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Assessing the Benefits of U.S. Customs and Border Protection Regulatory Actions to Reduce Terrorism Risks

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Prepared for the U.S. Department of Homeland Security and Industrial Economics, Inc.

HOMELAND SECURITY AND DEFENSE CENTER

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Preface

About This Document

Executive Order 12866, as supplemented by Executive Order 13563, requires federal agencies to evaluate the benefits, costs, and other impacts of major regulations prior to promulgation. For regulations intended to confer benefits under circumstances of extreme uncertainty, such as commonly arise in the context of homeland security, this requirement has proven especially challenging. This document is based on a workshop on this topic that was conducted jointly by the RAND Corporation and Industrial Economics, Incorporated, on November 29, 2011, titled "Assessing the Benefits of U.S. Customs and Border Protection Regulatory Actions to Reduce Terrorism Risks."

The workshop, which was sponsored by U.S. Customs and Border Protection, brought together leading experts in the field of regulatory analysis and terrorism risk. The objective of the workshop was to examine alternative approaches for estimating the benefits of regulations designed to reduce the risks of terrorist attacks on U.S. soil. The observations presented in this document are not RAND's but reflect those of the workshop participants. This document should be of interest to those in the homeland security community and in other policy communities who are concerned with the conduct of benefit-cost analysis under circumstances of extreme uncertainty. Readers may also be interested in related RAND research on terrorism risk analysis and management, including

- Brian A. Jackson, Edward W. Chan, and Tom LaTourrette, "Assessing the Security Benefits of a Trusted Traveler Program in the Presence of Attempted Attacker Exploitation and Compromise," WR-855-RC, Santa Monica, Calif.: RAND Corporation, 2011.
- Andrew R. Morral and Brian A. Jackson, *Understanding the Role of Deterrence in Counterterrorism Security*, OP-281-RC, Santa Monica, Calif.: RAND Corporation, 2009.
- Henry H. Willis and Tom LaTourrette, "Using Probabilistic Terrorism Risk Modeling for Regulatory Benefit-Cost Analysis: Application to the Western Hemisphere Travel Initiative Implemented in the Land Environment," *Risk Analysis*, Vol. 28, No. 2, April 2008, pp. 325–339.

The RAND Homeland Security and Defense Center

This research was conducted in the RAND Homeland Security and Defense Center, which conducts analysis to prepare and protect communities and critical infrastructure from natural disasters and terrorism. Center projects examine a wide range of risk management problems,

including coastal and border security, emergency preparedness and response, defense support to civil authorities, transportation security, domestic intelligence, technology acquisition, and related topics. Center clients include the Department of Homeland Security, the Department of Defense, the Department of Justice, and other organizations charged with security and disaster preparedness, response, and recovery. The Homeland Security and Defense Center is a joint center of the RAND National Security Research Division and RAND Infrastructure, Safety, and Environment.

Information about the Homeland Security and Defense Center is available online (http://www.rand.org/multi/homeland-security-and-defense/). Inquiries about homeland security research projects should be sent to:

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Summary

Executive Order (E.O.) 12866, as supplemented by E.O. 13563, requires federal agencies to evaluate the benefits, costs, and other impacts of major regulations prior to promulgation. For regulations intended to confer benefits under circumstances of extreme uncertainty, such as commonly arise in the context of homeland security, this requirement has proven especially challenging. To assist U.S. Customs and Border Protection (CBP), a key component of the U.S. Department of Homeland Security (DHS), in meeting these challenges, the RAND Corporation and Industrial Economics, Incorporated, conducted a workshop in November 2011, titled "Assessing the Benefits of U.S. Customs and Border Protection Regulatory Actions to Reduce Terrorism Risks," that drew together leading experts in the field of regulatory analysis and terrorism risk.

Most of the ideas that emerged from the workshop pertained to either qualitative modeling, quantitative modeling, or data collection. Participants also considered a set of cross-cutting issues, specifically those of analytical capacity, transparency, and presentation. A distillation and synthesis of the emerging ideas, recurring themes, and (albeit few in number) points of contention among the participants suggested several recommendations to assist CBP in meeting the challenges of improving the benefit-cost analysis of terrorism security regulations:

- **Aim for break-even work that is more descriptive.** Comprehensive or "full" benefit-cost analysis is likely neither attainable nor desirable, given the extent of uncertainty and related analytical challenges, but break-even analysis can be used to explore the implications of uncertainty and describe conditions under which benefits could exceed costs for particular regulations.
- **Incorporate "storytelling" into regulatory analysis and consider adopting logic modeling as part of the regulatory development process.** Logic models can be used to support benefit-cost analysis, break-even analysis, and regulatory development, more generally, by helping to identify and articulate plausible links between regulatory actions and outcomes.
- **Strengthen internal modeling capacity and leverage existing risk assessment methods, when possible, including DHS/Office of Risk Management and Analysis (RMA) and computable general equilibrium (CGE) models**. A varied, multidisciplinary toolkit can be used to assess big effects and shed light on uncertainty. For example, CGE models can be used to calculate welfare effects; DHS/RMA's risk assessment models to estimate risk; and, as already noted, logic models to "tell the story" of a regulatory action and its effects.
- **Develop and adopt DHS-wide standards for reliable expert elicitation.** Learning more about best practices—to better understand the technique's strengths, weaknesses, and

applicability to benefit-cost analysis—and establishing criteria based on those practices would help to ensure that expert elicitation throughout DHS produces reliable results.

- **Improve basic science in potentially important but under-explored areas of terrorism consequences, including behavioral responses, mental health, and fear.** Not only does fear have behavioral implications that can impact the probability or magnitude of effects, it may have direct bearing on an individual's mental health, well-being, and happiness.
- **Incorporate pilot studies and other natural experiments into regulatory design.** Regulatory rollouts that create natural experiments, e.g., through pilot programs, interim final rules, or phased implementation, may yield data and enable analysis that provides insight to the effects of final rules.
- **Improve transparency.** It may be possible to improve the transparency of benefit-cost analysis, e.g., by sharing information when doing so would not jeopardize security and expanding verification and validation.

Acknowledgments

We are especially grateful to the workshop participants for taking time from their busy schedules to lend their expertise to this event. We also thank Elena Ryan and Seth Renkema of U.S. Customs and Border Protection for initiating and sponsoring the workshop, and we gratefully acknowledge Jennifer Baxter of Industrial Economics, Incorporated (IEc), for inviting us to partner with IEc and for all her work developing the agenda, informing the debate, and reaching out to the participants. In addition, we wish to thank the workshop participants for their thoughtful comments and suggestions in preparing the proceedings. We are indebted to Jessica Yeats for taking detailed and accurate notes, which were essential for preparing these proceedings. Lastly, we wish to thank Peter Brownell of RAND for his review of the proceedings, which are much stronger for his input.

Abbreviations

CBP	U.S. Customs and Border Protection
CGE	computable general equilibrium
DHS	U.S. Department of Homeland Security
E.O.	executive order
IEc	Industrial Economics, Incorporated
OMB	Office of Management and Budget
RMA	Office of Risk Management and Analysis
WHTI	Western Hemisphere Travel Initiative

SECTION 1

Introduction

Executive Order (E.O.) 12866 (Clinton, 1993), as supplemented by E.O. 13563 (Obama, 2011), requires federal agencies to evaluate the benefits, costs, and other impacts of major regulations prior to promulgation. For regulations intended to confer benefits under circumstances of extreme uncertainty, such as commonly arise in the context of homeland security, this requirement has proven especially challenging. To assist U.S. Customs and Border Protection (CBP), a key component of the U.S. Department of Homeland Security (DHS), in meeting these challenges, the RAND Corporation and Industrial Economics, Incorporated (IEc), conducted a workshop, titled "Assessing the Benefits of U.S. Customs and Border Protection Regulatory Actions to Reduce Terrorism Risks," that drew together leading experts in the field of regulatory analysis and terrorism risk. The objective of the workshop was to examine alternative approaches for estimating the benefits of CBP regulations designed to reduce the risks of terrorist attacks on U.S. soil.

Implementing Guidance

In its implementing guidance for E.O. 12866 and related authorities ("Circular A-4"), the U.S. Office of Management and Budget (OMB, 2003, pp. 2–3) stipulates that an evaluation of benefits and costs should do the following:[1]

1. Explain how the actions required by the rule are linked to the expected benefits. Separate analyses should be done for each of the alternatives.
2. Identify a baseline. Benefits and costs are defined in comparison with a clearly stated alternative. This normally will be a "no action" baseline: what the world will be like if the proposed rule is not adopted. Comparisons to a "next best" alternative are also especially useful.
3. Identify the expected undesirable side effects and ancillary benefits of the proposed regulatory action and the alternatives. These should be added to the direct benefits and costs as appropriate.

[1] As explained by OMB in the preamble to the circular, "This Circular provides the Office of Management and Budget's (OMB's) guidance to Federal agencies on the development of regulatory analysis as required under Section 6(a)(3)(c) of Executive Order 12866, 'Regulatory Planning and Review,' the Regulatory Right-to-Know Act, and a variety of related authorities."

OMB (2003, p. 2) affirms that the motivation for the analysis is to learn whether the benefits of an action are likely to justify the costs or to discover which of various possible alternatives would be the most cost-effective, but OMB also notes that efficiency might not be the only or the overriding public policy objective.

OMB asks agencies undertaking a benefit-cost analysis to quantify anticipated benefits and costs to the extent possible but recognizes that quantification, particularly monetization, may not be feasible in all cases. In instances in which it is not possible to monetize benefits or costs, an agency may calculate them in terms of physical units, e.g., stream miles of improved water quality or increases in game fish populations (OMB, 2003, p. 27); when physical units are unattainable, an agency may, instead, provide alternative information to support the regulatory process:

> Even when a benefit or cost cannot be expressed in monetary units, you should still try to measure it in terms of its physical units. If it is not possible to measure the physical units, you should still describe the benefit or cost qualitatively.[2] (p. 10)

OMB also emphasizes the importance of reporting "transfers" separately and, thus, identifying the net effects of a proposed regulation on "aggregate social welfare."[3] According to OMB (2003, p. 46),

> You [the agencies and establishments conducting the benefit-cost analysis] should report transfers separately and avoid the misclassification of transfer payments as benefits or costs. Transfers occur when wealth or income is redistributed without any direct change in aggregate social welfare. To the extent that regulatory outputs reflect transfers rather than net welfare gains to society, you should identify them as transfers rather than benefits or costs.

Analytical Challenges

CBP, like other DHS components, faces considerable challenges in conducting benefit-cost analyses for regulations designed to reduce the risks of terrorist attacks on U.S. soil.[4] Whereas the anticipated costs might be reasonably well defined, the benefits, which hinge on the avoidance of damages under extremely uncertain conditions, tend to be difficult to measure. Insomuch as terrorism security regulations are intended to deter or otherwise prevent terrorist attacks, the benefits come from the averted damages (DHS, 2009; Willis et al., 2005; Willis and LaTourrette, 2008). Estimating those benefits would typically involve evaluating society's willingness to pay to avoid terrorism-related damages or, lacking information on willingness to pay, estimating the expected change in terrorism-related damages that would result

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[2] OMB also allows the possibility of cost-effectiveness analysis (p. 10) and "threshold" or "break-even" analysis (p. 2). See the later discussion of break-even analysis, below.

[3] In economic parlance, a measure of "aggregate social welfare" is the overall economic "surplus" of consumers and producers, itself a measure of economic well-being. Consumer surplus measures aggregate net benefits to consumers; that is, the difference between what a consumer is willing to pay for a quantity of a good or service and what he or she actually pays, summed over all consumers. Likewise, producer surplus measures aggregate net benefits to producers; that is, the difference between a firm's threshold price and the actual price of the good or service, summed over all firms.

[4] For purposes of this report, we refer to these types of regulations as "terrorism security regulations."

from implementation of the new regulation (Smith, Mansfield, and Clayton, 2008; Willis and LaTourrette, 2008). Both approaches—assessing willingness to pay or the expected change in damages—require an explicit characterization of the underlying risk of a terrorist attack. However, benefit-cost analysis has yet to overcome two analytical challenges associated with estimating the baseline level of terrorism risk and the anticipated effects of proposed security measures on that risk: a lack of data with which to estimate terrorism risks and an inability to anticipate how terrorists will adapt to changes in the security environment (Ezell et al., 2010; Merrick and Parnell, 2011; National Research Council, 2010).

Relevant, reliable, and accurate data for evaluating either the baseline risk posed by terrorists or the anticipated change in risk resulting from a regulation are scant for two reasons. First, there have been few terrorist attacks or attempted attacks in the United States or in comparable contexts. Second, the few attempted attacks have varied greatly in nature, thus providing little data with which to characterize even those scenarios drawn from actual experience. As a result, the record of terrorism does not allow for extrapolation of risk estimates that consider the different ways terrorists might attack in the future. Even when careful analysis of the historical record provides a means to estimate the baseline risk, it is difficult to know whether or how much that risk may have changed because of some deliberate security measures adopted under a regulation or because of some other factors whose effects cannot be isolated.

Conventional treatments of risk, such as those focusing on probability and consequence or on threat, vulnerability, and consequence, also fall short, in part because terrorist adversaries are adaptive and the environment is dynamic (Ezell et al., 2010; Willis et al., 2005). Changes in circumstances might lead an adversary to adopt a new strategy to achieve the same end or to alter the overall intensity of its efforts. When an analysis is possible, concerns about releasing or "backing out" security-sensitive information have sometimes constrained federal agencies' ability to carry out assessments and to vet models or publish findings.

In response to these conceptual and practical challenges, CBP has been using a "break-even" approach to conduct regulatory impact analysis. Rather than attempt to estimate benefits directly, break-even analysis identifies the conditions necessary for the benefits of the regulation to exceed the costs:

> It will not always be possible to express in monetary units all of the important benefits and costs. . . . . If the non-quantified benefits and costs are likely to be important, you should carry out a "threshold" analysis to evaluate their significance. Threshold or "break-even" analysis answers the question, "How small could the value of the non-quantified benefits be (or how large would the value of the non-quantified costs need to be) before the rule would yield zero net benefits?" (OMB, 2003, p. 2)

The relevant conditions, such as baseline risk and risk reduction, can then be evaluated for feasibility. The method does not, however, project whether the regulation will achieve necessary risk reductions. Although offered as an option in Circular A-4, CBP has expressed interest in identifying novel approaches to valuing benefits and, potentially, moving beyond break-even analysis.

Workshop Objectives, Charge, and Format

To assist CBP in meeting the challenges of assessing the benefits of terrorism security regulations, RAND and IEc conducted a day-long workshop in November 2011, titled "Assessing the Benefits of U.S. Customs and Border Protection Regulatory Actions to Reduce Terrorism Risks." The workshop provided an opportunity for leading experts in the fields of regulatory analysis and terrorism risk to identify and discuss alternative approaches for valuing the benefits of CBP regulations, specifically those designed to reduce the risk of terrorist attacks.[5]

Four participants were asked to prepare presentations describing possible short- and long-term approaches to improving the analysis of terrorism security regulations and to provide advice and guidance related to developing and implementing these approaches. These are included in Appendix C. To help focus the presentations and to facilitate comparisons in a common context, participants were asked to discuss how their approaches would be applied to a rule recently implemented by CBP and the U.S. Department of State: the Western Hemisphere Travel Initiative (WHTI). WHTI tightened and streamlined the documentation requirements for travelers entering the United States from certain countries in the Western Hemisphere, including Canada and Mexico. It was implemented in the air environment in 2006 and the land and sea environments in 2009. Prior to WHTI, regulations permitted U.S. citizens and nonimmigrant aliens from Canada, Bermuda, and Mexico to enter the United States without a passport. Subsequent to WHTI, regulations require that nearly all entrants present either a passport book, passport card with vicinity-read radio-frequency identification chip, CBP trusted traveler card, DHS Enhanced Driver's License, or Merchant Mariner Document. See IEc (March 2008).

Using WHTI as a point of reference, the presentations and surrounding discussions addressed questions about

1. differences between the proposed approaches and other types of regulatory benefits analyses
2. prior analyses (regulatory or other) from which methods or findings could be applied
3. any models that could be used in analyses
4. anticipated software or other computing requirements
5. anticipated data needs and data collection options
6. consistency with OMB guidance for estimating the benefits of regulations.

The emphasis of the workshop was on benefits related to terrorism security; however, participants were also encouraged to address when and how it would be appropriate to consider ancillary benefits. As CBP faces far fewer challenges in estimating potential costs, the costs of the sample rule, including indirect effects, such as increased wait times or business losses resulting from decreased border crossings, were explicitly excluded from the workshop.[6]

The remainder of this report of the workshop proceedings draws together key elements of the presentations, discussions, and recommendations of the group. It is not intended to serve as a transcript of the workshop; rather, it is intended to provide a distillation and synthesis of emerging ideas, recurring themes, and, though limited in number, noteworthy points of con-

[5] Appendix A contains a complete list of participants; Appendix B provides the agenda for the workshop.

[6] Nevertheless, some participants did choose to address unintended consequences as a secondary issue.

tention among the participants.[7] This report does not attribute remarks to particular individuals, except as the authors of the presentations that they prepared in advance of the workshop.

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[7] Sections 2, 3, and 4 draw information solely from the presentations and discussions at the workshop, unless specifically noted otherwise.

SECTION 2

Emerging Ideas and Recurring Themes

Although CBP expressed interest in identifying novel approaches to valuing benefits and, potentially, moving beyond break-even analysis, participants did not issue a call for a new analytical paradigm; instead, they identified opportunities to augment existing approaches and create a stronger analytical foundation for future assessments. The discussions lent support to benefit-cost analysis as a useful analytical construct in the regulatory process and break-even analysis as an important means of confronting uncertainty.[1] Given the potential for feedback, the completion and review of a benefit-cost analysis can provide agencies, the Congress, and the public with a means of iterating toward better policies and practices. For example, the benefit-cost analysis of a congressionally mandated regulation could shed light on an unintended cost, which might then lead to a change in law, which might, in turn, result in the adoption of a less costly but still effective regulatory strategy.[2] On balance, the discussions supported what one participant termed "the traditional role" of benefit-cost analysis as a descriptive tool rather than a normative tool, one better suited to informing regulatory decisions than to prescribing them. Participants also stressed the value of benefit-cost analysis as a tool for explaining the reasoning behind regulatory decisions.

Most of the ideas that emerged from the workshop pertained to either qualitative modeling, quantitative modeling (both statistical and simulation), or data collection, potentially through expert elicitation and natural experiments. Throughout the day, participants spoke to the importance of focusing on the "big" or main effects of proposed regulations—referring to the major averted damages (e.g., death and injury, property losses, other substantial economic losses[3]) and potentially including some important ancillary effects and unintended consequences. With regard to methodological improvements, participants suggested targeting "low-

[1] See Baxter's "Overview of Challenges" in Appendix C for more information about break-even analysis. In discussing the relationship between benefit-cost analysis and break-even analysis, participants noted that the two are effectively equivalent under conditions of extreme uncertainty: in particular, if the probability of a terroristic attack is fundamentally "unknowable." The two approaches make use of the same information, but they arrange that information differently. In particular, break-even analysis treats uncertain parameters as variables rather than as known parameters. For more on this relationship, see Hammitt's presentation in Appendix C.

[2] Participants noted one instance in which a cost estimate drove a change in law and another in which a cost estimate drove a change in promulgation, absent a change in law. Regarding the latter, they identified the Importer Security Filing and Additional Carrier Requirements ("10+2") rule (see later discussion) as a case in which the benefit-cost analysis revealed uncertainty over outcomes, including costs, and led to a change in promulgation. CBP chose to issue an interim rule to allow time to develop a better understanding of the potential effects of the regulatory action and, if needed, adjust the final rule to mitigate undesirable consequences.

[3] Examples added by authors for illustrative purposes.

hanging fruit." Participants also considered a set of cross-cutting issues, specifically those of analytical capacity, transparency, and presentation.

Qualitative Modeling

Participants took up issues of qualitative modeling in three different but related contexts:

1. in setting out plausible links between regulatory actions and outcomes, including direct benefits, ancillary benefits, and unintended consequences, per Circular A-4 guidance
2. in identifying benefits despite the limitations of quantification, particularly in comparative assessments of alternative rules
3. in valuing more or better information, a potential positive outcome that might be underaddressed in regulatory analysis.

Linking Actions to Outcomes

A presentation on "logic modeling" introduced a qualitative modeling approach that is rooted in program planning and evaluation and can be used to shed light on the logical connections between regulatory actions and outcomes (see Greenfield et al. in Appendix C). The approach could enable CBP and other agencies that confront extreme uncertainty to link rules, actions, and benefits; it can be used to create a roadmap with which to articulate the agency's program "story" (i.e., the what, why, and who of a program), identify how a proposed regulation would affect that story, and assess resultant changes in capabilities and outcomes in terms of the story.

Identifying Benefits Despite Challenges

Discussions about the analytic challenges described in Section 1, i.e., those presented by uncertainty and pertaining to data availability and model validation, suggested a more central role for storytelling in benefit-cost analysis.

One participant referred to a paper, "The Arithmetic of Arsenic" (Sunstein, 2002), by the current administrator of OMB's Office of Information and Regulatory Affairs. Recalling a key point of the paper, the participant asserted that

> . . . our uncertainty about the net benefits of rules is typically so great that the [quantitative] analysis has very little value in distinguishing among candidate rules that are within the feasible set. And maybe the analysis can suggest that some of the candidates are bad, but the theoretical idea of finding the optimal level of regulation is a very misleading idea in this context.

The participant concluded that one could still reasonably ask for a "logical story" as to how a proposed rule would plausibly reduce terrorist attacks or risks, possibly including some discussion of countervailing effects (see later discussion of adaptive behavior) and some quantification of the costs and big effects. While simple analytical models might prove useful to characterizing those effects, discussions during the workshop raised caution about efforts to develop complex models, citing the limited value of putting extensive effort into detailed analysis of aspects of scenarios given uncertainty about whether and how terrorism will evolve.

Valuing Information

The implementation of a new regulation can generate more and better information, which can, in turn, have value to both the government and, possibly, to individuals and institutions outside the government. In effect, informational gains can lead to improvements in "situational awareness." For example, tightening and streamlining the documentation requirements for travelers entering the United States under WHTI might help to shed light on who is crossing the border, when they are crossing, how often they are crossing, and, sometimes, with whom they are crossing.[4] Participants cited the Importer Security Filing and Additional Carrier Requirements rule (commonly known as "10+2")[5] as an example of a regulatory action leading to data collection, compilation, and sharing that might confer benefits on both the government and private sector. Shippers would present new information to the U.S. government—in some instances, "new" only to the government, and in others, "new" to the shippers as well—and they might also share information among themselves.[6]

Participants considered whether any of the available approaches could be used to tease out the value of better information, hence situational awareness, not just to CBP, but to other DHS components, other agencies, and to those outside the government who are affected by regulations. If a regulation is expected to increase situational awareness in either the government or the private sector, could any of the approaches be used to value the effect? The logic model appeared to hold promise as a tool for a conceptual exploration of those gains. One could use a logic model to trace the flow of information through a program—eventually, to those who use the information—and to assess how a regulatory action would affect that flow; one could also use the model to articulate the role of information in linking different programs and agencies.

Quantitative Modeling

Quantitative modeling provides the possibility of numerically estimating the magnitude of the benefit of a terrorism security regulation and uncovering unanticipated effects. While potentially more demanding than qualitative modeling, e.g., in terms of needs for behavioral understanding and data, it can provide a more precise description of the effects of a regulation and thus more definitive guidance to decisionmakers.

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[4] This example derives partly from a workshop presentation (see Greenfield et al. in Appendix C), from conversations with CBP held during a facility visit on October 19, 2011, and from the description of the intent of WHTI in IEc (March 2008).

[5] CBP (2009) summarizes the terms of the rule: "Under the new rule, before merchandise arriving by [ocean] vessel can be imported into the United States, the 'Importer Security Filing (ISF) Importer,' or their agent (e.g., licensed customs broker), must electronically submit certain advance cargo information to CBP in the form of an Importer Security Filing." See also IEc (November 2008).

[6] CBP (2009) also summarizes the intent of the rule: "The information submitted in Importer Security Filings improves [CBP's] ability to identify high-risk shipments in order to prevent smuggling and ensure cargo safety and security." IEc (November 2008, p. 5-5) addresses potential benefits to the private sector:

> Such ancillary benefits might include long-term improvements in supply-chain efficiency resulting from the sharing of higher quality information in a more timely fashion among supply chain participants. In addition, improved visibility into the supply chain might make the transportation of illegal goods, such as merchandise fraudulently advertised as being the product of well-known U.S. companies more difficult.

IEc (p. 5-24) posited that this could be especially valuable to importers "who currently have little insight into the process."

Throughout the workshop, discussions of quantitative models highlighted the extent to which CBP and other agencies, on the one hand, have been reliant on external—oftentimes proprietary—modeling capacity and, on the other, might benefit from tapping into operational and up-and-coming internal capacity. These discussions, perhaps more so than those of qualitative methods, also highlighted opportunities to build on advances in other policy arenas. In contemplating particular quantitative approaches, participants called for attention to big or main effects; however, they did not dismiss the potential significance of ancillary effects or unintended consequences, which might be indirect but still important.

As a practical matter, participants identified four opportunities for advancement, in decreasing order of perceived tractability:

1. Make use of emergent DHS risk modeling capacity.
2. Exploit computable general equilibrium (CGE) models to identify welfare effects.
3. Better characterize behavior, including precautionary, responsive, and adaptive behavior.
4. Better understand the consequences of fear of terrorism.

Making Use of New Capabilities

One presentation, that of Cheesebrough and Wise (see Appendix C), demonstrated the growing analytic capabilities of the DHS's Office of Risk Management and Analysis (RMA), consisting of a set of interdisciplinary modeling, simulation, and risk and decision analysis approaches and tools drawn together over the past three years that support risk assessment. The presentation called attention to the potential to make use of emergent "in-house" capabilities in regulatory benefits assessment.

Adjacent discussions suggested that the ease with which these tools could be applied to specific proposed rules would depend on the details of the rule. In the case of WHTI, which affects terrorism risk in a fairly general (i.e., non-scenario-specific) way, applying these tools might have taken only a few weeks of effort had the models been available at that time. The components of the models that address "upstream," phenomena, that is, activities occurring prior to or upon a terrorist's entry into the United States, would have required only a small number of changes or additions, e.g., probability distributions for modes and points of entry and countervailing risks; the components of the models that address "downstream" phenomena, that is, activities occurring after a terrorist's entry into the United States, could have been implemented largely as-is.

Exploiting CGE Models to Identify Welfare Effects

CGE models appeared to present an attractive but not fully exploited option for assessing the benefits of terrorism security regulations. A CGE model can be used to identify "welfare effects," net of transfers, including those stemming from the indirect and induced losses that might cascade through the economy in the event of a terrorist attack.[7] Notwithstanding OMB's interest in separating transfers (2003, p. 46), participants noted that most economic

[7] "CGE models simulate the flow of commodities and factors of production (i.e., labor, capital, and natural resources) among producers and households to assess how a change in policy or an economic shock affects the size and composition of the economy" (U.S. Environmental Protection Agency, Office of Air and Radiation, March 2011, p. 8-2). In addition, they can also be used to measure the net change in social welfare (i.e., the change in overall consumer and producer "surplus" across markets) that results from shifts in production or a reallocation of resources.

studies of the consequences of terrorist attacks tend to focus on gross "economic impacts," generally measured as changes in production or employment. This is true even in those instances in which the studies make use of a CGE model. Participants observed that it is not unusual for agencies to work with the results of economic impact studies that employ CGE models, but that net changes in social welfare have often not been calculated or included in the publication. Depending on the study, it might not be difficult to revisit the analysis and calculate or parse the welfare effects. As noted during the discussion of Cheesebrough and Wise's presentation, DHS/RMA is adding CGE modeling capacity to its analytical base and expects it to be fully operational in one or two years. Once operational, leveraging that internal DHS capability might require relatively little additional effort.

Better Characterizing Behavior

Recognizing links between how individuals and institutions behave before, during, and after terrorist attacks, the underlying risks of terrorist attacks, and the potential effects of regulatory actions, participants discussed a need to better characterize behavior. Participants advanced three general types of behavior: precautionary, responsive, and adaptive. *Precautionary behavior* refers to the actions taken by individuals and institutions to mitigate the risk of attack; *responsive behavior* refers to the actions taken by individuals and institutions after an attack to mitigate consequences or recover; *adaptive behavior* refers to the actions taken by terrorists to evade or work-around security measures.[8] Participants framed behavioral modeling as a longer-term endeavor than leveraging new capabilities or exploiting CGE models.

Discussions about precautionary behavior suggested a need to understand how individuals and institutions react to perceived threats and regulatory actions. Individuals and institutions may act on their own to reduce the level of terrorism risk, to reduce fear or anxiety, or both. Regardless of the particular reason, their behavior may entail costs to them and society.

Among the most discussed forms of precautionary behavior were those involving changes in individuals' consumption patterns; that is, their decisions about what activities to partake in and what purchases to make. In the wake of 9/11, individuals chose to fly less and drive more, take fewer vacations, attend New Year's Eve celebrations in Times Square less heavily, ride public transit less often, avoid buying homes in specific markets, etc.[9] In each instance, they made consumption decisions, at least partly motivated by fear, that left them less well off than they had been prior to 9/11. The decisions entailed opportunity costs and, in some instances, may have entailed health costs to them and others. For example, driving rather than flying after the 9/11 attacks may have reduced the fear of dying in a terrorist attack, but may have resulted in increased travel time and perhaps traffic accidents and net pollution emissions. If a regulation were to alleviate individuals' concerns about a threat and reduce costly changes in consumption patterns, then it could be said to have reduced some of the expected damages.

Participants posited that more or better information about actual risks, related to or apart from regulatory actions, could help to shape perceptions in a way that would make individu-

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[8] These are not formal definitions, but reflect the terms of use, albeit not uniform, of the workshop participants. In some instances, the participants used the term *behavioral responses* as a more general category, encompassing a wide range of behaviors.

[9] The authors expanded the list of examples to include vacations and housing for illustrative purposes. Participants also referenced government decisions to shut down commerce after 9/11 as a precautionary action leading to "self-inflicted damage."

als less likely to make costly consumption decisions. But participants also questioned whether having that information could have unintended consequences; for example, having visible evidence of risks in the form of added policing might only serve to increase individuals' anxiety.

The discussion of precautionary behavior also provided another opportunity for participants to consider the difference between transfers and net welfare effects. If a terrorism security regulation merely reallocates costs, then it entails "only" a transfer.[10] To illustrate, consider a case involving commercial property and fences: Absent a regulation, tenants, fearing intrusions, might choose to install fences as a precautionary measure; if a security regulation then requires that landlords provide fences, meeting the same specification and with no change in efficiency, it would only shift the cost from tenants to landlords, who might still pass the costs back to tenants via higher rents.[11]

Discussions about responsive behavior were narrower in scope but drew attention to the possible importance of distinguishing between long- and short-run phenomena. One presentation (see Kousky in Appendix C) spoke to responsive behavior in the wake of Hurricane Katrina—e.g., Do people choose to rebuild or move out?[12]—that might generalize to other circumstances requiring similar decisions. In a later discussion, a participant noted that the relevance of responsive behavior might be limited to a small set of events, e.g., an attack with biological agents, where outcomes may depend strongly on the immediate actions of individuals and institutions, but that in those instances a clear understanding of that behavior could be crucial.

Discussions about adaptive behavior, like those of precautionary and responsive behavior, also suggested a need to understand the reactions of individuals and institutions, but, in this case, those of "intelligent adversaries." Adaptive behavior came to light as an important source of difficulty in anticipating regulatory-induced changes in risk. If, for example, a terrorist adapts to a regulatory action by altering his or her decision about the location or mode of attack, the action, through its effect on the terrorist's behavior, might also be altering the probability of specific events, hence, damages. The presentation by Hammitt (see Appendix C), pointed out that making it harder for a terrorist to use one access route would make another route relatively more attractive, thus creating a countervailing risk. In the case of WHTI, a terrorist arriving in the United States might opt for a different point of entry, e.g., one that is not an official border crossing.

Understanding the Consequences of Fear

Causing fear in a population to achieve some larger goal is often a core motivation of terrorism (Hoffman, 2006). To the extent that fear manifests itself as a consequence of either the threat or realization of a terrorist attack, participants touched on at least three different ways

[10] Though not addressed explicitly during the workshop, one could still argue for the desirability of a transfer, e.g., on the basis of distributional considerations.

[11] The authors drew this example from the workshop discussions, but with some adaptation to simplify. Similarly, if the government were to provide the same fences with equal efficiency, there would be no net welfare effect.

[12] Here, the discussion also touched on precautionary behavior insomuch as part of the rebuilding decision might involve choices about construction technologies—e.g., Are buildings being constructed to withstand stronger winds?—that relate to individuals' and institutions' experience of the event and concerns about future events.

that it might result in damages.[13] First, as addressed above, it could affect decisions people make about their "consumption," which could entail opportunity and other costs to them and society. Second, fear resulting from the threat or realization of terrorism could lead to mental health trauma, such as post-traumatic stress disorder, anxiety, or depression. Third, short of causing changes in behavior and mental trauma, fear might reduce a person's overall level of well-being, peace of mind, or happiness.

Reductions in each of these consequences could be considered among the benefits of terrorism security regulations and, thus, should be captured in an assessment of regulatory benefits. However, participants noted that these types of benefits, particularly those relating to mental health and happiness, are rarely incorporated in regulatory assessments. One participant indicated that it could be especially difficult to incorporate fear or anxiety in a benefits estimate because they are not necessarily proportional to the probability or likely magnitude of an attack; hence, they may not be scalable to a reduction in expected harm.[14]

Workshop discussions suggested that each of these areas, i.e., behavior, mental health, and happiness, presents an opportunity for basic research to improve the science underlying benefit-cost analysis and its implementation. Changes in consumption patterns could be captured, in theory, if the analysis includes indirect economic effects and models accurately reflect behavioral changes. Mental health trauma could be addressed as an injury or illness, but, while widely acknowledged, it has not been well measured in this context. The concept of happiness is attracting greater attention in the area of welfare economics but, in its formative stages, has not yet been addressed in this type of benefit-cost analysis.

Data Collection

Workshop presentations and surrounding discussions acknowledged the scarcity of data with which to assess the benefits of regulatory action, citing gaps in collection—both avoidable and unavoidable—and security considerations as reasons for the scarcity, but also discussed the extent to which data, per se, are truly a limiting factor.

Participants considered expert elicitation and natural experiments as a two possible means of gathering information and informing regulatory assessments.

Expert Elicitation

Most of the presentations referenced expert elicitation as a potentially valid and valuable source of data. However, the discussions during and after those presentations highlighted the importance of distinguishing between a process of true "expert elicitation" and a mere gathering of "expert opinion": The former involves empirically validated techniques designed to reliably collect unbiased estimates, whereas the latter sometimes involves unstructured queries without giving adequate attention to question framing or expert selection.

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[13] Studies of public reactions to terrorism have demonstrated how extensive the reactions of fear can be following terrorist attacks and how levels of fear experienced are driven by combination of geographic proximity, social connection, and media exposure (Fischhoff et al., 2003; Silver et al., 2002).

[14] Participants referenced Adler (2004), Sunstein (1997 and 2003), and Sunstein and Zeckhauser (2011) as sources of insight to conceptualizing, modeling, and measuring fear.

In discussing reliable expert elicitation, participants identified important limitations and productive uses. Although the participants framed expert elicitation as a plausible means of parameterizing uncertainty, they emphasized that expert elicitation cannot be used to "create data," absent underlying knowledge, or be expected to "eliminate uncertainty." Quoting one participant, "Some people may say 'we don't have the data . . . so let's go get some experts to create the data,'" but, said the participant, that will not work—"if the experts don't know, your eliciting isn't going to help." For that reason, the participant suggested the importance of using established criteria for elicitation at DHS, i.e., that it be used only when it is possible to posit an answerable question to a group of individuals that has some basis for making a judgment. For example, in the case of WHTI, it might have made sense to ask a counterfeiting expert about the ease of producing a passable false document, but it might not have made sense to ask him or her about the feasibility of developing better software to detect fraudulence.[15] Reliable expert elicitation might also be quite costly in terms of time and funding requirements.

Participants also voiced concerns about common misconceptions surrounding the interpretation and implications of probability estimates. A group of experts might, for example, conclude that the risk of an event—be it a terrorist attack, a financial crisis, or an oil spill—is less than 1 percent. The event might be deemed unlikely, but it cannot be ruled out. If the attack, crisis, or spill were to happen, one might be tempted to cite the event as evidence of the experts' fallibility, but the fact that it happened would not necessarily contradict the experts' view.

Notwithstanding these limitations and concerns, some participants argued for the value of expert elicitation in establishing the bounds of unknowing and, potentially, "closing the loop" in break-even analysis. Although calculating a break-even point does not require estimating the probability of a particular event, they noted that expert elicitation could be used to establish the likelihood of ending up above or below the break-even point.

The workshop also addressed the question of expertise, specifically the definition of *expert* and the related challenges of properly selecting individuals to serve on expert panels and appropriately valuing differences in their perspectives and judgments. Participants observed that there are methods for dealing with at least some of these issues, such as "seed questions" for calibrating results, and that making use of expert elicitation in the context of benefits assessment would require a clear understanding of those methods and of other "best practices," more generally.[16]

Natural Experiments

Participants raised the possibility of using natural experiments to gain insight to the benefits of terrorism security regulations.[17] Although the idea emerged from a discussion about fear, as the

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[15] Example added by authors for illustrative purposes.

[16] Participants recommended U.S. Environmental Protection Agency (August 2011) as a valuable resource for investigating best practices.

[17] Natural experiments or quasi-natural experiments in economics are serendipitous situations in which persons are assigned randomly to a treatment (or multiple treatments) and a control group, and outcomes are analyzed for the purposes of putting a hypothesis to a severe test; they are also serendipitous situations where assignment to treatment "approximates" randomized design or a well-controlled experiment. (DiNardo, 2008)

For the purposes of benefit-cost analysis, the regulatory action or change would fill the role of "treatment." If, for example, an airport security measure, such as a new passenger or baggage screening technology, is implemented as a pilot

discussion unfolded, it became apparent that the approach could shed light on a larger number of issues pertaining to regulatory effects and processes. One participant, noting the difficulty of quantifying fear, wondered whether it would be possible to roll out a regulation in a way that would create a natural experiment and support an "event analysis." Others indicated "yes," and pointed to pilot programs, interim final rules, and staggered or phased implementation, e.g., WHTI, as variations on the theme. They also noted important limitations; for example, pilot testing must occur in an environment that is representative of the larger policy environment. If a port security program is tested in ports that are very small or otherwise differ from ports of concern, a study of the pilot program might provide little insight to the ultimate effects of promulgation. The discussions suggested that such experiments might provide insight to other types of consequences and provide valuable information for both developing regulations and fine-tuning actions.

Cross-Cutting Themes

Issues of analytical capacity, transparency, and presentation also featured prominently in the discussions. These issues relate to modeling (qualitative or quantitative) and data collection.

Modeling Capacity

Discussions throughout the workshop suggested that an initial investment in a strong analytical base—that is, a set of broadly applicable descriptive and empirically based models—could pay off for CBP in more rigorous regulatory assessments in the future. However, it also became apparent during the presentations that opportunities exist to make use of current models, including some models already in use in DHS/RMA to support risk assessment. As noted above, it might have taken relatively little effort to apply the DHS/RMA models to the WHTI assessment, had the models been in place and operational at that time. An assessment of WHTI would have required only a handful of changes or additions to the upstream (pre-entry and entry) components of the models and little or no change to the downstream (post-entry) components. It might also be possible to extract welfare effects from CGE models, whether in-house or external.

Transparency in Analysis

Participants agreed on the need for better visibility in regulatory analysis and pointed to three sources of obscurity: concerns about security, reliance on proprietary models, and model complexity. Although legitimate security concerns and reliance on proprietary models might continue to thwart efforts to create a more open analytical process, it seemed plausible that more information could be revealed, with appropriate levels of care, and that it might be possible to reduce CBP's and other agencies' reliance on proprietary models in future assessments, perhaps by leveraging some of the DHS/RMA models cited above. An agency might be able to show an analysis when doing so would not reveal intelligence sources and methods, security vulnerabilities, or sensitive defense capabilities. Concerns about complexity pertained not just to proprietary models, but also to any publically available or in-house models. (DHS/RMA's

program, it might be possible to collect data on behavior (passenger, equipment operator, etc.) pre- and post-pilot and compare that change with that of a control group that did not participate in the pilot program.

risk assessment models require tens of thousands of inputs.) Participants argued for keeping things "simple," whenever simplicity will suffice, in future benefit-cost models. To the extent that the use of sensitive data, proprietary models, and complex models is unavoidable, one might still illuminate the process with more or better use of model verification, validation, and accreditation.

Presentation of Information and Results

Discussions indicated a commonly held view that single approaches, single numbers, and single answers would not suffice and could even mislead. One participant noted that "looking at the same information in different ways can help someone understand it better." Another spoke to the value of representing the results of benefit-cost and break-even analysis as complementary: For example, a positive net result in a benefit-cost analysis might reflect an underlying assessment that the probability of a particular type of attack is "X"; however, a break-even analysis might indicate that the probability could be as low as "Y" and the benefits would still exceed the costs. The comparison yields a range that the decisionmaker can wrestle with and say "I feel comfortable it's [the probability is] within that range. . . ."

SECTION 3

Points of Contention

Insomuch as the workshop yielded any points of contention, substantial differences were most apparent in participants' views on the sufficiency of economic tools, particularly those geared toward estimating effects, and the merits of using alternative decision criteria to address uncertainty.

Whereas some participants argued that available tools for estimating the consequences of terrorist events, including existing estimates of willingness to pay for a value of statistical life,[1] were good enough for capturing the big effects, others suggested that there were important "big gaps," especially with regard to measuring welfare effects and characterizing behavior—precautionary, adaptive, and responsive behavior. The disagreement was not as much about the facts of the matter—no one disputed the existence of gaps—but about their importance, i.e., whether the tools were already "good enough."

Participants also disagreed as to whether a departure from the usual benefit-cost analysis criteria, i.e., efficiency and cost-effectiveness, could lead to advances in regulatory analysis. Some participants suggested working with alternative decision criteria, such as "robustness," to address the challenges of extreme uncertainty; however, another pushed back, describing the use of alternative criteria as potentially "dangerous because it can be misunderstood as hiding assumptions." For example, if evaluating a terrorism security regulation for robustness, one might test whether it works well over a large share of scenarios, such as terrorist attacks that use different ports of entry or weapons.[2] However, in doing so, one would need to assume, at least implicitly, that the selected scenarios were, in fact, the likely scenarios. On that basis, one might find themselves assuming away a core problem, or even *the* core problem, faced by benefit-cost analysis: a fundamental lack of knowledge as to which scenarios are likely. Alternative decision criteria might be seen as skirting uncertainties around "changes in harms" or "probability." The participant urged explicit consideration of the magnitudes of both: "looking at just the probability is no good," "looking at just the consequences is no good," and "anything that tries to pretend you cannot look at the whole picture can be misleading."

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[1] The "value of statistical life" refers to the measurement—monetized value—of society's willingness to pay for a marginal reduction in the risk of premature death (OMB, 2003, p. 29; Viscusi and Aldy, 2003). Participants engaged in little discussion about the value of statistical life, but indicated general support for the approach and some interest in further exploring whether the value of statistical life might be different—specifically, higher—in the context of terrorism security regulations than in other policy contexts because of catastrophe aversion and dread. They were not certain whether the literature, to which some in the room had contributed, could weigh in definitively and were skeptical as to whether the difference would matter analytically. (For additional information, see, e.g., Robinson, 2008, Robinson et al., 2010, and Viscusi, 2009.)

[2] Examples added by authors for illustrative purposes.

SECTION 4

Recommendations

The foregoing distillation and synthesis of emerging ideas, recurring themes, and points of contention suggests several recommendations to assist CBP in meeting the challenges of improving the benefit-cost analysis of terrorism security regulations. Whether taken individually or in combination, none of these recommendations can address all of CBP's—and other such agencies'—methodological needs, but they can help to provide a stronger foundation for benefit-cost analysis in the future.

- **Aim for break-even work that is more descriptive**. Comprehensive or "full" benefit-cost analysis is likely neither attainable nor desirable, given the extent of uncertainty and related analytical challenges, but break-even analysis can be used to explore the implications of uncertainty and describe conditions under which benefits could exceed costs for particular regulations.
- **Incorporate "storytelling" into regulatory analysis and consider adopting logic modeling as part of the regulatory development process**. Logic models can be used to support benefit-cost analysis, break-even analysis, and regulatory development, more generally, by helping to identify and articulate plausible links between regulatory actions and outcomes.
- **Strengthen internal modeling capacity and leverage existing risk assessment methods, when possible, including DHS/RMA and CGE models.** A varied, multidisciplinary toolkit can be used to assess big effects and shed light on uncertainty. For example, CGE models can be used to calculate welfare effects; DHS/RMA's risk assessment models to estimate risk; and, as already noted, logic models to "tell the story" of a regulatory action and its effects.
- **Develop and adopt DHS-wide standards for reliable expert elicitation.** Learning more about best practices—to better understand the technique's strengths, weaknesses, and applicability to benefit-cost analysis—and establishing criteria based on those practices would help to ensure that expert elicitation throughout DHS produces reliable results.
- **Improve basic science in potentially important but under-explored areas of terrorism consequences, including behavioral responses, mental health, and fear.** Not only does fear have behavioral implications that can impact the probability or magnitude of effects, it may have direct bearing on an individual's mental health, well-being, and happiness.
- **Incorporate pilot studies and other natural experiments into regulatory design.** Regulatory rollouts that create natural experiments, e.g., through pilot programs, interim

final rules, or phased implementation, may yield data and enable analysis that provides insight to the effects of final rules.

- **Improve transparency.** It may be possible to improve the transparency of benefit-cost analysis, e.g., by sharing information when doing so would not jeopardize security and expanding verification and validation.

APPENDIX A

Workshop Participants

Jennifer Baxter	IEc
Tony Cheesebrough	DHS, RMA
Victoria A. Greenfield	RAND
James K. Hammitt	Harvard University and Toulouse School of Economics
David Houser	DHS, Office of the General Counsel
Carolyn Kousky	Resources for the Future
Tom LaTourrette	RAND
Seth Renkema	DHS, CBP, Economic Impact Analysis Branch, Regulations and Rulings, Office of International Trade
Lisa Robinson	Independent Consultant
Andrew Rollo	DHS, CBP, Economic Impact Analysis Branch, Regulations and Rulings, Office of International Trade
Elena Ryan	DHS, CBP, Economic Impact Analysis Branch, Regulations and Rulings, Office of International Trade
Scott Savitz	RAND
Charlotte Skey	DHS, Office of the General Counsel
Henry H. Willis	RAND
Ryan Wise	DHS, RMA
Jessica Yeats	RAND

APPENDIX B

Workshop Agenda

8:00–8:30 am	Registration and Continental Breakfast
8:30–8:45 am	Introduction and Format for Workshop *Moderator:* Tom LaTourrette (RAND)
8:45–9:30 am	Overview of Challenges Identified During the Development of Estimates of the Benefits of U.S. Customs and Border Protection Regulations *Presenter:* Jennifer Baxter (IEc)
9:30–10:30 am	Applying Modeling and Simulation to Estimate Risk Reduction Benefits for Regulatory Benefit-Cost Analysis *Presenter:* Tony Cheesebrough (DHS, RMA)
10:30–10:45 am	Coffee Break
10:45–11:45 am	Using Logic Models to Assess Security Benefits *Presenter:* Victoria A. Greenfield (RAND)
11:45–12:45 pm	Characterizing Benefits of Anti-Terrorism Rules *Presenter:* James K. Hammitt (Harvard University and Toulouse School of Economics)
12:45–1:30 pm	Lunch
1:30–2:30 pm	Improving Estimation of the Benefits of Terrorism Risk Reduction: Learning from Environmental Economists? *Presenter:* Carolyn Kousky (Resources for the Future)
2:30–3:30 pm	Summary and Discussion of Observations *Moderator:* Henry H. Willis (RAND)
3:30–3:45 pm	Coffee Break
3:45–5:00 pm	Summary and Discussion of Observations (cont.) *Moderator:* Henry H. Willis (RAND)

APPENDIX C

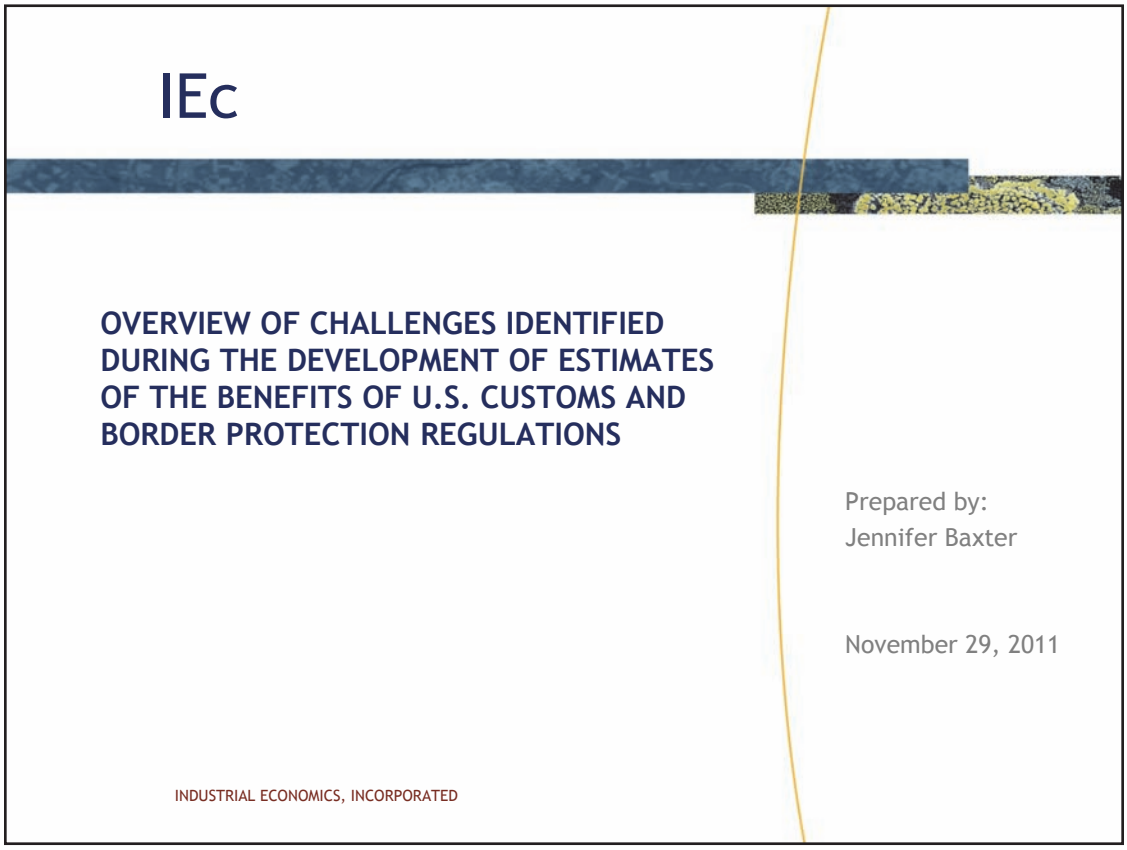
Invited Presentations from Workshop Participants

This appendix contains five presentations: the four invited presentations and an overview (see below). The presentations are organized in the order in which they were given during the workshop. They have not undergone peer review or formal editing. By and large, they appear here much as they appeared during the workshop, with only minor clarifications, typographical corrections, and formatting changes.

- Jennifer Baxter, "Overview of Challenges Identified During the Development of Estimates of the Benefits of U.S. Customs and Border Protection Regulations," IEc.
- Tony Cheesebrough and Ryan Wise, DHS/RMA, "Applying Modeling and Simulation to Estimate Risk Reduction Benefits for Regulatory Benefit-Cost Analysis," DHS/RMA.
- Victoria A. Greenfield, Henry H. Willis, and Tom LaTourrette, "Using Logic Models to Assess Security Benefits," RAND.
- James, K. Hammitt, "Characterizing Benefits of Anti-Terrorism Rules," Harvard University (Center for Risk Analysis) and Toulouse School of Economics (LERNA-INRA).
- Carolyn Kousky, "Improving Estimation of the Benefits of Terrorism Risk Reduction: Learning from Environmental Economists?" Resources for the Future.

Overview of Challenges Identified During the Development of Estimates of the Benefits of U.S. Customs and Border Protection Regulations

Presenter: Jennifer Baxter (IEc)



Background

- Congress passes laws governing the United States and authorizes U.S. Customs and Border Protection (CBP) to put those laws into effect by promulgating regulations.
- The amount of discretion available to CBP as it crafts regulations depends on the language of the specific law. For example:
  - **Intelligence Reform and Terrorism Prevention Act of 2004 (IRTPA):** Requires that the Secretary of Homeland Security, in consultation with the Secretary of State, develop and implement a plan to require travelers entering the United States to present a passport, other document, or combination of documents, that are "deemed by the Secretary of Homeland Security to be sufficient to denote identity and citizenship." (Section 7209)
  - **Maritime Transportation Security Act of 2002 (MTSA):** Requires that the Secretary of Homeland Security, in consultation with the Transportation Security Oversight Board, develop a program to evaluate and certify secure systems of international intermodal transportation, including "…developing performance standards to enhance the physical security of shipping containers, including standards for seals and locks" (Section 70116(b)(3))
  - **Security and Accountability for Every Port Act of 2006 (SAFE Port Act):** The Secretary of Homeland Security "shall require the electronic transmission to the Department of additional data elements for improved high-risk targeting, including appropriate elements of entry data…to be provided as advanced information with respect to cargo destined for importation into the United States prior to loading of such cargo on vessels at foreign ports." (Section 203(b)).

Why does CBP undertake benefit-cost analysis?

- In certain circumstances, Congress explicitly directs CBP to consider economic information as it promulgates regulations. For example:
  - In promulgating the Importer Security Filing and Additional Carrier Requirements (10+2) rule, the SAFE Port Act required CBP to "consider the cost, benefit, and feasibility" of the proposed action. (Section 203(c)(1)).
  - For the recent visa waiver program for Guam and the Commonwealth of the Northern Mariana Islands (CNMI), Congress required a "listing of any Country from which the Commonwealth has received a significant economic benefit from the number of visitors for pleasure within the one-year period preceding the date of enactment…unless the Secretary of Homeland Security determines that such country's inclusion on such list would represent a threat to the welfare, safety, or security of the United States or its territories… (Consolidated Natural Resources Act Section 702(b))
- Absent explicit direction from Congress, several other laws and executive orders compel consideration of economic information.
  - **Executive Order 12866** ***Regulatory Planning and Review*** (1993) directs federal agencies to "assess the costs and benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." (Section 1(b)(6))
  - **Executive Order 13563** ***Improving Regulation and Regulatory Review*** (2011) reaffirms the direction and principals provided in Executive order 12866.
  - The **Regulatory Flexibility Act of 1980 (RFA)**, as amended by the **Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA)**, requires federal agencies to consider the economic impacts of their regulations on small entities to minimize those impacts.
  - The **Unfunded Mandates Reform Act of 1995 (UMRA)** requires federal agencies to assess the economic effects of their regulations on state, local, and tribal governments and the private sector.

How is benefit-cost analysis used?

- A well-crafted benefit-cost analysis following best practices laid out in OMB's *Circular A-4* contributes to the regulatory development process in several ways:
  - **Consideration of regulatory alternatives:** OMB directs agencies to consider the benefits and costs of the proposed regulation and several alternatives. Depending on data availability, the economic analysis can identify efficient alternatives (net benefits are positive) and information about the cost-effectiveness of each option.
  - **Baseline definition:** Circular A-4 directs Agencies to clearly define the world without the regulation. This process and the collection of necessary data often highlight important attributes of affected environment that influence the development of the rule.
  - **Predicting responses to the regulation:** Economic information about preferences can highlight unanticipated positive and negative effects of the proposed regulation.
  - **OMB clearance:** If the economic analysis is insufficient, OMB may return the rule to CBP for further consideration, delaying or a proposed rule or forcing the Agency to start over.
  - **Protection against future litigation:** While citizen suits are not permitted under Executive Orders, Agencies can be sued for failing to comply with the RFA or UMRA. Furthermore, to the extent that the law necessitating the regulation requires economic analysis, citizen suits over the Agency's consideration of the best available economic information are possible.

Defining benefits

- OMB directs Agencies to measure regulatory benefits in welfare terms, i.e., estimates of how much individuals are willing to pay for the proposed improvement
  - Generally, it is difficult to obtain a single, holistic estimate of willingness to pay for a program or regulation
  - Economists often apply a damage function approach
- In the context of CBP's security regulations, application of either approach requires information about the baseline security risk and incremental changes in risk resulting from proposed regulation
- CBP lacks information quantifying the risk change resulting from its regulatory alternatives. In addition, if information about such risk changes were available, data on the value of these changes is subject to considerable uncertainty. As a result, benefit-cost analysis cannot play its traditional role in the development of CBP regulations.

Necessary risk information is limited

- Early attempts by CBP to estimate the risk reductions resulting from proposed regulations encountered several challenges:
  - Unlike natural disasters, the historical record on the frequency and severity of terrorist events in the United States is too small to provide a meaningful basis for projecting future risks.
  - The development of new risk models was difficult to implement in the typical timeframe for promulgating a regulation.
    - Baseline risk modeling efforts in other parts of DHS required the collection of a significant amount of new data and relied on expert-elicitation processes to estimate the probability of different threat-consequence scenarios.
    - Evaluation of the efficacy of different regulatory alternatives required new rounds of expert elicitation.
    - The models often relied on classified information that could not be included in the publicly-available administrative record supporting new regulations.
- Furthermore, interest in investing the time and effort in detailed benefit-cost analysis was limited as there was a general sense that any rule potentially preventing another 9/11 attack as "worth it," regardless of the regulatory costs.

The near-term solution…break-even analysis

- In 2005, faced with increased scrutiny from OMB regarding the potential costs and benefits of proposed security regulations, CBP began using break-even analysis.
- According to OMB,

  > It will not always be possible to express in monetary units all of the important benefits and costs.…If the non-quantified benefits and costs are likely to be important, you should carry out a "threshold" analysis to evaluate their significance. Threshold or "break-even" analysis answers the question, "How small could the value of the non-quantified benefits be (or how large would the value of the non-quantified costs need to be) before the rule would yield zero net benefits?" (Circular A-4, p. 2)

- CBP has implemented two different approaches to break-even analysis of security regulations:
  - A scenario-based approach that estimates the necessary reduction in the probability of a specific type of terrorist attack; and
  - A broad-based approach that relies on estimates of total baseline terrorism risk in the U.S. and estimates the necessary percentage reduction in that baseline risk

Limitations of scenario-based break-even analysis

- Scenarios selected for comparison must reflect the types of events likely to be affected by the regulation
  - Requires understanding of plausible linkages between the proposed action (e.g., requiring individuals to show a valid passport to enter the United States) and the types of events likely to be attempted absent the regulation (e.g., detonation of a bomb on a train or airplane).
  - For regulations aimed at keeping harmful people or weapons out of the U.S., it may be difficult to capture the full range of plausible events.
- Requires the valuation of the "avoided costs" of terrorist events. Data necessary to monetize these costs may be limited or require integration into more sophisticated models to estimate welfare losses.
  - Much of the economic research published to date on terrorist events focuses on the regional economic impacts of such events, rather than the change in welfare experienced by the U.S. as a whole. Additional analysis of market data in these studies to estimate welfare losses is possible but often requires coordination with the original authors of the studies and additional information about behavioral response to market changes. Where such effort is not feasible, we often extract from these studies only the elements of the damage estimates that we can be certain represent losses to society (rather than transfers), such as casualty counts and property damage. As a result, estimates of avoided costs may omit key cost categories (e.g., the opportunity cost of business interruption).
  - Methods for valuing avoided fatalities and nonfatal injuries exist; however, DHS decision-makers question whether benefits transfer of willingness to pay to avoid fatalities associated with more familiar risks (e.g., workplace fatalities) understates the benefits of security regulations. They generally believe that individual willingness to pay to reduce terrorism-caused fatalities or injuries is likely to be larger than the values for other types of risk reductions; however, the existing literature does not necessarily confirm this belief.
  - Even if total avoided costs can be estimated, such an ex-poste approach to valuation may understate willingness to pay to avoid the event.

Limitations of scenario-based break-even analysis (continued)

- The results of the break-even analysis are difficult to interpret.
  - The baseline probability of the subject attack is unknown. As a result, it can be difficult to evaluate whether the critical change in risk, e.g., the need to avoid one event every 10 years, is feasible given the existing threat.
- The approach focuses on reductions in the number of successful attacks, rather than the potential for the proposed rule to reduce the severity of the consequences of an attack. For example, a proposed rule limiting the number of terrorist who are able to enter the United States may not only reduce the likelihood of an event; it may also force terrorist groups to focus on smaller-scale events requiring less manpower.
- The simplicity of the model does not allow analysts to evaluate reductions in the probability of multiple types of attacks simultaneously. Given the generally broad nature of CBP's regulations, it is unlikely that a proposed regulation affects a only one attack/consequence scenario.
- This simplistic approach does not account for target-shifting. That is, although the risk of one type of event may decrease, terrorists may shift focus to another type of event, resulting in an offsetting increase in risk.

Limitations of break-even analysis relying on broad estimates of baseline terrorism risk

- This approach is more appealing because it addresses several key failings of the previous, scenario-based approach.
  - Assuming the model of terrorism risk is robust, regulators have a baseline against which they can evaluate the feasibility of the required risk reduction.
  - It implicitly allows for the consideration of multiple attack/consequence scenarios simultaneously.
  - By focusing on the break-even "risk" reduction as opposed to changes in the probability of events, it captures potential changes in both probability and consequences.
- However, it is also subject to several limitations, including:
  - The models are expensive to build and maintain, and often contain proprietary or classified information. As a result, they may not be appropriate for a rulemaking process that requires transparency and public disclosure of information.
  - Existing models may not include a complete accounting of terrorism risk. For example, the model used in the Western Hemisphere Travel Initiative (WHTI) analysis was developed for the insurance industry, and therefore only includes people or assets that are insurable. The model omits the value of at-risk resources not subject to insurance (e.g., government property, uninsured individuals).
  - The models may value the consequences of terrorist attacks in ways that are inconsistent with welfare economic theory or current best practices applied by CBP. It may be difficult to update values assumptions for use in regulatory analysis.

Concluding thoughts about break-even analysis

- Both break-even approaches previously employed by CBP suffer from two basic flaws:
  - They cannot provide information about whether the proposed rule is economically efficient.
  - They do not allow for meaningful comparison of regulatory alternatives where the costs of the alternatives are similar.
- Break-even analysis is most useful in two situations:
  - Highlighting extreme cases, i.e., regulations where the costs are so large relative to the resources at risk that net positive benefits are unlikely.
  - Providing additional information related to the size of the "gap" between quantified costs and non-risk related benefits, such as quantifiable time savings.
- Application of the scenario-based approach may have some use in addressing OMB's direction to describe the link between the proposed action and desired outcome, as this information is necessary to justify the selection of consequence scenarios.

Ancillary Benefits

- For rules where analysts are unable to monetize or even quantify intended benefits, Agencies may have incentive to work harder to identify, quantify, and/or monetize ancillary benefits.
- OMB states that consideration of ancillary benefits is appropriate.
  - Analysts should "Identify the expected undesirable side effects and ancillary benefits of the proposed regulatory action and the alternatives. These should be added to the direct benefits and costs as appropriate." (*Circular A-4*, p. 3)
- Monetization of ancillary benefits could be incorporated into break-even analysis, reducing the required risk reductions.
- Decision-makers should carefully consider the appropriateness of justifying a proposed rule based solely on ancillary benefits, particularly where quantification of these benefits is subject to significant uncertainty and/or these benefits deviate substantially from the purpose and intent of the subject law or the Agency's mission.

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Applying Modeling and Simulation to Estimate Risk Reduction Benefits for Regulatory Benefit-Cost Analysis

Presenter: Tony Cheesebrough (DHS, RMA)
Authors: Tony Cheesebrough and Ryan Wise (DHS, RMA)

2011-11-29

Applying Modeling and Simulation to Estimate Risk Reduction Benefits for Regulatory Benefit-Cost Analysis

Homeland Security

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Outline

1. Overview of the Office of Risk Managements and Analysis (RMA)
2. Quantitative definition of risk
3. Visualizing model structure as an event tree
4. Examples
   A. Baseline event risk prior to implementing the Western Hemisphere Travel Initiative (WHTI)
   B. Event risk following WHTI
   C. Estimating deterrence and countervailing risks
5. Algebraic functional form
6. Model inputs
   A. Expert elicitation of event probabilities
   B. Program effectiveness judgment inputs
7. Application to regulatory benefit-cost analysis
   A. Comparing benefits to costs
   B. Sensitivity and uncertainty analysis
   C. Simple results presentation
8. Strengths, assumptions, and limitations
9. Scale, pace, and computational requirements

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SAFER COMMUNITIES. 2

RMA Overview

- Founded in April 2007 as part of the National Protection and Programs Directorate to enable and advance the effective management of risk by the homeland security enterprise
- 39 Full Time Equivalents (FTEs)
- Variety of skill sets
  - Economics and operations research
  - Quantitative policy analysis
  - Engineering and physical sciences
  - Business and public administration
  - Computer science and information systems
- Located near Gallery Place/ Chinatown

"We must apply a **risk-based framework** across all homeland security efforts in order to identify and assess potential hazards…determine what levels of relative risk are acceptable, and prioritize and allocate resources among all homeland security partners." (*National Homeland Security Strategy)*

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Quantitative definition of risk

- In analyzing risk we are attempting to envision how the future will turn out if we undertake a certain course of action (or inaction).
- Fundamentally, risk analysis consists of an answer to the following three questions (Kaplan and Garrick, 1981):
  - What can happen? (i.e., What can go wrong?)
  - How likely is it to happen?
  - If it does happen, what are the consequences?

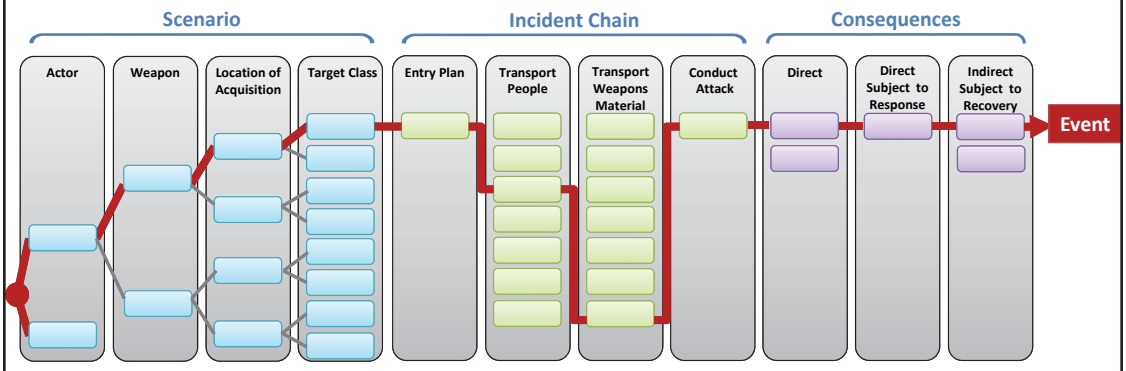
Modeling and simulation to estimate risk

- Models are simplified representations of reality and can take many forms: physical, conceptual, mathematical, etc.
  - More formally, models are approximations, representations, or idealizations of selected aspects of the structure, behavior, operation, or other characteristics of a real-world process, concept, or system.
- In simplified terms, we model risk as sets of triplets that answer the three risk questions:

$$<e_i, p_i, c_i>$$

  - where e_i is an event identification or description;
  - p_i is the probability of that event; and
  - c_i is the consequence or evaluation measure of that event, i.e., the measure of damage.
- Simulations are models that behave or operate like a given process, concept, or system when provided a set of controlled inputs.
  - In technical terms, we implement our risk models as stochastic, discrete event simulations using Monte Carlo computational algorithms that rely on repeated random sampling to compute results.

Visualizing model structure as an event tree



RAPID

- 1051 Scenarios
- 311 Incident Chains
- 50,075 Unique Events

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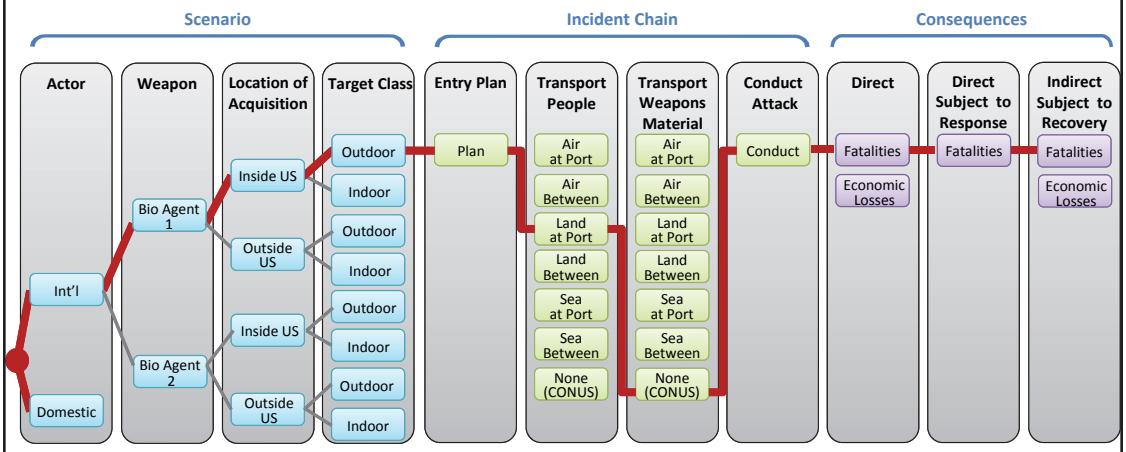
Example: baseline event risk prior to WHTI



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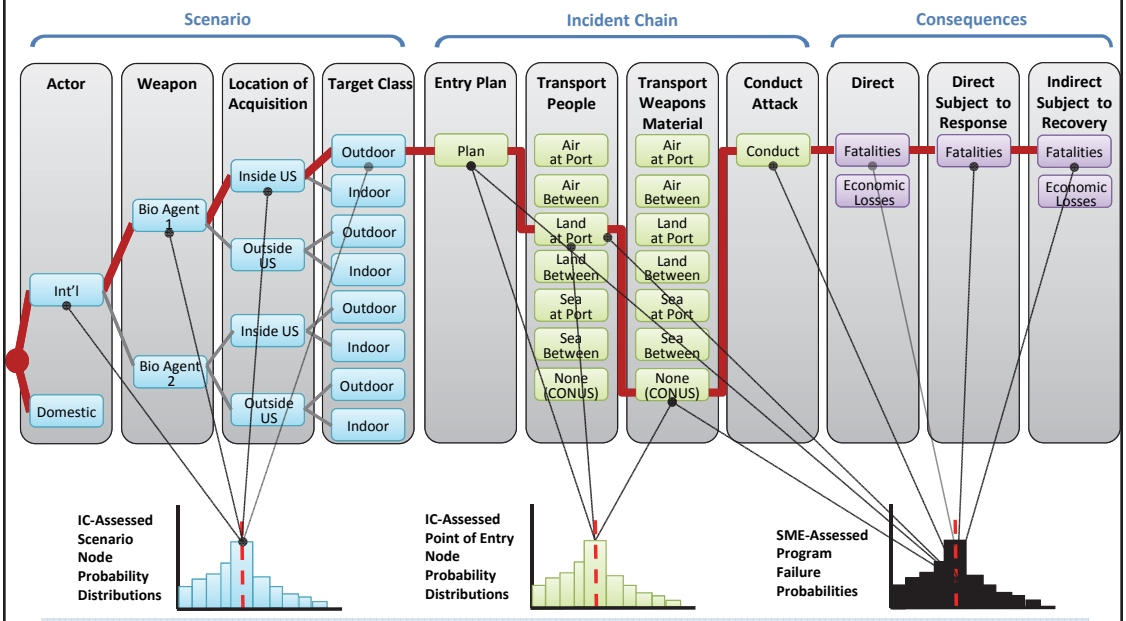
Example: baseline event risk prior to WHTI, (continued)



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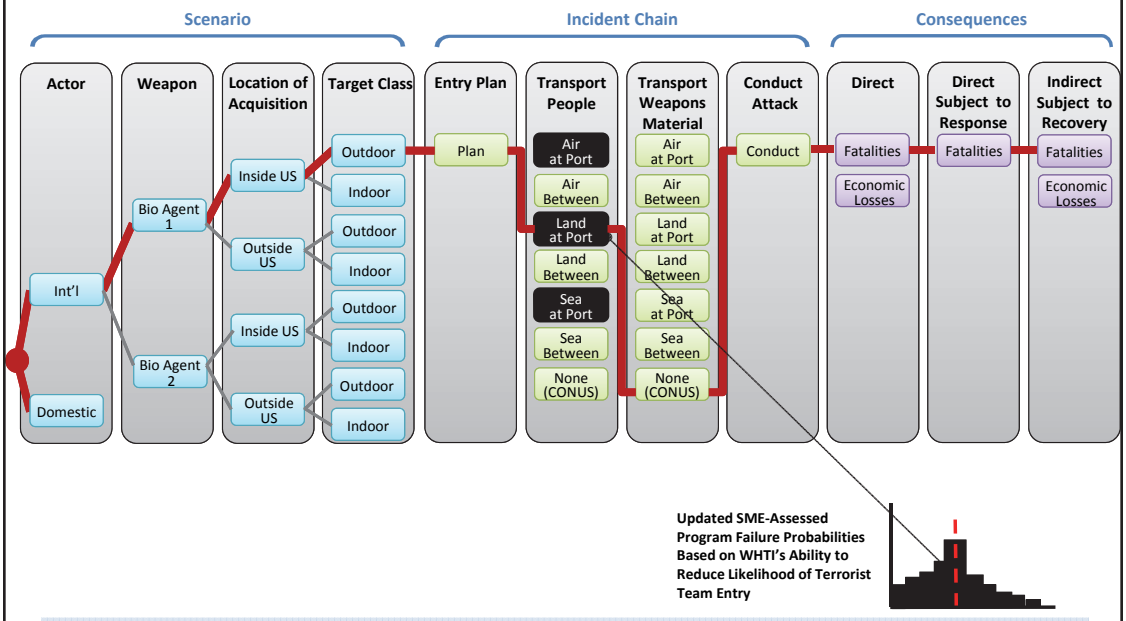
Example: event risk following WHTI implementation



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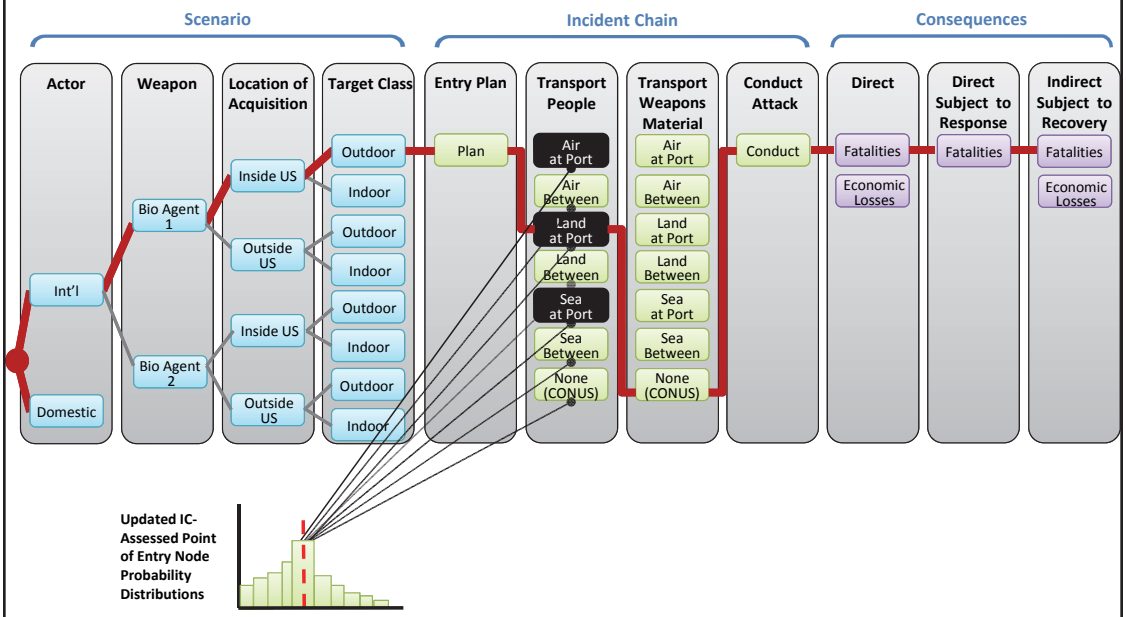
Example: estimating deterrence and countervailing risks



Functional form parameters

Risk per event = Frequency x Branch Probability x Consequences

Frequency

- Probability distribution for Incident Set annualized frequency of initiation (λ_j)

Probability Information

- Modeled relative probability of Event (P_e)
  - Combination of Scenario and Incident Chain Probabilities

Program Information

- Probability that a DHS program fails to mitigate a step in an Incident Chain (Pf_{IC})
- Probability that a DHS program fails to mitigate a specific consequence (Pf_c)

Economic Consequences

- Immediate economic impact (C_{E_1})
- Economic impact subject to recovery (C_{E_2})

Human Consequences

- Immediate fatalities (C_{H_1})
- Fatalities subject to response (C_{H_2})
- Fatalities subject to recovery (C_{H_3})

Color Code Key

- Blue = probability information
- Green = program effectiveness information
- Purple = consequence information

Risk reduction functional form for single program and event

- Reduced risk is the difference in risk associated with programs.
- Risk reduction for a given program *k* for any event *e* within an incident set *j* is the product of event *e*'s probability and consequences, when all programs (except *k*) are accounted for.

Human risk reduction per year for program *k* acting on event *e* within incident set *j*

$$R_{H_e}^{\text{Program k}} = \left(\lambda_j \times P_{e_j}\right) \times \left[\left(\prod_{i=1}^{m} Pf_{IC\,i} \right) \times \left[C_{H_1} + \left(Pf_{H_2} \times C_{H_2} \right) + \left(Pf_{H_3} \times C_{H_3} \right) \right] - \left(\prod_{i=1}^{m} Pf_{IC_i,k} \right) \times \left[C_{H_1} + \left(Pf_{H_2,k} \times C_{H_2} \right) + \left(Pf_{H_3,k} \times C_{H_3} \right) \right] \right]$$

Economic risk reduction per year for program *k* acting on event *e* within incident set *j*

$$R_{E_e}^{\text{Program k}} = \left(\lambda_j \times P_{e_j}\right) \times \left[\left(\prod_{i=1}^{m} Pf_{IC\,i} \right) \times \left[C_{E_1} + \left(Pf_{E_2} \times C_{E_2} \right) \right] - \left(\prod_{i=1}^{m} Pf_{IC_i,k} \right) \times \left[C_{E_1} + \left(Pf_{E_2,k} \times C_{E_2} \right) \right] \right]$$

Model inputs

What can go wrong?

- Scenarios identify threats of concern by attack method, weapon type, and target classes for specific types of nuclear, radiological, biological, chemical, and explosive terrorist attacks.
- Incident chains with mutually exclusive options are also identified (e.g., mode and point of entry).

If it does happen, what are the consequences?

- Fatalities are estimated using models such as Hazard Prediction and Assessment Capability (HPAC), a physics-based DOD model that estimates deaths based on exposure to toxic material dispersal in terms of blast radii (for nuclear) or plume size (in the case of CRN).
- Economic consequences are modeled in terms of:
  - Direct impacts, which are changes in the output of industries immediately affected by the attack, including industries that provide remediation activities and industries that experience reduced business volume due to public avoidance of the target area;
  - Indirect impacts, or changes in output of industries that sell goods and services to an industry directly affected by the attack; and
  - Induced impacts, or changes in output of all industries caused by changes in household income.

How likely is it to happen?

- Historical data on terrorism is sparse (fortunately); therefore, subject matter experts in the intelligence community are elicited for judgments on scenario and incident chain probabilities.
- Programmatic SMEs are elicited for judgments on the effectiveness of countermeasures.

Expert judgment in risk analysis

- Judgments are necessarily used in the study of any complex technical problem, and throughout any analysis, expert judgment is essential.
  - For example, judgments are made in the selection of models and analysis forms.
  - Data sources need to be identified and their use has to be assessed. If judged useful, data have to be collected and interpreted.
- While expert judgment is always used, this use has often been informal, implicit and undocumented.
- Verbal or qualitative judgments lack a common basis for interpretation and comparison, while making judgments quantitative allows them to be combined with other sources of information and to be manipulated in models.
- Quantification does not mean certainty; rather, quantification allows experts to more clearly indicate how uncertain they are about an issue or topic, making it *harder* for others to misconstrue or misuse results of an assessment.
  - Capturing uncertainty is critical, and processes have been designed to do so in a consistent and appropriate manner, eliciting distributions or ranges, not only averages.
  - Central values or point estimates are never reported on their own – uncertainty is always characterized.

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History and current use of expert elicitation for rare events

- WASH-1400 – 1975: one of the first demonstration of probabilistic risk assessment as a method for tackling the probability estimation problem for low-frequency events.
- Assessed accident risk for nuclear power plants (probability of complete core meltdown assessed at 1 in 20,000 per reactor per year).
- NUREG-1150 – 1991: updated PRA approach based on Three-Mile Island, and improvements in risk assessment research.
- New NRC assessment: will include effect of emergency preparedness and other mitigating factors.

Organizations currently using elicitation-based risk analysis

- Nuclear Regulatory Commission
- Department of Energy
- Environmental Protection Agency
- Department of Defense
- NASA
  - 1967 Apollo flight loss – spawned one of the earliest comprehensive studies
  - 1969 Goal: Probability of loss of life < 1% (space shuttle task group)
  - 1983 probabilistic risk analysis of shuttle flights: NASA administrators quickly abandoned PRA, but later events proved accuracy of analysis
- Intelligence Community
- DHS: Terrorism Risk Analysis

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Expert elicitation of event probabilities

- Due to the paucity of usable terrorism data, the lack of justifiable statistical methods for forecasting threat, and the practical challenges of conducting experimentally-designed security evaluations, alternative means must be used to estimate the probability of terrorism scenarios and the effectiveness of homeland security programs.
- *Statistics, as a subject, is the…science of handling data. On the other hand probability, as a subject, we might say is the science of handling the lack of data. Thus, one often hears people say that we cannot use probability because we have insufficient data…[but] we see that this is a misunderstanding. When one has insufficient data, there is nothing else one can do but use probability*. (Kaplan and Garrick, 1981)

Elicitation Protocol: NUREG 1150

Elicitation approach is based on Bayesian theory of probability and on decision analytic models and techniques for eliciting and using expert judgments. The overall process for eliciting expert judgments consists of the following steps:

1) Identification and selection of the experts;
2) Training in probability judgments;
3) Presentation and discussion of the uncertain events and quantities;
4) Analysis and data collection;
5) Presentation and discussion of the results of step 4;
6) Elicitation;
7) Analysis, aggregation, and documentation.

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Expert elicitation tool

- RMA has a DHS internally developed tool based in Excel + R for expert elicitation of Dirichlet distributions.
- Other tools could be used (e.g., Crystal Ball, @Risk, Excalibur).
- The key for any of these tools is to:
  - capture expert rationale used in making judgments; and
  - characterize uncertainty as probability distributions.

Notional Data

What is the estimated relative frequency with which an **Internaitonal Terrorist Group** would select each of the four agents being considered?

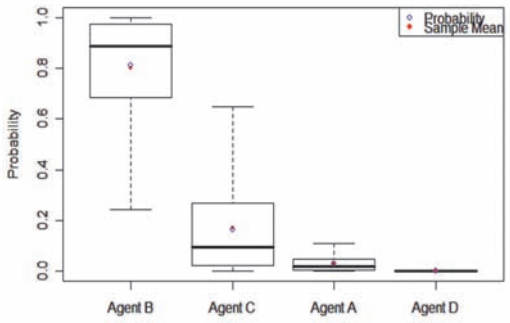
Agent / Material	Rank, High to Low (1=Highest)	Relative to most likely (most likely = 1)	Inverse Ratios	Probability
Chemical Agent B	1	1	1	**81.07%**
Chemcial Agent C	2	5	0.2	**16.21%**
Chemical Agent A	3	30	0.03333	**2.70%**
Chemical Agent D	4	10000	0.0001	**0.01%**
		Sum of Inverse Ratios	1.23	

K Estimation	
Most Likely Probabilty	0.8107
5th Percentile	0.2
95th Percentile	0.9
Range Calculation	3
Upper Calculation	39
Lower Calculation	1

Key Details to Keep in Mind

Only consider terrorism attacks on the U.S. Homeland (not U.S. interests abroad).
Time frame of interest is 2010-2012.

Comment(s)	Excel Cell(s)
Expert has a lot of experience with Chemical Agent B.	



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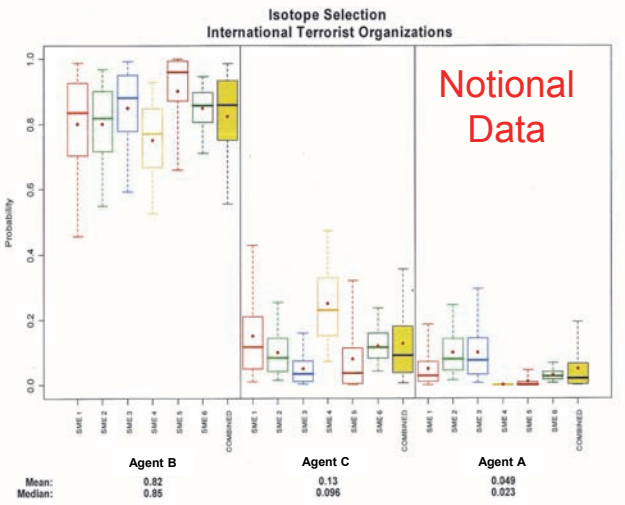
Reviewing results with experts

- The Excel + R Tool also permits showing all the elicited data to experts:
  - By individual (each expert's Dirichlet distribution shown as an individual box plot);
  - And as aggregated (yellow box plot summarizing a mixture distribution).
- The discussion of results and aggregation should let experts remain anonymous in the review process.



Notional output from an expert elicitation on probability of an agent being selected for use in an attack

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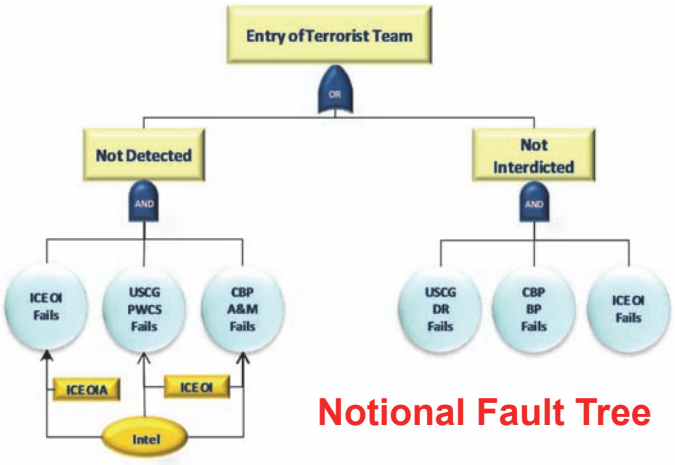
Program effectiveness judgment inputs

- Fault Trees map DHS programs and non-DHS programs to specific events in order to estimate event failure probabilities: in the example to the right, this is the probability that the programs in blue will fail to stop the entry of a terrorist team.
- Fault trees quantify program impacts on event likelihood by modeling how programs can act individually and in concert to manage risk.
- Subject matter experts are elicited for their judgments of how well each program performs its designated role(s), such as detection and interdiction.



Notional Fault Tree

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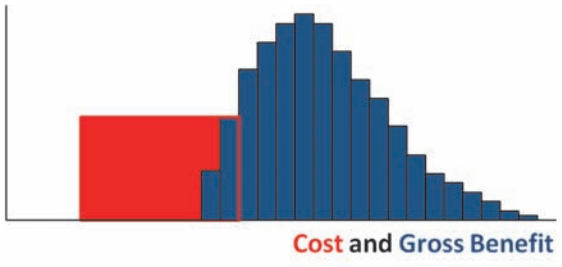
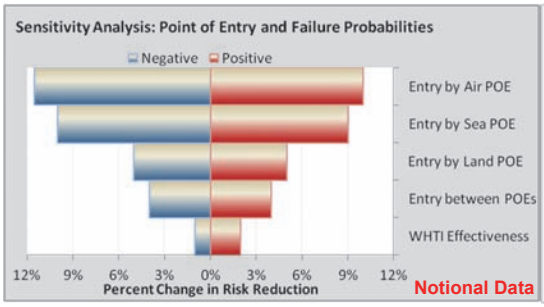
Comparing benefits to costs

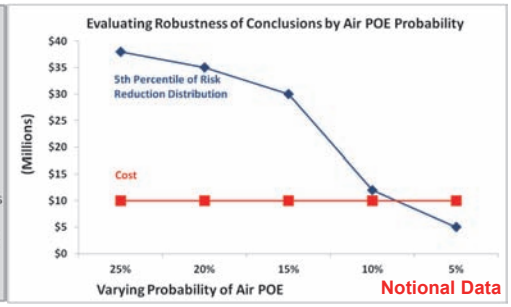
- Accounting for uncertainty, modeling and simulation allows for the estimation of distributions for baseline risk and reduced risk and thus gross benefit.
- Even if the regulation is cost-beneficial at the mean, the left-hand tail of the distribution of gross benefits may overlap with the distribution of costs.
- Thus we evaluate the chance that WHTI is not cost-beneficial by computing the probability that gross risk reduction benefits are greater than or equal to costs, or the probability that net risk reduction benefits are greater than or equal to zero.



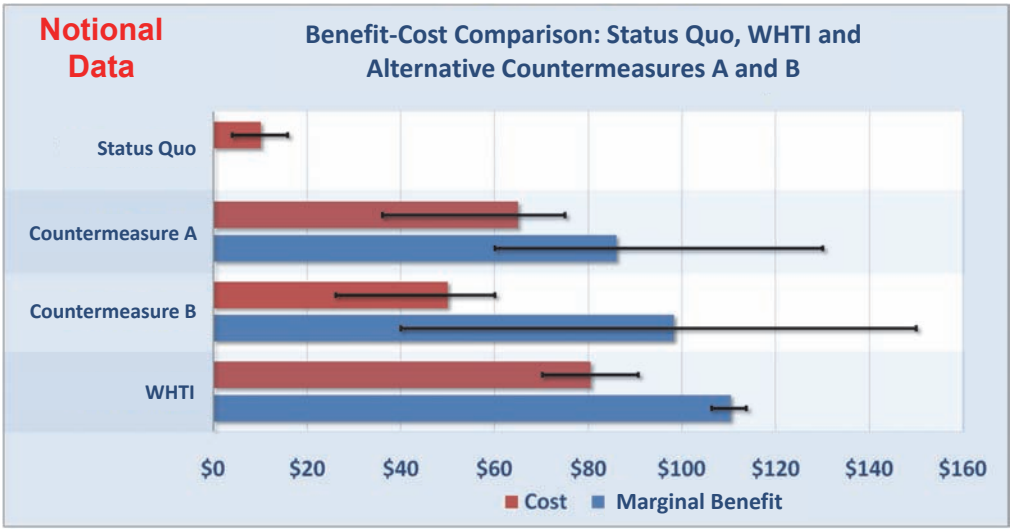
Sensitivity and uncertainty analysis

- In prescribing "Key Elements of a Regulatory Analysis," OMB Circular A-4 states that a good analysis provides the results of formal sensitivity and other uncertainty analyses.
- Modeling and simulation of quantitative risk analysis allows for the formal inclusion of both:
  - Sensitivity analysis: the computation of the effect of changes in input values or assumption on the outputs.
  - Uncertainty analysis: the computation of the total uncertainty induced in the output by quantified uncertainty in the inputs and models.
- Failure to perform systematic sensitivity and uncertainty analysis leaves both analysts and decision makers unable to judge the adequacy of the analysis, and the conclusions reached.





Simple results presentation



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Strengths, assumptions, and limitations

- Strengths
  - Relies on expert-assessed probabilities and consequences rather than lay people's perceptions of risk (as distinct from public valuations).
  - Quantitatively characterizes all input and output uncertainties to allow for sensitivity and other uncertainty analyses.
  - Is flexible enough to support relatively granular or general scenarios for subject matter experts to think about when providing probabilistic estimates of events, program effectiveness, and consequence.
- Assumptions and limitations
  - Though public valuation of fatality risk can be incorporated via a willingness-to-pay-based value-of-statistical life, economic risk is not as readily valued.
  - Since elicited probabilities are assumed to reflect terrorist preferences until updated, this approach assumes that a static, point-in-time assessment of current risk is adequate for long-term rule-making; this is also true of alternative game-theoretic approaches.
  - Though OMB's Final Information Quality Bulletin for Peer Review allows for national security exemptions, use of classified intelligence judgments as inputs limits transparency and may also limit the ability to present some aggregated results publicly.
  - Eliciting effectiveness from programmatic SMEs may yield the most detailed insights from those most familiar with unique operational roles, but doing so creates a principal-agent problem and presents a degree of moral hazard with asymmetric information.

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Scale, pace, and computational requirements

Scale and pace

- All baseline CBRNE terrorism event consequences and probabilities for scenarios, incident chains, and program failure have already been assessed as part of DHS BTRA, CTRA, RNTRA, ITRA, and RAPID risk assessments.
- Only 3 WHTI program failure probability distributions and 7 countervailing risk POE distributions would need to be elicited.
- At this reduced scope, elicitation protocol would require approximately 4 to 12 hours of intelligence analysts' time and 8 to 24 hours of program SMEs' time.

WHTI-specific computational requirements

- Software capable of Monte Carlo simulations over probability distributions (e.g., Matlab, Crystal Ball);
- Software and programs for statistical analysis and visualization of simulation results (e.g., Excel, R, Matlab); and
- Database software (e.g., Excel, Access, or SQL).
- Note: risk analysis for existing CBRNE events required specialized models for estimating the human and economic effects of various terrorism attacks, as well as software and programs for modeling induced and indirect economic effects (e.g., IMPLAN for I/O modeling, GAMS for CGE modeling).

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Thank You.

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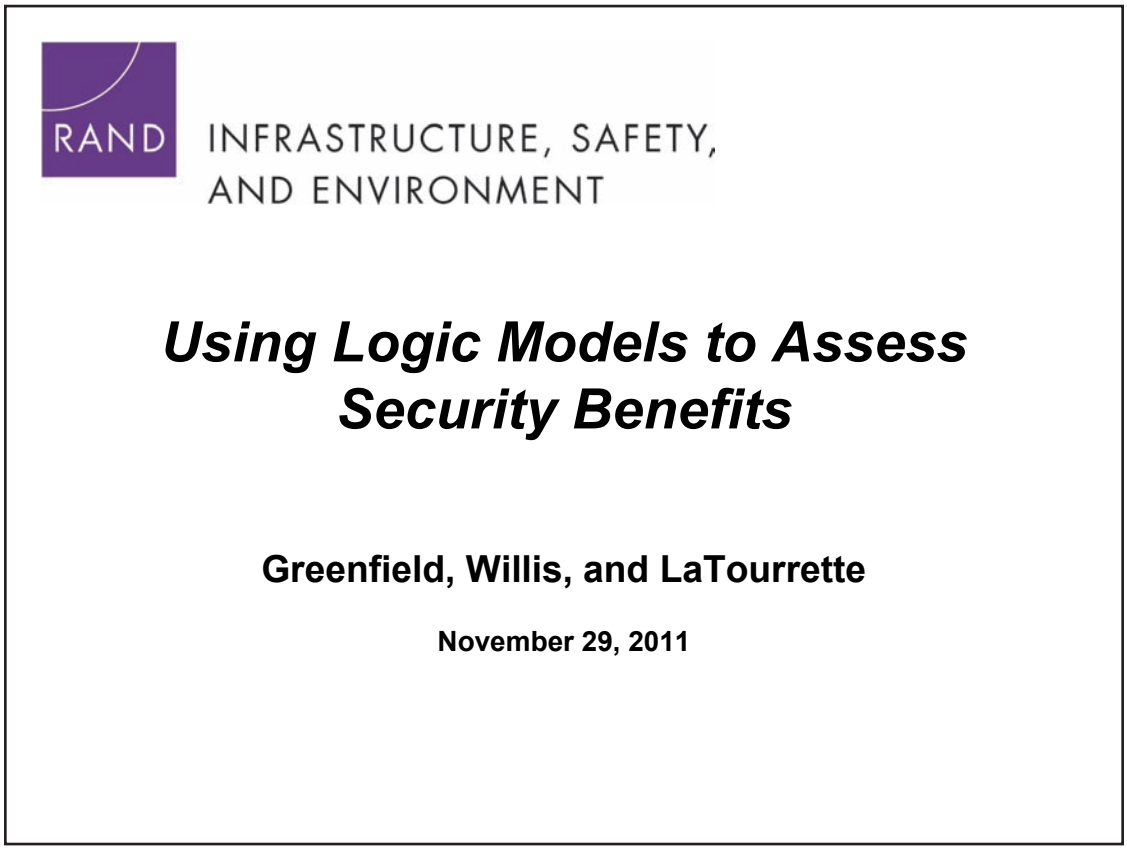
Using Logic Models to Assess Security Benefits

Presenter: Victoria A. Greenfield (RAND)
Authors: Victoria A. Greenfield, Henry H. Willis, and Tom LaTourette (RAND)



Project Origins and Approach

- **CBP seeking to develop methods to assess security benefits of proposed rules**
- **RAND approach uses logic model to estimate benefits qualitatively and, as far as possible, quantitatively**
  - **Builds on available information about program operations, strategy, and responsibilities**
  - **Does not result in point estimate**

RAND 2

Outline

➢**Describe Role of Logic Model**

- **Develop Illustrative Logic Model for Processing Information and Controlling Entry**
- **Demonstrate Application to WHTI**
- **Discuss Conclusions**

RAND 3

OMB Circular A-4 Provides Guidance for Assessing Benefits of Rules*

- **Favors quantification, especially monetization**
- **Allows other approaches if quantification is too difficult or could be misleading**

  "When important benefits and costs cannot be expressed in monetary units, BCA [benefit-cost analysis] is less useful, and it can even be misleading…." (p. 10)

- **Outlines key elements of regulatory analysis (pp. 2-3)**
  - **Explain links between rules, actions, and expected benefits**
  - **Identify "no action" or "next best" baseline**
  - **Identify expected undesirable side effects and ancillary benefits**

*See OMB, *Circular A-4*, "Subject: Regulatory Analysis," September 17, 2003

RAND 4

*Logic Model Can Be Used to Link Rules, Actions, and Benefits**

- **Articulating CBP's "program story"—what, why, and who—as foundation for analytical assessment**
- **Identifying ways in which proposed regulation, e.g., WHTI, would affect program story**
- **Assessing regulatory-induced changes in *capabilities* and *outcomes* in terms of program story**

*Logic models can also be used to specify performance objectives per E.O. 13563; for additional information on potential uses, see, e.g., Greenfield, V.A., V. Williams, and E. Eiseman, *Using Logic Models for Strategic Planning and Evaluation, Application to the National Center for Injury Prevention and Control*, TR-370-NCIPC, RAND, 2006

RAND 5

Articulating CBP's Program Story

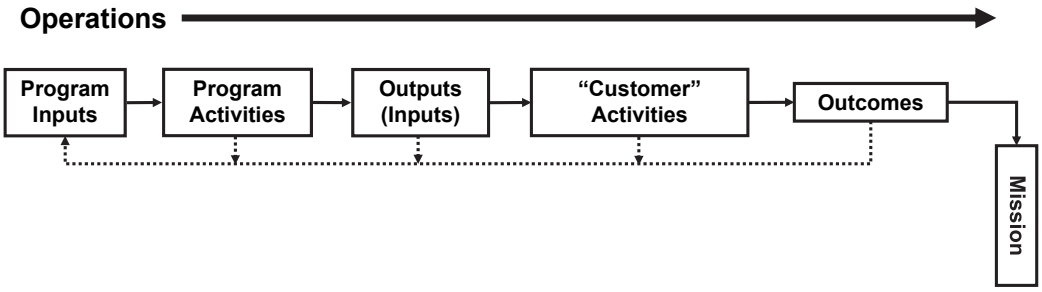
- **Describe operations**
  - ***What* are you doing?**
- **Describe strategy**
  - ***Why* are you doing it?**

Map operations to strategy
Do the pieces—what and why—fit together?

- **Delineate responsibilities and boundaries**
  - ***Who* are "you"?**
  - **What external factors affect your performance?**
  - **What are the ancillary benefits of your program?**
  - **What are the potential side effects of your program?**
  - **How do you gauge progress?**

RAND 6

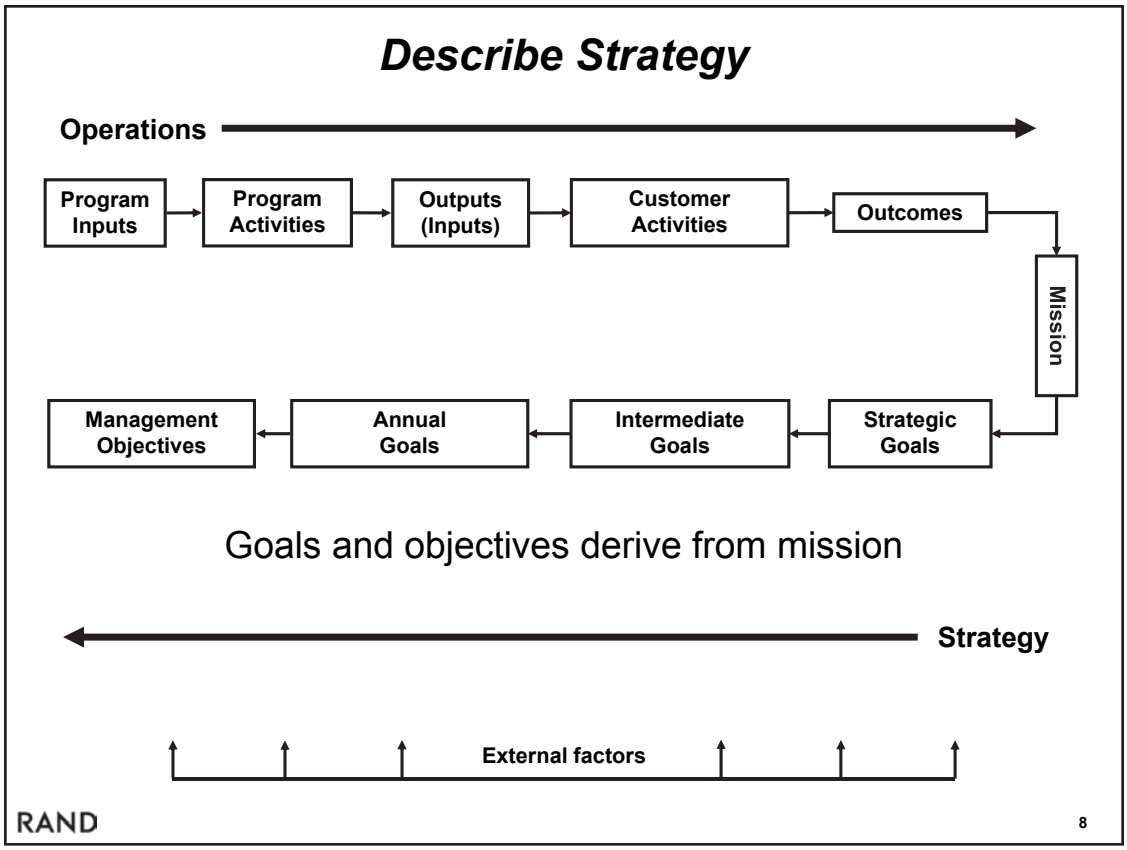
Describe Operations

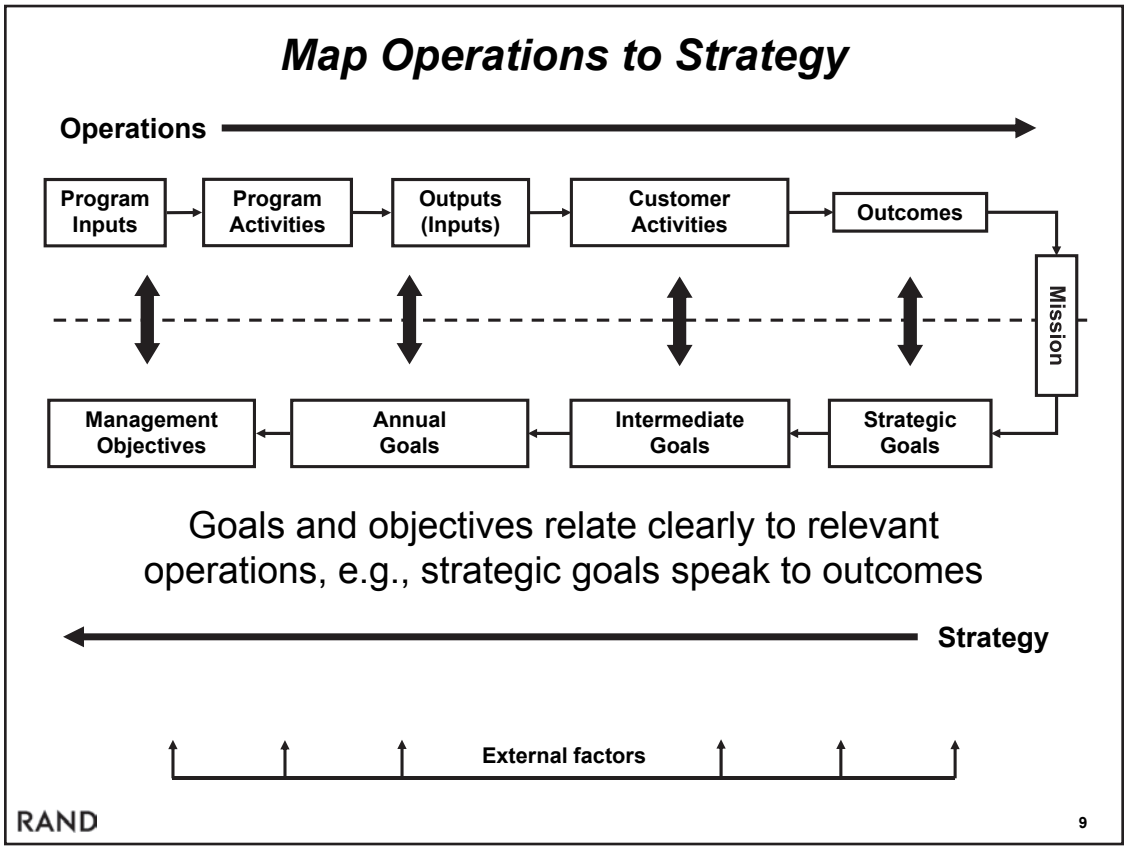


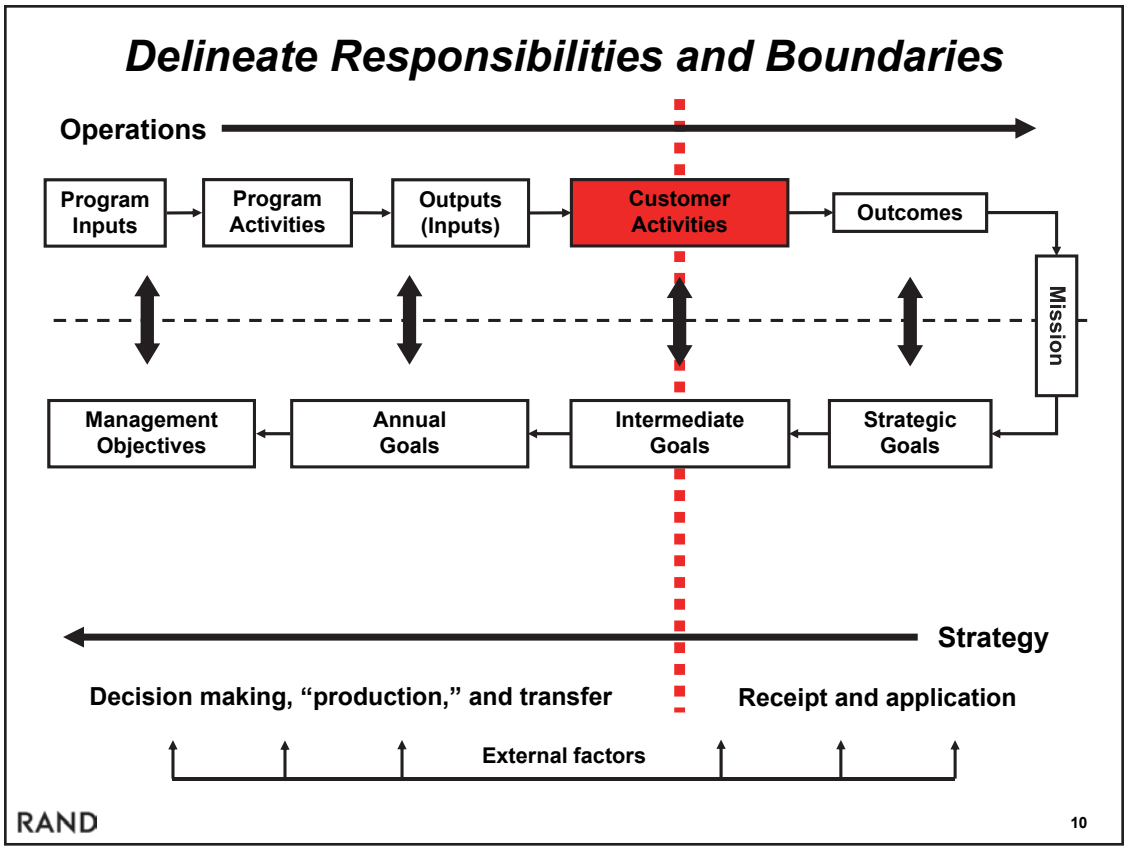
"Customer" represents an interface and might include supported or partner programs

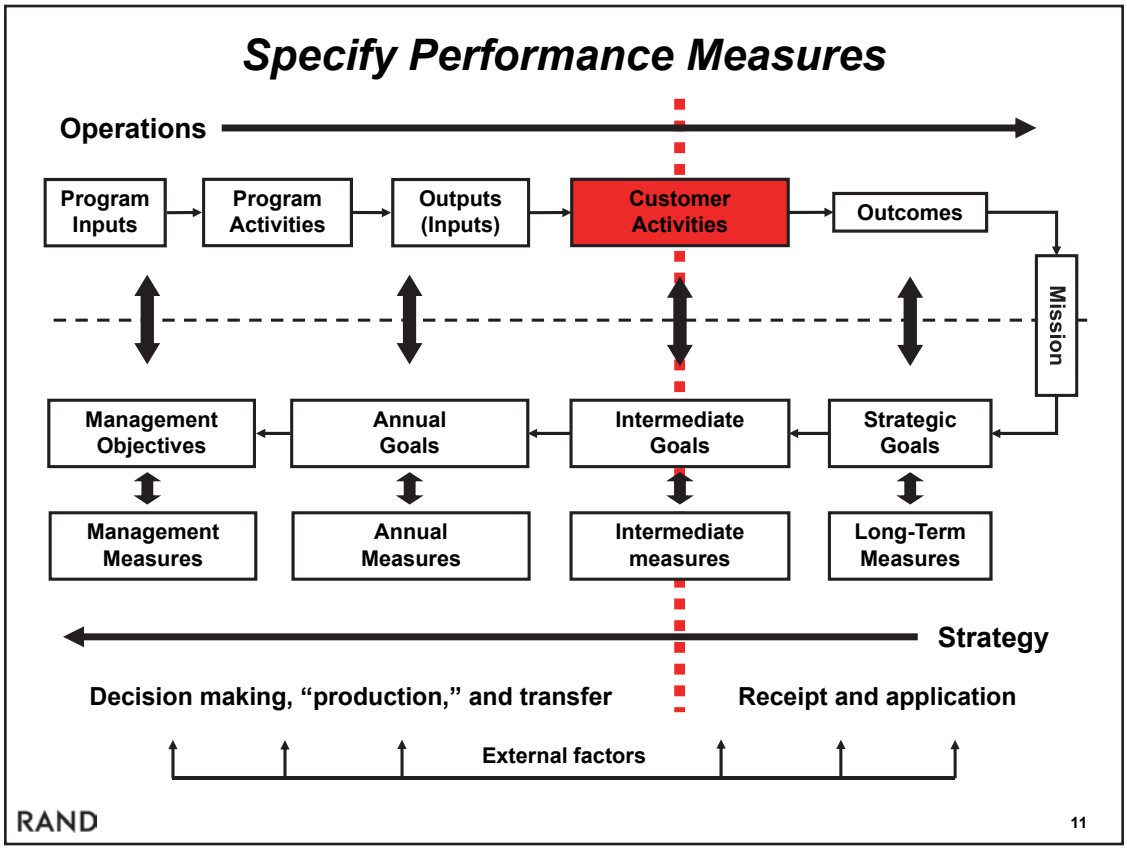
Operations contribute to mission attainment, both sequentially and with feedback

RAND 7

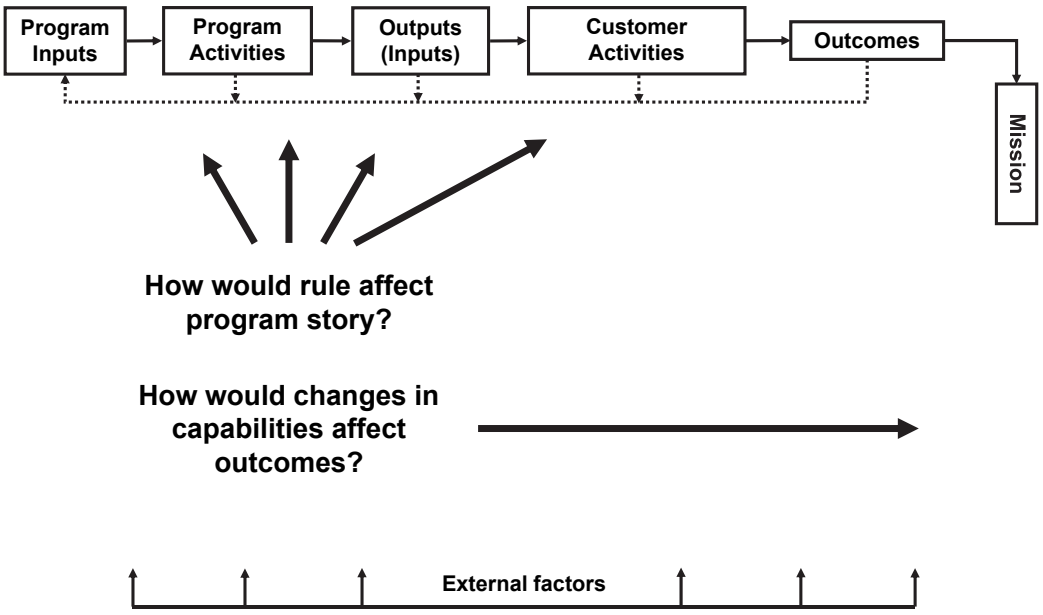

Describe Strategy
Operations
Program Inputs
Program Activities
Outputs (Inputs)
Customer Activities
Outcomes
Mission
Management Objectives
Annual Goals
Intermediate Goals
Strategic Goals
Goals and objectives derive from mission
Strategy
External factors
RAND
8


Map Operations to Strategy
Operations
Program Inputs
Program Activities
Outputs (Inputs)
Customer Activities
Outcomes
Mission
Management Objectives
Annual Goals
Intermediate Goals
Strategic Goals
Goals and objectives relate clearly to relevant operations, e.g., strategic goals speak to outcomes
Strategy
External factors
RAND
9


Delineate Responsibilities and Boundaries
Operations
Program Inputs
Program Activities
Outputs (Inputs)
Customer Activities
Outcomes
Mission
Management Objectives
Annual Goals
Intermediate Goals
Strategic Goals
Strategy
Decision making, "production," and transfer
Receipt and application
External factors
RAND
10


Specify Performance Measures
Operations
Program Inputs
Program Activities
Outputs (Inputs)
Customer Activities
Outcomes
Mission
Management Objectives
Annual Goals
Intermediate Goals
Strategic Goals
Management Measures
Annual Measures
Intermediate measures
Long-Term Measures
Strategy
Decision making, "production," and transfer
Receipt and application
External factors
RAND
11

Identifying Programmatic Effects and Assessing Changes in Capabilities and Outcomes

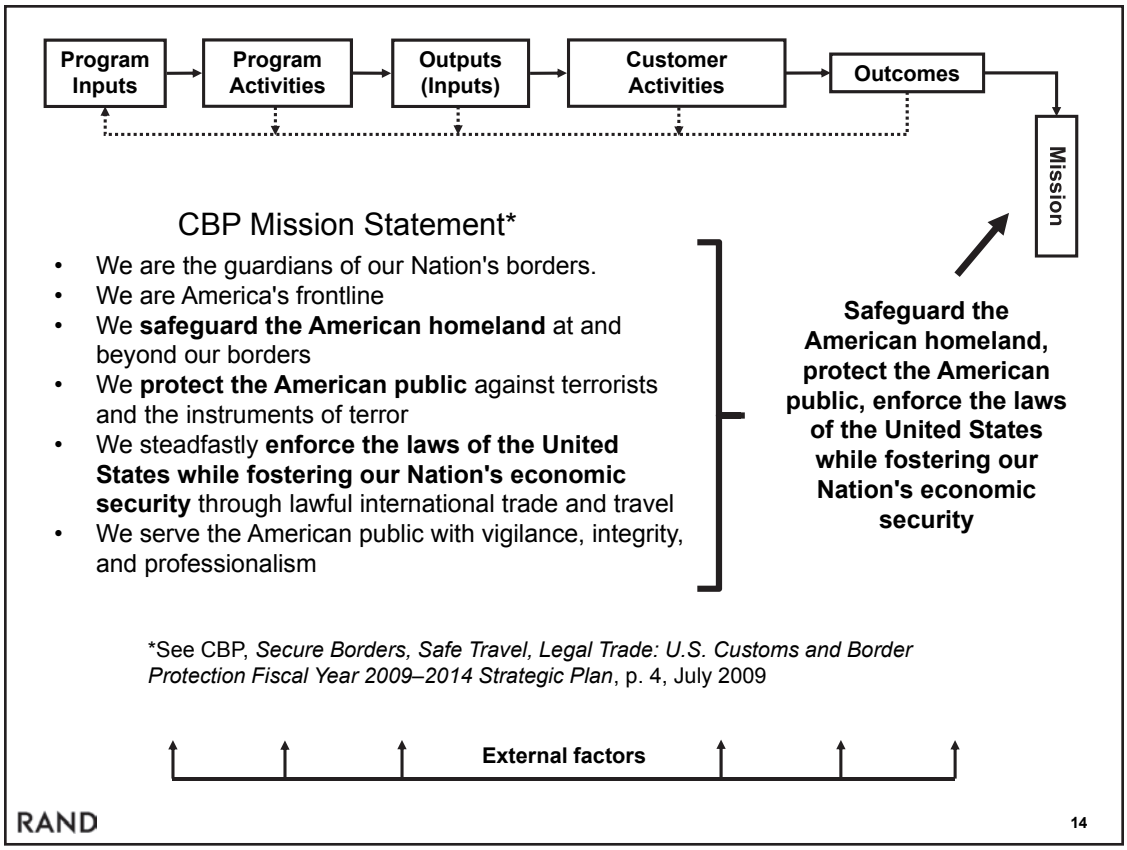


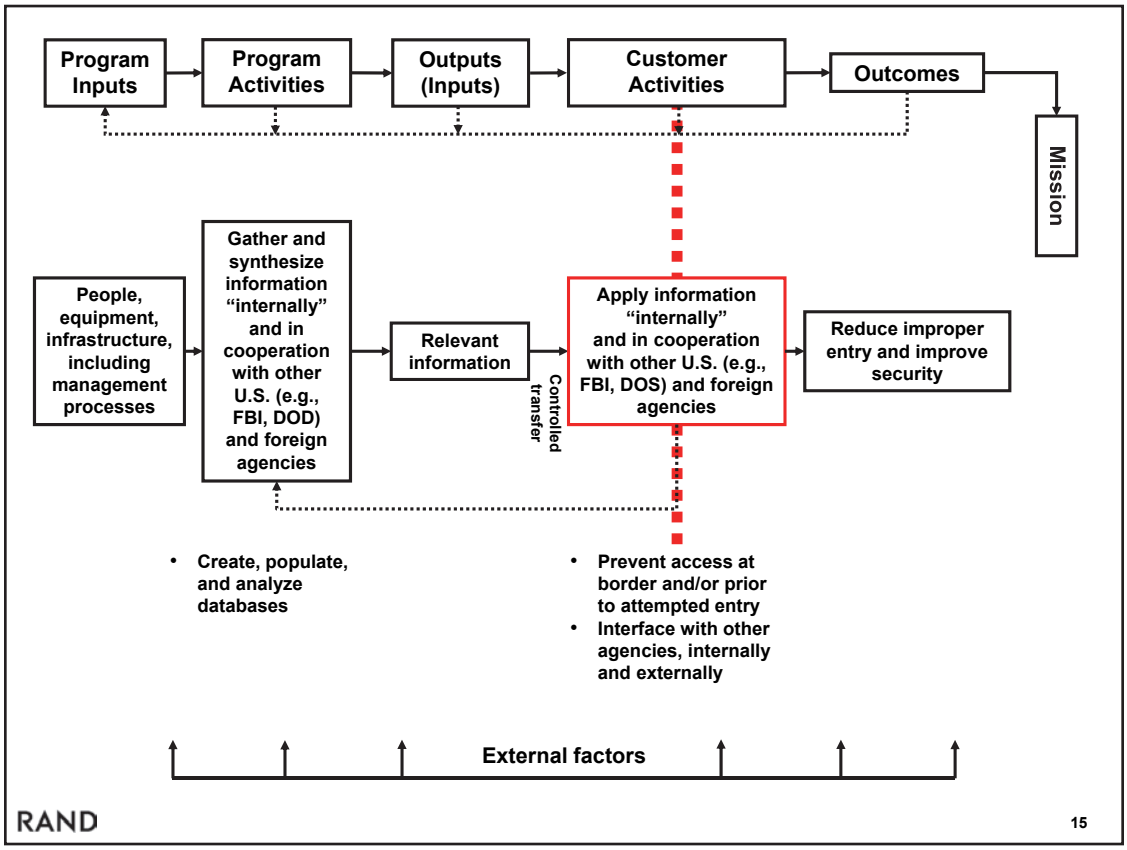
RAND 12

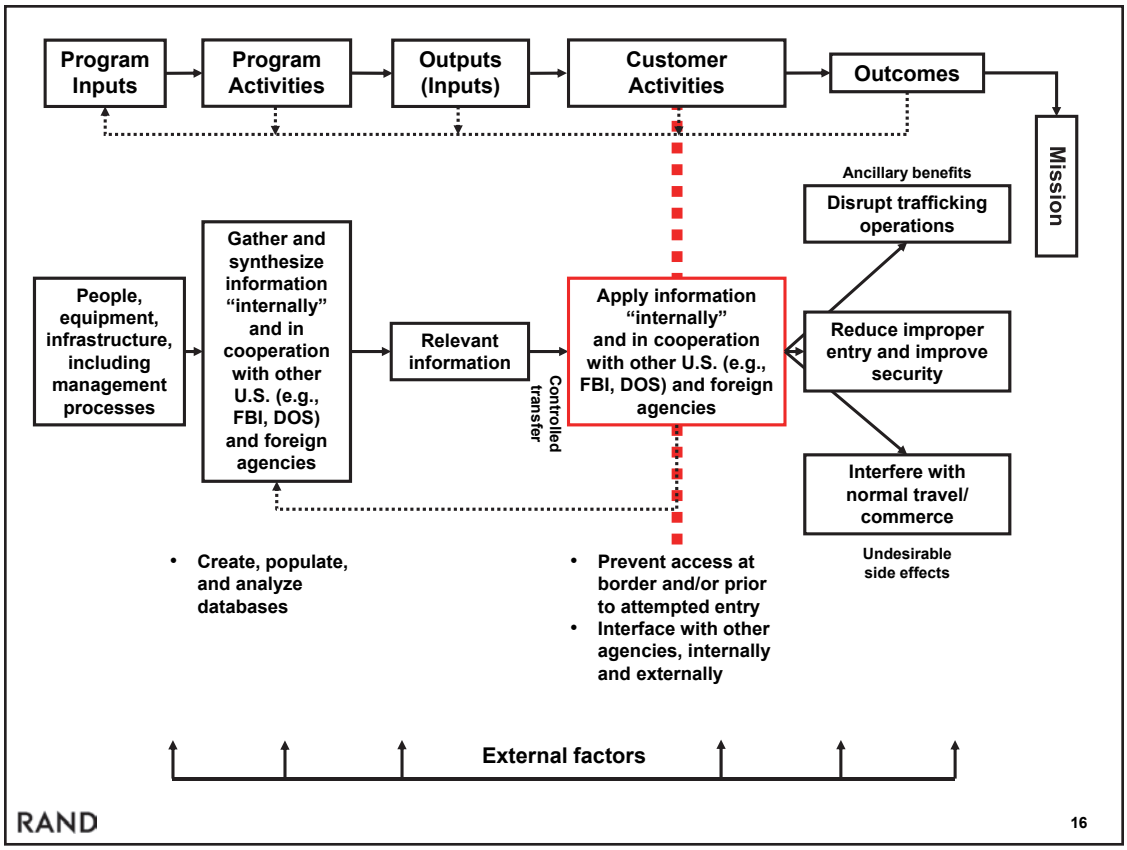
Outline

- Describe Role of Logic Model
- ➢Develop Illustrative Logic Model for Processing Information and Controlling Entry
- Demonstrate Application to WHTI
- Discuss Conclusions

RAND 13


Program Inputs
Program Activities
Outputs (Inputs)
Customer Activities
Outcomes
Mission
CBP Mission Statement*
We are the guardians of our Nation's borders.
We are America's frontline
We safeguard the American homeland at and beyond our borders
We protect the American public against terrorists and the instruments of terror
We steadfastly enforce the laws of the United States while fostering our Nation's economic security through lawful international trade and travel
We serve the American public with vigilance, integrity, and professionalism
Safeguard the American homeland, protect the American public, enforce the laws of the United States while fostering our Nation's economic security
*See CBP, Secure Borders, Safe Travel, Legal Trade: U.S. Customs and Border Protection Fiscal Year 2009–2014 Strategic Plan, p. 4, July 2009
External factors
RAND
14


Program Inputs
Program Activities
Outputs (Inputs)
Customer Activities
Outcomes
Mission
People, equipment, infrastructure, including management processes
Gather and synthesize information "internally" and in cooperation with other U.S. (e.g., FBI, DOD) and foreign agencies
Relevant information
Controlled transfer
Apply information "internally" and in cooperation with other U.S. (e.g., FBI, DOS) and foreign agencies
Reduce improper entry and improve security
Create, populate, and analyze databases
Prevent access at border and/or prior to attempted entry
Interface with other agencies, internally and externally
External factors
RAND
15



Outline

- **Describe Role of Logic Model**
- **Develop Illustrative Logic Model for Processing Information and Controlling Entry**
- ➢**Demonstrate Application to WHTI**
- **Discuss Conclusions**

RAND 17

Border Entry Operations Involve Three Steps

- **Individual approaches border**
- **Individual presents identification documents**
- **Customs agent obtains documents***
  - **Verifies authenticity**
  - **Enters information**
    - **Checks information against databases**
    - **"Feeds" databases**
  - **Makes decision to allow or disallow entry**

*Vicinity-read radio-frequency identification chip does not require physical handling

RAND 18

WHTI in a Nutshell

- **Prior to WHTI, regulations permit U.S. citizens and nonimmigrant aliens from Canada, Bermuda, and Mexico to enter United States without passport**
- **Subsequent to WHTI, regulations require that nearly all entrants (land, sea, or air) present either**
  - **Passport book**
  - **Passport card with vicinity-read radio-frequency identification chip**
  - **CBP trusted traveller card**
  - **DHS Enhanced Driver's License**
  - **Merchant Mariner Document**

RAND 19

How Would WHTI Affect Program Story?

- **WHTI does not affect structure of story but might affect key "parameters"**
- **Additional, more consistent documentation requirements might, for example**
  - **Reduce processing time**
  - **Improve quantity and/or quality of information**
  - **Increase evidentiary burden on travelers and shippers**
- **WHTI might, ultimately, affect program outcomes**

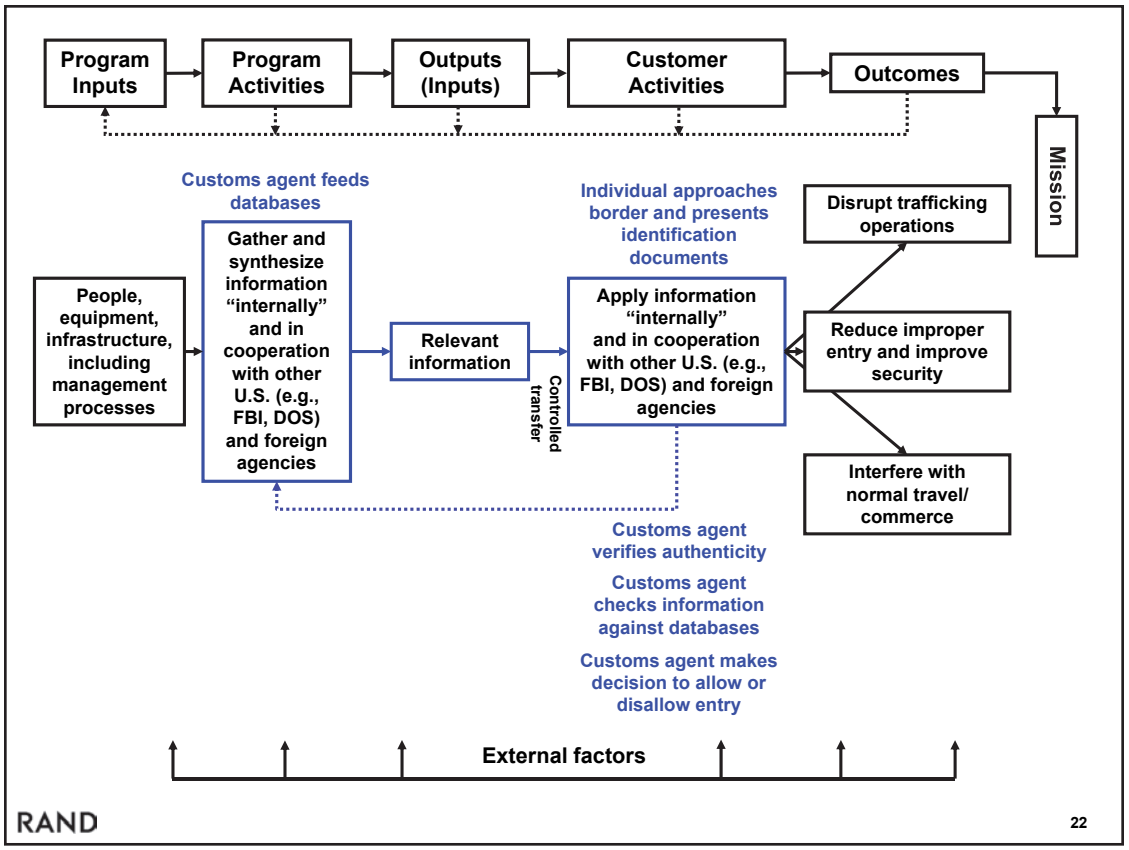
RAND 20

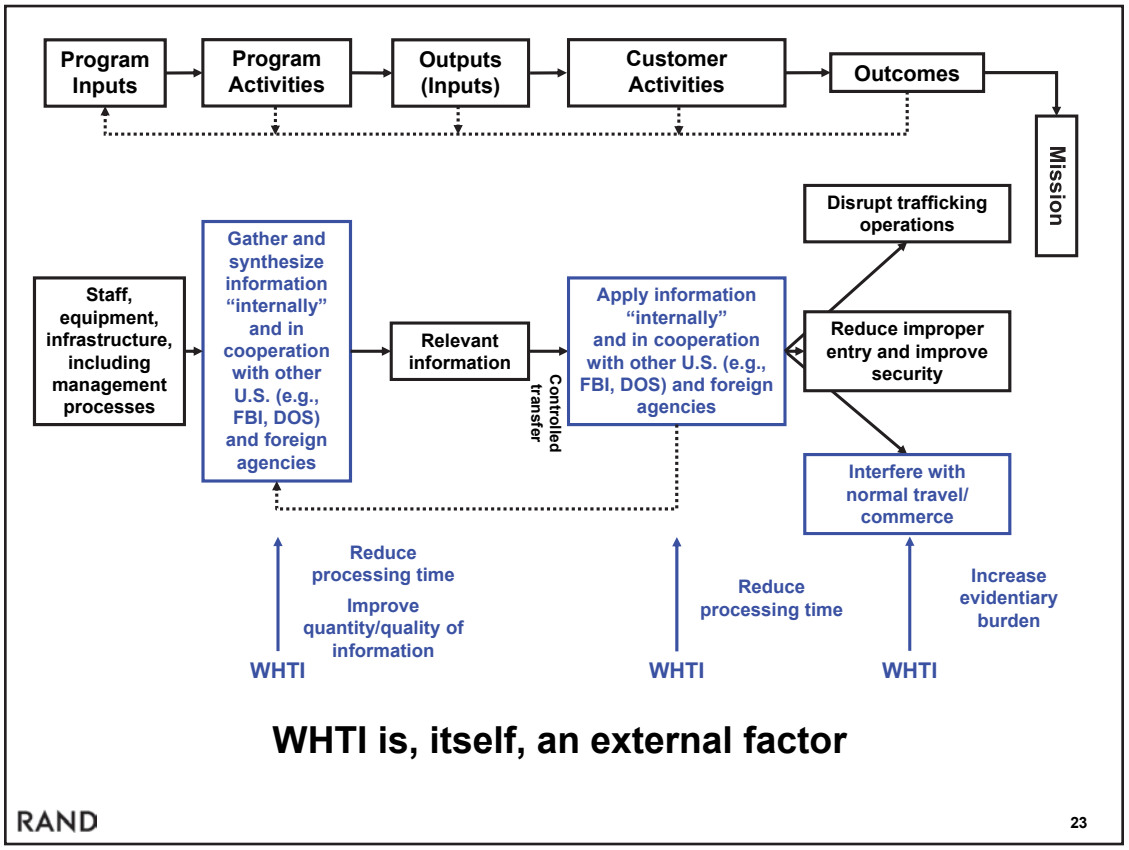
How Would Changes in Capabilities Affect Outcomes?

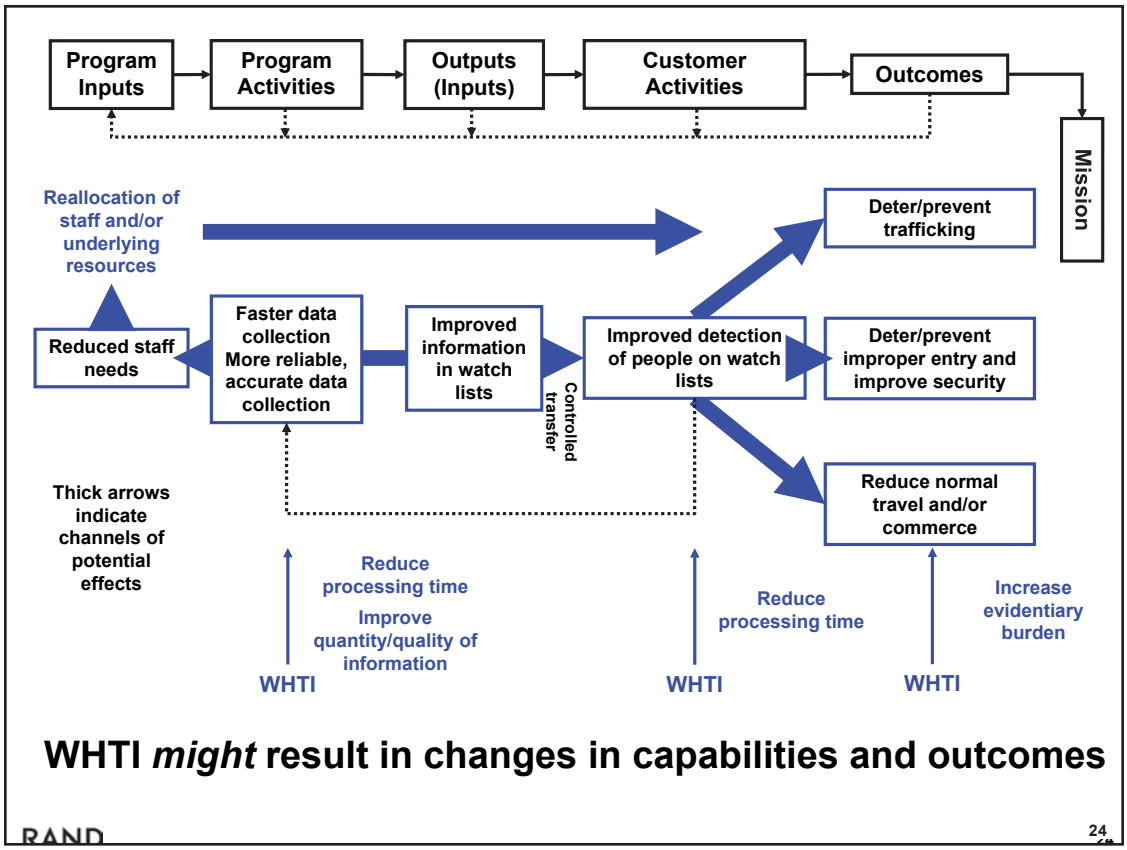
- **Reduction in processing time***
  - ***Potential* for reallocation of staff and/or underlying resources to meet other needs**
- **Improvement in quality/quantity of information**
  - ***Potential* to deter/prevent improper entry**
  - ***Potential* to deter/prevent other undesirable behavior, e.g., drug and human trafficking**
- **Increase in evidentiary burden**
  - ***Potential* to interfere with normal travel and commerce**

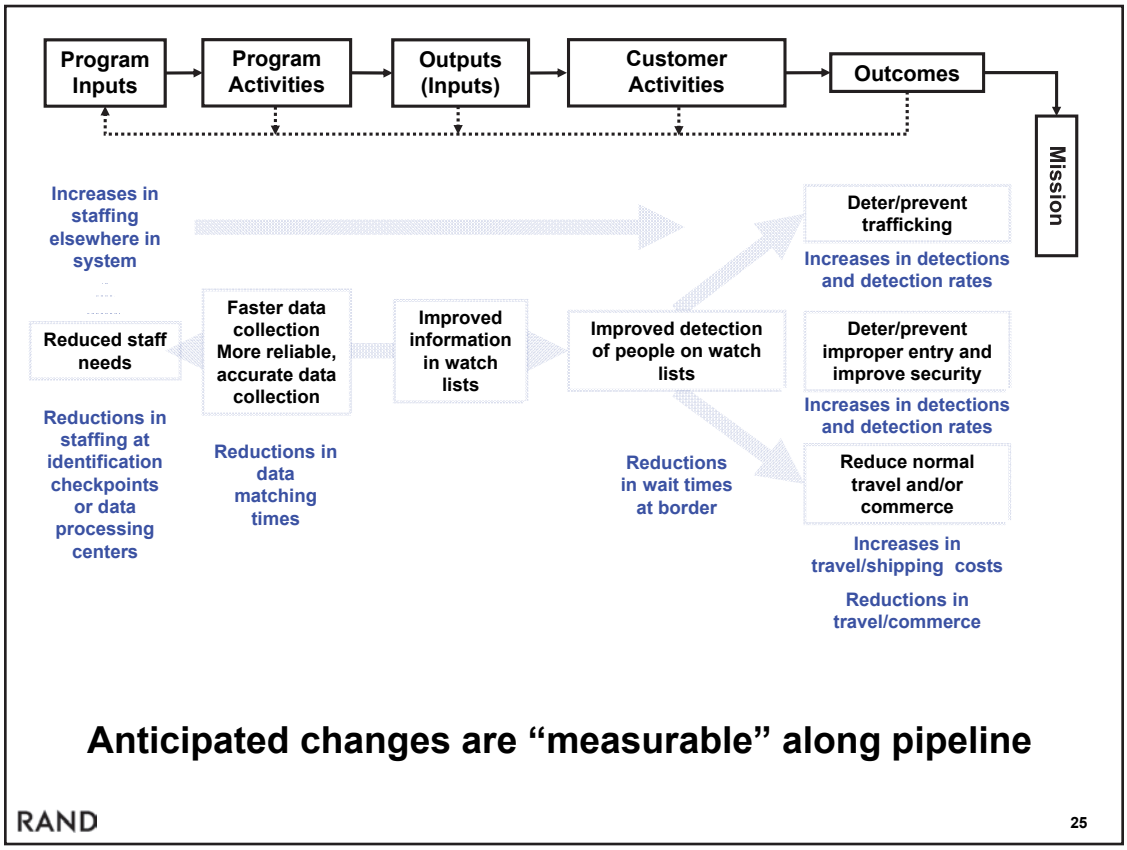
*Also *potential* to promote normal travel and commerce

RAND 21


Program Inputs
Program Activities
Outputs (Inputs)
Customer Activities
Outcomes
Mission
Customs agent feeds databases
Individual approaches border and presents identification documents
Disrupt trafficking operations
People, equipment, infrastructure, including management processes
Gather and synthesize information "internally" and in cooperation with other U.S. (e.g., FBI, DOS) and foreign agencies
Relevant information
Controlled transfer
Apply information "internally" and in cooperation with other U.S. (e.g., FBI, DOS) and foreign agencies
Reduce improper entry and improve security
Interfere with normal travel/ commerce
Customs agent verifies authenticity
Customs agent checks information against databases
Customs agent makes decision to allow or disallow entry
External factors
RAND
22


Program Inputs
Program Activities
Outputs (Inputs)
Customer Activities
Outcomes
Mission
Disrupt trafficking operations
Staff, equipment, infrastructure, including management processes
Gather and synthesize information "internally" and in cooperation with other U.S. (e.g., FBI, DOS) and foreign agencies
Relevant information
Controlled transfer
Apply information "internally" and in cooperation with other U.S. (e.g., FBI, DOS) and foreign agencies
Reduce improper entry and improve security
Interfere with normal travel/ commerce
Reduce processing time
Improve quantity/quality of information
Reduce processing time
Increase evidentiary burden
WHTI
WHTI
WHTI
WHTI is, itself, an external factor
RAND
23

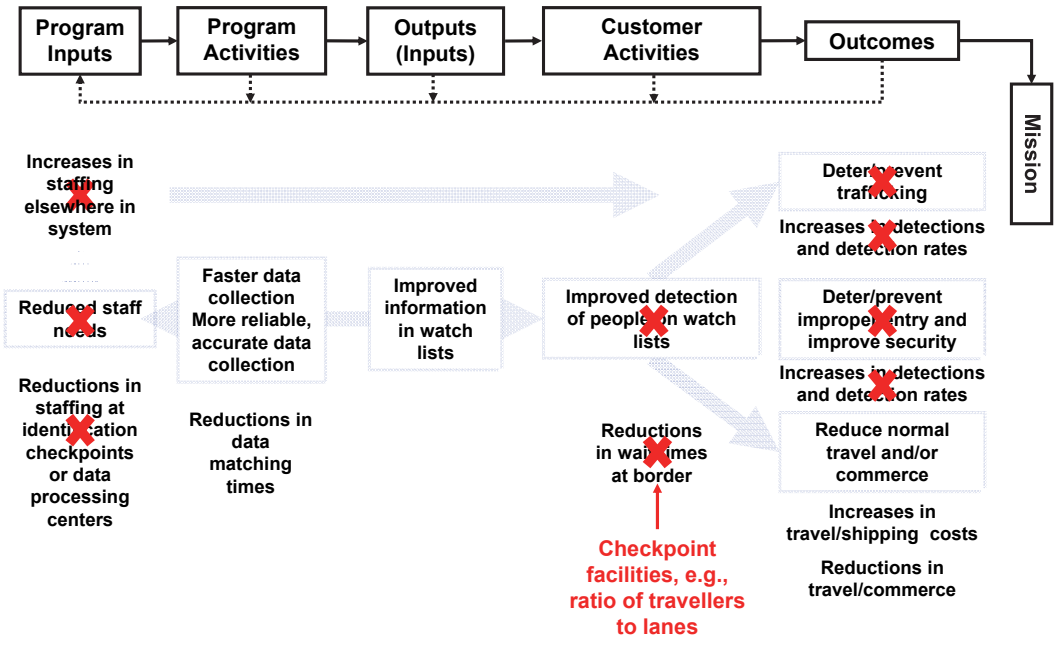

Program Inputs
Program Activities
Outputs (Inputs)
Customer Activities
Outcomes
Mission
Reallocation of staff and/or underlying resources
Reduced staff needs
Faster data collection More reliable, accurate data collection
Improved information in watch lists
Controlled transfer
Improved detection of people on watch lists
Deter/prevent trafficking
Deter/prevent improper entry and improve security
Reduce normal travel and/or commerce
Thick arrows indicate channels of potential effects
Reduce processing time
Improve quantity/quality of information
WHTI
Reduce processing time
WHTI
Increase evidentiary burden
WHTI
WHTI *might* result in changes in capabilities and outcomes
RAND
24


Program Inputs
Program Activities
Outputs (Inputs)
Customer Activities
Outcomes
Mission
Increases in staffing elsewhere in system
Reduced staff needs
Reductions in staffing at identification checkpoints or data processing centers
Faster data collection More reliable, accurate data collection
Reductions in data matching times
Improved information in watch lists
Improved detection of people on watch lists
Reductions in wait times at border
Deter/prevent trafficking
Increases in detections and detection rates
Deter/prevent improper entry and improve security
Increases in detections and detection rates
Reduce normal travel and/or commerce
Increases in travel/shipping costs
Reductions in travel/commerce
Anticipated changes are “measurable” along pipeline
RAND
25

Changes Would Occur Along Pipeline, but Depend on Other External Factors

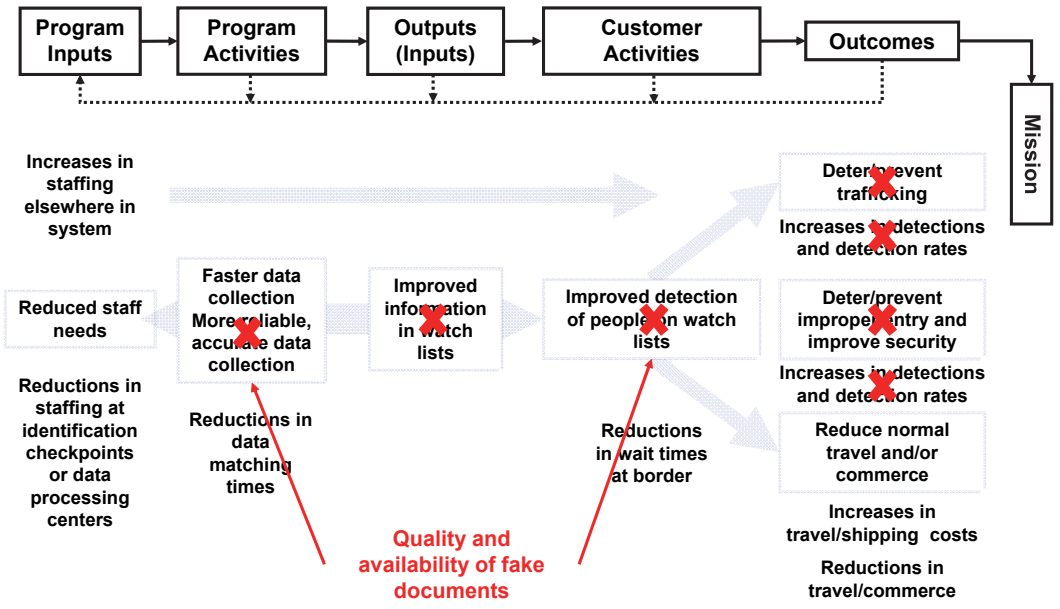
- **Presence and sufficiency of infrastructure**
  - **Checkpoint facilities, e.g., ratio of travellers to lanes**
  - **information technology**
- **Quality and availability of fake documents**
- **Communication between CBP and other U.S. government and foreign officials**

RAND 26



Changes depend on other external factors

RAND 27



Changes depend on other external factors

RAND 28

Logic Model Carries Light Technical Burden but Power Depends on Quality of Data

- Approach does not rely on
  - Large numbers of assumptions
  - Complex computing or statistical methods
- Approach is more convincing with good data
  - Estimating benefits, side effects along pipeline
  - Estimating benefits, side effects vis-à-vis outcomes

Approach cannot give point estimate

RAND 29

Outline

- **Describe Role of Logic Model**
- **Develop Illustrative Logic Model for Processing Information and Controlling Entry**
- **Demonstrate Application to WHTI**
- ➢**Discuss Conclusions**

RAND 30

Conclusions

- **Application of tried-and-true methodology may advance benefits "estimation" at low cost**
  - **Logic model cannot provide single, absolute measure, but can improve rationale behind regulatory action**
  - **Once developed, analytical burden of use is modest**
- **Logic model provides tool for**
  - **Articulating CBP program story**
  - **Identifying ways in which proposed regulation would impact program story**
  - **Assessing regulatory-induced changes in *capabilities* and *outcomes* in terms of program story**

Approach is widely applicable

RAND 31

Abbreviations

CBP	U.S. Customs and Border Protection
DHS	U.S. Department of Homeland Security
DOS	U.S. Department of State
E.O.	Executive Order
FBI	U.S. Federal Bureau of Investigations
OMB	U.S. Office of Management and Budget
WHTI	Western Hemispheric Travel Initiative

RAND 32

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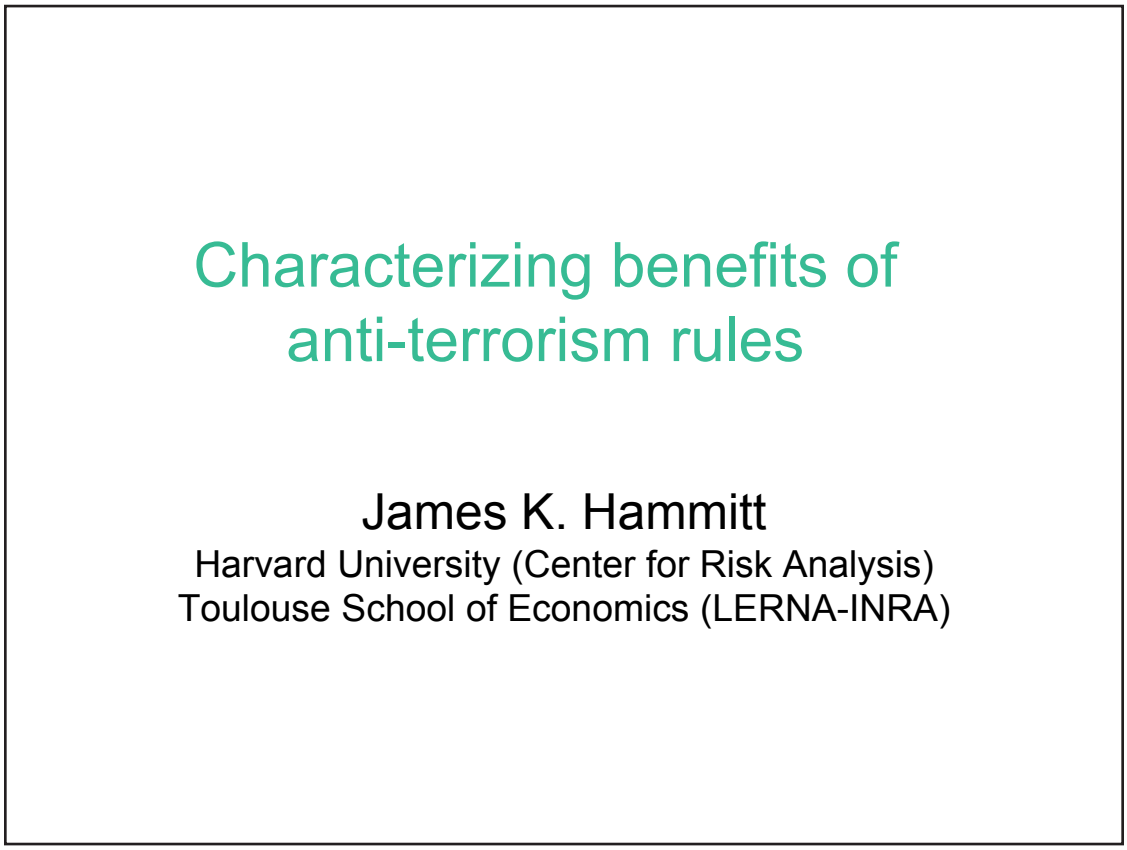
RAND 33

Characterizing Benefits of Anti-Terrorism Rules

Presenter: James K. Hammitt
(Harvard University and Toulouse School of Economics)



Purpose of regulatory assessment

Evaluate if rule benefits US population

- Approximate by whether total benefits to population exceed total costs

Costs (opportunity cost of resources, other harms)

- Government
  - Labor (border agents), equipment (e.g., screening devices)
- Others (e.g., commercial & other travelers)
  - Time waiting for inspections, invasive screening procedures
  - Restriction of civil liberties

Benefits

- Protection from terrorism

Quantities / magnitudes matter – question of tradeoffs

2

Benefits = reductions in

Harm from terrorist attacks

- Deaths, injuries, destruction of property, disruption

Precautionary behaviors

- Labor & capital devoted to hardening & protecting potential targets
- Other behavioral response (e.g., driving rather than flying, avoiding signature events)

Fear & anxiety

3

BCA & break-even analysis use same information, just present it differently

Assume primary benefit is reduction in harm from attacks

$\Delta(P \cdot L) \approx \Delta P \cdot L$ [$+ \Delta L \cdot P + \Delta P \cdot \Delta L$]

Benefit-cost analysis

$NB = \Delta(P \cdot L) - C > 0$

- ΔP, ΔL, C are uncertain
- Represent uncertainty by probability distributions, calculate probability distribution of NB
- Sensitivity analysis: for what values of ΔP, ΔL, C are NB > 0?

Break-even analysis

Assume uncertainty about ΔP much larger than about ΔL and C

$NB = \Delta P \cdot L - C > 0$

$\Delta P > \Delta P^* = C / L$

- Uncertainty analysis: calculate probability distribution for ΔP^* (for which NB is positive)
- Sensitivity analysis: calculate ΔP^* for alternative values of C, L

4

Transparency v. secrecy

Some information should be withheld from terrorists

- Details of protective systems at targets, entry portals

Regulatory assessments cannot include secret information (?)

- Limits ability of public & others to evaluate quality
- RMS model

5

Estimating benefits

Harm from terrorist attacks

Precautionary behaviors

Fear & anxiety

6

Harm from terrorist attacks

Bottom up (damage function)

- Estimate deaths, injuries, property destruction, disruption
  - Scenarios (discrete cases) or probability distributions (continuous or discrete)
- Value elements of damages

7

Estimating reductions in probability & damages

- Intelligent adversary
  - Likely to respond to protective actions (those it knows or can discover)
- Protective measures (protecting a target or an access route) have two effects
  - Make attack more difficult
    - Prevent attacks
  - Increase relative difficulty of target/route
    - Divert attacks
- Assessment must consider countervailing risk increases
  - Make decisions strategically, including portfolio effects

8

Estimating reductions in probability & damages

- Expert judgment is essential
  - Actuarial estimates inadequate – limited data, great heterogeneity over time & location, conditions change so present & future may not be like past
  - RAND database
- Subjective probabilities
  - Quantification of belief
  - There is no correct value
  - Experts may hold different probabilities
  - Hard to evaluate & compare quality
  - Broad range of values may be legitimate

9

Estimating benefits

Precautionary behaviors
- Specific to regulation
- Model, estimate from analogous cases

Fear & anxiety
- Not necessarily proportional to risk
- Placebos
  - Effective if known?

Both types depend on public information, confidence in measures, perceived risks

10

Valuing elements of damages

Deaths & injuries
- Conventional estimates exist
  - Limited for non-fatal injuries
- Premia for ambiguity or catastrophe aversion?
  - Plausible but little information about magnitude
  - Literature suggests effect much smaller than order of magnitude

Property destruction
- Replacement cost
- Premium for historically or culturally significant structures

Disruption
- Bottom-up model of time & productivity losses
  - Hard to model interactions
- Top-down analogy/extrapolation from effects of other catastrophic events, e.g., industrial accident, hurricanes, tornados, earth-quakes
  - Provide insight into how people respond

11

Valuing elements of damages

Precautionary behaviors

- Demand curves for travel modes, travel-cost methods, engineering-cost methods

Anxiety & fear

- Stated preference, monetized QALYs (Adler)

12

Positive v. Normative BCA?

Conventional BCA includes mix of individual/public and expert/scientific inputs

- Values of benefits & costs based on individual preferences
- "Objective" assessment of risks and other consequences

Individual behavior and perceptions sometimes inconsistent with economic model

- Cognitive errors?
- Oversimplified model?

How should BCA incorporate departures from model?

- Populism v. paternalism?
- Role of government?

13

Behavior often differs from standard economic model

Behavior is wrong?

- Cognitive error (susceptibility to framing, excess attention to salient attributes, nonlinear use of probabilities)
- Self-control problems (procrastination)

Model is wrong?

- Omits important attributes (type of mortality risk)
- Idealized assumptions (perfect information & processing)

14

BCA Includes Two Steps

Predicting consequences of alternative policies

- Positive question
- Predict as accurately as possible, use descriptively accurate models
  - Departures from standard economic model may be appropriate

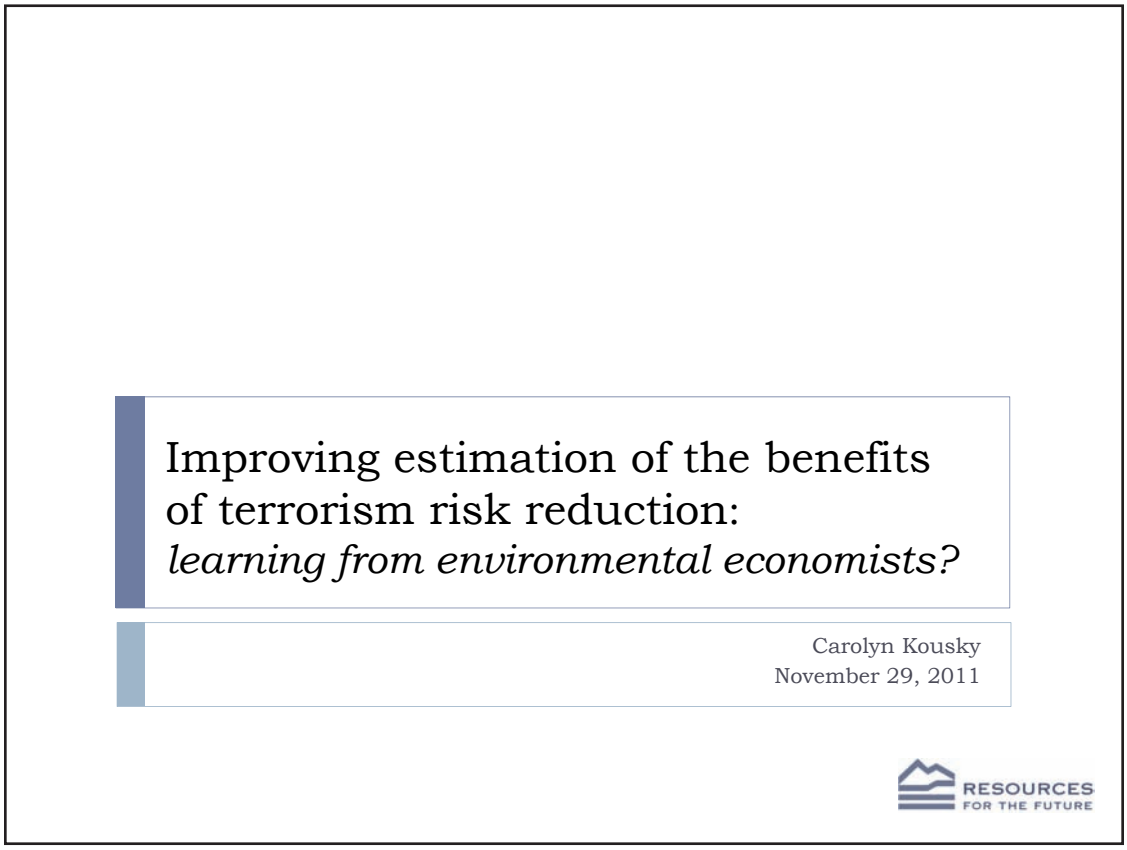
Evaluating consequences of alternative policies

- Normative question
- Use consumers' reflective, informed preferences
- How can these be determined?

15

Improving Estimation of the Benefits of Terrorism Risk Reduction: Learning from Environmental Economists?

Presenter: Carolyn Kousky (Resources for the Future)



Overview of talk

To estimate benefits associated with reducing terrorism risk need:

1) to know how risk will change with the regulation
    1) Estimating baseline risk
    2) Estimating how baseline risk altered by regulation
2) the value of that risk change

Estimating Changes in Risk

What can we learn from climate economics?

- Initial approach was to maximize economic efficiency using Integrated Assessment Models
- emissions → temperature → economic impacts
- Though these models can be solved to yield "optimal" solutions, those answers are dependent on the assumptions and biases in the model and its paramaterization
- Initial damage functions calibrated from small temperature changes and limited sectors
- But, like terrorism, it is the long tails that matter!
- Get a huge range of "answers" based on model assumptions

Aggregate models with black boxes

- Risk = probability x consequences
- Probability
  - Estimate probabilities with different scenarios for population, economic growth, climate sensitivity, etc.
  - Feedbacks/tipping points /climate thresholds difficult to model well
- Consequences
  - Exposure and population well mapped
  - But some threats outside realm of experience and these could be large portion of losses in expected value terms
  - Indirect consequences not well modeled (cascading consequences; interactions & feedbacks)
  - Aggregation not easy –cross-sectoral interactions

Often the benefits that matter are local

- Multiple climate impacts (multiple types of attack)
- Multiple locations for impact (multiple targets)
- Getting to local impacts from abatement policies
  - Couple downscaling with local models
- For WHTI, aggregate risk reduction might be OK; other regs will be more targeted at types of attack or targets
  - Need to explicitly model at this scale or back out from aggregate down to local impacts

Getting inside the black boxes: some tools to help – **Structured Expert Judgment**

- Experts can quantify uncertainty as subjective probability
- Treat expert judgments as scientific data
- Use when there are theories and measurements relevant to the problem but variables of interest cannot be directly measured themselves
- Protocols – (e.g., Cooke 1991)

Pre-Elicitation
(1) Definition of case structure
(2) Identification of target variables
(3) Identification of query variables
(4) Identification of performance/seed/calibration variables
(5) Identification of experts
(6) Selection of experts
(7) Definition of elicitation format document
(8) Dry run exercise
(9) Expert training session
Elicitation
(10) Expert elicitation session (individually)
Post-Elicitation
(11) Combination of expert assessments
(12) Discrepancy and robustness analysis
(13) Feed back
(14) Post-processing analyses
(15) Documentation

Getting inside the black boxes: some tools to help – **Structured Expert Judgment**

- Defining good query variables
  - e.g. not exponent in arbitrary damage function
- Elicitation format

How long will it take before a successful terrorist attack on the US occurs by a terrorist who enters the country using false documentation at a Mexican or Canadian crossing? Please state your 5%, 50% and 95% values, taking account of:

- **All other current security measures remaining unchanged**
- **Current 'introduction effort' remaining unchanged (as in invasive species)**
- **Terrorists adapt strategies to the new situation over time**
- **Statistical fluctuations**

Getting inside the black boxes: some tools to help – **Structured Expert Judgment**

- Need to identify calibration variables
  - Example:

In London 2000, weekly average PM_{10} was 18.4 μg/m^3. What is the ratio:

$$\frac{\text{\# non-accidental deaths in the week with the } \textbf{highest} \text{ average } PM_{10} \text{ concentration (33.4 μg/m}^3\text{)}}{\text{Weekly average \# non-accidental deaths.}}$$

5% :_____ 25%:_____ 50% :_____ 75%:_____95%:_____

- Can use these to do better than equal weighting of experts
  - **Statistical likelihood**
    - Are the expert's probability statements statistically accurate?
  - **Informativeness**
    - Probability mass concentrated in a small region, relative to background measure (e.g. uniform distribution over entire range)

Getting inside the black boxes: some tools to help – **Structured Expert Judgment**

- Who are the experts
  - Nordhaus 1994 survey found natural scientists more likely to think climate change could lead to "severe economic consequences" and economists (non-environmental) least likely.
  - For terrorism?
    - Academics studying terrorism?
    - Border agents?
    - CIA analysts?
- EJ can be costly and time intensive – may not be worth it
  - Cheaper and faster if sacrifice some quality

Concerns with Structured Expert Judgment

- Some opposition:
  - Can be costly and time intensive
  - False sense of precision
  - Delay in regulatory rule making
  - Lack of expertise within agency
  - Remember: SEJ quantifies, but does not remove uncertainty
- EPA guidance paper on use of EJ; could do something similar for CBP

Getting inside the black boxes: some tools to help – **Precursors and Near Misses**

- Precursors: conditions, events, and sequences that precede and lead up to events of a certain severity
- Allows for more data to estimate the probability of an attack
- Requires an incident reporting system
- Can be used to reveal unknown failure modes or for trending safety of system. Here could be combined with other tools to help model relationship between regulations and risk reduction.
  - E.g. Data on number of times passport scan matches positive against terrorist watch list? Number of people investigated further based on differing documentation? How many arrested suspected terrorists entered US from Canada or Mexico?
  - RMS 2008 reports that there have been over 30 attack plots uncovered in US since 2001 (use details on these to support and calibrate model – e.g. revising downward likelihood of surface to air missile attack)
- Not just terrorist activities, but trends in vulnerability and security

Cascading uncertainty

- Cascading uncertainty (Schneider 1983)
  - Emissions→carbon cycle response→CS→regional change→possible impacts
- Need uncertainty analysis not just within model, but across models (e.g. Kopp et al 2011)

Valuing Changes in Risk

Getting to WTP

- Want to estimate willingness-to-pay to reduce risk
- Risk of multiple types of damage (e.g., Hurricane Katrina)
  - Structural damage, including productive capital
  - Indirect economic effects
  - Loss of life and injury
- Some impacts can be estimated in dollars
  - Models of structural damage; business interruption
- Others require translating metric, e.g. lives lost, to dollar value
  - Environmental economists have long history of this

Fear and indirect economic impacts

- Behavioral responses can play a large role (e.g. rebuilding post-Katrina)
- Fear → Actions → Economic consequences
- More research needed linking level of fear to behavior
  - Surveys difficult to use; studies show people believe their DM is not driven by "visceral" emotions but by rational deliberation (Lowenstein, 2000)
  - Econometric analyses linking tourism to terrorist risk; hedonic studies linking housing prices to crime rate; investors in financial markets (example: Becker and Rubenstein 2011)
  - Note not all security measures reduce fear and thus increase economic activity.
- More straightforward models of the impact of changes in demand, say, can then be used to model the economic consequences

A presumption of risk aversion

- Risk neutrality has been argued as not appropriate for climate change since the potential impacts are global, damages could be very large, and correlation among risks undermines any risk sharing arrangement (Newbold and Daigneault 2010).
- Survey evidence that people are more risk averse for catastrophic impacts, large loss of life, or serious injury
- Similar arguments in favor of a risk averse position could be made for estimating benefits of reducing terrorism risk

Risk aversion and non-market impacts

- Loss of life
- Injury
- Risk averse individuals will pay more than ED to eliminate a risk

  WTP = ED + RP
- There is a value to changes in perceived safety; fear

Valuing non-market impacts

1. Revealed Preference Approaches

   Infer value of a good from market transactions
2. Stated Preference Approaches

   Ask people hypothetical questions
3. Model utility explicitly
   - IAMs assume CRRA utility
     - Tangles preferences
     - Work from Weitzman loosely suggests that due to massive uncertainties and thick tail, WTP for abatement could swamp everything (and with CRRA, be infinite)
     - Caution from climate work is that utility functions that work well in middle part of distributions might not work well at all at extremes
   - But this work does show that thinning the tail can be enormously valuable to people
4. Put more weight on worst case outcomes

RP: Averting behavior

- Private purchases to reduce a risk are a proxy for the value of risk aversion
- E.g.: water filters, safer cars
- Can be difficult to tease out only risk reduction because related to other changes in the good or may produce other benefits

CV approaches

- Many approaches – often designed as referendum
- Study design matters a great deal; there are "best practices"
- Dealing with anomalies
  - Anchoring; protest zeros; not adhering to budget constraint
- Difficult to test validity

CV to value reductions in terrorism risk

- Embedding effect may exist (Viscusi and Zeckhauser 2003)
- What is the specific "commodity" being valued?
  - Commodities being valued should be as decomposed as matters to people's utility – but still need to be able to identify substitution and complementarity
  - Don't want people to have to make assumptions about links between what you ask and what they care about – could introduce error
- Concern about "action bias" or an "emotion premium" (Sunstein and Zeckhauser 2010)
- Divergence between actual and perceived risk reduction?

CV to value reductions in fear

- People willing to pay to feel safer or to be less fearful?
- Should this be a benefit in CBA? (Adler 2004)
  - Price "fear days"?
  - Or change from particular regulation?
  - Is a regulation "fear inert"?
- Isolating value of reducing fear?
  - For CV, may not want actual changes in risk, but description of the visual clues people would have that risk may have changed
- "Fear entrepreneurs"

Be careful of double counting

- Damage categories:
  - Structural damage
  - Indirect economic
  - Loss of life
  - Injury
  - RP
- Using wage hedonics, depending on context, could include both of last two categories and RP
- Does the VSL already include concerns about fear?
- Averting behavior – cost of smoke alarm (no fear value) and improved safety in car (some fear value)

Learning from Benefits Transfer

- Tempting to use benefits transfer when little work directly on terrorism
  - Done often with VSL
- But lit that people value risks differently depending on their control, fear or dread, etc.
- With terrorism, deaths clustered, perception of risk and absolute level of risk is heterogeneous in population, dimensions of value other than damage and lives lost (national pride; fear) (Viscusi 2009)
  - Viscusi found respondents value reduction in terrorism deaths more highly than reduction in deaths from natural disasters and as highly as traffic deaths, which are more diffuse and personal risk is greater.

Is quantification and valuation of some benefits foolish?

Cautionary tale for CBA?

- When include range of plausible assumptions for damage function, utility (risk aversion), as well as unknowns in climate system, get enormous range of answers.
- Studies have found economic justification for shockingly large range of policies from doing almost nothing to fast and aggressive abatement.
- So some arguing this not a good approach for problems with deep uncertainty.

Alternatives to CBA?

- Just make them less decisive
  - Use models to build intuition; do not take numbers literally.
  - Use models to make assumptions explicit.
- Robust policies
- Win-win polices
- Optimizing under a risk constraint
  - This may be where economics is best suited – determining least-cost strategies and designing policies to meet targets (Ackerman et al 2009)
  - How do you identify the risk constraint?

On the other hand…

- Lots of uncertainty everywhere
- IAMs do let you ask the question: what beliefs are required for benefits to be large? What beliefs are required for benefits to be small?
- "Sometimes the best that can be done is to specify an exceedingly wide "benefits range," one that does not do a great deal to discipline judgment." But CBA can still be better than the intuitive judgments people make – (Sunstein 2002)
- Large literature on how people make "bad" or "wrong" decisions in cases of risk and uncertainty – or sometimes irrational may be rational after all

Ancillary benefits to research approach?

- Some of the methods to improve the benefit estimate may have ancillary benefits in terms of better identifying the most effective policies, in getting policymakers to pay attention to the most likely threats, or in better identifying and integrating public preferences in policymaking

Thank you

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