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## Economics of National Security: Some Basic Economies of National Security

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**Working Paper No. 249**

**“Economics of National Security”**

**KEVEN M. MURPHY**

**AND**

**ROBERT H. TOPEL**

**George J. Stigler Center  
for the Study of  
the Economy and the State  
The University of Chicago**

## ECONOMICS OF NATIONAL SECURITY<sup>‡</sup>

### Some Basic Economics of National Security<sup>†</sup>

By KEVIN M. MURPHY AND ROBERT H. TOPEL\*

National security economics is a nascent field in our discipline.<sup>1</sup> We define *national security* (NS) as the set of public policies that protect the safety or welfare of a nation's citizens from substantial threats. While NS policies are typically thought of in terms of military assets, our definition includes the development and deployment of any public good that would mitigate catastrophic outcomes for a large segment of the population. Thus we include certain investments in public health, safeguarding supplies of certain natural resources, as well as environmental and climate policies designed to mitigate possibly catastrophic future outcomes. Our main focus is on the common structure of these problems, and in particular on the value and form of NS investments. We reach several substantive conclusions.

First, NS investments provide societal insurance against widespread harm. Because of this insurance property, optimal NS investments may have very low or even negative expected rates of return—they pay off precisely when willingness

to pay for mitigation is highest. Then the social rate of discount applied to NS capital can be quite low—often below the “risk free” rate. We relate this general principle to recent debates over the proper rate of discount to apply to investments in “climate capital” and related policies that might avert substantial harm from uncertain future climate outcomes.

Second, some types of NS capital can be used in a variety of circumstances, while others have more specialized purpose. Investments in military preparedness are obviously useful in the event of large-scale war, but they also avert or mitigate smaller conflicts and protect external supplies of important resources, such as oil, or the sovereignty of important trading partners. Investment targeted at extreme events (war) then has spillovers, reducing potential harm in less threatening situations as well—a form of complementarity or economy of scale/scope. Conversely, the “peace dividend” from elimination of a large potential threat—such as the end of the Cold War—reduces NS investment, which increases danger in other circumstances.

Third, potential NS threats are highly uncertain in terms of both occurrence and magnitude. This raises the value of solutions that are flexible and scalable because they can be deployed on large scale *ex post* once the magnitude of a threat is known. We demonstrate that *ex ante* choice of flexibility is determined by the distribution of threats, and a greater likelihood of extreme threats raises the elasticity of supply of *ex post* mitigation. We frame this as a trade-off between taking current precaution against future harm versus investments in scalable technologies that can be deployed as events unfold. We also show that a higher probability of extreme events raises the demand for flexibility but may reduce current precaution.

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<sup>†</sup>To view additional materials, and author disclosure statement(s), visit the article page at <http://dx.doi.org/10.1257/aer.103.3.1>.

<sup>1</sup>Enter “national security economics” into a web search engine, and the first entry returned is the site of the NBER Working Group on Economics of National Security. Reminiscent of Jacob Viner’s quip that “economics is what economists do,” the Group studies national security.

### I. An Economic Framework for National Security

NS policy involves current investments in NS “capital” and the technologies to effectively deploy it. NS capital might take the form of specialized hardware—like ships and planes—or technologies and human capital that have little peacetime use. Alternatively it may represent health R&D that mitigates the potential effects of a viral pandemic, diplomacy, or precautionary current emissions reductions that reduce the potential for future climate harm. To keep things simple we take these threats as exogenous, ignoring strategic behavior by an adversary.

Assume the current generation can invest in  $\lambda$  units of NS capital with cost  $K(\lambda)$ . With income  $y_0$ , current consumption of a representative citizen is  $c_0 = y_0 - K(\lambda)$ . Future ( $F$ ) harm is uncertain, with two forms. The first is a reduction in living standards  $D(M, \delta)$  in state of nature  $\delta$ . This can be mitigated via  $M(\lambda; \delta)$ ;  $D'_M < 0$ ,  $M'_\lambda > 0$ . The second is increased mortality indexed by hazard  $H(M; \delta)$  and survivor probability  $e^{-H}$ . The social planning problem is

$$(1) \quad \text{Max}_\lambda U = u(y_0 - K(\lambda)) + \phi E[u(y_F - D(M; \delta))e^{-H(M; \delta)}],$$

where  $\phi < 1$  is a generational discount factor. Optimal choice of  $\lambda$  satisfies

$$(2) \quad K'(\lambda) = E[\mu_F(\delta)[-V_F H'_M - D'_M]M'_\lambda] = \bar{\mu}_F \bar{X}_F + \text{cov}(\mu_F, X_F).$$

In (2)  $\mu_F(\delta)$  is the marginal rate of substitution between future and current consumption in state  $\delta$ ,  $X_F = [-V_F H'_M - D'_M]M'_\lambda$ , and  $V_F = u(c_F)/u'(c_F)$  is the value of a statistical life (VSL). Then  $-V_F H'_M - D'_M \equiv W_F$  is willingness to pay for an increment of mitigation from NS capital. Equation (2) is very simple, but it has several important implications.

First, the returns on NS investments are  $X_F = W_F M'_\lambda$ . In contrast to the typical return on financial assets where we expect  $\text{cov}(\mu_F, X_F) < 0$ , it is natural that  $\text{cov}(\mu_F, X_F) > 0$  for many NS investments—by mitigating catastrophe, NS capital has its greatest return when  $\mu_F(\delta)$  is large. Let  $x_F(\delta) = X_F(\delta)/K'(\lambda)$  be the marginal return per dollar invested and define the “risk free” rate

of return as  $r_f = -\ln(\bar{\mu}_F)$ . Then the expected rate of return on NS capital is  $r_N = \ln(\bar{x}_F)$ , so

$$(3) \quad r_N = r_f - \text{cov}(\mu_F, X_F) = r_f - \sigma_\mu^2 b_{x,\mu}.$$

Equation (3) is in standard asset pricing form. The twist is that  $b_{x,\mu} > 0$  is not only plausible for NS investments, it may be their defining characteristic. Then  $r_N < r_f$ : NS capital can have very low rates of return because it provides a form of national insurance.

While this point is general, it is particularly relevant to recent debate over the “proper” rate of discount applied to actions that would mitigate future climate change. *The Stern Review on the Economics of Climate Change* (2006) argued that rates of discount applied to distant future harm should be quite low—on the order of 1 percent, because it is morally improper to discount the utility of future generations. Whatever one’s moral stand, this “argument” ignores the fact that interest rates are market-determined prices that equate current desires to consume with what is available. Observed prices are much higher than what *Stern* advocates, which is the critique of *Stern* offered by Nordhaus (2007) and Weitzman (2007). Even so, our equation (3) indicates that appropriate rates of discount applied to NS investments can be uniquely low because of their insurance value, not some moral principle.

The second line of (2) provides an additional reason that NS investments may be unusually valuable. Cost-benefit discussions of NS capital often frame future harms in terms of an impact on future GDP, as an indicator of potential harm to living standards. But (2) says that it makes a great difference whether a (say) 2-percent reduction in future output is caused by a reduction in per capita output for everyone or (at the other extreme) a catastrophe that kills off 2 percent of the population. If the latter, losses are not marginal. The lethal event wipes out the full value of surplus as reflected in the value of statistical life,  $V_F$ . Current evidence puts  $V_F$  at about six times lifetime consumption,<sup>2</sup> so the multiple on the value of life-threatening events is roughly a factor of six compared to events that impact productivity alone.<sup>3</sup>

<sup>2</sup> See the discussion in Murphy and Topel (2006).

<sup>3</sup> We provide a more extensive discussion in our 2011 paper with Gary S. Becker.

## II. Extreme Threats and Scalable Security Technologies

Extreme security threats may have low probability, but (by definition) they have large destructive potential. Historical examples include the outbreak of war on a large scale or pandemics that cause sudden and widespread death. Extreme future costs of greenhouse gas (GHG) emissions—say an increase in temperature of 10°C or more—cannot be ruled out. These extremes place a premium on our ability to scale defensive efforts once the magnitude of a threat is revealed. For example, physicist Dyson (2008) argues that removal of GHGs from the atmosphere is feasible, and (if developed) such a technology could be deployed in large scale if climate outcomes prove extreme. Uncertainty over the form and magnitude of military threats supports development of highly scalable defenses—soldiers can be recruited and deployed quickly, but the scale of response depends on the availability of previously developed capital.

To keep things simple we ignore mortality risks and focus only on potential harm to future living standards. Express future consumption in state  $\delta$  as  $c_F = y_F - z_F - \delta[D - M(\lambda, z_F)]$ . Here  $M(\cdot)$  represents mitigation of harm, which employs time- $F$  resources  $z$  that can be deployed once  $\delta$  is known, while  $\lambda$  is NS capital (physical capital or knowledge) developed ex ante. Higher values of  $\delta$  make mitigation more valuable. For example, in a climate context  $D$  may represent the atmospheric concentration of GHGs, while  $\delta$  represents uncertain future harm per unit of GHG concentration. Then  $M$  represents the future ability to abate GHG concentrations, say by geoengineering or the physical removal of GHGs.

We assume two possible Cobb-Douglas mitigation technologies  $\alpha$  and  $\beta$ . If both are deployed against  $\delta$  then  $c_F = y_F - z_\alpha - z_\beta - \delta[D - T_\alpha \lambda_\alpha^{1-\alpha} z_\alpha^\alpha - T_\beta \lambda_\beta^{1-\beta} z_\beta^\beta]$ . Ex post choice of  $z_\alpha$  yields  $z_\alpha = \lambda_\alpha [\alpha T_\alpha \delta]^{1-\alpha}$ , so the elasticity of response to  $\delta$  is  $(1 - \alpha)^{-1}$ . Let  $\alpha > \beta$  so  $\alpha$  is more scalable ex post; for example,  $\beta = 0$  means that investment in  $\lambda_\beta$  is nonscalable—a “precaution” such as reducing current emissions or increasing diplomacy.<sup>4</sup> This

<sup>4</sup> This would be true if uncertainty were about the cost of emissions, captured by  $\delta$ . If uncertainty were over the

precautionary approach is weighed against a technological alternative  $\alpha$  that can be scaled as circumstances warrant. Collecting results, eliminate  $z$  and write  $c_F = y_F - \delta D + \lambda_\alpha \delta^{\frac{1}{1-\alpha}} + \lambda_\beta \delta^{\frac{1}{1-\beta}}$ .<sup>5</sup> It is then obvious that with only a single threat  $\delta$  and constant costs of investment both technologies will not be employed—one or the other is better. With  $\alpha > \beta$  the payoff from  $\alpha$  is more convex in  $\delta$ , so it would be preferred for values of  $\delta$  above some threshold. But with a distribution of threats each technology has advantages in some range, and both can be employed in equilibrium.

Now assume constant costs  $P_\alpha$  and  $P_\beta$  with  $P_\alpha > P_\beta$ . The investment problem is:

$$(4) \quad \text{Max}_{\lambda_\alpha, \lambda_\beta} U = u(y_0 - P_\alpha \lambda_\alpha - P_\beta \lambda_\beta) + \phi E \left[ u \left( y_F - \delta D + \lambda_\alpha \delta^{\frac{1}{1-\alpha}} + \lambda_\beta \delta^{\frac{1}{1-\beta}} \right) \right]$$

After some algebra, the necessary conditions are

$$(5) \quad P_\alpha = E \left[ \mu_F(\delta) \delta^{\frac{1}{1-\alpha}} \right] \quad P_\beta = E \left[ \mu_F(\delta) \delta^{\frac{1}{1-\beta}} \right]$$

The expressions on the right of (5) are the incremental values of each type of NS capital, reflecting the insurance properties discussed earlier. To isolate the key determinants of demand, let  $\pi_j = \text{Pr}(\delta_j)$  with  $\delta = 0$  in some state. Then  $d\pi_j > 0$  raises expected harm and

$$(6) \quad \frac{\partial \lambda_\alpha}{\partial \pi_j} \propto \delta_j^{\frac{1}{1-\alpha}} - \Phi_\beta \delta_j^{\frac{1}{1-\beta}}$$

$$\frac{\partial \lambda_\beta}{\partial \pi_j} \propto \delta_j^{\frac{1}{1-\beta}} - \Phi_\alpha \delta_j^{\frac{1}{1-\alpha}},$$

where  $\Phi_\beta > 1$  and  $\Phi_\alpha < 1$ . Expressions (6) define critical values of  $\delta$  for which “demands” are increasing or decreasing. To make the distinction stark, let  $\beta = 0$ , so the alternatives are

level of future emissions (say by other nations) while  $\delta$  was known, then a technology with  $\beta = 0$  provides value but no hedge against risk.

<sup>5</sup> Specifications that automatically satisfy the restriction  $M < D$  add complication without much additional insight.

precautionary sacrifice versus flexible technology deployable ex post. Then

$$(7) \quad \frac{\partial \lambda_\alpha}{\partial \pi_j} > 0 \Leftrightarrow \delta_j^{1-\alpha} > \Phi_\beta,$$

$$\frac{\partial \lambda_\beta}{\partial \pi_j} < 0 \Leftrightarrow \delta_j^{1-\alpha} > \Phi_\alpha^{-1}.$$

With only one technology  $d\pi_j > 0$  increases investment. But alternatives create substitution, so one or the other approach becomes *less* useful when particular risks are more likely. If  $\delta_j$  is large,  $d\pi_j > 0$  raises demand for the scalable technology  $\alpha$ , but ex ante precaution may decline. For example, current efforts to reduce carbon emissions are less attractive if future harm is so costly that the scalable technology becomes economically viable. Similarly, with a scalable military option greater threats may reduce the use of precautionary tools such as diplomacy and aid.

### III. Conclusions

We have defined *national security* as a class of public good investments designed to mitigate the potential for large-scale societal losses. We show that NS investments may have very low or even negative expected rates of return because they pay off precisely when marginal willingness to pay for mitigation efforts is highest. This means that the social rate of discount applied to such investments can be quite low—often below the “risk free” rate. Further, NS investments often apply to events in which mortality risks are high, such as military conflicts and disease prevention, which also raises their value because potential losses are not marginal reductions in

consumption, but rather the full value of lives that may be lost.

NS capital that can be applied against a variety of threats exhibits an economy of scale or scope, in which greater potential harm from one type of threat drives greater investment, which enhances security against other threats. Viewed the other way around, the “peace dividend” provided by the elimination of an extreme threat rationally reduces investment, which makes other threats more costly due to reduced capacity. Finally, we demonstrate the value of ex ante technologies that are flexible and scalable ex post, when the nature of threats is known. More extreme threats will raise the value of such scalable alternatives but may reduce the value of ex ante precaution.

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