Uncertainty and Deterrence

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ABSTRACT   The decision to initiate or refrain from war is accompanied by multifarious uncertainty. Uncertainty deters, but deterrence is uncertain. What looks like the better option may be more uncertain than the alternative, so the decision maker may choose the putatively less attractive option. We develop an analytical framework for studying this reversal of preference. The analysis uses two concepts: the innovation dilemma and robust satisficing. A decision maker faces an innovation dilemma when choosing between a new, innovative, but poorly understood option, and a standard option that is more thoroughly understood. The decision maker wants the best possible outcome, but all outcomes are highly uncertain. The robustly satisficing choice is the one that satisfies critical requirements despite large error or surprise. We discuss an historical example: the 6 Day War. We also apply our analysis to a theoretical question: Does uncertainty increase the propensity for war?

KEYWORDS: Deterrence, Uncertainty, Info-Gaps, Robustness, Satisficing, Innovation Dilemma, Six Day War.

Introduction

Strategic decisions of war or peace are surrounded by uncertainty arising from geopolitics, the adversary's intentions, third parties, doctrinal innovations, new technologies and more. What looks

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like the better option may, due to surprising future developments, turn out much worse than a putatively worse option. When one option looks better but is far more uncertain than another option, the planner may select the latter option even though it is putatively less attractive. In making one's own choices, or when anticipating the choices of an adversary, one must consider both the estimated outcomes of the options and the uncertainties of these estimates. Preference ranking of options may be reversed from their putative order due to uncertainty. We develop an analytic framework for studying this reversal of preference in evaluating deterrence that does not depend on any probabilistic assumptions. We are not proposing a theory of deterrence, but rather a method for analyzing and choosing between options. The analysis is based on two concepts: the innovation dilemma and robustly satisfying critical requirements.

We respond to two weaknesses in theories of deterrence. First, the treatment of uncertainty is inadequate. Deductive mathematical approaches from rational-choice theory often treat uncertainty as a probability which, even when labeled as subjective, is too structured to capture the richness of decision makers' ignorance. Inductive or case-based theories are vulnerable to Solomon's error of presuming that the rich diversity of the past characterizes the rich variability of the future.[2] In fact, the future is far more surprising and inventive than the past. Second, rational choice theories of deterrence presume that the decision maker's goal is, and should be, to achieve the substantively best possible outcome. This is not prescriptively feasible under severe uncertainty. Rather, decision makers should prioritize their options according to robustness against surprise in attempting to achieve critical (not necessarily optimal) outcomes.

A decision maker faces an **innovation dilemma** when choosing between a new and innovative option and the current state of the art.[3] The innovation dilemma is a paradigm, a metaphor—originating in the technological realm—that is relevant to decisions under uncertainty in all domains, including the strategic decision to initiate or refrain from war. Returning to the metaphor, new technologies often yield better outcomes than standard technologies. However, what is new is usually less thoroughly studied and less well understood than what is old. Hence the new technology may entail unexpected and severely adverse consequences that could make it much worse than the current state of the art. The strategic planner who must choose between an innovative strategy and a more standard policy faces an innovation dilemma. The innovation dilemma is a paradigm for the dilemmas of uncertainty that face the strategic planner, even when the options do not entail innovative technology. The innovation dilemma is—in many situations—an instance of the security dilemma[4] due to the great uncertainty surrounding the intentions and capabilities of a state's potential adversaries, as discussed elsewhere.[5]

Robust satisficing is motivated by severe uncertainty. Good outcomes are better than bad outcomes, suggesting that the best outcome is best. However, when an option must be selected despite severe uncertainty in the outcomes of all available options, the logic of outcome-optimization is not implementable: we don't know which option will have the best outcome. In this situation the strategic decision maker in a deterrent situation can ask: what outcome must be achieved, or equivalently, what is the worst tolerable outcome? Under severe uncertainty, the robust-satisficing planner chooses the option that will achieve the required outcome over the widest range of deviation

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[2]"That which was, will be; that which was done, will be done again; there is nothing new under the sun", *Ecclesiastes,* 1:9.

[3]Yakov Ben-Haim, Craig D. Osteen and L. Joe Moffitt, 2013, Policy dilemma of innovation: An info-gap approach, *Ecological Economics,* 85: 130–138.

[4]Robert Jervis, 1978, Cooperation under the security dilemma, *World Politics,* vol.30, no.2, pp.167–214.

[5]Yakov Ben-Haim, 2014a, Strategy selection: An info-gap methodology, *Defense & Security Analysis,* 30(2): 106–119, see pp.108–109.

of future reality from current anticipation. The robust-satisficing choice may differ from the outcome-optimizing choice, as we will see.

We will show how robust-satisficing is used to manage an innovation dilemma in the context of strategic decisions of war or peace. We are not proposing a theory of deterrence, but rather a method for analyzing and choosing between options. We critique deterrence theory in the next section. In the subsequent section we present a formal analysis of info-gap robust-satisficing,[6] the innovation dilemma and the loss of deterrence. The following section discusses an historical example. Our goal is not descriptive, but rather to illustrate how decision makers could have implemented robust-satisficing as a decision strategy. We then consider a theoretical application, stressing prescription over description.

Three caveats are needed.

First, we discuss binary choices between war and no-war. However, strategic choices are rarely binary. Nonetheless, our analysis provides a conceptual framework for understanding and supporting real decision processes under uncertainty.

Second, our discussion is limited (but not entirely) to conflict between two states. The world is never strictly bipolar, though sub-conflicts, camps or coalitions often emerge that resolve confrontations into bipolarity at some level. Extension to multi-state conflict remains largely unexplored.

Third, we discuss "the planner" or "the decision maker", while governments are rarely unitary actors. However, our analysis can be applied separately to individual protagonists, illuminating their positions. Moreover, the info-gap robust-satisficing methodology is a prescriptive tool for individuals.

Critique of Deterrence Theories

We discuss two issues: treatment of uncertainty, and optimization of outcomes.

Treatment of Uncertainty

We begin by considering deductive rational choice theories.

Huth and Russett conceptualize an expected utility model that "involves analysis of inference about the utilities decision-makers attach to outcomes, and the probabilities they attach (however crudely or vaguely) to achievement of those outcomes."[7]

Wagner, in a series of articles, develops an approach to deterrence based on game theory, with incomplete information represented by subjective probabilities, primarily in the context of bipolar nuclear competition. Wagner argues that bargaining between competing powers exists solely because of "lack of complete information about each other's values."[8] The bargaining hinges on assessments of credibility or probability of threat, rather than certainty of threat. Wagner subsequently argues that "the use of nuclear counterforce strategies ... are not necessarily inconsistent with rational behavior".[9] These game theoretical arguments depend on incomplete information, represented by probabilities of, for instance, strikes, counter-strikes, and levels of damage. Putative values of these probabilities can lead to rational prioritization among the options (e.g. counterforce

[6]Yakov Ben-Haim, *Info-Gap Decision Theory: Decisions Under Severe Uncertainty,* (2006, 2nd edition, London: Academic Press).

[7]Paul Huth and Bruce Russett, 1984, What makes deterrence work? Cases from 1900 to 1980, *World Politics,* 36(4): 496–526, p.498.

[8]R. Harrison Wagner, 1982, Deterrence and Bargaining, *Journal of Conflict Resolution,* 26: 329–358, pp.339, 343.

[9]R. Harrison Wagner, 1991, Nuclear deterrence, counterforce strategies, and the incentive to strike first, *American Political Science Review,* 85:727–749, p.746.

strike or not). Wagner continued the exploration of game theory for "formalization of theories of deterrence that incorporate incomplete information, learning and the development of reputations", and also studied "how much misperception by foreign decision-makers is consistent with rationality, in light of these new developments in game theory."[10] Wagner (1992) has a long section entitled "Deterrence and Uncertainty" in which he explains that each protagonist "must estimate the probability" that the other protagonist will act or not act in particular ways. Furthermore "probability ... can only be a subjective probability" (p.119). After characterizing subjective probability, he explains why it is not necessarily unique, and shows that evaluation of probability can be quite involved. He also notes that there can be dispute over utility assignments (pp.119, 124).

Rapoport, responding to Wagner (1992), emphasizes the "formidable difficulty" in game theory in obtaining a "meaningful operational definition of subjective probability" and a "meaningful operational definition of utility" which "become insuperable in the context of nuclear deterrence".[11] McGinnis, also responding to Wagner (1992), criticizes the "implausibility of some of the underlying assumptions", especially the heavy computational burden required of decision makers to implement a game theoretical analysis. He notes that "neither preferences nor beliefs can be directly observed, and yet knowledge of both is crucial to any determination of equilibrium conditions."[12] Achen and Snidal reply, as presumably Wagner would also, that rational deterrence theory does not suppose the agents actually implement the game theory analysis; only that their behavior is consistent with its rational predictions.[13] McGinnis criticizes the use of game theory because it will "tightly constrain the range of uncertainty", while in fact agents may be uncertain about other's preferences and types and degrees of rationality. McGinnis adds that "crucial aspects of any empirical situation remain outside the formal structure" of game theory.[14]

Wagner's important contribution was incorporation of incomplete information in a game theoretic treatment of deterrence. This incorporation is limited, however, to probabilistic representation of uncertainty. While strict Bayesians maintain that all uncertainty and ignorance can be represented with subjective probability, Wagner expressed some reservations about Bayesian learning, despite its attractive features.[15]

Kilgour and Zagare study deterrence and credibility of threats given "lack of information about the preferences of one's opponent."[16] They consider the prisoners' dilemma and modifications of it, recognizing that "[t]he real world, of course, is not so simple or transparent. It is characterized by, among other things, nuance, ambiguity, equivocation, duplicity, and ultimately uncertainty. Typically, policymakers are unable to acquire complete information about the intentions of their opponents; at best, they can hope to obtain probabilistic knowledge of these key determinants of interstate behavior." (p.312).

Authors from historical-inductive schools address uncertainties such as those mentioned by Kilgour and Zagare, but without employing probability. Stein, in case studies of deterrence in the Middle

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[10]R. Harrison Wagner, 1992, Rationality and Misperception in Deterrence Theory *Journal of Theoretical Politics,* 4(2): 115–141, p.115.

[11]Anatol Rapoport, 1992, Deterrence theory discussion: III: Comments on 'Rationality and misperceptions in deterrence theory', *Journal of Theoretical Politics,* 4(4): 479–484, p.481.

[12]Michael D. McGinnis, 1992, Deterrence theory discussion: I: Bridging or broadening the gap? A comment on Wagner's 'Rationality and misperception in deterrence theory', *Journal of Theoretical Politics,* 4(4): 443–457, pp.446, 447.

[13]Christopher H.Achen and Duncan Snidal, 1989, Rational deterrence theory and comparative case studies, *World Politics,* 41(2): 143–169, pp.160, 164.

[14]McGinnis, 1992, *op. cit.,* p.448.

[15]Wagner, 1992, *op. cit.,* pp.138–139.

[16]Kilgour, D. Marc and Frank C. Zagare, 1991, Credibility, uncertainty, and deterrence, *American Journal of Political Science,* 35(2): 305–334, p.306.

East, emphasizes that success or failure of deterrence depends on leaders' judgments, suspicions and fears on many diverse issues, including opportunities, vulnerabilities, challenges, political or psychological needs, balance of power, broad historic or intrinsic interests, and long-term strategic reputation. Also, a leader's attention to issues may change over time as circumstances change.[17]

Likewise, Lebow and Stein claim that theories of deterrence based on rational choice theory "are incomplete and flawed" because judgments of "[s]ubjective expected utility will vary enormously depending on actors' risk propensity and relative emphasis on loss or gain" and because they ignore factors such as domestic politics. They also point out that leaders' preferences will change over time. They assert that "Misperception and miscalculation arise from faulty evaluation of available information. Studies of deterrence and intelligence failures find that error rarely results from inadequate information but is almost always due to theory and stress driven interpretations of evidence."[18] In a subsequent publication Lebow and Stein point out that "[e]xisting theories of deterrence rely on technical, context-free definitions of deterrence, but deterrence—and any other strategy of conflict management—takes on meaning only within the broader political context in which it is situated" and that historical context is also important. Furthermore, deterrence may be intertwined with other goals such as compellence.[19]

Probabilistic analyses supply valuable insights, though these depend on strong assumptions. For example, Denter and Sisak show how loss of deterrence may result from "incomplete information" modeled as parametric uncertainties represented by probability densities on bounded finite intervals, and other more explicit assumptions.[20]

Not all deductive theories rely exclusively on probability. Nalebuff, for instance, recognizes that "in the presence of incomplete or imperfect information ... there is no longer any guarantee that the calculations will provide a unique answer." This "indeterminacy" may lead to "a multiplicity of equilibria" which is not resolved probabilistically.[21] Recognition that uncertainty may transcend probability is welcome and needed, to which we will return subsequently. Nonetheless, Nalebuff uses strong probabilistic assumptions. Nalebuff's most important innovation is the study of expectations by each protagonist of other protagonists' behavior. "Each side starts with some expectation about the distribution of the other's parameter. For analytic convenience, we take the initial beliefs to be uniformly distributed between zero and one." (p.320). One might wonder how such a model captures, for instance, Egyptian President Nasser's uncertain expectations in the mid 1960s about Saudi and Jordanian reaction to Egyptian involvement in the civil war in Yemen, Israeli reaction to Egypt's closing the straits of Tiran, and Arab public reaction to forward deployment of Egyptian forces in Sinai.

The approach to uncertainty in the present paper, based on info-gap theory, is non-probabilistic and provides a potential supplement or alternative to probability. Info-gap models of uncertainty are well suited to representing ignorance, for instance incomplete information about protagonists' preferences.[22] Likewise, the non-uniqueness of subjective probability or utility, mentioned by Wag-

[17]Janice Gross Stein, 1987, Extended deterrence in the Middle East: American strategy reconsidered, *World Politics,* 39(3): 326–352, p.329–331, 333.

[18]Richard Ned Lebow and Janice Gross Stein, 1989, Rational deterrence theory: I think, therefore I deter, *World Politics,* 41(2): 208–224, pp.208–9, 211, 214, 217.

[19]Richard Ned Lebow and Janice Gross Stein, 1990, Deterrence: The elusive dependent variable, *World Politics,* 42(3): 336–369, pp.351–2, 353, 355.

[20]Philipp Denter and Dana Sisak, 2014, The fragility of deterrence in conflicts, *Journal of Theoretical Politics,* DOI: 10.1177/0951629813511712, first published on January 19, 2014.

[21]Barry Nalebuff, 1991, Rational deterrence in an imperfect world, *World Politics,* 43(3): 313–335, see pp.313, 328.

[22]Yakov Ben-Haim and Keith W.Hipel, 2002, The graph model for conflict resolution with information-gap uncertainty in preferences, *Applied Mathematics and Computation,* 126: 319–340.

ner,[23] can be captured with info-gap theory.[24] Most importantly, info-gap robust-satisficing can be implemented conceptually without resorting to mathematics[25] as we will discuss subsequently. The innovation dilemma developed here can lead to rational reversal of preference among the options in light of one's uncertainties, as we will explain. The present paper takes the view that ignorance and deception may preclude knowledge of probabilities or even full identification of the event space. Info-gap robust-satisficing provides a response that is epistemically less demanding than probabilistic approaches.

We now consider the potential deficiency—for managing uncertainty—of historical case studies. Studying the past refines one's judgment and insight about possible futures. The case-based school claims, rightly, that historical, political, psychological and organizational factors underlie comprehensive understanding of human affairs. However, that very contextualization may limit the ability to anticipate and respond to surprising future contexts.

Lebow and Stein write that "[e]xisting theories of deterrence rely on technical, context-free definitions of deterrence, but deterrence—and any other strategy of conflict management—takes on meaning only within the broader political context in which it is situated. That context defines the strategy: it informs the purposes for which it is used." Furthermore, "[d]eterrence encounters are embedded in two kinds of contexts. The first ... concerns the specific situation in which a deterrence encounter arises. The second is historical; it consists of the expectations that the adversaries have of each other, themselves, and third parties."[26] Similarly, George and Smoke write that "deterrence at the substrategic levels of conflict is highly context-dependent, [and] there is a critical need in policy making for good situational analysis."[27]

As understanding becomes more contextually detailed it becomes more contextually contingent and potentially less pertinent to the future. Scholars are well aware of the tradeoff between contingency and generality, as George and Smoke illustrate with the concept of "conditional" or "contingent generalizations".[28] The info-gap robust-satisficing strategy discussed in this paper is a tool for managing that tradeoff. Solomon's error could be re-phrased as saying that the worst that was, is as bad as it will ever get. Contextual understanding must support imaginative recognition that things will be different, possibly worse. One cannot know what is not yet devised or discovered, and guessing the future is usually infeasible. One can however prioritize one's options according to their robustness against future surprise while aiming to satisfy critical goals. This robust-satisficing approach can lead rationally to reversal of preference among options, especially when facing an innovation dilemma, as we will see.

Optimization of Outcomes

Rational choice theory postulates that "Actors ... seek to optimize preferences in light of other actors' preferences and options."[29] Likewise Nalebuff, in discussing the role of expectations in rational deterrence theory, asserts the centrality of "maximizing behavior".[30] What is postulated is that ac-

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[23]Wagner, 1992, *op. cit.,* p.119.

[24]John K. Stranlund and Yakov Ben-Haim, 2008, Price-based vs. quantity-based environmental regulation under Knightian uncertainty: An info-gap robust satisficing perspective, *Journal of Environmental Management,* 87: 443–449.

[25]Ben-Haim, 2014a, *op. cit.*

[26]Lebow and Stein, 1990, *op. cit.,* pp.353, 355.

[27]Alexander L.George and Richard Smoke, 1989, Deterrence and foreign policy, *World Politics,* 41(2): 170–182, p.180.

[28]George and Smoke, 1989, *op. cit.,* p.171.

[29]Christopher H. Achen and Duncan Snidal, 1989, Rational deterrence theory and comparative case studies, *World Politics,* 41(2): 143–169, p.150.

[30]Nalebuff, 1991, *op. cit.,* p.321.

tors attempt to optimize the substantive quality of the outcome. We will claim that, prescriptively, it is better to optimize the reliability or confidence of achieving critical goals, than to try to achieve the highest possible goal. It is not optimization per se that is objectionable. We advocate optimizing the robustness. But robustness is an attribute of a decision, not a substantive "good" that is enjoyed at the outcome. It is unrealistic, as we will show subsequently, to try optimizing the substantive outcome under severe uncertainty.

Downs explains that "the calculus [of rational deterrence theory] thrives on optimization, but it is compatible with the addition of numerous constraints that collectively dull the effects of the optimization assumption to the point where they are unrecognizable and quite mild."[31] Constraints limit the domain on which solutions are sought, but do not alter the logic of seeking the substantively best outcome. This may be infeasible and undesirable under severe uncertainty, as will be demonstrated later.

Zagare focuses on the incomplete knowledge and limited analytical capability of the decision maker. Citing Luce and Raiffa,[32] he studies the instrumentally rational actor "who, when confronted with 'two alternatives which give rise to outcomes, ... will choose the one which yields the more preferred outcome.'"[33] However, under severe uncertainty, what looks like the more preferred option may turn out worse than the alternative. We will show that, when facing an innovation dilemma, this can rationally lead to choosing the putatively less preferred option.

Zagare explains that "only two axioms, associated with the logical structure of an actor's preference function, are implicit" in instrumental rationality: connectivity and transitivity. "Connectivity simply means that an actor be able to make comparisons among the outcomes in the feasible set and evaluate them in a coherent way." Transitivity means that if option A is preferred to B, and B is preferred to C, then A is preferred to C. Zagare continues: "Surely these are minimal requirements for a definition of rationality. Without them, choice theory would be well-nigh impossible."[34]

Transitivity and connectivity imply that the agent chooses the option that is anticipated to yield the best outcome. However, sensible decision makers can hold non-transitive preferences as illustrated by Condorcet's paradox in aggregating preferences over several voters.[35] Also, connectivity depends on identifying all relevant options, which is often challenging or even infeasible. Both axioms depend on the preferences being stable over time, which need not hold. March has criticized the rigidity of such axioms as "strict morality", noting that "saints are a luxury to be encouraged only in small numbers."[36]

Huth and Russett "assume that decision-makers are rational expected utility maximizers. ... We use 'rational' in the sense of being able to order one's preferences, and to choose according to that ordering and perceptions of the likelihood of various outcomes. ... [This] does not require that perceptions be accurate, or that a given decision-maker's preferences be the same as other people's."[37] Decision makers acknowledge the fallibility of their information and understanding, and are motivated to hedge their choices against error. Robust-satisficing is a method for doing this that

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[31] George W. Downs, 1989, The rational deterrence debate, *World Politics,* 41(2): 225–237, p.235.

[32] Duncan R. Luce and Howard Raiffa, 1957, *Games and Decisions: Introduction and Critical Survey,* New York: Wiley, p.50.

[33] Frank Zagare, 1990, Rationality and deterrence, *World Politics,* 42: 238–60, p.240.

[34] Zagare, 1990, *op. cit.,* p.241.

[35] Ken Binmore, 2009, *Rational Decisions,* Princeton University Press, Princeton. Steven J. Brams, 2008, *Mathematics and Democracy: Designing Better Voting and Fair-Division Procedures,* Princeton University Press, Princeton.

[36] James G. March, 1988, Bounded rationality, ambiguity, and the engineering of choice, in David E. Bell, Howard Raiffa, and Amos Tversky, eds., *Decision Making: Descriptive, Normative, and Prescriptive Interactions,* Cambridge University Press, p.51.

[37] Huth and Russett, 1984, *op. cit.,* p.499.

does not necessarily maximize over expected or putative outcomes.

Deterrence and Uncertainty

We distinguish between two aspects of the relation between deterrence and uncertainty. First, uncertainty deters. Second, deterrence is uncertain.

On the first point, that *uncertainty deters,* Harkabi wrote:[38]

> Deterrence, one can suppose, results not from certainty that the threat [of massive nuclear response] would be realized, but from uncertainty that it would not be realized. Thus, it is not certainty, but rather doubt, that deters.

In a similar vein, but not limited to the nuclear context, Schelling wrote that the threat of a limited war "is a threat that all-out war *may* occur, not that it certainly will occur, if the other party engages in certain actions." Hence, "[t]he supreme objective [of limited war] may not be to *assure* that it stays limited, but rather to keep the risk of all-out war within moderate limits *above zero.*"[39] The other party is deterred by the uncertain possibility of all-out war.

The second point, that *deterrence is uncertain,* derives from myriad uncertainties in planning, preparing, and executing war. The difficulty is the tremendous uncertainties in anticipating the development of the conflict. *'History* [meaning the future] *has a habit of being richer and more ingenious than the limited imaginations of most scholars or laymen.'*[40] Kahn analogizes to an engineer's design of a building that must perform

> under stress, under hurricane, earthquake, snow load, fire, flood, thieves, fools, and vandals. ... Deterrence is at least as important as a building, and we should have the same attitude toward our deterrent systems. We may not be able to predict the loads it will have to carry, but we can be certain there will be loads of unexpected or implausible severity.[41]

The calculations and estimates that underlie deterrence are mostly deliberative, not quantitative, and always highly uncertain.[42] For example, evaluating local military power balance underlies deterrence assessment.[43] However, evaluating future local power balance is highly uncertain because it depends on many case-specific factors: geo-politics, adversary capability and commitment, extent of forward-deployed friendly combat power, the adversary's unknown future access-denial technologies etc. Similarly, deterrence depends in part on 'deciding what targets are most valuable in the state to be deterred'.[44] In the Persian Gulf War of 1991 the U.S. threat to remove Saddam's regime was an effective choice of target which, Szabo argues, deterred the use of weapons of mass destruction (WMD) by the Iraqi regime. In other situations, identifying high-value targets may be much more difficult and uncertain because they depend on unfamiliar cultural values of the adversary as in a conflict with the Taliban or in the Vietnam War.

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[38]Yehoshafat Harkabi, *War and Strategy,* in Hebrew, (1990, Tel Aviv: Maarachot Publishers), 221–222.

[39]Thomas C. Schelling, *Strategy of Conflict,* (1960, Boston: Harvard University Press), pp.191, 193.

[40]Herman Kahn, *On Thermonuclear War,* (1961, 2nd ed., Princeton, NJ: Princeton University Press), 137, italics in original.

[41]*ibid.* 138.

[42]Colin S. Gray, 2010, Deterrence resurrected: Revisiting some fundamentals, *Parameters,* Winter, 99–106. 100.

[43]Michael S. Gerson, 2009, Conventional deterrence in the second nuclear age, *Parameters,* Autumn, 32–48.

[44]David Szabo, 2007, Disarming rogues: Deterring first-use of weapons of mass destruction, *Parameters,* Winter, 71–84, 82.

Assessing or planning deterrence depends on judgments based on the best available knowledge. However, this knowledge is inevitably wrong, sometimes substantially wrong, and the error may have 'unexpected or implausible severity'. This article focusses on the implications of this for deterrence and its failure. Stated differently, even though uncertainty deters, we will demonstrate that deterrence can be lost because of uncertainty. Not in the sense that enemies miscalculate, but in the sense that prioritization of options (e.g. use WMD or don't use WMD) is fundamentally altered under severe uncertainty. This may be important in explaining paradoxical or seemingly irrational breakdown of deterrence. Our emphasis, however, is prescriptive: how planners can manage uncertainty in deterrent situations. We focus on conventional or nuclear deterrence, though info-gap robust-satisficing is a generic decision methodology applicable to any deterrent situation such as asymmetric war or deterring terror.[45]

Innovation Dilemma: Formal Analysis

In this section we formulate the concept of an innovation dilemma, which is a paradigm for decision under severe uncertainty, through which we will identify situations in which deterrence may fail. We begin by presenting a formal analysis of the innovation dilemma. We then discuss the relation between the prisoner's dilemma and the innovation dilemma and summarize the formal characteristics of the info-gap analysis of the innovation dilemma.

Analysis

The choice and its dilemma. An analyst must choose between two alternatives with severely uncertain outcomes. One alternative is purportedly better, but also much more uncertain, than the other. Our analysis is based on info-gap decision theory in which 'uncertainty' means substantial lack of knowledge or understanding about essential aspects of the problem.

Consider a conflict between two states. We will reason from the position of one side, and we must choose between two highly stylized strategies: either initiate war (IW), or do not initiate war (NIW). In our hypothetical example, NIW is vastly more attractive than IW because available knowledge and understanding indicates that the other side won't initiate war, so war would not ensue. (Our analysis is also applicable to the reverse situation where IW is more attractive.)

However, the available knowledge and understanding—referred to as our 'model'—is highly uncertain. This uncertainty is especially acute regarding our adoption of NIW. The adversary's reasoning may differ from ours, and we may not fathom their thinking. For instance, regarding the Strategic Defense Initiative in the mid-1980's, Windmiller wrote: 'The Soviets are fundamentally different from Americans in their politics, ideology, social system, the way they think about peace and security, and in their world outlook.'[46] Attitudes may differ towards counter-value (civilian and economic targets) rather than counter-force (targeting retaliatory capability) as a IW strategy. Thus NIW is accompanied by substantial uncertainty and might result in vastly greater damage than anticipated because the adversary might pre-empt with IW.

There is of course uncertainty about the outcome of adopting IW, for which the damage might be 'severe', or perhaps 'huge', or maybe even 'devastating'. The range of this uncertainty, while

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[45]Amir Lupovici, 2010, The emerging fourth wave of deterrence theory—Toward a new research agenda, *International Studies Quarterly,* 54(3): 705–732, pp.718–720.

[46]David E. Windmiller, 1986, SDI: A strategy for peace and stability or the end to deterrence? *Parameters,* Summer, 16–25, 21. See also John M. Weinstein, 1982, Soviet civil defense and the us deterrent, *Parameters,* March, 70–83, 70.

significant, is much less than the uncertainty attendant upon NIW.

In summary, while NIW is anticipated (based on our model) to have better outcome than IW, the model is more uncertain regarding NIW and so NIW could be worse than IW. This is an *innovation dilemma:* should we choose the purportedly better but more uncertain and hence potentially worse alternative (NIW), or should we choose the purportedly worse but more accurately predictable and potentially better alternative (IW)? The innovation dilemma induces a decision methodology based on robustness against uncertainty that is different, both normatively and prescriptively, from what is usually called optimization, as we now explain.

Models and outcomes. We use the term 'model' to refer to our information, knowledge and understanding, both quantitative as well as contextual, subjective or intuitive. We refer to outcomes and suppose that better outcomes have less of something (like less destruction), while poorer outcomes have more.

Model-based optimization of the outcome. Our model—assuming it is correct—indicates that NIW will lead to a better outcome (less destruction) than IW. The model indicates preference for NIW over IW, which is called 'model-based optimization of the outcome'. This is a good choice when the model is pretty good. However, info-gap theory provides a critique of this decision strategy when facing severe uncertainty, as we will see.

As things go wrong. NIW is better than IW according to our best understanding. But we have good reason to believe that our understanding is substantially wrong, that is, the model is accompanied by severe uncertainty. This leads to a fundamental tradeoff that is central in info-gap theory. This tradeoff will ultimately lead to a mechanism for loss of deterrence that supports decision making under severe uncertainty. We first explain the idea intuitively.

Suppose we err just a little: our information and understanding is just a little bit wrong. What is the worst outcome that could happen with NIW, or with IW? If the worst were to happen (assuming we err just a little) which strategy would we prefer? Since NIW is purportedly better than IW, it's reasonable to suppose that the worst outcome with NIW (with very small error) is still better than the worst outcome with IW. We would probably still prefer NIW over IW.

However, the magnitude of the advantage of worst-NIW over worst-IW, at small error, is probably less than the magnitude of advantage of putative-NIW over putative-IW. This is because NIW is much more uncertain than IW. NIW can go wrong in more ways, and more severely, than IW.

Now suppose we err a bit more. Worst-NIW is perhaps still better than worst-IW, but the advantage of NIW over IW is now even smaller.

At some horizon of uncertainty the worst-NIW just equals the worst-IW. At even greater horizon of uncertainty the advantage switches over to IW: worst-NIW is now worse than worst-IW.

So which do we choose, NIW or IW? The choice depends on how wrong our model is, but this we don't know. Herein lies the innovation dilemma. A graphical metaphor, and then a re-interpretation, will lead us towards a solution that assists in choosing between alternatives.

Graphical representation. We now consider a useful graphical metaphor for the tradeoff between the horizon of uncertainty and the worst possible outcome of a strategy. The graphs do not represent quantitative analysis. They support judgment and deliberation to reach a decision, as we will see.

First consider fig. 1, dealing only with the NIW option.

The vertical axis is the horizon of uncertainty in our model, so the lowest point on the vertical axis is labeled 'no uncertainty'. Higher points on the vertical axis represent greater uncertainty, such as 'small' or 'large' uncertainty.
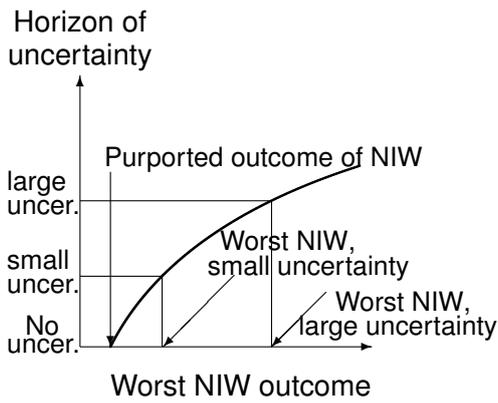
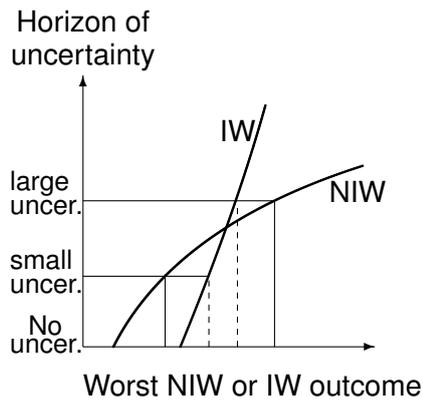Figure 1: Uncertainty vs worst outcome for NIW.

Figure 2: Uncertainty vs worst outcome for NIW and IW.

The horizontal axis represents the worst possible outcome of NIW, for each corresponding horizon of uncertainty. The point at which the curve intersects the horizontal axis, at no uncertainty, is the purported no-war estimate of damage, based on our model, of the outcome of NIW. The worst possible outcome gets worse (larger: more destruction) as the horizon of uncertainty increases. Thus the curve slopes up and to the right. The positive slope represents an irrevocable **tradeoff:** The worst that can happen gets progressively worse as the horizon of uncertainty increases.

Fig. 2 shows uncertainty vs worst outcome for both strategies.

We see in fig. 2 that the purported outcome for NIW is better (smaller destruction) than the purported outcome for IW, as seen by the relative positions of the horizontal intercepts of the two curves.

We also see in fig. 2 that, at small uncertainty, the worst NIW outcome is still better than the worst IW outcome: the short solid vertical line is to the left of the short dashed vertical line.

However, the curves cross each other because the IW curve is steeper than the NIW curve. IW is steeper than NIW because NIW is accompanied by greater uncertainty than IW.

This intersection of the curves results in the fact that, at large uncertainty, the worst NIW outcome is now worse than the worst IW outcome: the long solid vertical line is to the right of the long dashed vertical line (the reverse of the short vertical lines at small uncertainty). In other words, at large uncertainty IW is predicted to have a better worst-outcome than NIW. At large uncertainty we would prefer IW over NIW, while at small uncertainty we preferred NIW over IW, when considering worst possible outcomes. The preference between the strategies is not universal; it changes, depending on what level of uncertainty we consider or equivalently, what level of destruction we will accept.

Before continuing to explore the implications of this preference reversal, we need to provide a different interpretation of the axes in figs. 1 and 2.

The tradeoff: Robustness vs. performance. The curve in fig. 3 is the same as the curve in fig. 1: starting at any specified uncertainty on the vertical axis, the arrows across and down lead us to the corresponding worst possible outcome of NIW at that horizon of uncertainty.

Fig. 4 is the same as fig. 3, except that we now reverse the direction of reasoning. Looking at the horizontal outcome axis, we ask: what is the worst outcome we can tolerate? What is the maximum tolerable damage? Let's denote the worst outcome that is still tolerable (the critical or greatest acceptable damage) by D_c. Now we ask the **robustness question:** what is the greatest horizon of uncertainty that we can tolerate? What is the greatest horizon of uncertainty up to which

we are sure that the outcome will not be worse than D_c? The arrows up and to the left in fig. 4 lead us to the answer. The resulting point on the vertical axis is the greatest tolerable uncertainty of the NIW strategy, for this outcome requirement. We will call this the **robustness to uncertainty** of NIW for this choice of critical damage. The robustness is large when vast uncertainty is tolerable; small robustness implies great vulnerability to uncertainty.

We can now understand the tradeoff mentioned earlier in this section. As the required outcome becomes less demanding (further to the right, accepting greater damage) the intervention is more robust to ignorance. Conversely, the positive slope of the robustness curve in fig. 4 implies that robustness-against-uncertainty decreases as the outcome requirement becomes more demanding (further to the left, lower critical damage).

This tradeoff between robustness and the outcome requirement is intuitively obvious, but it has important implications for choosing a strategy, especially when facing an innovation dilemma, as we now explain.
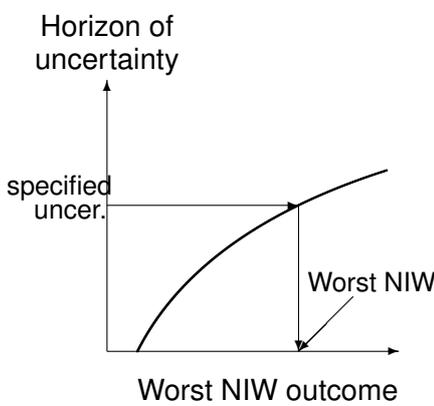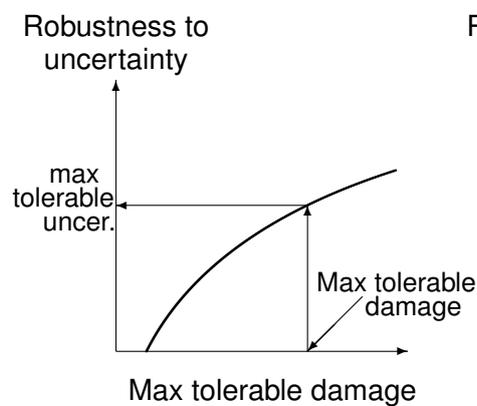

Figure 3: Uncertainty vs worst outcome for NIW.

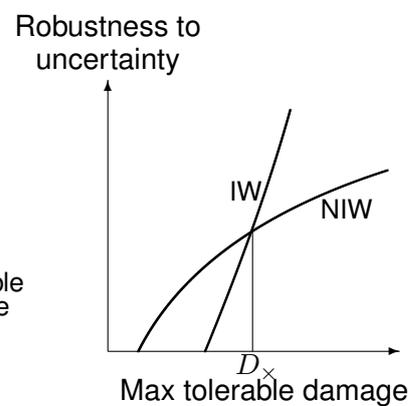Figure 4: Robustness vs maximum tolerable damage for NIW.

Figure 5: Robustness vs maximum tolerable damage for NIW and IW.

Preference reversal and the innovation dilemma. In fig. 5 we plot the robustness curves for IW and NIW. These curves cross each other just as in fig. 2. The intersection between the robustness curves in fig. 5 expresses the innovation dilemma.

Comparing NIW and IW in fig. 5 we see that NIW is purportedly better (horizontal intercept further left) but more uncertain (lower slope) than IW. The greater uncertainty of NIW causes the robustness of NIW to increase more slowly as the critical requirement is relaxed: the curve for NIW rises more slowly than the curve for IW as we move right on the horizontal axis (greater critical damage). Hence their robustness curves intersect because NIW hits the horizontal axis to the left of IW.

The graphical manifestation of the innovation dilemma, and of the resulting preference reversal, is that the robustness curves of the two alternatives intersect in fig. 5. NIW is more robust, and hence preferred over IW, if the outcome requirements are very demanding (the performance requirement is less than $D_\times$). For less demanding outcome requirements (the performance requirement exceeds $D_\times$) then IW is more robust than NIW and hence IW is preferred.

The purported preference is for NIW over IW, which implies that war would (purportedly) be avoided. However, if the acceptable level of damage is large enough (exceeding $D_\times$), then IW is preferred over NIW, which implies that war occurs and deterrence has failed. In other words,

uncertainty leads to the possible loss of deterrence even though the putative preference of both parties is for the avoidance of war. This mechanism acts even though the robustness curves in fig. 5 are schematic and cannot be evaluated quantitatively. The value of $D_\times$ is unknown, but deterrence can fail as a result of uncertainty even though the best knowledge and understanding of both parties indicate that no-war is preferred.

Robust satisficing. This decision strategy entails two elements. The first element is called 'satisficing': the decision maker must satisfy an outcome requirement. Second, more robust-ness against uncertainty is preferred over less robustness. Taken together, robust-satisficing is the decision-strategy that chooses between alternatives to achieve the required outcome as robustly as possible. Robust satisficing attempts to satisfice the requirements over the widest range of deviation of reality from the model.

Robust satisficing is conceptually different from outcome-optimization and may lead to differ-ent decisions. The model-based outcome-optimal choice is for NIW over IW, as illustrated by the horizontal intercepts in fig. 5: NIW is predicted by our model to be better than IW. The robust-satisficing choice is the same if the critical requirement, D_c, is less than the crossing level $D_\times$. On the other hand, robust-satisficing and outcome optimization disagree if D_c exceeds $D_\times$. Outcome optimization and robust-satisficing may, or may not, agree in managing an innovation dilemma. How-ever, even when they agree on the decision, they disagree on the reason for the decision. That is, outcome-optimization and robust-satisficing are normatively and prescriptively different: the stan-dard of what constitutes a good decision is different, and the actual decision that is made can be different.

Summary of Formal Conclusions and Comparison to the Prisoner's Dilemma

The prisoner's dilemma has been fruitfully applied to deterrence and other military decisions under uncertainty.[47] The prisoner's dilemma and the innovation dilemma both deal with choice under uncertainty, but they illuminate different aspects of the challenge despite a superficial similarity.

		Prisoner B	
		Testify	Silent
Prisoner A	Testify	A: heavy fine B: heavy fine	A: freedom B: hung
	Silent	A: hung B: freedom	A: light fine B: light fine

Table 1: Prisoner's dilemma

In the prisoner's dilemma, table 1, if both prisoners remain silent they are both fined lightly. If they both testify they are both fined heavily. If one testifies and the other remains silent then the first goes free and the second is hung. For each prisoner, testifying is the choice that minimizes the worst outcome given the unknown choice of the other prisoner. This min-max outcome (heavy fine) is worse than the light fine they would both receive if both remain silent. The dilemma for each prisoner is that remaining silent is the most dangerous choice (one could get hung) and yet it would have a fairly good outcome if both remain silent (light fine).

An innovation dilemma is the choice between two options where the purportedly better option could be worse than the other option. This is different from the prisoner's dilemma in which the

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[47]Frank C.Zagare, 1985, Toward a reformulation of the theory of mutual deterrence, *International Studies Quarterly,* 29(2): 155–169. Harkabi, 1990, *op. cit.,* p.299. Kilgour and Zagare, 1991, *op. cit.*

potentially best option (testifying and going free) is *not* also the potentially worst option (remaining silent and being hung). So the prisoner's dilemma is not an innovation dilemma, and an innovation dilemma is not a prisoner's dilemma, but the difference is not only structural.

The info-gap analysis of an innovation dilemma begins by recognizing the severe uncertainty of one's knowledge (what we've called the model). This leads to three conclusions. First, model-based predictions are unreliable and hence prioritization of the options according to model-based predictions is also unreliable (represented by the horizontal intercepts of the robustness curves in fig. 5). Second, as a consequence, the decision maker must ask: what is the worst outcome that is acceptable. This is different from asking: what is the best outcome that is consistent with one's knowledge. Third, if the putatively better option is also more uncertain, then the other option will be more robust to uncertainty if the outcome requirement is not too demanding (the robustness curves in fig. 5 cross one another). The innovation dilemma is a choice between two options, where the purportedly better option is more uncertain and could be worse than the other option. The info-gap resolution of the dilemma is to select the option that most robustly satisfies the decision maker's outcome requirement.

The prisoner's dilemma highlights the difference between individual and collective rationality, or between selfish and altruistic behavior. The prisoner's dilemma demonstrates how uncertainty can inhibit cooperation that otherwise would be mutually beneficial. The innovation dilemma reveals the reversal of preference between options resulting from the robust advantage of the sub-optimal option for achieving some critical outcomes. The info-gap analysis of robustness shows that outcome-optimization can be more vulnerable to uncertainty than sub-optimal satisficing of a critical goal.

Both the prisoner's dilemma and the innovation dilemma highlight deficiencies of the min-max or worst-case decision strategy, but in different ways.

In the prisoner's dilemma, the worst that can happen if one testifies is a heavy fine, which is less onerous than the worst that can happen if one keeps silent (being hung). Testifying minimizes the maximum penalty and is the min-max choice. The min-max choice, however, differs from the collaborative choice that would result in a better outcome for all (light fine). The altruistic or group-conscious decision maker should not use the min-max strategy, assuming all other decision makers are like-minded.

The min-max choice for an innovation dilemma can be understood by referring to fig. 2. At a large level of uncertainty, the worst that happens with IW is better than the worst that happens with NIW, so IW minimizes the worst outcome and is the min-max choice. However, the min-max choice may not be the most robust choice for achieving a specified outcome. For example, suppose that the analyst agrees that the uncertainty is large. But suppose that the decision maker must achieve an outcome that is better (smaller) than the value on the horizontal axis at which the curves intersect in fig. 2. The min-max choice is IW while NIW is more robust against uncertainty for achieving the required quality of outcome. In this case, the min-max optimum and the robust optimum do not agree. The decision maker who is charged with achieving an outcome better than the crossing value should not use the min-max strategy even though the uncertainty is large.

Historical Example of Uncertainty and Deterrence—Six Day War: Israeli Decision to Attack

We will demonstrate how the innovation dilemma provides a prescriptive model for decision making in an historical case. Fig. 5 is the graphical paradigm. NIW is the preferred option based on the best

available but highly uncertain information and understanding. If this information and understanding (the model) were correct, then IW would entail greater loss. However, the model is uncertain, and more so in the case of NIW than IW. Thus, while NIW is purportedly better, it could lead to worse outcome than IW. This dilemma is portrayed in the graphical metaphor of fig. 5 by the crossing robustness curves. The dilemma is resolved by choosing the option that would lead to an acceptable outcome over the widest range of unknowns; by choosing the option that most robustly satisfies the critical outcome requirement.

The Israeli decision to initiate war on 5 June 1967 against an array of Arab states provides a good example of decision making in the face of an innovation dilemma. We analyze the options to initiate war (IW) or to not initiate war (NIW) from the perspective of Israeli decision makers. The claim is not that this is how the decision makers actually reasoned, but that this reasoning is implementable and instrumentally justifiable.

The model in support of IW. Tensions grew between Israel, Syria, Egypt, and subsequently Jordan and other Arab countries in mid May 1967. Exchange of fire between Israel and Syria in the north had occurred repeatedly over the years and intensified in April due to Israeli and Syrian disputes over agricultural use of demilitarized zones, Syrian support of terrorist actions against Israel, and operations to divert sources of the Jordan river in Syrian and Lebanese territory to bypass Israel. Egyptian President Nasser responded, in support of Syria, with a series of threatening actions on Israel's southern border. On 18 May Egypt demanded the immediate departure of the United Nations Emergency Force that was stationed in the Sinai desert since the end of the 1956 Sinai war, to which U.N. secretary general U Thant acquiesced with little resistance. Egypt then began a massive buildup of infantry, armor and air power in the Sinai, partly deployed offensively and close to the Israel-Egypt border. Syria and Jordan mobilized massively, together with significant troop movements to the theater from Iraq and other Arab countries. On 22 May Egypt announced the closure of the Straits of Tiran to Israeli shipping. The U.S. tried to enlist maritime countries in the 'Regatta Plan' to sail through the Straits of Tiran, accompanied by destroyers from the 6th fleet, asserting international rights of free passage. Regatta never materialized. On 30 May Egypt and Jordan signed a mutual defense pact allowing Egyptian forces to operate from Jordan and placing Jordanian forces under Egyptian command, creating a strategic threat close to the main Israeli population centers.[48] Arab public opinion and leadership pronouncements vigorously expressed the desire to change the status quo: to liberate Palestine and to eliminate the State of Israel.[49]

The model in support of NIW. The Egyptian force buildup in the Sinai during May 1967 seemed closely parallel to 'Operation Retama' in February 1960. Egypt brought two divisions to the Sinai following escalation between Syria and Israel in early 1960. In response Israel rushed re-enforcements to the south, placed her air force on alert, and began diplomatic exchanges to assure all parties that Israel had no offensive intentions against Syria or Egypt. Tensions ran very high until Nasser removed Egyptian forces from Sinai late in February 1960 and declared that he had saved Syria from war with Israel, thereby strengthening his stature as a pan-Arab leader. The situation in May 1967 looked similar, and Egyptian moves were widely understood, at least at first, as demonstrative but not expressing actual desire for war. Furthermore, Israeli strategy in 1967 was predicated on big-power support. President de Gaulle rebuffed Israeli approaches and President Johnson repeatedly asserted that 'Israel will not be alone unless it decides to go it alone', clarifying U.S. unwillingness to

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[48] Ami Gluska, *Eshkol, Give the Order! Israel's Army Command and Political Leadership on the Road to the Six Day War, 1963–1967,* in Hebrew, (2004, Tel Aviv: Maarachot Publishers), 47.

[49] *ibid.* 199.

support an Israeli initiation of war either verbally or materially, thus supporting NIW.[50] Finally, Israeli strategy was aimed at maintaining the status quo by existence of vast deterrent force. As long as Israeli deterrence is effective, NIW is preferred.[51]

Uncertainty, the innovation dilemma and analysis of robustness. If the model of NIW is correct then IW would initiate an unnecessary war so NIW is, putatively, preferable. In fig. 5, the robustness curve for NIW intersects the horizontal axis at a lower (better) value of 'Maximum tolerable damage' than the curve for IW.

The uncertainty in the NIW model is prodigious, especially regarding Egyptian intentions in 1967 and the strength of the parallel to Operation Retama in 1960. The Arab military deployment in 1967 far exceeded that in 1960 so, even if this reflected Nasser's hand being forced by circumstances in 1967, the possibility of an Arab IW was not negligible. An Arab IW on the small number of highly vulnerable Israeli airfields could be disastrous for Israeli ability to repulse a 3-front invasion.[52] In other words, the actual damage resulting from even moderate error in the NIW model could far exceed the putative damage of the alternative, IW.

The uncertainty in the IW model hinges on uncertainty about foreign support, and on the Israeli assessment that a surprise Israeli attack would succeed rapidly. Rapid success would obviate the need for diplomatic support (primarily from the US) and for matériel from foreign powers (primarily France and Britain) during the conflict. Confidence in rapid success eroded somewhat as time passed and the Arab military deployment strengthened. Arab deployment was enormous, but deficiencies in Egyptian logistics, training, and command structure supported the Israeli assessment. Uncertainty about foreign, especially US, support was prominent.

The uncertainty in the IW model is substantially less than in the NIW model. In fig. 5, the IW robustness curve is much steeper than the NIW curve, indicating that IW is less vulnerable to uncertainty. Thus, even at moderate uncertainty, the maximum damage that could result is less from IW than from NIW. The innovation dilemma is that NIW is putatively better but more uncertain and hence potentially worse than IW. Graphically, the dilemma is reflected in the robustness curves crossing one another in fig. 5.

Israeli Defense Minister Moshe Dayan, Israeli Chief of Staff Yitzhak Rabin and most members of the Israel Defense Force General Staff, all supported preemptive strike against Egyptian forces to gain the advantage of air superiority by eliminating the Egyptian air force and crippling the massive offensive Arab deployment. On June 4th, 12 out of 14 Israeli cabinet ministers voted to initiate war the following morning.[53] This decision follows the logic of robust-satisficing: choosing the option that will lead to an acceptable outcome despite vast uncertainty. One can imagine, counterfactually, that the cabinet would have chosen NIW if it had felt that the model supporting this option was fairly certain. However, this putative first choice was rejected (after several agonizing weeks) in favor of the IW option that would lead (or so they hoped) to lower loss despite the surprises yet to be revealed. We are not imputing a specific mode of reasoning to the Israeli decision makers. Rather the claim is that the robust-satisficing methodology was an implementable method of analysis that could have been used in this historical case.

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[50] Michael, B. Oren, *Six Days of War: June 1967 and the Making of the Modern Middle East,* (2003, New York: Ballantine Books), 157.

[51] Gluska, *op. cit.* 199, 401.

[52] *ibid.* 60.

[53] Oren, *op. cit.,* 157–158.

Theoretical Application: Does Uncertainty Increase the Propensity for War?

In the previous section we saw how decision makers could use info-gap robust-satisficing approaches in three historical situations. We now consider how the info-gap robust-satisficing decision strategy can guide theoretical analysis in support of decision making.
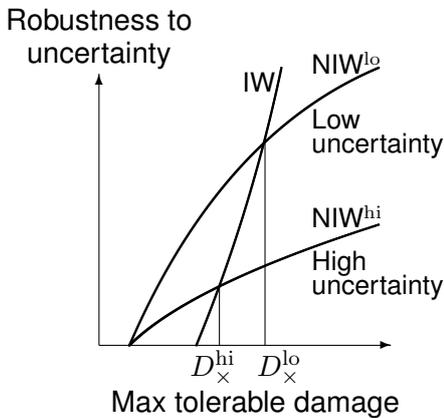

Figure 6: Robustness curves: polarity increases uncertainty of NIW.
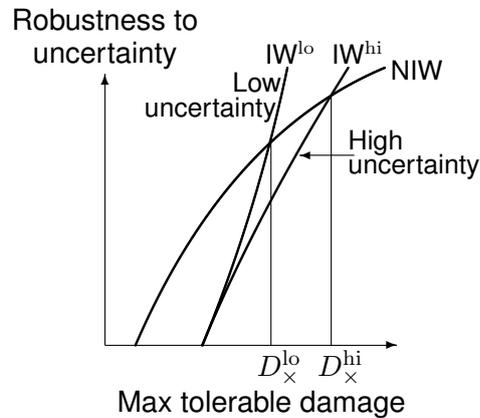
Figure 7: Robustness curves: polarity increases uncertainty of IW.

A state must choose between two prototypical strategies: NIW ('no initiation of war') or IW ('initiation of war'). The purported optimal preference—based on the available model—is for NIW over IW. The propensity for war increases if the propensity for preference-reversal from NIW to IW is increased by uncertainty. Suppose that one or both protagonists' perceptions change between an overall low level, to an overall high level of uncertainty. E.g., when the U.S. discovered a small number of nuclear warheads on Cuba in 1962, U.S. uncertainty regarding Soviet intentions increased greatly. We examine how an increase in uncertainty influences the robustness curves for these two strategies.

Consider a special case: uncertainty of NIW increases, without increased uncertainty of IW. E.g., new nuclear capability in unstable countries raises the possibility of IW on their part, so NIW by a traditional power has more uncertain outcome.[54] The uncertainty is severe because a small regional power with limited nuclear capability might argue that a superpower would 'deter itself from using nuclear weapons because of the prospect of collateral damage to the region'.[55] NIW can also become uncertain if new defensive technology is ambiguous and could be interpreted offensively by an adversary. E.g., President Reagen's Strategic Defense Initiative could protect U.S. offensive missiles or U.S. cities. The former is defensive: missiles are protected for use in retaliatory strikes. The latter is offensive: missiles are not defended because they're intended for 1st strikes and cities are defended against retaliation. The ambiguity could make adversarial IW more likely.[56] In these examples, uncertainty surrounding IW by the traditional power is not changed.

Fig. 6 shows robustness curves for this situation. The robustness of IW is unchanged, but the

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[54] Frederick R. Strain, 1993, Nuclear proliferation and deterrence: A policy conundrum, *Parameters,* Autumn, 85–95, 85–86.

[55] *ibid.* 87.

[56] Windmiller, *op.cit.* 20.

robustness of NIW is reduced due to increased uncertainty of NIW. The maximum acceptable damage up to which NIW is robust-preferred is reduced: $D_\times^{\mathrm{hi}}$ is smaller than $D_\times^{\mathrm{lo}}$. Consequently, a reversal of robust preference from the putative optimum, NIW, to robust preference for IW, occurs at a lower damage threshold due to increased uncertainty in NIW. The increased uncertainty of NIW causes greater tendency for selection of IW and hence an increased tendency for war. This tendency is further strengthened because, over the range of critical damage for which NIW is more robust than IW, the robustness of NIW is lower due to high uncertainty.

Now consider the reverse special case: increased uncertainty of IW, without increased uncertainty of NIW. See fig. 7. Comparing this with fig. 6 shows a reverse direction of change. In fig. 7 the threshold for preference reversal from NIW to IW *increases* as uncertainty increases: $D_\times^{\mathrm{hi}}$ is larger than $D_\times^{\mathrm{lo}}$. This is the reverse of fig. 6. Furthermore, in fig. 7, when NIW is more robust than IW, the robustness-advantage *increases* because uncertainty in IW increased, unlike fig. 6.

In summary, we cannot conclude that increased uncertainty will necessarily strengthen, or necessarily weaken, the propensity for preference reversal from NIW to IW and thus increase the propensity for war, as is sometimes claimed. IW and NIW are influenced in opposite directions by uncertainty. However, the analysis identifies what aspects of a scenario determine the impact of uncertainty. The analyst must assess the counteracting impacts of uncertainty on the two options, NIW and IW.

Our discussion is purely qualitative; magnitudes of these tendencies cannot be deduced. Nonetheless, the monotonicity and shifts of the robustness curves, due to increasing uncertainty, are unambiguous. The tendencies that we deduced hold for all robustness curves.

Conclusion

We summarize our analysis by returning briefly to the stylized example discussed at the beginning. Consider conflict between two states. One state, initially deterred from war, must choose between No Initiation of War (NIW) and Initiation of War (IW) when this is an innovation dilemma: NIW purportedly has a better outcome than IW, but NIW is far more uncertain. Reversal of preference to IW reflects loss of deterrence by the other state. The info-gap robust-satisfying decision methodology for managing an innovation dilemma is to choose the option that is more robust-to-uncertainty for achieving a specified goal.

Fig. 5 is the schematic graphical representation of this dilemma in terms of robustness curves when NIW is purportedly the better choice so that preference reversal constitutes loss of deterrence. The graphs do not represent quantitative analysis. They are a metaphor of the concept of preference reversal that can arise in response to uncertainty. The graphs support judgment and deliberation in reaching a decision.

If the analyst requires that the level of damage be less than the value at which the two options are equally vulnerable to uncertainty ($D_\times$, where the robustness curves in fig. 5 cross one another) then NIW is preferred over IW. In this case the purported optimum, NIW, is also the more robust option. However, if the analyst is willing to accept greater damage, then greater robustness to uncertainty is achieved with IW. The putatively better option is not necessarily the most robust (and hence preferred) option. The anticipated best option is not necessarily the most robust for achieving specified goals.

The robustness curves in fig. 5 are schematic and we don't expect analysts to be able to evaluate them numerically or to make quantitative comparison between a numerical value of $D_\times$ and an

explicit value for maximum acceptable damage. The innovation dilemma is real even though it is not quantitative, and the choice of a option can rationally be made by qualitative verbal deliberation. We can expect that in some situations an analyst will choose IW over NIW—as in the Israeli decision in 1967—by arguing that this is the most reliable and responsible action in light of the vast uncertainties, especially those associated with NIW. In such situations, deterrence has been lost due to the impact of uncertainty. In other situations the purportedly better but more uncertain option, NIW, may be chosen. Finally, in some situations, no decision is made, or conflicting decisions are adopted, for institutional or other reasons.

The 6 Day War example illustrates how protagonists could use info-gap robust-satisficing in decision making. The info-gap analysis of robustness against uncertainty provides a basis for deliberation and subsequent prioritization of options. If one option is more robust-to-uncertainty than another option, for achieving specified required outcomes, then the first option is preferred. However, if the greatest robustness is very low, then the analyst is led to explore new options. Alternatively, if all options are very immune to surprise, then the analyst can revise the requirements and demand better outcomes than were initially viewed as feasible.

A theoretical paradigm, such as info-gap robust-satisficing, is neither sufficient nor necessary for military success, as Winton concludes in his study of Generals Patton and Grant.[57] However, '[t]o a mind that artfully combines discipline with intuition, theory offers the opportunity to roam freely back and forth between the general and the particular.'[58] Theory supports deliberation and decision.

Deliberation takes place, conceptually, on both axes of schema such as fig. 5. The analyst makes judgments about how bad an outcome one can accept (or, equivalently, how good an outcome is required), and judgments about how much uncertainty is tolerable. These judgments use models: historical precedent, theoretical insight, contextual understanding, data, social or organizational values and goals, and judgments of reliability or uncertainty of the previous elements. This analysis is particularly useful when facing an innovation dilemma: one option seems better than another (based on available models) but the putatively better option is also more uncertain. Like all dilemmas, an innovation dilemma has horns, but these can be managed systematically with an info-gap robust-satisficing analysis.

Bibliography

Achen, Christopher H. and Duncan Snidal, 1989, Rational deterrence theory and comparative case studies, *World Politics,* 41(2): 143–169.

Ben-Haim, Yakov, *Info-Gap Decision Theory: Decisions Under Severe Uncertainty,* (2006, 2nd edition, London: Academic Press).

Ben-Haim, Yakov, 2014a, Strategy selection: An info-gap methodology, *Defense & Security Analysis,* 30(2): 106–119.

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[57] Harold R. Winton, 2011, An imperfect jewel: Military theory and the military profession, *Journal of Strategic Studies,* December, vol.34, no.6, 853–877, 870.

[58] *ibid.* 874.

Ben-Haim, Yakov, 2014b, On strategic uncertainty and its implications, working paper.

Ben-Haim, Yakov and Keith W.Hipel, 2002, The graph model for conflict resolution with information-gap uncertainty in preferences, *Applied Mathematics and Computation,* 126: 319–340.

Ben-Haim, Yakov, Craig D. Osteen and L. Joe Moffitt, 2013, Policy dilemma of innovation: An info-gap approach, *Ecological Economics,* 85: 130–138.

Binmore, Ken, 2009, *Rational Decisions,* Princeton University Press, Princeton.

Brams, Steven J., 2008, *Mathematics and Democracy: Designing Better Voting and Fair-Division Procedures,* Princeton University Press, Princeton.

Denter, Philipp and Dana Sisak, 2014, The fragility of deterrence in conflicts, *Journal of Theoretical Politics,* DOI: 10.1177/0951629813511712, first published on January 19, 2014.

Downs, George W., 1989, The rational deterrence debate, *World Politics,* 41(2): 225–237.

Edwards, Paul, ed., 1996, *The Encyclopedia of Philosophy,* Simon and Schuster Macmillan, New York.

Friedman, Milton, 1953, *Essays in Positive Economics,* University of Chicago Press, Chicago.

George, Alexander L. and Richard Smoke, 1989, Deterrence and foreign policy, *World Politics,* 41(2): 170–182.

Gerson, Michael S., 2009, Conventional deterrence in the second nuclear age, *Parameters,* Autumn, 32–48.

Gluska, Ami, *Eshkol, Give the Order! Israel's Army Command and Political Leadership on the Road to the Six Day War, 1963–1967,* in Hebrew, (2004, Tel Aviv: Maarachot Publishers).

Gray, Colin S., 2010, Deterrence resurrected: Revisiting some fundamentals, *Parameters,* Winter, 99–106.

Harkabi, Yehoshafat, *War and Strategy,* in Hebrew, (1990, Tel Aviv: Maarachot Publishers).

Huth, Paul and Bruce Russett, 1984, What makes deterrence work? Cases from 1900 to 1980, *World Politics,* 36(4): 496–526.

Huth, Paul K., 1988, Extended deterrence and the outbreak of war, *American Political Science Review,* 82(2): 423–443.

Huth, Paul and Bruce Russett, 1990, Testing deterrence theory: Rigor makes a difference, *World Politics,* 42(4): 466–501.

Jervis, Robert, 1978, Cooperation under the security dilemma, *World Politics,* vol.30, no.2, pp.167–214.

Kahn, Herman, *On Thermonuclear War,* (1961, 2nd ed., Princeton, NJ: Princeton University Press).

Kilgour, D. Marc and Frank C. Zagare, 1991, Credibility, uncertainty, and deterrence, *American Journal of Political Science,* 35(2): 305–334.

Lebow, Richard Ned and Janice Gross Stein, 1989, Rational deterrence theory: I think, therefore I deter, *World Politics,* 41(2): 208–224.

Lebow, Richard Ned and Janice Gross Stein, 1990, Deterrence: The elusive dependent variable, *World Politics,* 42(3): 336–369.

Luce, Duncan R. and Howard Raiffa, 1957, *Games and Decisions: Introduction and Critical Survey,* New York: Wiley.

Lupovici, Amir, 2010, The emerging fourth wave of deterrence theory—Toward a new research agenda, *International Studies Quarterly,* 54(3): 705–732.

Luttwak, Edward N., 1984, *The Pentagon and the Art of War: The Question of Military Reform,* Simon and Shuster, New York.

March, James G., 1988, Bounded rationality, ambiguity, and the engineering of choice, in David E.Bell, Howard Raiffa, and Amos Tversky, eds., *Decision Making: Descriptive, Normative, and Prescriptive Interactions,* Cambridge University Press

McGinnis, Michael D., 1992, Deterrence theory discussion: I: Bridging or broadening the gap? A comment on Wagner's 'Rationality and misperception in deterrence theory', *Journal of Theoretical Politics,* 4(4): 443–457.

Menashri, David, 2014, Iran thirty-five years after the Islamic Revolution: A conversation with David Menashri, *Israel Journal of Foreign Affairs,* 8(1): 9–21.

Miller, Steven E., Sean M. Lynn-Jones, Stephen Van Evera, eds., *Military Strategy and the Origins of the First World War,* (1991, Princeton, NJ: Princeton University Press).

Mitcham, Carl, 1994, *Thinking through Technology: The Path between Engineering and Philosophy,* University of Chicago Press.

Nalebuff, Barry, 1991, Rational deterrence in an imperfect world, *World Politics,* 43(3): 313–335.

Oren, Michael, B., *Six Days of War: June 1967 and the Making of the Modern Middle East,* (2003, New York: Ballantine Books).

Popper, Karl R., 1968, *The Logic of Scientific Discovery,* Harper & Row, New York.

Rapoport, Anatol, 1992, Deterrence theory discussion: III: Comments on 'Rationality and misperceptions in deterrence theory', *Journal of Theoretical Politics,* 4(4): 479–484.

Schelling, Thomas C., *Strategy of Conflict,* (1960, Boston: Harvard University Press).

Singer, J.D., ed., *The Correlates of War: II, Testing Some Realpolitik Models,* (1980, New York: Free Press).

Stein, Janice Gross, 1987, Extended deterrence in the Middle East: American strategy reconsidered, *World Politics,* 39(3): 326–352.

Stranlund, John K. and Yakov Ben-Haim, 2008, Price-based vs. quantity-based environmental regulation under Knightian uncertainty: An info-gap robust satisficing perspective, *Journal of Environmental Management,* 87: 443–449.

Strain, Frederick R., 1993, Nuclear proliferation and deterrence: A policy conundrum, *Parameters,* Autumn, 85–95.

Szabo, David, 2007, Disarming rogues: Deterring first-use of weapons of mass destruction, *Parameters,* Winter, 71–84.

Wagner, R. Harrison, 1982, Deterrence and Bargaining, *Journal of Conflict Resolution,* 26: 329–358.

Wagner, R. Harrison, 1991, Nuclear deterrence, counterforce strategies, and the incentive to strike first, *American Political Science Review,* 85:727–749.

Wagner, R.Harrison, 1992, Rationality and Misperception in Deterrence Theory, *Journal of Theoretical Politics,* 4(2): 115–141.

Weinstein, John M., 1982, Soviet civil defense and the us deterrent, *Parameters,* March, 70–83.

Windmiller, David E., 1986, SDI: A strategy for peace and stability or the end to deterrence? *Parameters,* Summer, 16–25.

Winton, Harold R., 2011, An imperfect jewel: Military theory and the military profession, *Journal of Strategic Studies,* December, vol.34, no.6, 853–877.

Zagare, Frank C., 1985, Toward a reformulation of the theory of mutual deterrence, *International Studies Quarterly,* 29(2): 155–169.

Zagare, Frank, 1990, Rationality and deterrence, *World Politics,* 42: 238–60.