National Missile Defense and Deterrence

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The current stance of the Bush administration has renewed debate on the implications of national missile defense. While a large part of that debate concerns its technical and economic feasibility, there is also considerable debate concerning the ramifications of national missile defense for international peace and stability. Unfortunately, few studies have analyzed the implications of missile defense through the lens of deterrence theory. Those that have were based on classical deterrence theory, which is plagued by a variety of logical inconsistencies and empirical anomalies. Accordingly, I examine the implications of national missile defense for deterrence from the vantage point of an alternative theory of deterrence, perfect deterrence theory. The results indicate that national missile defense generally enhances the stability of deterrence; the greatest threat missile defense poses is causing dissatisfaction in potential challengers.

The development of systems that defend against ballistic missiles has been a recurring topic of discussion in both academic and governmental circles since the first ballistic missile, the V-2, was deployed by Germany during the Second World War. National missile defense (NMD) was hotly debated during the late 1960s and early 1970s, leading to the Anti-Ballistic Missile Treaty between the United States and Soviet Union in 1972.

Debate was renewed in earnest during the 1980s following Reagan's famous Star Wars speech and the resultant Strategic Defense Initiative. Although discussion quieted dramatically in the 1990s, the election of George W. Bush in 2000 renewed debate on the implications of national missile defense (Payne 2001). Despite debate over missile defense, President Bush announced an American withdrawal from the ABM Treaty in December 2001, and pressed forward with the development and deployment of a national missile defense program.

A large part of the debate over missile defense concerns its technical and economic feasibility. Many argue that the technologies required for effective missile defense are so far beyond our reach that any defense system developed in the near-term is bound to be highly ineffective. Furthermore, national missile defense is costly, regardless of its effectiveness. Nonetheless, the United States is currently developing and deploying a national missile defense system. As of December 2005, ten ground-based interceptors (8 in Alaska, 2 in California) have been emplaced (Missile Defense Agency 2005). Current plans call for up to 40 ground-based interceptors to be deployed by 2010 (Government Accountability Office 2005).

There is also debate concerning the ramifications of national missile defense for international politics. In particular, some claim that an effective defense against nuclear retaliation would undermine deterrence, thereby significantly increasing the likelihood of international conflict (Brams and Kilgour 1988; Lebovic 2002; Powell 2003). These concerns flow from classical deterrence theory, a la Schelling (1960, 1966), a point that has even been made in the news media (Zakaria 2001). However, classical deterrence theory is plagued by a variety of logical inconsistencies and empirical anomalies (Zagare 1996; Quackenbush 2005). Zagare and Kilgour (2000) have developed an alternative theory of deterrence, perfect deterrence theory, which is logically consistent and has enjoyed strong support through a series of empirical tests (Quackenbush 2006; Senese and Quackenbush 2003; Quackenbush and Zagare 2006).

Accordingly, I examine the implications of national missile defense for deterrence from the vantage point of perfect deterrence theory. Following a review of the existing literature, I apply perfect deterrence theory to examine the impact of missile defense effectiveness on deterrence. I also examine the impact that Challenger's satisfaction and risk propensity have on the likelihood of deterrence success. The analysis demonstrates that national missile defense generally makes deterrence success more likely.

National Missile Defense and International Security

Much has been written on national missile defense, particularly in the past three decades.[1] Some scholars have focused on evaluating the basic factors that lead to varying missile defense effectiveness (e.g., Wilkening 2000; Lebovic 2002), while others (e.g., Lennon 2002; Wirtz and Larsen 2001; Urayama 2004; Sokolsky 2001) have debated anticipated reactions by Russia, China, and other countries. The largest portion of the literature (e.g., Krepon 2003; Cordesman 2002; Lindsay and O'Hanlon 2001; Lennon 2002; Wirtz and Larsen 2001; Miller and Van Evera 1986) has

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[1] Denoon (1995) provides a useful historical overview of the development of missile defense programs within the context of United States national security policy through the 1990s. For a detailed review of the 1980s literature on the strategic defense initiative, see Lawrence (1987).

focused on evaluating various policy options confronting the United States with respect to national missile defense. This literature is noteworthy in its lack of consensus on the impact that national missile defense would have on deterrence. Some (e.g., Lindsay and O'Hanlon 2001) have argued that effective defense is stabilizing and should thus be pursued, while many others (e.g., Miller 2001) have argued that national missile defense is inherently destabilizing and should be avoided.

Unfortunately, none of these analyses of the impact of national missile defense have been based upon deterrence theory. This is particularly troubling because debate over one of the most important national security policy choices today is guided by what is, at best, an incomplete understanding of the actual ramifications on deterrence. Two notable exceptions are the works by Brams and Kilgour (1988) and Powell (2003), which both approach the issue through the lens of classical deterrence theory.

Brams and Kilgour (1988) focus their analysis on Reagan's Strategic Defense Initiative. They account for possession of missile defense systems by both sides within a game-theoretic model of mutual deterrence based on Chicken. As with classical deterrence theory more generally, Brams and Kilgour conclude that a second-strike capability is the key to successful deterrence. Therefore, they conclude that a comprehensive missile defense system would undermine deterrence because it threatens the opponent's second-strike capability.

However, the Deterrence Equilibrium that Brams and Kilgour (1988) base their conclusions upon is not subgame perfect. As they note, "if deterrence for any reason should fail, it is irrational to retaliate, even on a probabilistic basis, because retaliation leads to a worse outcome" (Brams and Kilgour 1988: 9). But their entire analysis rests on precisely this irrational threat of retaliation. Thus, while they assume that states are rational when being deterred, Brams and Kilgour must simultaneously assume that states are irrational when issuing deterrent threats. In order to maintain logical consistency, perfect equilibria—which allow only rational threats—are needed (Harsanyi 1977; Quackenbush 2004; Zagare 1990).

Powell (2003) conducts a more sophisticated analysis of the impact of national missile defense on deterrence within the umbrella of classical deterrence theory. He assumes that the underlying preference orderings are consistent with Chicken—most importantly, that concession is always preferred to conflict. Rather than rely on irrational deterministic threats, Powell assumes that states are able to make threats that leave something to chance (Schelling 1960).

These threats allow Defender to circumvent the problem of irrational action by threatening to take action, "that raises the risk that the situation will go out of control and escalate to a catastrophic nuclear exchange" (Powell 2003: 90). Thus, rather than relying upon a threat to make an irrational choice for war, Defender can simply make a rational choice to raise the risk of war and leave the question of whether war starts or not to chance. Powell (1990, 2003) demonstrates that threats that leave something to chance not only lead to successful deterrence, but the resulting equilibrium is perfect as well.

However, the idea of threats that leave something to chance rests upon the possibility of accidental war. There is a lot of speculation about this possibility (e.g., Schelling 1966; Bracken 1983; Blair 1993; Sagan 1993), with the outbreak of World War I often cited as the prime example of an inadvertent war.[2] However, Trachtenberg (1991: 99) conducts an extensive examination of the coming of the First World War and concludes that:

> when one actually tests these propositions against the empirical evidence, which for the July Crisis is both abundant and accessible, one is struck by how weak most of the arguments turn out to be. The most remarkable thing about all these claims that support the conclusion about events moving "out of control" in 1914 is how little basis in fact they actually have.

The prime example of accidental war turns out to be not such a good example after all. Rather than support the idea, the outbreak of World War I actually undermines the idea of threats that leave something to chance. Contrary to Bracken (1983), evidence indicates that the idea of accidental nuclear war is unrealistic *because* of the history of the outbreak of World War I. States must choose whether to fight or back down; nature does not choose for them.

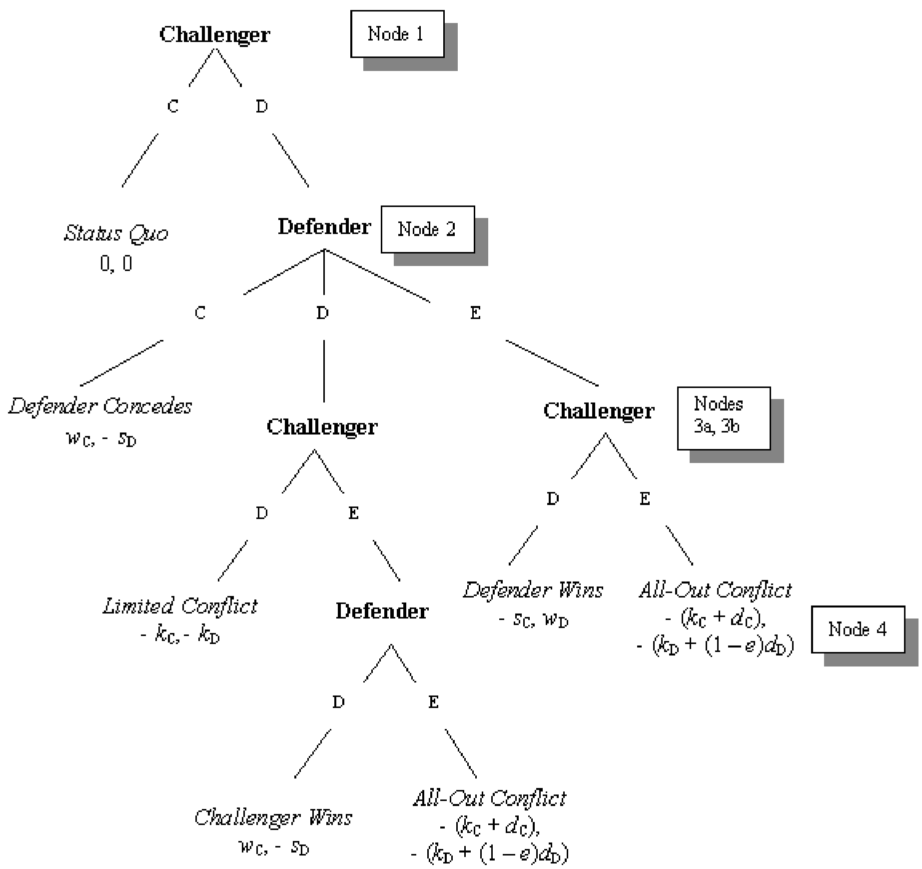
Unlike classical deterrence theory, perfect deterrence theory (Zagare and Kilgour 2000) requires that all conflict choices be made by the players, not nature. Furthermore, classical deterrence theory and perfect deterrence theory make different assumptions regarding the credibility of states' deterrent threats. A state's threat is credible if it is believable, and the threat is believable if it is (or might be) rational to carry out (Zagare 1990). Because classical deterrence theory assumes that concession is always preferred to conflict, it assumes that states' threats inherently lack credibility. Perfect deterrence theory argues that states sometimes prefer conflict to backing down. Furthermore, perfect deterrence theory demonstrates that these credible threats are important determinants of deterrence success.

Missile Defense Effectiveness and Deterrence

To explore the implications of perfect deterrence theory regarding the impact of national missile defense systems on deterrence, I utilize the Asymmetric Escalation Game developed by Zagare and Kilgour (1993, 2000). I focus on this game because it specifically models choices of escalation—precisely the choices that must be examined to understand the impact of national missile defense on deterrence. This game, shown in Figure 1, involves two players, Challenger

[2] For example, Bracken (1983: 65) states that the idea of accidental nuclear war might sound unrealistic "were it not for the history of the outbreak of World War I."

FIGURE 1
ASYMMETRIC ESCALATION GAME



and Defender. Challenger begins play by choosing whether to cooperate (C) or defect (D). If Challenger cooperates, the game ends with *Status Quo* as the outcome; if he defects, Defender must choose how to respond. At decision node 2, Defender can concede (C), respond-in-kind (D), or escalate (E). Depending on Defender's choice, Challenger can either escalate first (at node 3a) or counter-escalate (at node 3b), or not. If Challenger escalates first, Defender has an opportunity, at node 4, to counter-escalate. The outcomes associated with the various choices in the Asymmetric Escalation Game are summarized in Figure 1.

In keeping their analysis general, Zagare and Kilgour (2000) do not assume any particular components of each actor's utility for the various game outcomes. However, to understand the impact of national missile defense on deterrence, it is important to differentiate between the costs of conventional and nuclear war. To accomplish this and maximize comparability with Powell's (2003) analysis, I have incorporated his notation into the Asymmetric Escalation Game. Each state's utility for the *Status Quo* is normalized to be zero (gains from the status quo are positive; losses are negative). If a state concedes, it receives $-s$ while the winner receives w. If the two states fight, but do not escalate the conflict by using nuclear weapons, then the outcome is called *Limited Conflict* and each state receives $-k$, the cost of fighting a conventional war.

Finally, if both states escalate the conflict, then the outcome is called *All-Out Conflict*. Challenger receives $-(k_C + d_C)$, the cost of conventional conflict plus the cost of fighting a nuclear war. Defender, who possesses a NMD system, receives $-(k_D + (1- e)\, d_D)$, where e is the effectiveness of the NMD system. When $e = 0$, NMD is zero percent effective (or non-existant) and Defender's utility for *All-Out Conflict* is equivalent to Challenger's. As e increases, Defender's payoff for *All-Out Conflict* increases until, at $e = 1$ (i.e., 100 percent NMD effectiveness), Defender's utility is equal to her utility for *Limited Conflict* ($-k_D$).

Powell (2003) assumes that winning produces a gain from the status quo, whereas backing down produces a loss and nuclear war produces an even larger loss; i.e., that $w \geq 0 \geq -s \geq -d$. Furthermore, Powell assumes that these payoffs are common knowledge. In that case, the *Status Quo* is the sole subgame perfect equilibrium outcome, regardless of whether the cost of conventional conflict ($-k$) is greater than or less than the cost of backing down ($-s$). More importantly for the present analysis, the effectiveness of Defender's national missile defense system, e, has no impact on the equilibrium outcome.

With complete information, deterrence only fails if Challenger has a credible threat and Defender does not. For example, if $w_C \geq 0 \geq -k_C \geq -d_C \geq -s_C$, but $w_D \geq 0 \geq -k_D \geq -s_D \geq -d_D$, then Challenger's threat is credible because backing down produces his worst outcome whereas Defender's threat is not credible because she prefers backing down to conflict. In this case, the equilibrium outcome is *Defender Concedes*, as can easily be determined through backwards induction.

However, Defender's NMD system can have a stabilizing effect in these situations. As e increases, Defender's utility for conflict, $-(k_D + (1-e)\, d_D)$, increases. Eventually, the cost of *All-Out Conflict* will be reduced enough that Defender prefers this outcome to *Challenger Wins*. For example, if we assume, consistent with Powell's (2003) parameter assumptions, that $k_D = 0.1$, $s_D = 0.5$, and $d_D = 1$, then Defender's threat becomes credible when $e > 0.6$.

With complete information, national missile defense affects the likelihood of deterrence only under certain conditions. If Defender prefers conflict to backing down (i.e., is Hard, in the vernacular of perfect deterrence theory), then deterrence always succeeds, regardless of NMD effectiveness. However, if Defender is Soft (i.e., prefers concession to conflict) and Challenger is Hard, then NMD has an important impact. If Defender's missile defense system is effective enough, then Defender's costs for *All-Out Conflict* are reduced enough that she no longer prefers to back down; thus, her threat is credible. Hence, if classical deterrence theory is correct in its assumption that the high costs of nuclear war make all-out conflict the worst outcome, then effective national missile defense is stabilizing.

The more interesting and more empirically relevant situation to consider is where states have incomplete information regarding each others' preferences. In particular, while states can safely assume that others prefer winning to the status quo and the status quo to backing down, states face a great deal of uncertainty regarding other states' preference between conflict and backing down. That is, states often have incomplete information regarding their opponents' credibility.

In the Asymmetric Escalation Game, Defender has threats at two levels. The first threat is at the tactical (conventional) level, and its credibility is determined by her preference between *Limited Conflict* and *Defender Concedes*; the second is at the strategic (nuclear) level, and is determined by her preference between *All-Out Conflict* and *Challenger Wins*. Simultaneously modeling incomplete information regarding each of these threats leads to a quite complicated analysis (Zagare and Kilgour 1998).

However, this analysis can be simplified by focusing on a policy of flexible response, which the United States has relied upon since the 1960s (Denoon 1995). Zagare and Kilgour (1995, 2000) model this flexible response posture by assuming that Challenger is uncertain about Defender's preference between *All-Out Conflict* and *Challenger Wins*, but Defender is known to prefer *Limited Conflict* to *Defender Concedes*. Thus, Defender's tactical level threat is credible, but her strategic level threat is uncertain.

Zagare and Kilgour (2000) provide complete proofs and discussion of the perfect Bayesian equilibria that result from this game. The most relevant equilibria for the present analysis are called Limited Response Deterrence Equilibria (LRDE). At these equilibria Challenger never defects initially, so general deterrence always succeeds. Challenger is deterred because Defender always responds-in-kind with some positive probability. However, Defender never escalates first.[3] These equilibria exist when Defender's threat is credible enough to convince Challenger that initiating a challenge is too risky. Specifically, p_{Def} must be greater than the critical condition c^*, which I label Challenger's deterrence threshold, where:

$$c^* = \left(\frac{c_{DC} - c_{SQ}}{c_{DC} - c_{DD}}\right)\left(\frac{c_{ED} - c_{DD}}{c_{ED} - c_{EE+}}\right). \tag{1}$$

This expression is a function of c_{EE+}, which is Challenger's utility for *All-Out Conflict* when Hard. Substituting the parameters identified in Figure 1, c^* is:

$$c^* = \left(\frac{w_C - 0}{w_C - (-k_C)}\right)\left(\frac{w_C - (-k_C)}{w_C - (-k_C - d_C)_H}\right). \tag{2}$$

Note that e does not appear in this equation. Therefore, Defender's NMD effectiveness has no impact on c^*.

With complete information, missile defense has a stabilizing effect on deterrence by reducing Defender's cost of *All-Out Conflict* and thereby improving Defender's credibility. When information is incomplete, Defender's credibility is expressed by p_{Def}, the probability that Defender is Hard. Quackenbush (2006) developed a measure for p_{Def} based on a non-linear transformation of the difference between Defender's utility for conflict and her utility for backing down, weighted by Challenger's risk propensity. More formally,

$$p_{Def} = \left[\frac{\mathrm{Exp}[3(\Delta U)]}{1 + \mathrm{Exp}[3(\Delta U)]}\right]^{(1+R_{Ch})} \tag{3}$$

where ΔU is the difference between the utility for conflict and the utility for backing down, and R_{Ch} is Challenger's risk propensity, which varies from –1 (risk averse) to 1 (risk acceptant) as developed by Bueno de Mesquita (1985).[4] Here, the outcomes relevant to ΔU are *All-Out Conflict* and *Challenger Wins*. Substituting terms and simplifying leads to:

$$p_{Def} = \left[\frac{\mathrm{Exp}[3(s_D - (k_D + (1-e)d_D))}{1 + \mathrm{Exp}[3(s_D - (k_D + (1-e)d_D))}\right]^{(1+R_{Ch})}. \tag{4}$$

Note that as e increases, p_{Def} also increases. Thus, increasing effectiveness of Defender's missile defense system increases the likelihood that $p_{Def} > c^*$, which in turn makes general deterrence more likely to succeed.

3 At the only other deterrence equilibria of this game, called Escalatory Deterrence Equilibria, Defender always escalates first. However, these equilibria are based on Defender's implausible belief that, given Challenger's initial defection at node 1, Challenger is likely to be Soft.

4 Exp[x] represents the mathematical function e^x.

FIGURE 2
NMD EFFECTIVENESS AND DEFENDER'S CREDIBILITY WHEN BOTH STATES ARE SOFT

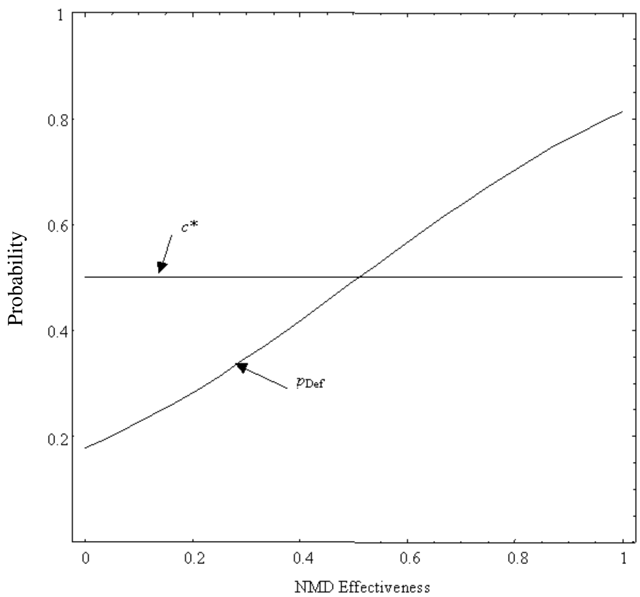
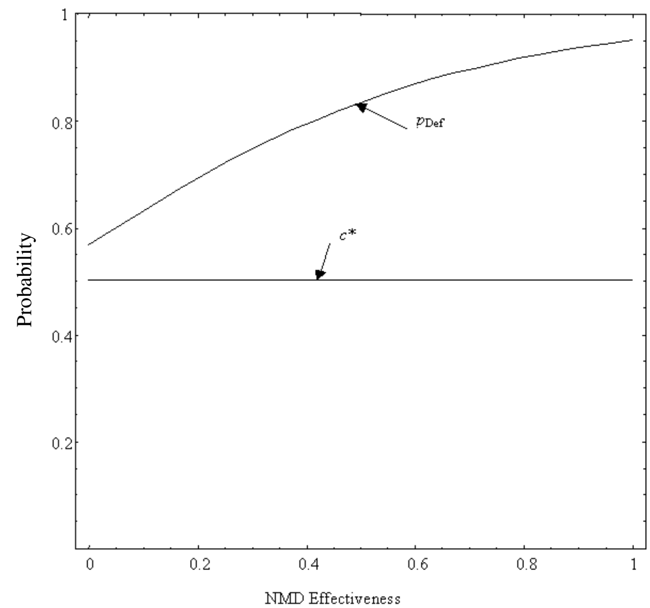


FIGURE 3
NMD EFFECTIVENESS AND DEFENDER'S CREDIBILITY WHEN BOTH STATES ARE HARD



A numerical example will help to visualize this process and make the relationship between national missile defense and deterrence more clear. Following Powell (2003), I assume that $w = 1$, $k_D = 0.01$, $k_C = 0.1$, $s = 0.5$, and $d = 1$ for Soft states; for Hard states, I assume that $w = 1$, $k_D = 0.009$, $k_C = 0.09$, $s = 1$, and $d = 0.9$.[5]

Figure 2 plots p_{Def} and c^* as e varies from 0 to 1 when each state is Soft.[6] As NMD effectiveness increases, Defender's credibility increases as well; however, Challenger's deterrence threshold remains constant. At low levels of missile defense effectiveness ($e < 0.51$), p_{Def} remains less than c^*; hence, Challenger will not be deterred because Defender lacks credibility. However, when Defender's missile defense system is more than 51 percent effective, p_{Def} is greater than c^*, so Defender's threat is credible enough to deter Challenger.

If Defender is Hard, then she prefers *All-Out Conflict* to *Challenger Wins* even without national missile defense. The relationship between p_{Def}, c^*, and e when each state is Hard is shown in Figure 3. As before, Defender's credibility increases as NMD effectiveness increases. However, missile defense does not impact the likelihood of deterrence success since Defender's credibility is always greater than Challenger's deterrence threshold, even with 0% effectiveness.

This analysis reaffirms a primary conclusion of perfect deterrence theory: threat credibility is "the quintessential determinant of deterrence success" (Zagare and Kilgour 2000: 296). As long as Defender's threat is credible, national missile defense is superfluous. However, if Defender prefers to back down rather than fight a nuclear conflict, then national missile defense has an important stabilizing effect. Note that classical deterrence theory assumes that all states prefer backing down to nuclear war. Although classical deterrence theorists argue that missile defense is destabilizing (e.g., Brams and Kilgour 1988), perfect deterrence theory demonstrates that, if nuclear war is the worst possible outcome, national missile defense greatly enhances the likelihood of deterrence success.

Missile Defense and Satisfaction

If national missile defense's only impact is on Defender's preferences, then increasing NMD effectiveness increases the likelihood of successful deterrence by making Defender's threat more credible. However, some have argued that American development of an effective NMD system will be destabilizing because it will lead to other states' dissatisfaction with the status quo (e.g., Bundy et al. 1984/1985; Miller 2001).

As discussed above, both sides have been assumed to receive a payoff of zero from the *Status Quo*. If Defender's defense system causes Challenger to be dissatisfied, then Challenger's utility from the *Status Quo* is not strictly zero. To account for dissatisfaction, I assume that Challenger's utility for the *Status Quo* is

$$c_{SQ} = -b\,e, \tag{5}$$

[5] These numerical values are used for each of the figures presented below. Changing specific values does not impact the conclusions, as long as their ordering remains the same.

[6] Defender's credibility parameter, p_{Def}, is a function of her type (Hard or Soft) because it is defined in terms of Defender's utilities for backing down and conflict (see equation 4). Thus, for this and each of the analyses to follow, I explore the impact of missile defense effectiveness separately when Defender is Hard or Soft.

FIGURE 4
MISSILE DEFENSE AND SATISFACTION WHEN BOTH STATES ARE SOFT

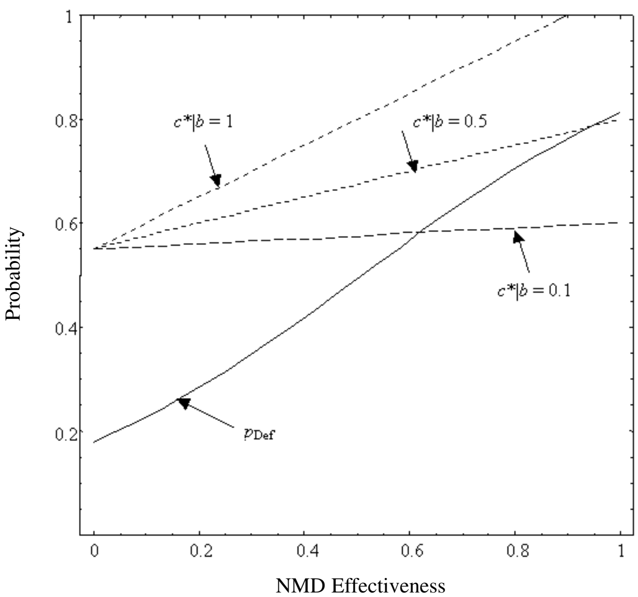
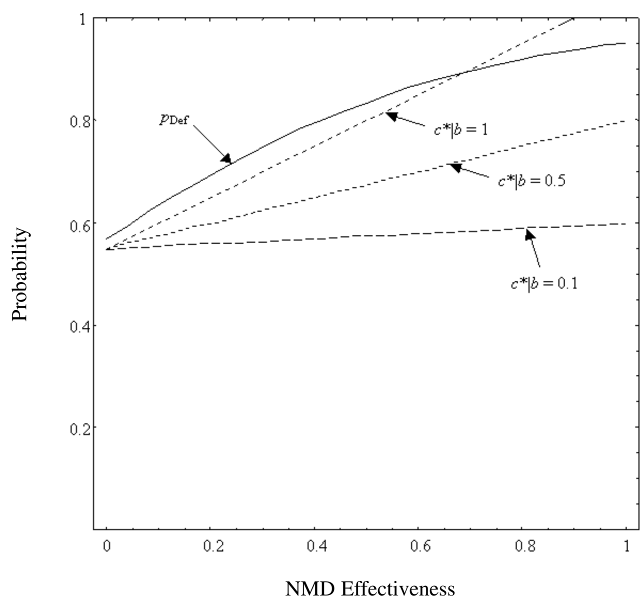


FIGURE 5
MISSILE DEFENSE AND SATISFACTION WHEN BOTH STATES ARE HARD



where b is a parameter that accounts for the extent to which Defender's NMD causes Challenger to be dissatisfied and e is Defender's NMD effectiveness. If $b = 0$, then Defender's defense does not affect Challenger's level of satisfaction; accordingly, c_{SQ} is always zero.

However, if b is greater than zero, then Challenger becomes increasingly dissatisfied with the status quo as Defender's defense system becomes increasingly effective, likely as a result of being less able to exert influence over Defender. Larger values of b indicate that Challenger is less satisfied with a given level of NMD effectiveness than smaller values of b.

The importance of Challenger's satisfaction with the status quo as a determinant of deterrence outcomes is highlighted by perfect deterrence theory (Zagare 2004). Equation 1 shows that Challenger's deterrence threshold, c^*, is a function of c_{SQ}. Therefore, substituting equation 5 into equation 1 results in

$$c^* = \left(\frac{w_C - be}{w_C - (-k_C)}\right)\left(\frac{w_C - (-k_C)}{w_C - (-k_C - d_C)_H}\right) \qquad (6)$$

as the appropriate specification of c^*, rather than equation 2.

Figure 4 shows the impact of e on p_{Def} and c^* (where b = 0.1, 0.5, and 1) when each state is Soft. At $b = 0.1$, c^* slopes slightly upward as e gets larger. This slightly increases the minimum level of missile defense effectiveness needed for successful deterrence (i.e., $p_{Def} > c^*$). As b increases, c^* slopes upward more sharply. At $b = 0.5$, a soft Defender's NMD effectiveness must be nearly 100 percent in order for $p_{Def} > c^*$. At $b = 1$, c^* slopes upward so sharply that p_{Def} is always less than c^*; thus, a soft Defender's threat is never credible enough to deter a very dissatisfied Challenger.

The relationship between e, p_{Def}, c^*, and b when each state is Hard is shown in Figure 5. The discussion above demonstrates that Defender's credibility parameter (p_{Def}) is always greater than Challenger's deterrence threshold (c^*) when Defender is Hard and Challenger's status quo evaluation is not affected by Defender's missile defense system (see Figure 3). When Defender's missile defense system does affect Challenger's satisfaction, Hard Defenders are again significantly more likely to deter Challenger. At low and moderate levels of b, p_{Def} is always greater than c^*. However, if b is very high, deterrence becomes more problematic. Specifically, when $b = 1$, p_{Def} is greater than c^* for lower levels of NMD effectiveness; but when e becomes too large, Challenger is so dissatisfied with the status quo that he is not deterable ($p_{Def} < c^*$).

Thus, the potential for NMD to increase Challenger's dissatisfaction with the status quo presents the greatest threat that national missile defense will undermine deterrence stability. However, it is important to note that Defender's credibility remains the most important determinant of deterrence success. If Defender prefers to back down rather than carry out its threat, then deterrence will always fail even without NMD.

On the other hand, if Defender prefers to retaliate rather than back down, and thus has a credible threat, then deterrence almost always succeeds. The only exception is when Challenger is highly dissatisfied by Defender's nearly perfect NMD system (see Figure 5). However, in this case Challenger's utility for the status quo is so low that the status quo is nearly his least preferred outcome (it is only slightly better than *All-Out Conflict*). Whether Defender's defense system would engender dissatisfaction to that extent is highly questionable; future research on this issue is clearly warranted.

FIGURE 6
MISSILE DEFENSE AND RISK PROPENSITY WHEN BOTH STATES ARE SOFT

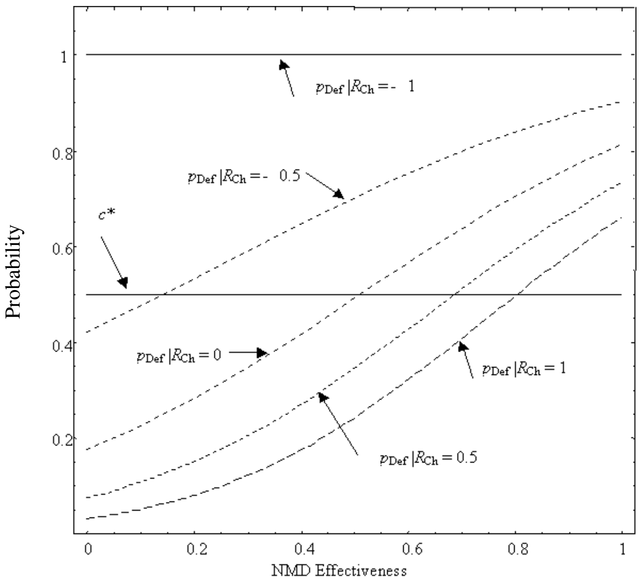
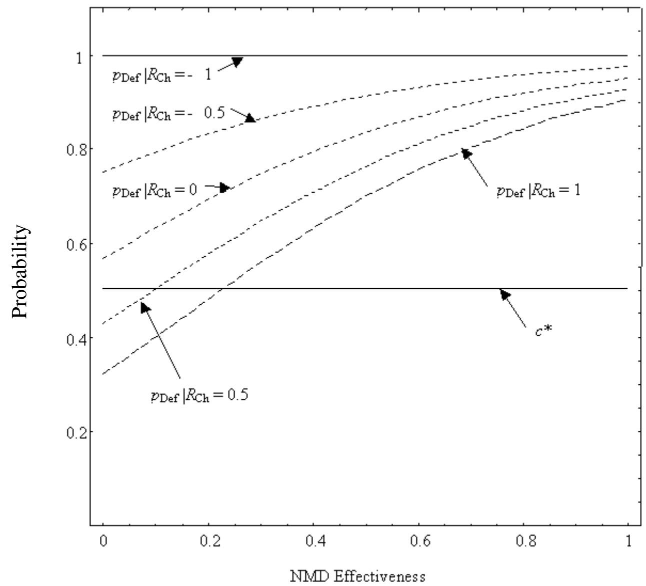


FIGURE 7
MISSILE DEFENSE AND RISK PROPENSITY WHEN BOTH STATES ARE HARD



Rogue States and Risk Propensity

To this point, it has been assumed that Challenger is risk neutral. Current American plans for NMD are intended to enhance deterrence of rogue states such as North Korea and Iran. Walt (2000) and Powell (2003) argue that rogue states are "especially willing to take risks" (Walt 2000: 193). Thus, in formal terms, rogue states are likely to be highly risk acceptant rather than being risk neutral (or risk averse).

The Bush and Clinton administrations have repeatedly argued that the United States needs to develop and deploy NMD systems because it is harder to deter highly risk acceptant, rogue states (Slocombe 2000). Is this view justified? More generally, what impact does Challenger's risk propensity have on the likelihood of deterrence success?

Fortunately, this question is easy to address within the theoretical framework developed here. Note from equation 4 that p_{Def} is a function of Challenger's risk propensity, R_{Ch}. The analyses above have assumed that Challenger is risk neutral ($R_{Ch} = 0$). However, the more risk averse ($R_{Ch} < 0$) Challenger is, the more he over-estimates Defender's credibility. For example, a completely risk averse Challenger ($R_{Ch} = -1$) will assume that Defender is always Hard ($p_{Def} = 1$). On the other hand, a risk acceptant Challenger ($R_{Ch} > 0$) will underestimate the probability that Defender is Hard. For example, a completely risk acceptant Challenger ($R_{Ch} = 1$) will estimate p_{Def} to be only 0.25 (rather than 0.5) even when ΔU is zero.

Figure 6 shows the impact of Challenger's risk propensity on deterrence when both states are Soft. The middle curve is p_{Def} when Challenger is risk neutral, and is equivalent to the plot of p_{Def} in Figure 2. As Challenger becomes more risk averse ($R_{Ch} < 0$), p_{Def} increases. Thus, Defender is able to deter Challenger ($p_{Def} > c^*$) even with an ineffective NMD system. However, if Challenger is risk acceptant ($R_{Ch} > 0$) as many have argued rogue states are, p_{Def} decreases. Challenger's underestimation of Defender's credibility makes it more difficult for deterrence to work; Defender's national missile defense system needs to be highly effective (around 70–80 percent) in order for her credibility parameter to be greater than Challenger's deterrence threshold.

The relationship between Challenger's risk propensity, NMD effectiveness, and deterrence when both states are Hard is shown in Figure 7. As seen in the situations examined above, deterrence is much more effective when Defender is Hard. However, if Challenger is highly risk acceptant then he underestimates Defender's credibility to such an extent that p_{Def} is less than c^* for low levels of NMD effectiveness. Therefore, although missile defense is unnecessary to deter a risk-neutral Challenger when Defender is Hard, a minimal level of NMD effectiveness (about 20–30 percent) is needed to deter a risk-acceptant Challenger.

It is harder to deter a risk-acceptant Challenger, and easier to deter a risk-averse Challenger, compared to a risk-neutral Challenger. For any level of risk-propensity, deterrence works best when Defender's threat is credible (i.e., Defender is Hard). Although national missile defense is not needed to deter a risk-neutral Challenger when Defender is Hard, NMD has an important stabilizing effect when Challenger is risk-acceptant. Thus, if the assumption that rogue states such as North Korea and Iran are highly risk-acceptant is correct, then the United States is justified in its belief that NMD would have an important effect on enhancing deterrence stability.

Implications

Debate on the implications of national missile defense for deterrence has been muddied by persistent failures to examine the issue from the vantage point of deterrence theory. In this paper, I have sought to address this void in the literature by applying perfect deterrence theory to examine the impact of missile defense effectiveness on deterrence.

The baseline analysis demonstrates that as long as Defender's threat is credible, national missile defense is superfluous. However, if Defender prefers to back down rather than fight a nuclear conflict, then national missile defense has an important stabilizing effect. Furthermore, the potential for missile defense to increase Challenger's dissatisfaction with the status quo presents the greatest threat that national missile defense will undermine deterrence stability, although even then deterrence almost always succeeds as long as Defender's threat is credible. Finally, the analysis shows that national missile defense has an important stabilizing effect when Challenger is risk-acceptant, as rogue states are often assumed to be.

These results demonstrate that national missile defense generally enhances the stability of deterrence. In particular, if classical deterrence theorists (e.g., Brams and Kilgour 1988; Powell 2003) are correct to assume that the high costs of nuclear war make conflict the worst possible outcome, then effective national missile defense is the only way to achieve successful deterrence. Nonetheless, perfect deterrence theory's conclusion that threat credibility is an important determinant of deterrence success is well supported here (Zagare and Kilgour 2000; Zagare 2004). National missile defense is stabilizing precisely because it makes Defender's retaliatory threat more credible.

The primary threat that missile defense will undermine deterrence is that it will engender strong dissatisfaction in other states. Although there is a lengthy literature debating this point (e.g., Lennon 2002; Wirtz and Larsen 2001; Urayama 2004; Sokolsky 2001), no one has conducted a rigorous empirical analysis of this issue. This remains a significant gap in the literature, and a rigorous analysis of the impact of American missile defense programs on other states' status quo evaluations is an important avenue for future research.

Following Powell (2003), I have focused on the situation where the defender in a situation of asymmetric deterrence possesses a missile defense system. This is the most relevant scenario today, as the United States is deploying a limited national missile defense system targeted at enhancing deterrence of small, 'rogue' states such as North Korea or Iran.

The limited missile defense system currently being deployed by the United States would pose no threat to the much larger nuclear arsenals of Russia and China (Wilkening 2000).[7] Lindsay and O'Hanlon (2001), among others, argue that the United States should keep its missile defense system limited in nature because a comprehensive NMD system would undermine Russia's second-strike capability and therefore undermine deterrence. However, perfect deterrence theory has demonstrated that a second-strike capability is not the panacea that classical deterrence theory has assumed it to be. Hence, a detailed analysis of a more comprehensive defense system from the perspective of perfect deterrence theory is another important direction for future research.

The primary policy implication of this study is that the development of national missile defense by the United States will have an important stabilizing effect on deterrence. In addition, missile defense may play an important role in efforts to halt and reverse nuclear proliferation (Utgoff 2002). However, the United States should also take steps to ensure that NMD does not engender widespread dissatisfaction in other states that form actual or potential nuclear threats.

[7] Wilkening (2000) demonstrates that missile defense system effectiveness is a function of 1) the number of NMD interceptors, 2) the number of attacking warheads, and 3) the probability that each warhead can be successfully tracked and intercepted. Therefore, although a limited NMD system might be highly effective against a state with a small number of warheads, it would be highly ineffective if the number of attacking warheads was much larger.

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