PROTECTING OUR HOMELAND: INCORPORATING VULNERABILITY TO TERRORISM IN STATE HOMELAND SECURITY GRANTS

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Abstract

Vulnerabilities realized following the terrorist attacks of September 11, 2001 highlight the need for the Federal government to allocate funding for the prevention and response to terrorist events based on vulnerability to terrorism. However, the funding formula used by the State Homeland Security Program (SHSP) is based on a lump sum to all states plus an incremental amount distributed by population. Therein the formula does not explicitly address varying risks across States.

The objective of this paper is to theoretically formulate an alternative formula to distribute grant funding based on vulnerability to terrorism across States. Empirical techniques are used to test three hypotheses regarding grant funding. State government data are used to infer the optimal funding levels to cover expected damages associated with various targets: population density, hazardous material sources, federal courts, hospitals, interstates, pipelines, power generation, public water use, airports, universities, port capacity, and confined feeding operations.

State allocations for the SHSP and the larger Homeland Security Grant Program (HSGP) are compared to allocations based on vulnerability to terrorism. Vulnerability-based allocations are calculated for all states. The difference between vulnerability-based allocations and the SHSP allocations indicate that the SHSP program over-compensates for population-based vulnerabilities and under-compensates for other vulnerabilities. The results suggest that the HSGP does not eliminate the population-bias of the SHSP.

1. Introduction

Since the terrorist attacks of September 11, 2001, considerable political discussion has centered on how to concentrate limited homeland security resources to areas of greatest need (GAO, 2003). Sources of funding for homeland security efforts to prevent, prepare, and respond to, future acts of terrorism can be found in a myriad of federal agencies, including the U. S. Department of Agriculture, and the Departments of Justice and Health and Human Services. Yet nowhere is the call to make better use of resources as important as it is in the Department of Homeland Security (DHS), the third largest Cabinet agency and the only one with the critical, core mission of protecting the country against another terrorist attack (DHS, 2003). Former DHS Secretary Ridge stated and current Secretary Chertoff have stated that allocations for the State Homeland Security Program (SHSP), the primary formula grant program for state and local government terrorism preparedness created by the Patriot Act (2001), must evolve to better target areas characterized by risk and vulnerability to terrorism (NACO, 2003; USDA, 2005), and there legislation pending in the House and the Senate to revise the homeland security funding formula to better assess risk and vulnerability.

The SHSP provides funding to enhance the capability of state and local jurisdictions to prepare for and respond to terrorist acts, including events of terrorism involving weapons of mass destruction and biological, nuclear, radiological, incendiary, chemical, and explosive devices (Patriot Act, 2001). To place grant programs in perspective, the SHSP is the original and the largest in monetary terms of six programs found in the Homeland Security Grant Program currently administered by the Office of Domestic Preparedness (ODP) within the DHS. Within the DHS, six programs are listed under the HSGP are: the State Homeland Security Program (SHSP), the Urban Areas Security Initiative (UASI), the Law Enforcement Terrorism Prevention Program (LETPP), the Emergency Management Performance Grants (EMPG), the Citizen Corps Program (CCP), and the Metropolitan Medical Response System (MMRS). Comparing the SHSP with the other programs, the SHSP represents 42% of the 2005 DHS/ODP $2.5 billion Homeland Security Grant Program and is the primary funding mechanism for states and local government first responders within the HSGP. Comparing the SHSP with the 50 largest federal formula grant programs, the SHSP has become a top-ranking federal formula grant program in terms of federal dollars spent, with Congressional appropriations to States averaging two billion dollars each year from fiscal years 2003 to 2005 (DHS, 2005).[1]

The controversy over the SHSP lies in formula used to distribute funds, with most states claiming that they receive either too much or too little of appropriated funds based on the risks that they perceive to be in their state. SHSP grants provide funding to States and local governments using a two-part formula which requires that 40% of the total allocation to be divided evenly among States, with the remaining 60% to be distributed to States based on share of population. State funding is then sub-granted to local governments who, in turn, use funding to address local vulnerabilities to terrorism.

While most states agree with former Secretary Ridge in that funding must target risks and vulnerabilities, each state has a unique perspective of vulnerability to terrorism yielding fifty different interpretations of “need” according to different possible loss scenarios (economic loss, loss of property, loss of life, etc.). Each of the two sides in this

[1] For example, the Congressional appropriation for the SHSP program was $2.06 billion, $2.2 billion, and $1.02 billion in fiscal years 2003, 2004 and 2005 respectively (DHS, 2004).

discussion formulates a need-based argument on its perception of the distribution of terrorism vulnerability, defined as the probability of an occurrence (terrorism risk) times the cost of the occurrence (loss). In economic terms, the two political positions represent different perceptions of the spatial distribution of terrorism risk. Terrorism risk can be uniformly distributed across states, or it can be clustered in populated areas. States which favor the state minimum portion of the current SHSP formula believe that terrorism risk is uniformly distributed over space, and that terrorism risk exists in populated and rural areas alike. Rural areas, for example, cite their vulnerability to agroterrorism, the use of a biological agent (e.g. anthrax, brucellosis, or wheat rust) against crops, livestock or poultry (USDA, 2004). Yet needs may not be based on risk perception but rather upon political beliefs. It is likely that perceptions of "need" may be clouded by political aims such as maximizing votes or maximizing intergovernmental grants so as to buy voter support (Grossman, 1994).

Within the context of political debate concerning homeland security funding formulas and federal pressure to target grants to areas in "need", the problem is that there is no consensus on a ranking of factors which make one state more or less vulnerable to terrorism, and there is no systematic method for determining which states are the "neediest". The objective of this paper is to test whether incorporating vulnerability to terrorism, according to different funding objectives (economic loss, loss of property, loss of life, etc.), would yield a different funding allocation than under the current SHSP allocation system, or under the larger Homeland Security Grant Program (HSGP).

2. Review of the Literature

Despite the controversy surrounding the SHSP funding formula[2], there has been no academic scholarship that this author is aware of, specific to the current funding formula, or methods for developing an alternative formula. This paper draws from the insights of the literature on methods and theories for evaluating government grant programs, including a discussion of the social welfare model and the production of public services and the literature on insuring against terrorism.

The social welfare model provides the theoretical context for evaluating motivations behind the SHSP and other government grant programs. According to this view, intergovernmental transfers improve social welfare (Bergstrom, 1973;Oates, 1999). The government acts as it were a benevolent dictator maximizing a social welfare function by providing grants to achieve fiscal redistribution, or equalizing cost disparities across all jurisdictions (Oates, 1999; Ladd and Yinger, 1994; Borck, 2003). As formula grants, homeland security grants bear likeness to other formula grant programs which aim to equalize fiscal disparities across jurisdictions such that less affluent jurisdictions will have levels of preparedness comparable to more affluent jurisdictions. In this way, the literature on social welfare maximization can be used in the development of an alternative model for homeland security grant funding.

In order to compare the current SHSP and HSGP formulas to a formula that incorporates vulnerability to terrorism, we need to develop a formula which systematically incorporates vulnerability to terrorism across states. The literature on the

[2] See the following news briefs: New York Times, October 28, 2004 "Poll Finds Most Americans Have Not Prepared for a Terror Attack," by Calvin Sims; Global Security Newswire, February 2, 2005, "U.S. Homeland Security Secretary-Designate Chertoff Seeks Improvement in Spending Priorities," By Joe Fiorill; U.S. Department of Agriculture, 2004. "On Alert for Agroterrorism", Policy Brief 5 (37) by Roy Frederick , (September 26, 2002) http://ianrnews.unl.edu/static/0209260.shtml, (last accessed 1-13-05)

production of public services and the literature on terrorism vulnerability and risk are instructive in the development of an alternative funding formula that incorporates vulnerability to terrorism.[3] The production of public safety services literature provides a framework for identifying cost disparities among jurisdictions, identifying how different environments may be more vulnerable to terrorism. This literature is beneficial in pointing to the factors that make the operation of public safety services (police and fire protection services) more costly to operate in one jurisdiction versus another jurisdiction. Analyzing disparities in cost would aid the social planner to target grant funding with the goal of equalizing cost differences in the provision of protection from terrorist events across jurisdictions.

Finally, risk analysis performed by private sector insurers and reinsures can be used to develop a list of targets and considerations that would be critical for the development of a grant formula that includes vulnerability factors. To date, only three private sector loss estimation models have been developed by three leading insurance firms: the National Council on Compensation Insurance (NCCI), the Insurance Services Office (ISO),[4] and Risk Management Solutions (RMS). Since their development, terrorism vulnerability assessment models have been used in the insurance industry and applied to thousands of potential targets, they provide a picture of the relative

[3] See W. Kip Viscusi and Richard J. Zechhauser, Recollection Bias and the Combat of Terrorism, *Journal of Legal Studies,* vol. 34 (January 2005). The authors here discuss the results of a survey assessing changes in perceptions on the vulnerabilities of terrorist attacks and their consequences pre and post-9/11; See also Ronald W. Perry and Michael K. Lindell Understanding Citizen Response to Disasters with Implications for Terrorism, *Journal of Contingencies and Crisis Management, Vol. 11, pp. 49-60 (2003); see also* W. Kip Viscusi and Richard J. Zeckhauser , Hindsight-Choice Bias in Combating Terrorism, Harvard Law School and Harvard University - John F. Kennedy School of Government, (2004)

[4] ISO Press Release, September 3, 2002. "AIR Worldwide Releases Terrorism Loss Estimation Model to Analyze Financial Impact of Terrorist Attacks of Insurers, Reinsurers and Corporations. www.iso.com/press release/2002/09 03 02.html (last accessed 6/6/04)

vulnerability by state, city, zip code.[5] Terrorism models help insurers and reinsures assess the premiums they should charge and how much coverage they can assume as well as for firms to better understand their exposure. The primary tools for vulnerability assessors are probability models which are used to calculate vulnerabilities, threat and criticality (or relative importance) of targets, and estimation of the chances of a specific set of events occurring and/or the potential consequences (Kunreuther, 2002). The literature on risk assessment can be used to identify and then determine the relative importance of targets.

3. Theoretical Model for Allocating Funds Based on Vulnerability

This section first presents the methodology for developing a new formula for allocating federal SHSP grants to states based on vulnerability target exposure. A comparison is then made between the new projected vulnerability-based allocations with the current allocations (using both the SHSP and the larger HSGP programs) to test whether incorporating vulnerability factors capturing projected economic loss into a homeland security funding mechanism would yield a different funding distribution across vulnerability factors and states than the current allocation system.

Developing a grant formula that will provide funding to states to prevent, protect against, and respond to terrorist events, requires consideration for the objectives of

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[5] Charles H. Anderton and John R. Carter , Applying Intermediate Microeconomics to Terrorism College of the Holy Cross - Department of Economics and College of the Holy Cross - Department of Economics (2004); Bruno S. Frey , Simon Luechinger and Alois Stutzer ,Calculating Tragedy: Assessing the Costs of Terrorism University of Zurich - Institute for Empirical Research in Economics (IEW) and University of Zurich - Institute for Empirical Research in Economics (IEW) (2004) Dorothy Manning , How Useful is the Economic Model of Crime in Assisting the War Against Terrorism? *Economic Affairs, Vol. 22, pp. 21-28, 2002*

terrorists. Terrorists are rationally minded actors who rely on violence or its threatened use to promote their political goals (Luechinger, 2003; Coster and Hankin, 2003). Terrorist organizations receive utility from the loss inflicted upon the adversary (Kunreuther, Michel-Kerjan and Porter, 2003). Terrorist loss objectives are achieved by: destabilizing a region or country by attacking certain targets that disrupt normal activities and create fear (Kunreuther et al 2003; Luechinger, 2004), redistributing power or property rights and extorting rents (Luechinger, 2004), causing mass casualties or mass destruction (Garrick, 2002; Rand, 2002; Coster and Hankin, 2003), or gaining attention from the media for political or economic impact (Luechinger, 2004). Given these terrorist objectives, how do terrorists accomplish their goal of inflicting damage?

Terrorists select targets to best meet their objectives. According to Rand (2002), the targets most likely to be the focus of terrorist organizations are bridges, dams, nuclear power plants, marine terminals, defense installations, banking and financial targets, water supplies, chemical plants, food and agricultural resources, police and fire departments, hospitals and public health systems, government offices and national symbols (ISO, 2004). Other possible targets are high profile skyscrapers, airports, large sport stadiums, and major corporate headquarters (Kunreuther et al, 2003).[6] Drake (1998) characterizes targets as one of two types. Cathartic targets are those targets attacked for expressive or symbolic reasons personal to the terrorist; instrumental targets are targets attacked to draw attention to terrorists' political aims (Drake, 1998; Coster and Hankin, 2003). However, target types may differ depending on the nature and goals of terrorist groups being examined (Kunreuther et al, 2003).

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[6] According to Al Queda's operational training manuals, the goals of Al Queda include economic disruption and mass casualties. Symbolic targets, defined as ones associated with the American way of life or those simply with name recognition, are also attractive (Woo, 2002).

Given this brief overview of terrorist goals and possible targets, the Federal government in its role as the social planner faces a terrorist that seeks to cause maximal casualties, property damage and economic loss. The model presented in this paper assumes that the Federal government responds to the terrorist objective by minimizing the expected damage caused by terrorist organizations in an allocation optimization problem constrained by a fixed budget. The social planner objective is to find the optimal lump-sum transfers (grant amounts) to States using a model similar to social welfare models constructed using individual utilities. The social planner accomplishes this by maximizing social welfare by minimizing damage across all jurisdictions, evenly using the "Benthamite" (or additive) formulation. Using the same terminology as the terrorist problem, a model is developed in which the social planner (the Federal government) minimizes expected damage to vulnerability targets located in all States, subject to a budget constraint. Briefly, the optimization problem can be stated as:

$$\underset{a_{ij} g_j}{Min E(D)} = \sum_{i}^{m} \sum_{j}^{n} p_i d_i s_{ij}$$

Where *E(D)* is expected damage, for all *i* and *j* where $i \in \{1,2,...m\}$ is the vulnerability exposure (target), and $j \in \{1,2,...n = 51\}$ is the U.S. State[7]. Terrorists inflict expected damage on a unit of a targets *i* which is equal to the probability of a terrorist strike on that target (the frequency), p_i, the monetary value of the damage that would result from a strike on that target (the severity), d_i. For a given vulnerability target *i*, total potential damage is the expected per unit monetary loss of a targets multiplied by the distribution of targets in a jurisdiction, s_{ij}. The Federal government seeks to minimize total damage

[7] The District of Columbia is treated as a state in this model (as it is in the SHSP and HSGP formulas).

occurring over all fifty-one states and over all targets. An assumption is made that the central government values damage equally across states.

With limited knowledge of when and where a terrorist attack may occur, the Federal government provides grants to state governments to assist in the preparation and response to an attack. Federal efforts to minimize damage are constrained by a budget, in this case a fixed security budget amount *G*. The budget constraint is formalized as:

$$G = \sum_{j}^{m} g_j = \sum_{i}^{m} \sum_{j}^{n} a_{ij} s_{ij}$$

States reallocate a_{ij} to each unit of target *i* in the State *j*. A simplifying assumption is used whereby there is one social planner, the federal government. State level governmental decisions regarding reallocations of g_j to a_{ij} are assumed to be made by one source. The state allocates the a_{ij} exactly as the central planning federal government would do so.

The relationship between grant funding and expected damage is a key feature of the theoretical model. Assume that the impact of government spending on reducing expected damage for a given target *i* takes the standard form of a convex damage function used in the economics of accidents literature (Viscusi, 1984; Shavell, 1984). After several modifications to the traditional function, the result is a damage mitigation formula with the following form:

$$p_i d_i = p_i^0 d_i^0 s_{ij} f(a_{ij}) \quad \text{where} \quad f(a_{ij}) = \left(\frac{k_i}{k_i + a_{ij}}\right)$$

The a_{ij} are reasonably assumed to be greater than zero, and $d_i^0 p_i^0$ represents the base level of expected damage in terms of property and lives lost with no federal spending considered. $f(a_{ij})$ is the mitigation of risk (in percentage of damage) per one unit of target endowment for a \$1 investment in mitigation (given that a_{ij} is measured in \$). k_i is a parameter describing damage mitigation effectiveness by target type *i*, and is closely related to the cost-benefit ration of those activities and yet is target–specific versus jurisdiction-specific.

In this way, the damage mitigation function is continuous, twice differentiable, and monotonically decreasing in government per unit target funding. The damage mitigation function has several notable properties. First, has the quality that federal spending on targets reduces damage.[8] Second, the function exhibits diminishing returns to investment in damage mitigation.[9] Roe (2004) uses a similar convex damage function in a study which seeks to find the optimal levels of consumer and industry effort to prevent and reduce the expected monetarized value of all market and nonmarket losses related to foodborne illness. The convexity assumption in Roe (2004) implies that the initial effort rapidly reduces total damages while additional effort reduces damages at a diminishing rate.[10] The convexity assumption is reasonable in this paper as government spending has a decreasing impact on deterring an attack or lessening the damage of an attack. Protective measures that "harden" a target reduce expected damage by serving as deterrents, and decreasing the expected marginal benefit of an attack (RAND, 2002; Koehane and Zeckhauser, 2002; Woo, 2003; Bruck and Wickstrom, 2004). Yet,

8 $\frac{\partial f}{\partial a_{ij}} < 0$

9 $\frac{\partial^2 f}{\partial a_{ij}^2} > 0$

10 According to Roe (2004), in cases where damages that are dictated by biological responses (pathogen survival under preventative treatments and health response to increasing pathogen ingestion) the pertinent physical relationships often conform to a nonconvex sigmoidal relationship where initial effort reduces damage very little but rapid reductions in damages are observed for higher effort levels (i.e., near the inflection point). Only after the inflection point is the function convex.

anecdotal evidence from the private sector suggests that while initial efforts such as installing fencing around an installation or alarms may have a large impact on expected damage, later efforts may not have as large of an impact and there will always remain some level of vulnerability (ISO, 2004), thereby supporting the use of the convexity assumption. Third, the damage mitigation function has the property that no mitigation investment damage equals the initial damage parameters.[11] This means that, in the absence of a federal grant for a state, damage caused with federal funding in place equals damage caused with no federal funding in place, or $p_i d_i = p_i^0 d_i^0$.

The problem that this paper addresses is one of choosing the optimal funding amounts for per-unit targets, a_{ij}, in order to minimize expected damage from terrorist attack on targets across all States. The resulting Lagrangian combines the minimization objective and budget constraint:

$$L = \sum_i^m \sum_j^n p_i^0 d_i^0 \left(\frac{1}{1+(a_{ij}/k_i)}\right) s_{ij} - \lambda\left(G - \sum_i^m \sum_j^n a_{ij} s_{ij}\right)$$

In the social planner model, the federal government provides grants to states[12] to cover vulnerability exposures, otherwise referred to as targets. The choice variables are the a_{ij}, the d_i, the p_i. The results show the optimal amount of funding a_{ij} for each unit of target s_{ij}. The key result from this optimization problem is that per-unit allocations vary by target and do not vary by jurisdiction. This result allows us to formulate a model for allocating funds based on vulnerability to terrorism based purely on allocations that are

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[11] $f(0) = 1$

[12] The SHSP has an 80% - 20% pass through requirement. This means that 80% of funds awarded to a state under the SHSP must be passed down to local government within a specified time period; the remaining 20% can be used by the state under the state's discretion (DHS, 2004).

target specific. These predicted allocations can then be compared to current allocations for each state, to gauge whether the current allocation mechanism covers target-specific risks. In this way, the predicted model can be used to offer predictions as to which states are over-funded and under-funded in the current system versus a vulnerability based allocation system.

Examining the difference between the current formula and a vulnerability based formula requires several steps. The first step, combining the vulnerability based formula with the current formula in one equation, requires using the model that includes vulnerability to terrorism (simplified in terms of three classes of targets) and the current government model. The difference in state shares of allocations between the current model and the vulnerability model can be stated as the difference in value between the vulnerability-based model and the government model allocations, taken as a share of total grant funding. States that are currently over-funded will have a negative deviance; States that are currently under-funded will have a positive deviation. In addition to comparing funding levels among States, the deviance model can be used to theoretically predict and empirically test the impact of changes in particular classes of targets on the deviation between the two models.

Three types of assets can be considered. Class 1 targets are those that are correlated with population, Class 2 targets are those that are equally distributed across all states, and Class 3 targets are those that are unsystematically distributed across all states.[13] Since the current governmental model provides funding based on share of population, it can be said that the current governmental model indirectly captures Class 1

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[13] Clearly the extreme assumption allowing for three classes of infrastructure is only meant to represent infrastructure (target) characteristics

targets, but perhaps not in the correct proportion of overall funding. In addition, since the current governmental model provides an equal amount of funding to all states, it is likewise possible that the current model captures Class 2 vulnerability factors, but again, there is no reason to believe the proportion of funding to equally distributed vulnerability factors is correct. The current model does not provide a portion of formula grant funding, neither directly nor indirectly, for Class 3 targets, and so the governmental model results and the vulnerability based model results should differ.

4. Empirical Methodology

The overall objective of this study is to suggest a new formula for allocating federal SHSP grants to states based on vulnerability target exposure, and then to compare the new projected vulnerability based allocations with the current allocations (using both the SHSP and the larger HSGP programs). If there is a difference between the two formula amounts, we can then examine which vulnerability targets have more or less of an impact on the difference. This section presents the methodology for comparing the current and the vulnerability based models and for examining the relative influence of particular vulnerability target exposure on the difference between the two models.

a. Developing Empirical Equations

A comparison between current SHSP allocations and allocations based on a vulnerability based model requires two sets of data, data on current federal allocations and data on allocations based on a vulnerability-based model. The DHS provides current SHSP allocation data. For any State, the SHSP is based on the application of a federal formula originating from the Patriot Act of 2001, to a congressionally appropriated amount for the SHSP program. The SHSP allocations in this study are taken from the DHS website for Fiscal years 2003 and 2004. The Fiscal 2005 allocations are calculated based on the Patriot Act formula and the SHSP funding amount in the DHS Appropriation Bill signed in October 2004 (DHS, 2004).

In contrast, data for vulnerability-based allocations at the federal level do not exist. However, state-level data for funding targets in jurisdictions has been developed. The State of Indiana identified variables that are critical to an assessment of terrorism vulnerability. Recognizing that the Indiana formula is one formula among others that States utilize to distribute funding to local governments, the vulnerability-based allocation system is an approximation to an optimal solution. No claim is being made that the Indiana allocations are optimal, only that they represent one solution to allocating funds based on vulnerability. The eleven variables identified by the State of Indiana to allocate funding across Indiana counties are collected for all states.

Table 1 describes the targets selected for this study listed by name, mean, standard deviation, and source. The first variable, *(DENSITY)*, is calculated as the number of people per square mile in the given state. The second variable, *(HAZARD)*, provides the tonnage of hazardous waste generated by each State. This variable gauges the supply of harmful chemicals in a State for their possible use as a terrorist weapon or as a terrorist target. The third variable, *(FED COURTS)* is the number of Federal courts in each State (circuit and district). The fourth variable is the number of registered hospitals for each State in 2004, *HOSPITALS)*, provided by the American Hospital Association (AHA). This variable is included as hospitals are necessary in responding to a terrorist attack. The fifth variable is *(INTERSTATES),* the number of interstate miles in a given State.

These roads provide the highest level of mobility, at the highest speed, for a long uninterrupted distance (U.S. Census, 2003). The sixth variable is the standardized amount of oil and gas production in every state, *(PIPELINES),* and serves as a proxy for pipeline miles in a given State. Energy sources are both economical and political strategic targets, for producer states and their clients. Pipelines are considered strategic targets and targets; since an interruption in the supply of natural resources would entail severe economic consequences, nations now consider their protection a significant national concern (Karmon, 2002). The seventh variable, *(POWER PLANTS),* is the power utility generation in every state in terms of gas, coal, and oil, measured in million BTU per capita. The eighth variable, (*PUBLIC WATER USE),* is water withdrawal for public use, measured in per capita million gallons per day, and measures the impact of drinking water contamination. The ninth variable,*(AIRPORTS),* measures the number of primary airports in every state, according to the Federal Aviation Administration (FAA). The tenth variable, *(UNIV),* is the number of undergraduate universities with more than 10,000 students. Universities of this size are considered targets for the large populations they serve and for their draw during sporting and other large campus events. The eleventh state-level variable is *(LIVESTOCK),* the number of livestock operations with confined feeding, taken from 1997 U.S. Census of Agriculture estimates for livestock populations which include beef cattle, dairy cattle, swine, and poultry. The final variable included in the literature and utilized in some of the models presented in this study is the tonnage of materials shipped on waterway ports, between states, within a state, and to foreign locations, *(PORTS)*.

Table 1: Summary Statistics for State-Level Data

Variables	Description	Mean	Std. Dev.	Source
2002 State Population Density (DENSITY)	Person/Square Mile	183	263	U.S. Census, 2002
Quantity of RCRA Hazardous Waste Generated (*HAZARD*)	Tons	796736	1312887	Quantity of RCRA Hazardous Waste Generated and Number of Hazardous Waste Generators, by State, 2001, tons generated,http://www.epa.gov/epaoswer/hazwaste/data/brs01/national.pdf
Federal Courts (*FED COURTS*)	Number	7	6	Federal Law Clerk Information System, 2004, https://lawclerks.ao.uscourts.gov/
Hospitals (*HOSPITALS*)	Number of all Registered Hospitals in U.S.	117	98	American Hospital Association, 2004 http://www.aha.org/aha/resource_center/fastfacts/fast_facts_US_hospitals.html#community
Insterstate Highway Miles (*INTERSTATES*)	Miles	910	599	State Statistical Abstract: No. 1053. Highway Mileage—Functional Systems and Urban/Rural: 2000, http://www.census.gov/prod/2003pubs/02statab/trans.pdf
Pipelines (*PIPELINES*)	Standardized oil production plus gas production	0	2	Energy Information Administration, Department of Energy, 2002 Distribution of Wells by Production Rate,Bracket, http://www.eia.doe.gov/pub/oil_gas/petrosystem/ar_table.html
Power Utility Generation (*POWER PLANTS*)	Sum gas, coal, nuclear. Per Capita, Million BTU	1777	1864	State Statistical Abstract: No. 946. Energy Consumption—End-Use Sector and Selected Source by State, 1997, http://www.census.gov/prod/2001pubs/statab/sec19.pdf
Water Withdrawl Use: Public Supply (*WATER USE*)	Per Capita, Million Gallons per day	862	1013	State Statistical Abstract: No. 368. Water Withdrawals and Consumptive Use—State and other areas,1995, http://www.census.gov/prod/2004pubs/03statab/geo.pdf
Public Primary Airports (*AIRPORTS*)	Number	7	6	Federal Aviation Administration, Primary Airports, CY 2003 Passenger Boarding and All-Cargo Data, ww.faa.gov/arp/planning/stats/#apttype
Universities with >10,000 students (*UNIVERSITIES*)	Number	8	13	Peterson's Thompson Search, undergraduate universities >10,000 students http://www.petersons.com/ugchannel/code/searches/srchCrit2.asp
Confined Feeding Operations (*LIVESTOCK*)	Number	10374	13464	Number of livestock operations with confined livestock, 1997,http://www.nrcs.usda.gov/technical/land/pubs/manntr.html
Tonnage of materials shipped on waterway ports *(PORTS)*	Tons	58096	95204	U.S. Army Corps of Engineers, Navigation Data Center (NDC), Waterborne Commerce Statistics Center (WCSC), New Orleans, LA. 2004 http://www.iwr.usace.army.mil/ndc/data/datastat.htm

The data are used to estimate the vulnerability based allocations. The State of Indiana uses a formula to allocate funding to Indiana counties. This formula can be used to calculate the allocation to each target, a_i. From the theoretical model, we know that allocations are target-specific and not jurisdiction-specific. The a_i can be summed to determine g_i for a given state and year. The vulnerability-based allocations to targets, the a_i, can be calculated in a series of five steps. After compiling numerical counts of targets for each of the fifty states, the first step involves placing ranking each state in percentiles according to the quantity of each of target in the jurisdiction. The second step involves ranking the percentiles into five quintiles. The percentile is the raw score. Next, the raw score (quintile) is multiplied by the weight assigned to the target (the Indiana weights are used for the first vulnerability model). The result is a weighted score for each target and each state. Summing across targets results in a total weighted score for the state. Each state's weighted score is normalized by multiplying the state's weighted score by the sum of weighted scores for all states, resulting in a normalized weighted score for the state. The final step is to multiply the normalized weighted score for each state by the Federal funding appropriation for the given year, for the grant program we are examining. This yields the vulnerability-based allocation for each state.

Table 2 displays the vulnerability-based funding allocations for five states. Two important pieces of information can be extracted from 2. First, Table 2 presents the vulnerability-based allocations to targets, the a_i, for a select sample of five states. According to the table, the vulnerability-based model predicts that Indiana should have allocated \$9 million, and Louisiana allocated \$12 million, to enhance the capabilities of local governments to protect hazardous material facilities in their respective jurisdictions. Indiana and California allocated more funding toward protecting agricultural targets, while Maine allocated more funding to airports, density and hazardous material facilities, than to anything else. One limitation to interpreting these results is that clearly two targets would not receive the same amount of funding exactly, as Table 2 infers. The approach using percentiles and quintiles eliminates the specificity that is needed for more detailed analysis. Another limitation is that the funding allocations among states are based on estimate for a_i which originate from Indiana's the prioritization of targets. A series of different prioritization mechanisms will be considered in a subsequent paper.

Table 2: 2003 Vulnerability Score per target Translated into Allocation dollars (mil. $) per target

	Indiana	Maine	California	New Jersey	Louisiana
DENSITY	13.5	9.0	18.0	22.4	13.5
HAZARD	9.0	2.2	6.7	6.7	11.2
FED COURTS	1.7	0.6	2.8	1.1	2.2
HOSPITALS	1.7	0.6	2.8	1.7	2.2
INTERSTATES	2.2	0.6	2.8	0.6	1.7
PIPELINES	3.4	1.1	5.6	1.1	4.5
POWER PLANTS	4.5	1.1	5.6	4.5	4.5
PUBLIC WATER USE	3.4	1.1	5.6	4.5	3.4
AIRPORTS	2.2	2.2	5.6	1.1	3.4
UNIVERSITIES	3.4	1.1	5.6	3.4	3.4
LIVESTOCK	3.4	1.1	3.4	1.1	2.2
Vulnerability-based Allocation (mil.$)	48.3	20.8	64.5	48.3	52.2

Source: Author's own computations

The vulnerability allocations are compared to the current SHSP and HSGP allocations. For a given jurisdiction, this deviation between the two models is the deviation between the amount provided by vulnerability-based model and the current governmental model, as a share of total homeland security grant funding available. The deviation between the formula allocations allows for the testing of hypotheses regarding the specific impacts of certain targets on the deviation. The model implies that states with more class 1 targets have a smaller deviation, which is less distorting for states that are under-funded and more distorting for states that are over-funded. States that have more class 2 targets have a smaller deviation which is less distorting for states that are under-funded and more distorting for states that are over-funded. States that have more class 3 targets have an larger deviation, which is more distorting for states that are under-funded and less distorting for states that are over-funded.

The following empirical formula can be used to test the three hypotheses stated in above related to certain target endowments on the deviation:

$$Deviance_{jt} = \mathbf{S}_{1j}\beta_1 + \mathbf{S}_{2j}\beta_2 + \mathbf{S}_{3j}\beta_3 + \varepsilon_{jt}$$

Where $\mathbf{S}_{1j}$ is a vector of class 1 targets, $\mathbf{S}_{2j}$ is a vector of class 2 targets, and $\mathbf{S}_{3j}$ is a vector of class 3 targets; $\beta_1, \beta_2, \beta_3$ are vectors and the respective coefficients for the classes of targets[14]; ε_{jt} is the error term clustered at the state level. The empirical predictions imply that:

$$\begin{cases} \beta_1 < 0 \\ \beta_2 < 0 \\ \beta_3 > 0 \end{cases}$$

[14] The case of $\beta_{1t}, \beta_{2t}, \beta_{3t}$, varying betas over time, will also be examined. Another expectation is that is that factors increase with time, $\beta_{is} < \beta_{is+1}$, for $i = 1,2,3$, and $s \in t$.

An examination of the coefficients will determine the effect of different targets on the deviation between the two formulas.

5. Results

The results for two hypotheses are being presented. One hypothesis being tested is whether the vulnerability based allocations from the first vulnerability formula differ from the current SHSP allocations. The model results presented in Figure 1 confirm that the current funding formula over-funds and under-funds states because it does not consider vulnerability. Figure 1 presents the difference between SHSP funding and funding resulting from a vulnerability based model. The states are shaded in different colors depicting how much more/less States currently receive compared to a vulnerability-based model. Distinctions can be made between states that are over-funded or under-funded by the SHSP formula. When a state is over-funded, this means that the vulnerability-based formula predicts a smaller funding amount than the current SHSP formula provides. When a state is under-funded, this means that the vulnerability-based formula predicts a larger funding amount than the current SHSP formula provides. Distinctions are made with five levels of funding: those states that are over-funded by 20% more (yellow), states that are over-funded between 5%-20% (red), states that are either over-funded or under-funded by 5% or less (blue), states that are under-funded between 5%-20% (white), and states that are under-funded by 20% or more (green). The figure shows that, combining the yellow and red states, 9 states currently over-funded; combining the white and green, 32 States under-funded by the current SHSP formula. Contrary to popular reports, the Midwestern states are generally under-funded using the current SHSP formula. According to Figure 1, four states receive 20% more funding than they would receive under a vulnerability based formula.

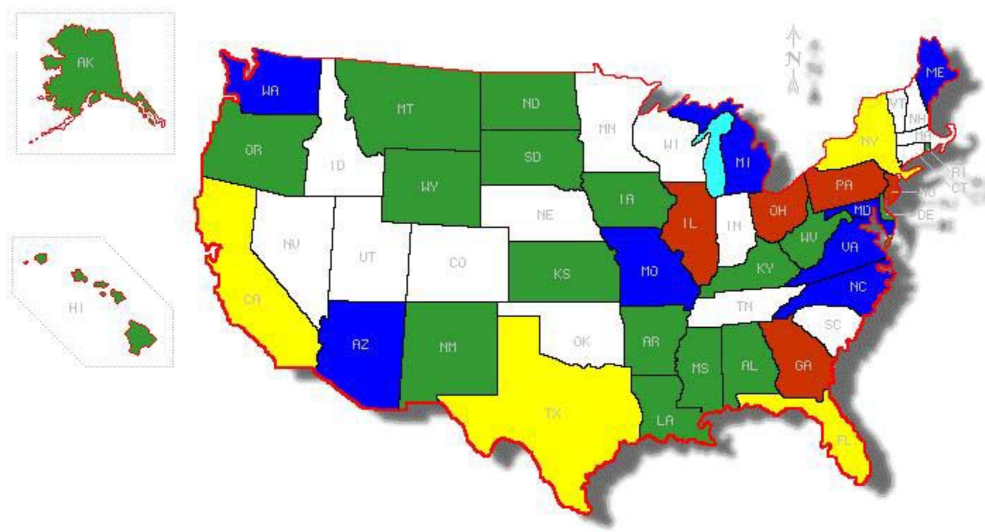

Figure 1: Geographical Distribution of Funding: State Differences between Vulnerability-based model and SHSP
Source: Author's own calculations
Note: Over-funded by 20% or more (yellow); over-funded by 5-20% (Red); Over-funded or Under-Funded by 5% or less (Blue); Under-funded by 5-20% (White); Under-funded by 20% or more (Green)

Using the proper HSGP funding allocations as just described, the deviation can also be used to show that, similar to the findings for the SHSP, there is a difference between the six grant programs in the HSGP and the vulnerability based formula. First, the funding programs added to the SHSP do not go to every state and only select states. The states that receive this additional funding are already over-funded. When the deviation between the vulnerability-based allocation and the SHSP allocation is negative, the state is currently over-funded. When the SHSP is combined with the other grant programs in the HSGP, states that were over-funded initially will remain over-funded. That the HSGP allocations do not to match the vulnerability based allocations is not entirely surprising due to the fact that the vulnerability formula omits vulnerabilities considered in the HSGP (e.g., seaports and transit systems), and that the programs added to the SHSP represent a smaller fraction in funding compared to the SHSP.

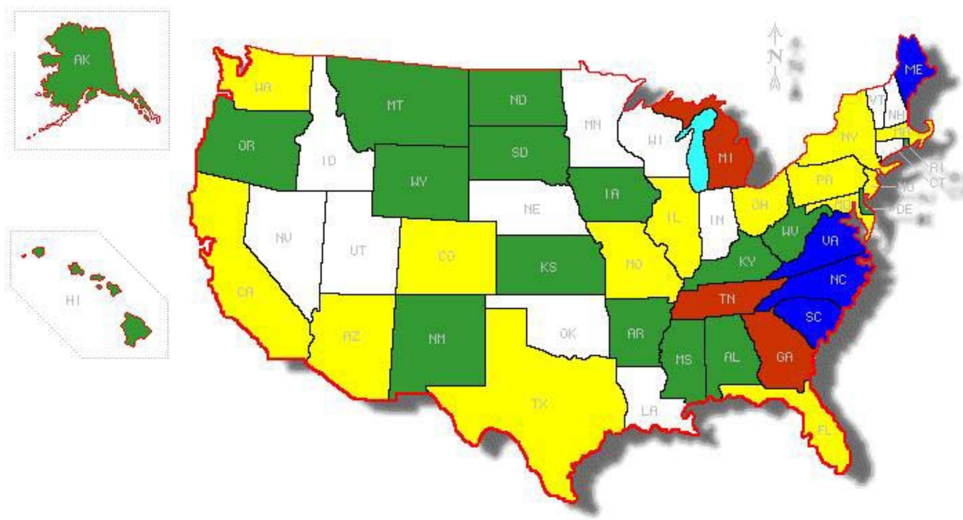

Figure 2: Geographical Distribution of Funding: State Differences between Vulnerability-based model and HSGP
Source: Author's own calculations
Note: Over-funded by 20% or more (yellow); over-funded by 5-20% (Red); Over-funded or Under-Funded by 5% or less (Blue); Under-funded by 5-20% (White); Under-funded by 20% or more (Green)

The result is that most states that received high levels of SHSP funding also receive high levels of HSGP funding, with the noted exceptions in DC, CO, WA, and HI. Half of the states listed received comparatively low levels of SHSP funding and also received little, if any, funding form other HSGP grant funding programs. While the fiscal situation for states that were under-funded using the SHSP program improves, the additional funding provided by the HSGP group of programs exacerbates already over-funded conditions of certain states. In fact, using the SHSP alone results in 35 states that are under-funded, while using the HSGP results in 24 states under-funded, a 22% decrease from the under-funded amount using the SHSP.

The second hypothesis that is being tested is that certain targets have more of an impact on the deviation between the two formulas. The results from an ordinary least squares (OLS) statistical regression suggest that three target types affect the deviation between the two formulas. According to the results in Table 3, four variables are significant at the 1% level (*HAZARD, INTERSTATE, UNIV, PIPE*), and two variables are significant at the 5% level (*DENSE, AIRPORTS).* All but two variables have the expected signs. As expected, targets that are correlated with population (e.g., large universities) will decrease the deviation suggesting that targets correlated with population are over funded in the current allocation of funding. Targets that are distributed throughout the U.S. in an unsystematic fashion (e.g. chemical facilities) as well as those distributed evenly (e.g. interstate highways) will increase the deviation between the two formulas. This suggests that the current formula under-funds targets that are unsystematically distributed and targets that are evenly distributed. The coefficient for pipeline miles is unexpectedly negative. We can only suggest that the proxy for pipeline miles is not the most accurate measure for pipelines miles throughout the U.S. The overall results suggest that the current formula under-funds targets that are unsystematically distributed and targets that are evenly distributed. Targets that are correlated with population are not under-funded.

Table 3: Empirical Results: Dependent Variable is the Deviation Between Current Model Grant Allocations and Vulnerability to Terrorism Model Allocations

Variable	Coefficient		t - value	Class Designation
DENSE	0.0001873	*	1.97	Class 3 (Unsystematic)
HAZARD	9.11E-08	**	2.55	Class 3 (Unsystematic)
FED COURTS	0.0050104		0.40	Class 2 (Even)
HOSPITALS	-0.0016839		-1.04	Class 1 (Pop) or Class 2 (Even)
INTERSTATE	0.0003308	**	3.04	Class 2 (Even)
PIPELINES	-0.0979792	**	-2.92	Class 3 (Unsystematic)
POWER PLANTS	0.0000265		0.43	Class 1 (Pop) or Class 2 (Even)
PUBLIC WATER USE	-0.0000802		-0.49	Class 1(Pop)
AIRPORTS	0.01831	*	1.69	Class 2 (Even)
UNIVERSITIES	-0.044271	**	-4.73	Class 1(Pop)
LIVESTOCK	-9.91E-07		-0.30	Class 3 (Unsystematic)

N=51. ** sig. at <0.01 level; * sig. at <0.05 level, +sig. at <.10 level, R-Square = 0.94

6. Conclusion

The policy implications for this research are twofold. First, presenting the would-be vulnerability allocation in contrast to the actual coverage suggests that the current funding formula does not distribute funding to optimally cover all vulnerability targets. This depends on what is optimal coverage. The effect is that some jurisdictions may be under-funded and some jurisdictions may be over-funded, implying that a more efficient allocation of federal resources is available. The results also suggest that certain types of targets are currently under-funded and over-funded. Presenting the would-be risk allocation in contrast to the actual coverage suggests great differences in distributions. The effect is that some jurisdictions and targets may be under-funded and some jurisdictions and targets may be over-funded implies that a more efficient allocation of federal resources is available. Under-funding of jurisdictions and targets may result in geographic weaknesses thereby defeating homeland security goals to protect the nation against terrorist attack.

This paper adds to the literature in the fields of economics and law in the following way. This paper adds to the economics literature by applying a social welfare model to Federal funding decisions. Since Governments are to a great extent institutions for redistribution (Broadway, 1997), this project adds to the public finance literature on redistributive policy as it pertains to discovering ways to make redistributive policy (protecting from terrorist events) more efficient. Finally, this paper provides an empirical examination of funding for counter-terrorism which can be used to inform current political debate on funding programs. The cross-sectional disparity in what each State would receive under the vulnerability model versus what they do receive provides guidance for lawmakers in geographic weaknesses for homeland security. Future work will examine how political factors influence decision-making, thereby contributing to the public economy and public choice literature as well as consideration for additional vulnerability scenarios and targets.

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