willing to pay to be pre-screened for one year's access to the faster security screening line whenever you travel by rail or subway in the Lower Manhattan area? (Please provide a numeric value equal to or greater than 0)

Assume that the program is revised so that 100% of bags and parcels are inspected at rail and subway stations heading to or leaving Lower Manhattan. This program would increase the level of security employed to keep transportation systems safe. However, there might be longer delays if passengers have to wait to undergo the screening process. Read the following statements and indicate your level of agreement with each, using the scale below.

1 Strongly Disagree
2 Disagree
3 Somewhat Disagree
4 Somewhat Agree
5 Agree
6 Strongly Agree

27.1: The inconvenience created by 100% inspections would be frustrating.
27.1A: I would continue to travel to Lower Manhattan despite the 100% inspections program.
27.1B: Searching my bags is a violation of my privacy.
27.1C: I would avoid traveling by subway or rail to Lower Manhattan because of the 100% inspections program.
27.1D: I would avoid bringing a bag or parcel with me when commuting by train or rail to Lower Manhattan.

Q27.2 Would you continue to travel by rail or subway knowing that you will be stopped and have your bags and parcels inspected?
1 Yes
2 No
If No Is Selected, Then Skip To Q27.6

Q27.3 Suppose upon entering the usual rail or subway station you use for getting to work you are directed to an inspection line where an officer says that there is a 5-minute wait. Would you be willing to wait?
1 Yes
2 No
If ‘Yes’ Is Selected
Q27.4 Since you agreed to wait 5 minutes, would you be willing to wait 10 minutes?
1 Yes
2 No
If ‘No’ Is Selected
Q27.5 Since you were NOT willing to wait 5 minutes, would you be willing to wait 3 minutes?
1  Yes
2  No

If ‘No’ Is Selected
Q27.6 Since you are NOT willing to wait to have your bags inspected, how else might you commute to work (check all that apply)?
1  Bus
2  Taxi
3  Walk
4  Carpool
5  Rail

Q27.7 Would you be willing to pay to be pre-screened (one-time iris scan, fingerprinting and background check) for one year’s access to a faster security screening line that cuts your wait time in half whenever you travel by rail or subway?
1  Yes
2  No
If No Is Selected, Then Skip To End of Block

Q27.8 Would you be willing to pay $60 for one year's access to the faster security screening line that cuts your wait time in half?
1  Yes
2  No

If ‘Yes’ Is Selected
Q27.9 Since you were willing to pay $60, would you be willing to pay $120 for one year's access to this faster security screening line, cutting your wait time in half?
1  Yes
2  No

If ‘Yes’ Is Selected
Q27.10 Since you were willing to pay $120, would you be willing to pay $240 for one year's access to this faster security screening line, cutting your wait time in half?
1  Yes
2  No

If ‘No’ Is Selected
Q27.11 Since you weren't willing to pay $60, would you be willing to pay $30 for one year's access to this faster security screening line, cutting your wait time in half?
1  Yes
2  No

Q27.12 What is the maximum amount in dollars per year you would be willing to pay to be pre-screened for one year's access to the faster security screening line whenever you travel by rail or subway in the Lower Manhattan area? (Please provide a numeric value equal to or greater than 0)
Q28.1 If your favorite store/restaurant in Lower Manhattan had a second location elsewhere in Manhattan, would you go there instead because of the 100% inspections program?
1 Yes
2 No

Q28.2 If your favorite store/restaurant were to offer a $7 discount on your total purchase, would you go to Lower Manhattan despite the subway inspections?
1 Yes
2 No
If ‘No’ Is Selected
Q28.3 Since you were NOT willing to accept a $7 discount, would you go to Lower Manhattan if your favorite store/restaurant were to offer a $12 discount on your total purchase?
1 Yes
2 No

If ‘No’ Is Selected
Q28.4 Since you were NOT willing to accept a $12 discount, would you go to Lower Manhattan if your favorite store/restaurant were to offer a $20 discount on your total purchase?
1 Yes
2 No

If ‘Yes’ Is Selected
Q28.5 Since you were willing to accept a $7 discount, would you go to Lower Manhattan if your favorite store/restaurant were to offer a $2 discount on your total purchase?
1 Yes
2 No

Q28.6 What is the minimum discount in dollars you would need on all purchases to visit a store/restaurant in Lower Manhattan instead of the same store/restaurant at another location in Manhattan? (Please provide a numeric value equal to or greater than 0)

Q28.7 Assume you just completed a day of shopping and dining in Lower Manhattan. You have collected several bags over the course of the day. Would you ride the subway or rail home knowing you would be stopped for an inspection?
1 Yes
2 No

Q29.1 Are you Male or Female?
1 Male
2 Female

Q29.2 What is your age?
2 18-21
3 22-25
4 26-30
Q29.3 What is your current marital status?
1 Single, never married, not cohabiting with significant other
2 Single, never married, cohabiting with significant other
3 Married
4 Divorced/Separated
5 Widowed

Q29.4 What is your current employment status? (Check all that apply)
1 Full-time (35 or more hours per week)
2 Part-time, single job
3 Part-time, multiple jobs
4 Homemaker
5 Student
6 Unemployed
7 Retired
8 On disability
9 Other ____________________

Q29.5 What year did you open your business?

Q29.6 Please provide the closest street intersection to where your business is located.

Q29.7 How many employees do you have?
1 1-5
2 6-20
3 21-50
4 51-100
5 100-500
6 500+

Q29.8 Why did you choose Lower Manhattan as the location for your business?
1 Rent
2 Security in the area
3 Government incentives/Stimulus program/Grant
4 Commercial environment
5 Other ________________

Q29.9 In which industry does your Lower Manhattan business belong? (U.S. Census)
1 Forestry, fishing, hunting or agriculture support
2 Mining
3 Utilities
4 Construction
5 Manufacturing
<table>
<thead>
<tr>
<th>No.</th>
<th>Industry</th>
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<tr>
<td>6</td>
<td>Wholesale trade</td>
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<td>Retail trade</td>
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<td>12</td>
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<td>Admin, support, waste management or remediation services</td>
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<td>Other services (except public administration)</td>
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<td>20</td>
<td>Unclassified establishments</td>
</tr>
<tr>
<td>21</td>
<td>Other _________________</td>
</tr>
</tbody>
</table>

Q29.10 Approximately, what are your monthly operating costs?

Q29.11 On average, how many customers/clients does your business serve on a weekday?
1. Zero, we are not open during the week.
2. 1-10
3. 11-30
4. 31-50
5. 51-75
6. 76-100
7. more than 100

Q29.12 On average, how many customers/clients does your business serve on a Saturday?
1. Zero, we are not open on Saturday.
2. 1-10
3. 11-30
4. 31-50
5. 51-75
6. 76-100
7. more than 100

Q29.13 On average, how many customers/clients does your business serve on a Sunday?
1. Zero, we are not open on Sunday.
2. 1-10
3. 11-30
4. 31-50
5. 51-75
6. 76-100
7. more than 100
Q29.14 What time(s) of the day is your store the busiest? (check all that apply)
1 9:00 am-10:00 am
2 10:00 am-11:00 am
3 11:00 am-12:00 pm
4 12:00 pm-1:00 pm
5 1:00 pm-2:00 pm
6 2:00 pm-3:00 pm
7 3:00 pm-4:00 pm
8 4:00 pm-5:00 pm
9 6:00 pm-7:00 pm
10 8:00 pm-9:00 pm
11 9:00 pm-10:00 pm

Q29.15 On average, how long does a customer spend in your store?
1 0-10 minutes
2 10-30 minutes
3 30-45 minutes
4 45-60 minutes
5 more than 60 minutes
6 I have no idea

Q29.16 On average, how much does a customer/client spend per transaction at your office/store?
1 $0-$25
2 $26-$50
3 $51-$100
4 $101-$150
5 $151-$250
6 $250-$500
7 $500-$1,000
8 more than $1,000

Q1160 What is the average MONTHLY gross operating revenue of business?
1 Less than $10,000
2 $10,000 to $25,000
3 $25,000 to $100,000
4 $100,000 to $1,000,000
5 More than $1,000,000

Read the following statements and indicate your level of agreement with each.
Read the following statements (Q1168-Q1168F) and indicate your level of agreement with each, using the scale provided below.
1 Strongly Disagree
2 Disagree
3 Somewhat Disagree
4 Somewhat Agree
5 Agree
Strongly Agree

Q1168: I am a supporter of the Occupy Wall Street movement.
Q1168A: I believe that the NYPD has imposed appropriate security measures, such as arrests and pepper spray, in response to the Occupy Wall Street demonstrations.
Q1168B: I have been contacted through a social media outlet about participating in an Occupy Wall Street demonstration.
Q1168C: I am concerned that the civil rights and liberties of protestors are being violated by security officials.
Q1168D: The Occupy Wall Street demonstrations are inconveniencing my daily routine.
Q1168E: I believe the Occupy Wall Street movement will result in policy changes addressing economic inequalities.

Q30.1 Are you Male or Female?
1 Male
2 Female

Q30.2 What is your age?
2 18-21
3 22-25
4 26-30
5 31-40
6 41-50
7 51-60
8 61 or over

Q30.3 What is your current marital status?
2 Single, never married, not cohabiting with significant other
3 Single, never married, cohabiting with significant other
4 Married
5 Divorced/Separated
6 Widowed

Q30.4 What is your current employment status? (Check all that apply)
1 Full-time (35 or more hours per week)
2 Part-time, single job
3 Part-time, multiple jobs
4 Homemaker
5 Student
6 Unemployed
7 Retired
8 On disability
9 Other ______________

Q30.5 How many consecutive years have you lived in Lower Manhattan?
______ Lived in Lower Manhattan
Q30.6 Choose which option best describes your current living situation.
1 Rent
2 Own
3 Board
4 Live with friends, family or other free of charge
5 Other ____________________

Q30.7 How much do you pay monthly for housing? (Please provide a numeric value equal to or greater than 0.)

Q30.8 How many times a week do you travel by train or rail?

Q30.9 What is your total annual household income?
2 Less than $10,000
3 $10,000 to $19,999
4 $20,000 to $29,999
5 $30,000 to $39,999
6 $40,000 to $49,999
7 $50,000 to $59,999
8 $60,000 to $69,999
9 $70,000 to $79,999
10 $80,000 to $89,999
11 $90,000 to $99,999
12 $100,000 to $149,999
13 $150,000 or more

Read the following statements and indicate your level of agreement with each. Read the following statements (Q1170-Q1170F) and indicate your level of agreement with each, using the scale provided below.

1 Strongly Disagree
2 Disagree
3 Somewhat Disagree
4 Somewhat Agree
5 Agree
6 Strongly Agree

Q1170: I am a supporter of the Occupy Wall Street movement.
Q1170A: I believe that the NYPD has imposed appropriate security measures, such as arrests and pepper spray, in response to the Occupy Wall Street demonstrations.
Q1170B: I have been contacted through a social media outlet about participating in an Occupy Wall Street demonstration.
Q1170C: I am concerned that the civil rights and liberties of protestors are being violated by security officials.
Q1170D: The Occupy Wall Street demonstrations are inconveniencing my daily routine.
Q1170E I believe the Occupy Wall Street movement will result in policy changes addressing economic inequalities.

Q31.1 Are you Male or Female?
1 Male
2 Female

Q31.2 What is your age?
2 18-21
3 22-25
4 26-30
5 31-40
6 41-50
7 51-60
8 61 or over

Q31.3 What is your current marital status?
2 Single, never married, not cohabiting with significant other
3 Single, never married, cohabiting with significant other
4 Married
5 Divorced/Separated
6 Widowed

Q31.4 What is your current employment status? (Check all that apply)
1 Full-time (35 or more hours per week)
2 Part-time, single job
3 Part-time, multiple jobs
4 Homemaker
5 Student
6 Unemployed
7 Retired
8 On disability
9 Other __________

Q31.5 From where do you commute?
1 Manhattan
2 Outer Boroughs (Bronx, Brooklyn, Queens, Staten Island)
3 New Jersey
4 Connecticut
5 Other __________

Q31.6 How much do you spend per day on commuting costs?
____ Daily Commuting Cost

Q31.7 How many consecutive years have you been working in Lower Manhattan?
____ Working in Lower Manhattan
Q31.8 What is your total annual household income?
2   Less than $10,000
3   $10,000 to $19,999
4   $20,000 to $29,999
5   $30,000 to $39,999
6   $40,000 to $49,999
7   $50,000 to $59,999
8   $60,000 to $69,999
9   $70,000 to $79,999
10  $80,000 to $89,999
11  $90,000 to $99,999
12  $100,000 to $149,999
13  $150,000 or more

Read the following statements (Q1172-Q1172F) and indicate your level of agreement with each, using the scale provided below.
1   Strongly Disagree
2   Disagree
3   Somewhat Disagree
4   Somewhat Agree
5   Agree
6   Strongly Agree

Q1172: I am a supporter of the Occupy Wall Street movement.
Q1172A: I believe that the NYPD has imposed appropriate security measures, such as arrests and pepper spray, in response to the Occupy Wall Street demonstrations.
Q1172B: I have been contacted through a social media outlet about participating in an Occupy Wall Street demonstration.
Q1172C: I am concerned that the civil rights and liberties of protestors are being violated by security officials.
Q1172D: The Occupy Wall Street demonstrations are inconveniencing my daily routine.
Q1172E: I believe the Occupy Wall Street movement will result in policy changes addressing economic inequalities.
Q1172F: The City of New York is over-investing in security responses to Occupy Wall Street demonstrations.

Q32.1 Are you Male or Female?
1   Male
2   Female

Q32.2 What is your age?
2   18-21
3   22-25
4   26-30
5   31-40
Q32.3 What is your current marital status?
1 Single, never married, not cohabiting with significant other
2 Single, never married, cohabiting with significant other
3 Married
4 Divorced/Separated
5 Widowed

Q32.4 What is your current employment status? (Check all that apply)
1 Full-time (35 or more hours per week)
2 Part-time, single job
3 Part-time, multiple jobs
4 Homemaker
5 Student
6 Unemployed
7 Retired
8 On disability
9 Other ______________

Q32.5 When was the last time you visited Lower Manhattan?
1 Past week
2 Past month
3 Past 6 months
4 Past 12 months
5 Over 1 year ago

Q32.6 Why did you go to Lower Manhattan? (check all that apply)
1 as a tourist
2 to socialize (e.g. eat/drink, a specific function, visit with friends and/or family)
3 to shop
4 to visit a museum or other cultural center
5 for business
6 other ______________

Q32.7 What is your total annual household income?
2 Less than $10,000
3 $10,000 to $19,999
4 $20,000 to $29,999
5 $30,000 to $39,999
6 $40,000 to $49,999
7 $50,000 to $59,999
8 $60,000 to $69,999
9 $70,000 to $79,999
Read the following statements and indicate your level of agreement with each.
Read the following statements (Q1173-Q1173F) and indicate your level of agreement with each, using the scale provided below.
1    Strongly Disagree
2    Disagree
3    Somewhat Disagree
4    Somewhat Agree
5    Agree
6    Strongly Agree

Q1173: I am a supporter of the Occupy Wall Street movement.
Q1173A: I believe that the NYPD has imposed appropriate security measures, such as arrests and pepper spray, in response to the Occupy Wall Street demonstrations.
Q1173B: I have been contacted through a social media outlet about participating in an Occupy Wall Street demonstration.
Q1173C: I am concerned that the civil rights and liberties of protestors are being violated by security officials.
Q1173D: The Occupy Wall Street demonstrations are inconveniencing my daily routine.
Q1173E: I believe the Occupy Wall Street movement will result in policy changes addressing economic inequalities.
1.5 Appendix 5: Principles That Apply to Security Against Terrorism

As presented in Chapter 3, principles that govern security against terrorism can be classified into six categories. Presented here are the six categories and related principles.

1.5.1 Principles of Security

- **Security is dynamic.** Security is not an engineering problem that can be solved, but rather an ongoing contest between security planners and their terrorist adversaries. As new security measures are implemented, terrorists will seek ways to evade or obviate them. When they do, new security measures will be required.

- **Security includes more than preventive measures.** What might be called “front-end” security measures aim at deterring, preventing, or at least complicating terrorists’ operational planning. “Back-end” measures may include facilitating rapid response by authorities or evacuating people from harm’s way. These are all part of security, broadly defined. Where public access and high volumes of people make front-end prevention difficult, the emphasis shifts to mitigation and response.

- **Security against terrorism is almost always reactive.** It is a common criticism that security is always fighting the last war. This is often true, and to a large extent, it is inevitable. This is not because those charged with security are incapable of thinking ahead. Since the threat of a terrorist attack is always statistically remote and resources for security are limited, without an attack to demonstrate an existing vulnerability, it is often difficult to mobilize resources and public support for security measures. Imagine asking airline passengers to remove their shoes before the “shoe bomber” made his attempt to sabotage an airliner. Although analysts know that some terrorist have portable surface-to-air missiles and that they have used them against civilian aircraft, mostly in conflict zones, deploying anti-missile technology on a commercial airliner fleet, which would costs tens of billions of dollars, would have little support—that is, unless a missile attack occurred. Then views would promptly reverse.

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The principles were assembled by Brian Jenkins from the broad literature and personal research.
• At the same time, imagine in the wake of a terrorist attack not taking immediate measures to prevent its easy repetition. Initially, those charged with security have reason to fear that the initial attack may be just the first of a series of attacks already in motion, or that it will inspire copycat attempts. These attempts have to be blocked. Subsequently, those charged with security will be obliged to show that they have taken steps to prevent the recurrence of what terrorists have already demonstrated. The political and public pressure to do so is enormous, although it may eventually subside.

• **Many factors in addition to the perceived threat affect decisions about the level of security.** These include the effect of the security measures on operations, their costs, their appropriateness in a democratic society, political pressures, the public’s acceptance, even aesthetics.

• **Security by itself does not prevent terrorism.** No determined terrorist abandons his effort for lack of a target. With virtually unlimited targets, terrorists blocked at one place can easily shift their sights to other equally suitable targets.

• **Security displaces the risk.** Terrorists rarely attack well-protected targets.

• **Randomness and unpredictability increase security.** Random searches may irritate the public, but randomness complicates terrorist planning.

• **Increased security obliges terrorists to become less discriminate in their attacks.** The trend toward indiscriminate attacks is occurring for other reasons as well, but such attacks can also cause a backlash that is counterproductive to the terrorists’ goals.

• **As terrorists become more indiscriminate, the task of security becomes harder.** The list of potential targets grows. Nothing can be excluded. The snipers in Northern Virginia, although not members of a terrorist organization, illustrate the point. Their killings were completely random and more terrifying for that reason.

• **Security measures should bring a net security benefit.** With some exceptions, security measures, especially those that are disruptive or costly, should do more than merely
displacing the risk elsewhere. For example, some argue that security perimeters should be erected around places of public assembly, such as airport terminals or shopping malls. This would not only be expensive and disruptive, it would still leave terrorists with a vast array of easily accessible public places to attack—public transportation, theater lobbies, supermarkets, any place where crowds gather—where they could achieve similar effects. The security investment and the disruptions caused by security measures would be significant, while the net gains would be slight. Exceptions include incidents where displacement itself is a net benefit, for example, denying terrorists easy access to a major political convention or to Times Square on New Year’s Eve. Where terrorists have demonstrated continuing determination to attack certain high-value targets, such as air transportation, security to make attacks more difficult also yields a net security benefit.

- **Security measures do have a deterrent effect.** While it is impossible to measure precisely, security measures do have a deterrent effect. Increased security, along with the adoption of no-concessions policies and a greater willingness to end hostage situations with force, did reduce the number of terrorist takeovers of embassies and barricade-and-hostage situations over a ten-year period. Despite its obvious challenges, increasing security screening, along with growing international cooperation, did bring about a significant decline in the numbers of attempted terrorist hijackings and bombings of airliners over a 30-year period. The decline occurred even though attacking commercial air transport remains a terrorist obsession, as demonstrated by recent events. In every example, however, it is not the preventive security measures by themselves that have deterred a terrorist attack, but an array of measures and policy instruments, including the destruction of terrorist organizations.

- **Security is cumulative.** Security regimes are seldom designed from scratch but instead are accumulations of measures imposed in response to specific events. It is extremely difficult to abandon accumulated measures and put into place a completely new regime. Change more often occurs incrementally.

- **Security measures against terrorism are (politically) more easily increased than reduced.** As a result, the imposition of extraordinary security measures hurriedly put into
place following an event and often intended to be temporary tend to become permanent features of the security landscape. There are some examples of temporary security measures being lifted, but leaders are generally reluctant to assume the increased risk that any reduction brings.

- **Illusion and deception are components of security.** What may appear to critics of security as a sham may not be assessed the same way by terrorist operatives who look not at the imperfections, but at the remaining risk. The shortcomings of a security regime may be obvious, but terrorists who may have only one chance to succeed, and for whom the consequences of failure are significant may view even a low risk of detection as too dangerous. Security measures are designed to affect the perceptions and calculations of the attacker as much as they are to prevent an actual attack.

- **Mystery is a critical deterrent.** We know from the testimony of terrorists themselves that uncertainty about the nature and effectiveness of security measures is often a deterrent. Terrorists attribute significant danger to security measures that they cannot see or readily understand.

- **There are no reliable measures of the effectiveness of security against terrorism.** There are broad indicators of the effectiveness of countermeasures, and we can track some long-term trends to show a decline in certain terrorist tactics, or terrorist attacks on certain sets of targets, over time as security increases. However, the absence of a terrorist attack can always mean either that security was effective as a deterrent, or that no attack was ever contemplated. It is impossible to count things that do not occur.

- **It is difficult to calibrate the effectiveness of specific counterterrorist security measures.** If the problem were a high-volume activity like shoplifting, it would be easy to measure the recurring loss, impose new security measures, and compare their costs to the measurable reduction in loss. However, although terrorist incidents occur rarely, the consequences can be great, making it difficult to measure loss. There often is not a one-to-one relationship between a security measure and a specific terrorist event. Instead, the effectiveness of multiple security measures must be evaluated.
• *Strict cost-benefit analysis does not readily work with terrorist measures.* We lack the metrics to measure true cost versus true benefit in terms of losses prevented, since the losses are so large, and so uncertain, and the deterrent effectiveness is, itself, uncertain.

1.5.2 General Principles of Terrorism

• *Terrorism does not pose a significant danger to individual citizens.* Compared with ordinary violent crime, terrorism poses a statistically small threat to the lives of individual citizens (the 9/11 attacks notwithstanding). In the past ten years, more than 160,000 people have been murdered in the United States—an improving but still a very high statistic. During the same period, terrorists in the United States have killed a little more than 3,000 people, including the 2,996 who died in the 9/11 attacks. The same disparity holds in countries that have lower crime rates than the United States but suffer higher levels of terrorism—many more people die as a consequence of ordinary crime. Comparing terrorism with other modes of armed conflict sharpens the contrast. Terrorists have killed thousands in the last quarter century, while millions have died in wars.

• *The primary threat of terrorism is to the community.* In addition to casualties, terrorists’ attacks can cause damage and economic disruption, can create alarm, and can oblige governments to devote vast resources to security. Terrorist attacks can prevent peace and provoke wars. These are significant costs.

• *Terrorist attacks are statistically rare and random.* This is not to say that terrorists select targets at random, but that the number of potential targets is so great that the occurrence of an attack on a particular target, from the defender’s perspective, is as if random. Of course, each attack is of high consequence to the victims.

• *Terrorism is episodic.* People’s perceptions of the terrorist threat are determined not by statistics, but by the latest spectacular incident. After each spectacular incident the level of concern rapidly diminishes. What was once an urgent demand for security comes to
be seen as a nuisance. This makes it difficult to sustain support for ongoing security measures.

- **Terrorism is geographically stable.** Although terrorists can strike anywhere in the world, terrorist threats are usually localized; areas where significant terrorist campaigns are taking place today are likely to be areas of significant terrorist activity in the future as the campaigns continue. Confederates distant from the principal theater of conflict may carry out terrorist attacks, but it is difficult for terrorists to sustain a truly global campaign. This is true even of global terrorist enterprises like those inspired by al Qaeda. Most al Qaeda–inspired attacks occur within a broad arc extending from the Mahgreb to Mumbai. Fewer attacks occur in Muslim regions beyond this arc. Only occasional attacks occur in other areas beyond it.

1.5.3 Principles Regarding Terrorist Threats

- **The terrorist threat appears greater than it actually is.** Terrorism works. By mounting spectacular acts of violence, terrorists create an atmosphere of fear and alarm, which causes people to exaggerate the strength of the terrorists and the threat they pose.

- **Since the terrorist threat is not easily quantified, it is difficult to determine the right level of security.** How much security is enough? This is not an easily answered question.

- **The burden of security against a terrorist attack is determined more by the magnitude or number of potential targets to be protected than by the actual magnitude of the terrorist threat.** A single terrorist incident involving aviation, for example, requires measures at hundreds of airports. Terrorists know and exploit this fact, boasting that their bombs cost only a few thousand dollars, while millions must be spent on security.

- **The volume of “noise”—threats, warnings, and reports of possible or impending terrorist attacks—is always high.** Captured terrorist documents often suggest that there are a substantial number of operations in the planning stages. Planning is continuous. Most of these projects are the expression of ambition, rather than operational plans.

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131 At the time of this writing it is not known whether the Boston Marathon attack had a causal relation to Chechen terrorist programs.
When not engaged in preparing or conducting actual operations, terrorists talk to each other; increasingly they communicate on the Internet. Much of their discourse concerns proposed operations and dreamed-of projects, fantastical, contemplated and discarded; however, the communications regarding these dreamed-of projects are intercepted by security services, overheard by informants, monitored in cyberspace, and reported. Terrorists may add to the noise by deliberately sowing disinformation, or they may communicate numerous threats to deliberately mislead and rattle authorities and spread alarm as part of their campaign. In addition, analysts surmise that arrests or trials of terrorists raise threats of reprisal or surmise that terrorist attacks are likely on certain anniversary dates, and they sensibly issue appropriate warnings. The result is a high volume of threats and warnings.

- **Most threats do not result in terrorist attacks, while most terrorist attacks are not preceded by specific warnings.** The overlap between the specific threats and warnings received and terrorist incidents that have actually occurred is very small.

### 1.5.4 Principles Regarding Terrorist Behavior and Decision-Making

- Terrorists can attack just about anything, anywhere, anytime, while governments and others charged with security cannot protect everything everywhere, all the time. This is unlike more conventional modes of armed conflict, which require belligerents to attack certain targets or categories of targets within certain periods of time in order to have military significance. Terrorists, therefore, always have the advantages of tactical initiative and choice.

- Terrorists select targets on the basis of their political suitability and symbolic value or the possibility of achieving high casualty rates first, and target vulnerability second. Terrorists start by looking at targets, or at least venues, that have iconic or emotional value. This strategy provides a long list, but not all of the targets are accessible to terrorists, therefore the list is narrowed to the more vulnerable locations. Since terrorists have virtually unlimited targets to attack, they will attack what they perceive to be the most vulnerable but still symbolically important target. Terrorists determined to kill in quantity and willing to kill indiscriminately may substitute possibilities of achieving high
body counts for political value. For example, surface passenger transportation may offer terrorists modest iconic value, apart from location in the heart of large cities, but it provides opportunities to cause significant casualties.

- Terrorists (and analysts of terrorism) can conjure up more potential convincing terrorist scenarios than security can possibly protect. Defenders therefore must decide how much they can devote to protection against events that are possible but that have not occurred, or that have occurred elsewhere, but not locally.

- Terrorists imitate what they perceive to be successful attacks. This reinforces the previous rule. Therefore, even though security may be seen as reactive, it makes sense to implement measures aimed at preventing the recurrence of specific types of attacks.

- Terrorists tend to be conservative in their decisions and more imitative than innovative; therefore, terrorist tactics evolve slowly—preferred targets are abandoned reluctantly. Protecting categories of targets terrorists have attacked before makes sense. In the absence of better security, they are likely to attack them again.

- Terrorists may sometimes attempt to penetrate modest security barriers, even when other tactics or easier venues are available, to demonstrate their prowess.

- As security has increased around terrorists’ preferred targets, they have tended to shift toward softer, less-protected targets. The shift from commercial aviation—although terrorists appear to remain obsessed with attacking commercial airliners—to more accessible surface transportation is a prime example.

1.5.5 Risk-Related Principles

- Risk equations in the domain of terrorism are almost always consequence-driven. Risk is usually calculated as a product of threat, vulnerability, and consequences. However, threat remains an uncertain component, not easily quantified, while vulnerabilities are virtually uncountable. Consequences are almost invariably calculated on the basis of worst-case scenarios, and in some analyses, consequences are deliberately weighted to
count more than threat. The result is that the consequences of an event overwhelm the probability of its occurrence, particularly when that probability is very remote.

- **The perceived consequences of a terrorist attack, more than the probability of its occurrence, determine the perceived risk and, consequently, the demand for security.**

The preceding rule has to do with calculations and with perceptions. The crash of an airliner with 100 persons on board has far greater effect on people’s calculation of risk than 100 automobile accidents in which one person dies, even though the total number of casualties is the same. Why? Risk involves the probability of an event times the consequences of that event. However, psychologists have learned that the perceived risk equals something closer to the probability of an event times the consequences squared. That would make the perceived risk in the hypothetical airline disaster one hundred times greater than the sum of 100 individual fatal accidents. According to this formula, the Oklahoma City bombing would produce the psychological effect of nearly 30,000 fatalities, nearly twice the annual number of homicides in the entire United States. And the 9/11 attacks would yield a psychological impact on the nation equivalent to ten million deaths—a body blow to the national psyche. Thus, whether the estimated probability of another 9/11-type of attack is one in the next 20 years or one in the next 50 years makes little difference—the threat is still perceived as being very serious. Security planners are forced to take into account demands for security based upon perceived risk.

- **Vulnerability is not a threat.** As previously discussed, analysts have shifted from threat-based analysis to vulnerability-based analysis. Although this has a certain utility, the observation that a target could be attacked does not mean that terrorists will attack it.

### 1.5.6 Public Expectations/Reactions Regarding Security

- **Public expectations of security are rising even as the level of violence is falling.** Even though the level of terrorist violence in the United States since 9/11 is less than that experienced during the 1970s, and the murder rate is falling, Americans are demanding more security. The public has adopted an unrealistic expectation of zero risk.
• After a terrorist attack, security by definition has failed, but the failure is considered worse because people believe that those charged with security could have (and should have) prevented such an attack. This view puts security planners in a bind. They cannot garner support for security measures against attacks they know might occur, but they are held liable for not doing so if an attack does occur. This leads to careful control of vulnerability assessments, restricting them to what can be secured instead of documenting scenarios for which there are no resources or no political will to address. This, in turn, can make security planners look foolish when something happens that was not on their scenario list.
1.6 Appendix 6: Analysis of the Probability of a Scenario Occurring

Analysis of the probability of a scenario occurring given a countermeasure portfolio is present.

Analysis of limit of the ratio \( \Pr\{\text{at least one scenario } S \text{ occurs } | p\} \) to \( \Pr\{\text{at least one scenario } S \text{ occurs}\} \)

\[
\lim_{l \to 0} \frac{\left(1 - \frac{\prod_{s} \left(1 + P_{sr}\right)}{\prod_{s} \left(1 - P_{s}\right)}\right)}{l} = \lim_{l \to 0} \sum_{s} P_{s} r_{s} + \frac{2}{l} F(P_{s}, r_{s}) + \ldots = \lim_{l \to 0} \sum_{s} P_{s} r_{s} + \frac{G(P_{s})}{l} + \ldots = \sum_{s} P_{s} r_{s}
\]

\( l = \) scaling factor
\( P_{s} = \Pr\{S\} = \) probability of scenario \( S \) occurring
\( r_{s} = 1 - EFRR(S)_{p} = \) reduction in risk for scenario \( S \) with countermeasures \( p \)
## 1.7 Appendix 7: Description of Parameter Inputs for Establishments

The following screen shot is taken from the “Assign Parameters” view in the PIE and shows the user input parameters for establishments. For explanation purposes, the parameters for the convenience stores are presented, but the description applies to the other establishments as well.

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability of Entering</td>
<td>A value between 0 and 1 representing the probability that a person will enter the store when they pass by.</td>
</tr>
<tr>
<td></td>
<td>In this example, there is a 50% probability that a person will enter the convenience store.</td>
</tr>
<tr>
<td>Time in store (mins)</td>
<td>A distribution representing the time (in minutes) a person will spend while in the store.</td>
</tr>
<tr>
<td></td>
<td>In this example, the time in store follows a uniform distribution between 0 minutes and 60 minutes. In other words, a person will spend some amount of time between 0 and 60 minutes, with all values equally probable.</td>
</tr>
<tr>
<td></td>
<td>Other options for distributions include exponential(mean); normal(mean); and triang(a,b,c). More details on random number distributions available in OMNeT++ can be found at <a href="http://www.omnetpp.org/doc/omnetpp/api/group__RandomNumbersCont.html">http://www.omnetpp.org/doc/omnetpp/api/group__RandomNumbersCont.html</a></td>
</tr>
<tr>
<td>Spending Transaction Value Ranges ($)</td>
<td>A series of dollar values representing the amount of money a person might spend while in the store. These values are used in conjunction with the spending probabilities.</td>
</tr>
<tr>
<td></td>
<td>$s_0, s_1, s_2, ..., s_n$ representing the following ranges</td>
</tr>
<tr>
<td></td>
<td>$(s_0, s_1], (s_1, s_2], ... (s_{n-1}, s_n]$</td>
</tr>
<tr>
<td></td>
<td>In this example, there are 5 values: 0, 50, 100, 150, and 250. This translates to the following 5 ranges:</td>
</tr>
<tr>
<td></td>
<td>- 0 dollars (0)</td>
</tr>
<tr>
<td></td>
<td>- up to 50 dollars (0,50]</td>
</tr>
<tr>
<td></td>
<td>- between 50 and 100 dollars (50,100]</td>
</tr>
<tr>
<td></td>
<td>- between 100 and 150 dollars (100,150]</td>
</tr>
<tr>
<td></td>
<td>- between 150 and 250 dollars (150,250]</td>
</tr>
</tbody>
</table>
| **Spending Probabilities (sum to 1)** | A series of values between 0 and 1, summing up to 1, used in conjunction with the spending transaction value ranges. 

\[ t_0, t_1, t_2, \ldots, t_n \text{ such that} \]

\[
\Pr\{\text{spending}(0, s_1]\} = t_0 \text{ and} \\
\Pr\{\text{spending}(s_n, s_{n+1}\} = t_n \text{ for } n > 0
\]

In this example, since there are 5 values for the spending transaction values ranges, there will also be 5 spending probabilities. The spending probabilities are 0.05, 0.60, 0.30, 0.05, and 0.00.

This means that:

- Probability of spending $0 is 0.05
- Probability of spending up to $50 is 0.60
- Probability of spending between $50-$100 is 0.30
- Probability of spending between $100-$150 is 0.05
- Probability of spending between $150-$250 is 0.00

When translated into the omnetpp.ini configuration file, the parameters for the Convenience Stores appear as:

```
**.Convenience*.store.serviceTime = uniform(0min,60min)  
**.Convenience*.store.category = 3  
**.Convenience*.store.capacity = 50  
**.Convenience*.store.values = "0 50 100 150 250"  
**.Convenience*.store.distr = "0.05 0.60 0.30 0.05 0"  
**.Convenience*.entry.proceed = 0.5  
**.Convenience*.exit.proceed = 1
```

The lines that appear in *italics* are predefined and hardcoded for the OMNeT++ model, while the other parameters have been assigned through the PIE interface by the user.
1.8 Appendix 8: Sample OMNeT++ Configuration File Used for Demonstration

```
[General]
ned-path = .;../queueinglib
#debug-on-errors = true
record-eventlog = false
#output-vector-file = ./results/CityRegion-0.vec
#output-scalar-file = ./results/CityRegion-0.sca
cmdenv-express-mode = true
**.vector-record-eventnumbers = false
print-undisposed=false
rng-class="cMersenneTwister"
num-rngs=1
repeat=1
seed-0-mt=0

#Shared Configurations
sim-time-limit = 4h
**.Arrival*.jobsize = 1
**.Arrival*.interArrivalTime = 1min + exponential(5min)
**.delay_crossing_*.*.delay = uniform(1min,2min)
**.delay_street_*.*.delay = uniform(2min,4min)

#Location of Establishments and Countermeasures
**.pos = "0 0"

#Subway Parameters
**.Subway.source.numJobs = -1
**.Subway.source.jobsize = 1
**.Subway.source.interArrivalTime = 1min + exponential(2min)
**.Subway.entry.proceed = 0.5
**.Subway.exit.proceed = 1

#Establishment Parameters
**.Bookstore*.store.serviceTime = uniform(0min,60min)
**.Bookstore*.store.category = 1
**.Bookstore*.store.capacity = 200
**.Bookstore*.store.values = "0 50 100 150 250"
**.Bookstore*.store.distr = "0.5 0.30 0.15 0.05 0.0"
**.Bookstore*.entry.proceed = 0.5
**.Bookstore*.exit.proceed = 1

**.Restaurant*.store.serviceTime = uniform(0min,60min)
**.Restaurant*.store.category = 2
**.Restaurant*.store.capacity = 150
**.Restaurant*.store.values = "0 50 100 150 250"
**.Restaurant*.store.distr = "0.02 0.93 0.05 0 0"
**.Restaurant*.entry.proceed = 0.5
**.Restaurant*.exit.proceed = 1

**.Convenience*.store.serviceTime = uniform(0min,60min)
**.Convenience*.store.category = 3
**.Convenience*.store.capacity = 50
**.Convenience*.store.values = "0 50 100 150 250"
**.Convenience*.store.distr = "0.05 0.60 0.30 0.05 0"
**.Convenience*.entry.proceed = 0.5
**.Convenience*.exit.proceed = 1
```
**.Shop*.store.serviceTime = uniform(0min,60min)
**.Shop*.store.category = 4
**.Shop*.store.capacity = 25
**.Shop*.store.values = "0 50 100 150 250"
**.Shop*.store.distr = "0.5 0.2 0.2 0.05 0.05"
**.Shop*.entry.proceed = 0.5
**.Shop*.exit.proceed = 1

#Model Without Countermeasures
[Config CityRegion0]
description = "2x2 model"
network = CityRegion

#Inactive Countermeasures
**.countermeasureQueue.category = 0
**.countermeasureQueue.capacity = 0
**.countermeasureQueue.serviceTime = 0min
**.entryECM.maxQueueWait = -1
**.entryECM.proceed = 1.0

**.CM*.entry.proceed = 1.0 #probability of proceeding through countermeasure
**.CM*.entryECM.maxQueueWait = 100 #maximum queue length willing to wait in countermeasure for inspection
**.CM*.queue.serviceTime = 0min #time for countermeasure
**.CM*.queue.capacity = -1

#Model With Countermeasures
[Config CityRegion1]
description = "2x2 model - with countermeasures"
network = CityRegion

#Active Countermeasures
#probability of proceeding through countermeasure (default: 1.0)
#maximum queue length willing to wait in countermeasure for inspection (default: -1)
#time for countermeasure (default: 0s)

#Active countermeasures at Convenience Stores
**.Convenience*.countermeasureQueue.category = 5
**.Convenience*.countermeasureQueue.capacity = -1
**.Convenience*.countermeasureQueue.serviceTime = uniform(10s,60s)
**.Convenience*.entryECM.proceed = 0.90
**.Convenience*.entryECM.maxQueueWait = 5
1.9 Appendix 9: The PIE

Analytics, modeling and simulation play an important role in the analysis of security risk vs. economic benefit in the UCASS study. A key goal of the project was to construct a Precision Information Environment (PIE), an analysis system that couples behavioral, risk and economic models, thereby supporting tactical evaluations and decision making either for strategic planning, or in the tactical stages of recovery from an attack. Multiple models from various disciplines were integrated in novel ways to develop a prototypical decision support tool.

As described in Chapter 1 of this technical report, the UCASS study involves the development of three kinds of models: discrete event simulations of pedestrian, vehicular and other traffic; economic models of the various costs attributable to security; and risk models that estimate the risk reduction capabilities of various security measures. Typically, discrete event simulation models are expected to be used in the absence of an event, such as those described in the list of key “scenarios” developed under the leadership of our MTI partners, and can be used to explore alternative security measures, such as the key ones under investigation in the UCASS project.

The economic models can be used with or without such events/scenarios, while the risk models estimate the deterrent or preventative effect of a security measure in relation to threat scenarios.

There are two cost categories that describe the countermeasures: (a) the setup cost of implementing a countermeasure; (b) the continuing cost due to the countermeasure, which includes the operating cost plus the impact due to expected loss of business revenue or similar costs. In addition, the event can be treated as having a cost which presumably is reduced if there is a countermeasure in place. As discussed in Chapter 1, the benefit of each countermeasure can also be represented directly as a fraction reduction in the risk, without specific quantification of the economic impact.

An early prototype of a UCASS decision support tool was implemented with three steps: (a) pre-processing step; (b) simulation input and execution step; (c) and a post-processing step. In the pre-processing step, the user chooses a security event/scenario from a drop-down list. Based on the selected event, the user chooses a security measure or portfolio of measures in an interactive
In the simulation input and execution step, the user is prompted to define specific input parameters and then clicks the selection tab for the execution, choosing to observe the simulation and accumulating economic activity outputs. The post-processing step is used to view the economic impact. This impact is a combination of the individual costs described previously in this report, which are obtained from the UCASS models, and the impact on commerce produced by the discrete event simulation.

The output of the PIE may be presented in Flash-based bubble charts such as graphs comparing risk to economic impact (see Chapter 1). As with other simulations, there are multiple runs, enabling a user to compare different portfolios of security measures in the presence or absence of an event occurring. A pictorial description of the PIE is given in what follows.

![Figure 1.9.1: Welcome Page for the PIE Where the User Selects the Model Topology to Use](image)

Once the model is selected, the user can view and modify security countermeasures and assign simulation parameters.

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132 A more sophisticated tool might use methods of recommender systems to modify the drop-down list of countermeasures depending on the security event.
Various security measures can be selected based on the type of security event.

Selected countermeasures are then added to the security profile.
The user can then view all the countermeasure parameters and modify quantities as necessary. The total capital costs of the security profile is also displayed.

Once the security profile is complete, the user can assign simulation parameters such as simulation duration, vehicle inspection time, bag and parcel check time, and subway inspection times.
The user can also specify expected transaction values for the various businesses in the model, such as restaurant, book store, and clothing store.

The user can review all the selections and run the simulation with the specified settings.
1.9.1 Challenges of Discrete Event Simulations

There are several challenges in this study related to Arena modeling and simulation. It is important to understand individuals’ buying behavior for a given area in order to thoroughly understand what attracts different people to the area. In addition, it is important to understand individuals’ attitudes towards security, as well as safety procedures for transportation and other infrastructure. Similarly, it is important to understand commercial stakeholders’ views, such as shop owners, of a high-security area in order to build good models.

There are unique challenges when modeling urban areas. Economic activity stems from commerce on the streets and in offices, shops and restaurants, all of which are embedded in an interconnected network of transportation routes frequented by large numbers of people making transactions. Clearly, there are modeling decisions to be made, such as the appropriate boundary or scale of the area, which includes both the size of the area to be covered and the number of people to be included in the model. Moreover, these chosen areas may be neighboring national landmarks, such as the WTC site, which require intense levels of security around the area. Decision-makers are therefore challenged to find the right balance between security and the free...
flow of people – an issue very similar to container inspection in port security, another area to which simulation modeling methodology has been extensively applied.
1.10 Appendix 10: Additional Information about the OMNeT++ Tool

OMNeT++ was selected so the simulation models are open source and accessible to user groups via the Internet.

As this work seeks to evaluate the tradeoff between commerce and security, our initial experimentation involved building a model for the study of a single restaurant. With this model, we are able to compare the throughput and the waiting times for parties (entities) through the restaurant (network) when no security measure is in place and when a variety of security measures are in place. From there, we added a number of businesses along city streets.

Parameters can be modified to obtain answers to “what if” questions. A decision maker using the PIE might ask, “What if a restaurant added a bag and parcel check before entering the building? How many fewer (or more) patrons would dine there?” Possible security measures for our initial restaurant model include a bag and parcel check, similar to a bag check at an airport or at a sporting event. Technically, a restaurant can be described as a network in which the parties move from the hostess to a table or bar, to dine, and finally to pay their bill (additional detail may be added to a model where appropriate). Throughout the process, each steps can be abstracted as a server with a queue. The addition of a security measure like a bag and parcel check is similar in nature and is modeled by inserting another server and queue.

Once a model has been defined through this abstraction process, it can be parameterized to reflect any security or commerce alternatives of interest, and the resulting output may be analyzed to determine the effect of these alternative parameters. Using a model to evaluate system behavior is less laborious and more flexible than real-world experiments.

Once a business model, such as the restaurant model, has been developed, it can be duplicated for entire city streets, and varied to represent other kinds of commercial activities.

In a notional extension, the network of streets can be overlaid on an aerial view of the region being modeled, and interventions can be dragged and dropped. This refinement was not developed in the current project, as time and resources were exhausted. The concept is suggested in Figure 1.10.1.
In Figure 1.10.1 OMNeT++ modules are seen in the right window and in the topology that is built over the image of a map. Modules are dragged and dropped, and then connected to form the resulting queuing network topology.

OMNeT++ allows for hierarchical modeling, meaning that modules are self-contained and reusable and that compound models may be assembled from simpler modules with no additional coding. That makes it possible to duplicate any given model and connect multiple models to form more complex networks that describe the urban area being studied.

Modules used in the development of the Lower Manhattan OMNeT++ model include sources, which are the point of origin for entities, classifiers, which determine the route a pedestrian takes, servers and queues, which model the service and holding locations for entities being processed in both businesses and in security countermeasures, delay modules, which simulate the time it takes entities to move along a street, and sinks, which are the point of exit from the
simulation for the entities. These basic building blocks in OMNeT++ allow for the queuing network that models commerce and security countermeasures in our urban area of interest.

1.10.1 Execution and Output
In OMNeT++, the configuration (.ini) files specify the model to be run, time limitation, random number generator, and service time distributions.

Simulations may be run in two modes (1) command line and (2) interactive. Command line mode minimizes input/output delays, yielding high performance. The interactive GUI allows for a view of what is happening and enables modification of parameters at run-time. Since the display cannot show more than one pedestrian at a time, the GUI mode was deemed inapplicable in this project.

Results from a simulation are written to output as vector and scalar files. Result files are text-based, so they may also be processed with statistical packages or other similar tools. Additionally, analysis tools are available in the simulation integrated development environment to visualize results.

The output files consist of three text files:

- .elog - event log file with detail on an event-level
- .sca - file of scalar statistics/details such as number of repetitions, replications, seed
- .vec - fixed form text file detailing events’ movement and timing.
REFERENCES


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