Short-term versus long-term military planning

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In this article, we analyze two rival countries that are involved in an arms race. We compare the consequences of myopic (period-by-period) planning versus rational (long-term) planning and show that although myopic planning is always favorable for both countries, they are likely to become locked in a prisoners' dilemma equilibrium in which they plan rationally but which results in overinvestment in arms procurement and underspending on civilian services. Some options to break out of the dilemma are explored.

Countries involved in an ongoing (military) conflict are usually caught up in an arms race and spend considerable resources to ensure an acceptable level of security vis-à-vis their rivals. For example, the base defense budget of the United States for 2009 is $515.4 billion,[1] and Israel's defense budget in 2008 was $11 billion, about 7.4 percent of its GDP. Both the U.S. and Israel allocate considerable shares of their defense budgets to procurement (mostly of sophisticated weapon systems) and to military R&D. For example, in 2009 the U.S. plans to spend $79.6 billion on military R&D activities and $104.2 billion on procurement.[2] The considerable resources that are committed to military build-up around the world and the substantial efforts of rival countries to achieve a military edge over their adversaries indicate that in allocating their resources between civilian (education, welfare, health, etc.) and military expenditure governments account for long-term considerations, at least when they plan their military order of battle (arrays).[3]

In this article, we analyze two rival countries that are involved in an arms race. We compare the consequences of myopic (period-by-period) planning versus rational (long-term) planning and show that although myopic planning is always favorable for both countries, they are likely to become locked in a prisoners' dilemma equilibrium in which they plan rationally but which results in overinvestment in arms procurement and underspending on civilian services. In general, they would be well-advised to consider other strategies to improve the welfare of their citizens without compromising their required security levels. A dynamic version of Kagan, Levkowitz, Tishler, and Weiss (2008) is employed, with real-world data, to show the likely existence of a prisoners' dilemma in the current Israeli-Syrian arms race.

The nature of arms race planning strategies

Since Richardson's seminal contribution,[4] economists have been analyzing arms races as a noncooperative game between two or more rival countries, each intent on accumulating weapon systems to build up their respective military power. The discussion has focused, among other issues, on the nature of the dynamic strategies adopted by the decisionmakers of the rival countries when allocating the government budget between arms procurement and civilian expenditure and on the characteristics of the resulting (Nash) equilibrium. Some researchers have considered open-loop Nash equilibrium strategies while others have considered closed-loop Nash equilibrium strategies.[5] The choice between them may not be critical as they exhibit similar properties, although a closed-loop equilibrium results in lower arms stocks and higher welfare than does an open-loop equilibrium.[6] Furthermore, the static Nash equilibrium exhibits the same properties as the open-loop Nash equilibrium.[7] There is also the conclusion of Brito and Intriligator (1995) that "since the actual mechanism involved in the allocation of resources in the countries involved is a complex combination of political and bureaucratic behavior, there is some virtue in simplicity."

Previous literature considers the strategies undertaken by the participants in the arms race as given (open-loop or closed-loop). In this article, as is the case in reality, we let the decisionmakers of the rival countries decide on the planning strategy, in addition to the allocation of the government budget between arms procurement and civilian expenditure. The decisionmakers can be either myopic, planning only one period at a time (time-step planning), or rational, determining, at the beginning of the first period, the allocation of the government budget, taking the rival's decisions into account, for the whole planning horizon (e.g., open-loop strategy).

Generally, this article suggests that solving military/political conflicts that evolve into an arms race by relying only on military might is an expensive and suboptimal solution. The better approach in an arms race setup is to consider political and economic strategies, in addition to the military option.

The growing importance of planning ahead

As weapon systems are becoming ever more sophisticated, the planning horizon plays an important role in their accumulation and in the overall military power build-up.[8] The development of a major weapon system involves several consecutive stages, each dependent on the previous one: technology feasibility study, pre-development, full-scale development, testing, integration, prototype, serial production, field deployment, and achieving full operational capabilities. This process may take 20 years or more to complete.[9] Even weapon systems that do not require full-scale development (weapon systems developed in the past) may require a considerable amount of time to upgrade and modernize. For example, the time from the procurement stage of a submarine to its full integration into the navy may be up to 10 years. Thus, the time it takes for a new weapon system to be fully deployed forces the

decisionmaker to take into account past procurement and the availability of an existing stock of weapons, as well as to envision the characteristics of the future battle field, including possible reactions of the adversary to future deployments of the weapon system.

The arms race and the prisoners' dilemma

The strategies of the rival countries may give rise to a prisoners' dilemma equilibrium in which both countries over-invest in arms procurement to counter each other's stocks of weapon systems, thus lowering civilian expenditure and, hence, the welfare (utility) of both countries. Smith, Sola, and Spagnolo (2000) present empirical evidence of a prisoners' dilemma equilibrium in the Greek-Turkish conflict. Snyder (1971) implements a prisoners' dilemma setup in several international conflicts, and Plous (1993) analyzes the nuclear arms race as a perceptual dilemma.

Here we follow Bar-El, Kagan, and Tishler (2008) and identify a different kind of prisoners' dilemma, one that emerges from the planning strategies of the rival countries. We show that although myopic (short-term) planning is always favorable for both rivals, they are more likely to be locked into a prisoners' dilemma in which they plan rationally (long-term), which results in higher stocks of weapon systems and lower welfare for both countries. Moreover, we find some evidence of the existence of a prisoners' dilemma equilibrium in the current Israeli-Syrian arms race.

The analytic framework

For expositional simplicity consider an arms race between two identical countries.[10] The level of security of each country is equal to its military capability (defined as its own stock of weapon systems) divided by the military capability of its rival.[11] Again, for brevity we assume that each country employs only one (aggregate) type of weapon system which depreciates at a constant rate over time. The objective of both countries is to maximize the discounted stream of utilities defined over its security level and civilian expenditure. The decisionmakers in the rival countries decide, in each period, on the allocation of their government budget between civilian services (which yield utility for only one period) and weapon systems. In addition, they decide on their planning strategy. That is, they can be either myopic, planning each period at a time (time-step planning) or rational, determining, in the first period, the allocation of the government budget and taking the rival's decisions for the whole planning horizon into account. The myopic decisionmaker plans one period (each planning period consists of five years, for example) at a time and in her decision in the first period, say, does not take into account the benefits (utility) of the weapon systems in future periods. The rational planner procures more weapon systems than the myopic planner since, at the beginning of the planning horizon, she takes into account future benefits (utility), which are positive, to be received from the procurement of weapon systems in earlier periods (weapon systems yield security over their lifetime, which may last many periods). In our simplified example the two rival countries are identical. Thus, both procure identical quantities of weapon systems regardless of whether they are myopic or rational, implying that the ratio of security levels equals one for both countries under either strategy. However, for a given government budget, larger quantities of arms procurement under rational planning imply a lower level of civilian services. Therefore, when the decisionmakers are rational they allocate fewer resources to civilian services than myopic decisionmakers, but supply the same security level as do myopic ones. Clearly, the utility levels of the citizens of both countries are lower (the same security level and fewer civilian services) under rational decisionmaking. Bar-El, *et al*. (2008) show a greater likelihood of being locked into a rational planning Nash equilibrium when the decisionmakers' discount factor is higher, the perceived benefit from security is higher, and the depreciation rate of weapon systems is lower.

The Israeli-Syrian arms race

To test our model we employ here a dynamic version of Kagan, Levkowitz, Tishler, and Weiss (2008) (henceforth KLTW) to determine the equilibrium strategies of the Israeli-Syrian arms race.

The KLTW model describes an asymmetric arms race between a developed (wealthy) Western country (Israel in KLTW's application) and a (relatively poor) less developed country (Syria in KLTW's application). Due to insufficient financial resources, human capital, and technological infrastructure, the less developed country cannot purchase sufficient quantities of expensive (and effective) modern weapon systems to achieve what it considers a proper security level. Therefore, this country may arm itself with cheaper weapons of mass destruction (WMD), in addition to conventional weapon systems. KLTW assume that the less developed country intends to use its WMD in future wars against its (stronger) rival and, possibly, other potential rivals. The objective of the government of each country is to maximize its discounted stream of utilities, which depends on its expenditure on civilian services and on its security level. The (different) attitudes of the Syrian and Israeli governments to security are embedded in the parameters of their welfare functions. KLTW describe each country's budget allocation between civilian services (education, municipal authorities, legal system, health, etc.) and security, where the latter is a function of the quantities and types of weapon systems in each country's arsenal and those of its adversary. More specifically, the less developed country purchases some conventional weapon systems and some (relatively cheap) WMD. The wealthy developed country purchases conventional weapon systems and, in addition, modern (and expensive) weapon systems which can effectively counter the WMD of its rival. As before, we assume that the central planners in both countries can be either myopic or rational. By using current data on government budgets, growth rates, and real prices of weapon

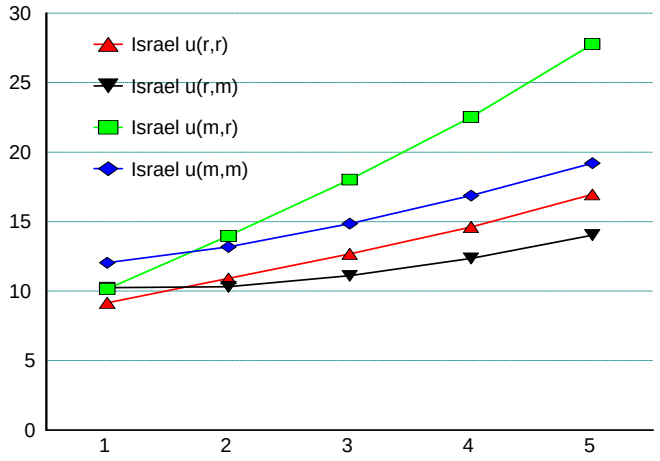

Figure 1: Israeli utility levels over 5 periods for 4 types of equilibria (m,m; r,r; m,r; r,m). Israel's strategy is listed second.

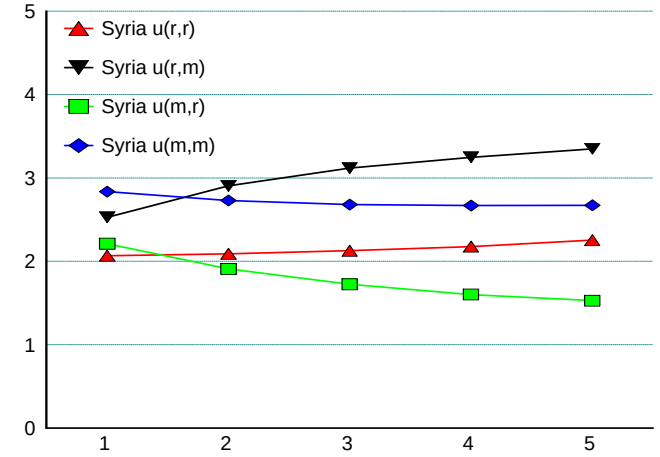

Figure 2: Syria's utility levels over 5 periods for 4 types of equilibria (m,m; r,r; m,r; r,m). Syria's strategy is listed first.

systems we compute the equilibrium solution of the Israeli-Syrian arms race for eight periods (each period consisting of five years) when both countries plan myopically (*m*,*m*), both plan rationally (*r*,*r*), when Syria plans rationally while Israel plans myopically (*r*,*m*), and vice versa (*m*,*r*). Figures 1 and 2 show the utility levels of both countries for the first five periods (25 years) of the planning horizon.[12]

During all five planning periods, Israel's utility level is higher under myopic planning than under rational planning (see Figure 1, where Israel's strategies are listed second). The same is true for Syria (Figure 2, where Syria's strategies are listed first).[13] Israel's utility is, generally, maximal when it plans rationally and Syria plans myopically (Figure 1). The same is true for Syria: its utility is, generally, maximal when it plans rationally and Israel plans myopically. This phenomenon explains why both countries will tend to plan rationally.

Table 1 presents the discounted values of the equilibrium utilities at the equilibrium solutions during the planning horizon (five periods). Clearly, although planning myopically is Pareto-preferred to planning rationally (compare the two numbers in the top-left corner of Table 1 to those in the bottom-right corner), the rational-rational (*r*,*r*) equilibrium is a dominant strategies Nash equilibrium. That is, because 11.2 > 10.3 and 7.9 > 6.9, Syria always prefers to choose rational planning if Israel first chooses either myopic or rational planning. Similarly, because 43.1 > 37.5 and 31.1 > 28.7, Israel always prefers to choose rational planning if Syria first chooses either myopic or rationally planning. The phenomenon of a prisoners' dilemma in the Syrian-Israeli arms race is robust. That is, it is present under a wide range of values that are centered around the parameters reported by KLTW.

Table 1: Discounted value of utility over 5 periods for 4 equilibria types (*m*,*m*; *r*,*r*; *m*,*r*; *r*,*m*)

Israel \ Syria	*myopic (m)*	*rational (r)*
myopic (m)	37.5 \ 10.3	28.7 \ 11.2
rational (r)	43.1 \ 6.9	31.1 \ 7.9

Note: The first-listed number is for Israel, the second for Syria.

Policy implications

Our results suggest that countries engaged in a noncooperative dyadic arms race will likely find themselves in an inferior (rational-rational) equilibrium in which each holds too high a stock of weapon systems without gaining the sought after military advantage on their respective rival.

This somewhat surprising result is due to the fact that (a) a dollar spent on weapon system procurement yields positive returns over several periods (as long as the weapon system lasts) while civilian government services benefit the public only once (most of government civilian expenditures are payments for salaries, social security, etc.) and (b) security is dependent on the rival's actions, that is, it equals one's military capability divided by the rival's capability. Hence, each dollar invested in arms procurement by one country will cause an increase in the procurement of weapon systems by the rival country (the "countering effect"). This phenomenon is at the heart of the arms race dilemma. A similar interpretation is given by Mendez (1997) in the context of a regional security organization. He argues that an increase in military power and deterrence by any member of the security organization is a "public good" for all member states of the organization, while it appears to be a "private bad" for the organization's opponents since it lowers their security.

Each (social welfare maximizing) country should identify the arms race dilemma and attempt to take it into account in its decisionmaking by using appropriate policy alternatives. There are two major policy options in this case. The first option is to reach some kind of agreement with the rival (directly or through a third party). The

second option is to institute force multipliers techniques.

Arms limitation agreements

In this article we demonstrate that the countering effect, where both countries engage in an arms race, results in a "rat race."[14] Acknowledging this outcome, a social welfare-maximizing policymaker should seek an arms limitation agreement to be monitored by a third party (a superpower such as the United States, or the U.N., for example) or a bilateral settlement with the rival.

KLTW provide an extensive discussion of two types of arms limitation agreements. The first type involves a third party that will compensate the less developed country for halting the procurement of weapon systems (or even reducing the existing stocks); the second type is an agreement in which the developed country compensates its rival for utility loss due to halting the procurement of weapon systems. In the latter case an agreement will exist only if both countries enjoy higher utility levels at the arm-limitation solution.[15]

Clearly, an arms limitation agreement in an asymmetric arms race is not a simple matter, and in reality the less developed country tends to cheat in these situations (particularly when the agreement was enforced by political and economic pressures and was not designed to its advantage). For example, in the agreement between North Korea and the United States (U.S.-North Korea Agreed Framework of October 1994) that set guidelines for the disarmament of the North Korean nuclear weapons, North Korea committed to freeze its nuclear proliferation policy. In return, the four parties to the agreement (North Korea, South Korea, China, and the U.S.) agreed to construct two light-water reactors to compensate North Korea for power supply lost and provide it with a yearly supply of 500,000 metric tons of crude oil. This agreement encountered major criticism in the United States and was labeled "surrendering to blackmail" on the grounds of high costs and lack of trust in the North Korean government. In November 2003, the construction of the two light-water nuclear reactors in North Korea was suspended in response to Pyongyang's failure to meet "the conditions necessary for continuing the project." Examination of the outcome of this agreement shows that although North Korea continued its proliferation efforts, it had to do so covertly and, hence, very slowly. That is, the United States achieved a substantial delay in the development of North Korean nuclear capabilities for a very low price (the annual cost of supplying the crude oil to North Korea was about $150 million in current prices). The total amount that was spent on this arms limitation agreement during the 11 years from its beginning to its termination was about $2.5 billion, donated by the 31 participating countries.[16] We believe that today, almost 15 years after the inauguration of the agreement, it can be considered a success despite its formal failure.[17]

Generally, the analysis here suggests that solving military/political conflicts by relying only on the military is an expensive and suboptimal solution.[18] The better approach in an arms race setup is to increase the array of options by adding new dimensions — political, economic, and other — to the menu of all possible solutions. We therefore conclude that policymakers should consider the option of arms limitation agreements. But arms races may evolve in unexpected ways. If a peaceful solution cannot be reached, policymakers should consider military strategies that ensure their country's military advantage.

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Force multiplier methods

Several force multiplier methods are available. First, *security and deception*. A military authority that acknowledges the arms race dilemma may try to gain advantage by classifying its relevant military information, mainly its order of battle and its tactics. Deception is also a method of concealing information from an adversary. The first method (security) is a passive one and the second (deception) is an active one. In our context, a country that succeeds in misleading its opponent may gain an advantage on the battlefield without overinvesting in an open long-term arms race.

Second, *training, force motivation, readiness, and effective operational concepts*. The right size of the order of battle is crucial for the country's military effectiveness. However, a shortfall of training, personnel motivation, and readiness, or weak operational concepts, are also likely to yield less than optimal military might. Clearly, a strategy of investing in R&D and spending on procurement has effects that are different to one of investing in training, forces motivation, readiness, and proper operational concepts. While the first (R&D and procurement) is long-term in nature, the second can be considered as short-term. During routine periods the military is better off spending sufficient resources on procurement and R&D. Once it is forced to prepare for a war or an active conflict on short notice, it is better off spending resources on short-term investments. This distinction between short-term and long-term planning is particularly relevant for countries with compulsory service, where most of the military personnel are retained only for short periods of time.

Third, *intelligence*. High quality intelligence is essential for cost effectiveness of the military. Countering the opponent's deception and investment in weapon systems can be achieved, among other ways, by increasing investment in improved intelligence (the effective use of a wide variety of techniques to obtain and assess information).

Fourth, *asymmetric response*. Military authorities should seek low-cost responses

to both the low-cost routine operations of less developed countries and terror organizations and their high-cost weapon systems. Using the appropriate conceptual response to the rival's military investments and actions will likely coerce the rival into "too high" military expenditure and, thus, a reduction in its allocation of resources to its military apparatus.

Fifth, *technology modularization*. Investing in all-purpose military technology seems to be a force multiplier. If a country is forced into long-term planning, the military authorities, recognizing the arms race dilemma, should invest in developing technology modules that can be assembled in the future into as yet unknown coherent weapon systems which will be able to respond to future (not yet known) threats.[19] There are plenty of examples of very expensive weapon systems that were abandoned due to huge cost overruns (the Israeli Lavi fighter plane, the U.S. DDG-1000 guided missile destroyer, the U.S. Comanche helicopter, etc.) and should not have been developed in the first place. There are counter examples in which investments in modular systems proved to be winners (various UAVs, SAR capability for improved radars, GPS, and more).

Sixth, *late response effect*. Armies tend to respond very late to signals from a dyadic opponent. Early acknowledgment of such signals may facilitate reduction in the investment in all types of defense expenditure. Two examples supporting the late response effect are, first, the Strategic Defense Initiative (SDI) initiated by President Reagan in March 1983 that was set to use ground and space-based systems to deter the USSR from nuclear attack on the U.S. and achieve a decisive advantage in the dyadic arms race between the two superpowers. The USSR collapsed in 1991, partly because it could not compete with the SDI initiative. And yet the United States continued its vast investment in developing the SDI and still does so today. Second, Kagan, Tishler, and Weiss (2005) argue (and show) that the Israeli response to Syria's declining conventional weapon systems, as well as to the Syrian build-up of WMD, came very late. Nevertheless, Israel continues to spend vast resources to counter the diminishing threat of Syria's conventional army.

Seventh, *spiral development*.[20] This project management methodology allows the military to obtain technological and other capabilities faster and at a lower cost, its major advantage being the reduction of the lead-time from the laboratory to deployment. It consists of producing and deploying systems based on mature technologies. When deployed, the first modules of capability will meet some, but not all, of the weapon systems required specifications. Future modules (and improvements) will incorporate new technologies that have, in the meantime, matured and can be fielded at a later stage. The series of modules represents a spiral of increasing capability of the final weapon system.

Summary and crisis management

In this article we argue that an arms race is likely to result in a prisoners' dilemma equilibrium in which the rival countries plan rationally and, thus, overinvest in arms procurement. The likelihood of a war breaking out may be higher, as may the damages due to war, when the rivals in an arms race overinvest in arms procurement.[21] Thus, our discussion indicates the importance of conflict management that can be enhanced by the involvement of a third party (like the U.S., the EU, or the U.N.). The role of the third party may involve negotiating the arms limitation agreement and assisting in inspection, as well as guaranteeing the agreement, and offering economic incentives to the two adversaries in return for concessions in their arms development and procurement. As is the case in the arms race described by KLTW, the main purpose of the inspection, guarantees, and economic incentives is to unlock the prisoners' dilemma.[22]

Notes

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1. Actual U.S. military expenditure in 2009 will be much higher; see Cordesman and Kaeser (2008b).

2. DoD (2008).

3. See, for example, the 30-year plan of the U.S. Navy (Kaeser, 2008), and the long-term U.S. Air Force plan (Cordesman and Kaeser, 2008a).

4. Richardson (1960).

5. Open-loop: See, for example, Brito (1972) and Deger amd Sen (1984). Closed-loop: See, for example, Simaan and Cruz (1975) and van der Ploeg and Zeeuw (1990).

6. See van der Ploeg and Zeeuw (1990).

7. See Panagariya and Shibata (2000).

8. See, for example, DoD (2003); Cordesman and Kaeser (2008b); Kaeser (2008).

9. Setter and Tishler (2006).

10. It is straightforward, although tedious, to extend the analysis to two different countries (see Bar-El, Kagan, and Tishler, 2008).

11. National security is usually measured as some function of the country's military capabilities relative to those of its rivals. Most studies define security as either the difference or the ratio between the country's stock of weapon systems and its adversaries' stock of weapon systems (see, e.g., Bolks and Stoll, 2000; Levine and Smith, 1997; Mantin and Tishler, 2004; Garcia-Alonso and Levine, 2007).

12. We solved the rational equilibrium solution for eight periods to eliminate the "last period effect" in the comparison of the two strategies.

13.Syria's strategies are always listed first and Israel's strategies are always listed second.

14. Akerlof (1976).

15. KLTW show that both options apply to the Israeli-Syrian conflict. Only the first option (involvement of a third party) applies to the North vs. South Korean conflict.

16. See KLTW.

17. The agreements that were reached in the Six Party Talks in September 2005 and February 2007 (Niksch, 2007) can be considered as a direct continuation of the earlier agreement and included a North Korean obligation for complete denuclearization in return for political and economic compensation by all the parties to the 2007 agreement.

18. See, for example, Brauer (2004).

19. Integrative technologies are good examples of these capabilities (see Setter and Tishler, 2006).

20. See, for example, DoD (2003) and Farkas and Thurston (2003).

21. See Brito and Intriligator (1984) and Wallace (1982).

22. See Levy (1985) for an analysis of the terms for mediating prisoners' dilemma conflicts and its application to the Namibian-South African conflict. See Sandler and Hartley (1995) for the role of monitoring and inspection in resolving prisoners' dilemma type arms races.

References

Akerlof, G. 1976. "The Economics of the Caste and of the Rat Race and Other Woeful Tales." *The Quarterly Journal of Economics*, Vol. 90, No. 4, pp. 599-617.

Bar-El, R., Kagan, K. and A. Tishler. 2008. "Myopic or Rational? Defense Budget Allocation and the Prisoners' Dilemma." Working Paper. The Institute of Technology and Society, Faculty of Management, Tel Aviv University.

Bolks, S. and R.J. Stoll. 2000. "The Arms Acquisition Process." *Journal of Conflict Resolution*, Vol. 44, No. 5, pp. 580-603.

Brauer, J. 2004. "Developing Peace Making Institutions: An Economist's Approach," pp. 137-153 in G. Harris, ed. *Achieving Security in Sub Saharan Africa: Cost-effective Alternatives to the Military*. Pretoria, South Africa: Institute for Security Studies.

Brito, D. L. 1972. "A Dynamic Model of an Arms Race." *International Economic Review*, Vol. 13, pp. 359-375.

Brito, D.L. and M.D. Intriligator. 1984. "Can Arms Races Lead to the Outbreak of Wars?" *The Journal of Conflict Resolution*, Vol. 28, No. 1, pp. 63-84.

Brito, D.L. and M.D. Intriligator. 1995. "Arms Races and Proliferation," pp. 109-163 in K. Hartley and T. Sandler, eds. *Handbook of Defense Economics*, Vol. 1. Amsterdam: Elsevier.

Cordesman, A.H. and H.U. Kaeser. 2008a. "America's Self-Destroying Air Power: Becoming Your Own Threat." Report. Center for Strategic and International Studies, Washington, D.C. http://www.csis.org/component/option,com_csis_pubs/task,view/id,4990/ [accessed 29 November 2008].

Cordesman, A. and H.U. Kaeser. 2008b. "Defense Procurement by Paralysis." Report. Center for Strategic and International Studies, Washington, D.C. http://www.csis.org/component/option,com_csis_pubs/task,view/id,5125/ [accessed 29 November 2008].

Deger, S. and S. Sen. 1984. "Optimal Control and Differential Game Models of Military Expenditure in Less Developed Countries." *Journal of Economic Dynamics and Control*, Vol. 7, pp. 153-169.

[DoD] United States, Department of Defense. 2003. "Instruction 5000.2: Operation of the Defense Acquisition System, Department of Defense." Washington, D.C.: Office of the Undersecretary of Defense.

[DoD] United States, Department of Defense. 2008. "RDT&E Programs (R-1): Department of Defense Budget Fiscal year 2009." Washington, D.C.: Office of the Undersecretary of Defense (comptroller).

Farkas, K. and M.P. Thurston. 2003. "Evolutionary Acquisition Strategies and Spiral Development Processes." *Program Manager Magazine*, July-August, 10.

Garcia-Alonso, M.D.C. and P. Levine. 2007. "Arms Trade and Arms Races: A Strategic Analysis," pp. 941-971 in T. Sandler and K. Hartley, eds. *Handbook of Defense Economics*, Vol. 2. Amsterdam: Elsevier.

Kaeser, H.U. 2008. "Abandon Ships." Report. Center for Strategic and International Studies, Washington, D.C. http://www.csis.org/component/option,com_csis_pubs/task,view/id,4816/type,1/ [accessed 29 November 2008].

Kagan, K., A. Tishler, and A. Weiss. 2005. "On the Use of Terror Weapons vs. Modern Weapon Systems in an Arms Race between Developed and Less Developed Countries." *Defense and Peace Economics*, Vol.16, No.5, pp. 331-346.

Kagan, K., A. Levkowitz, A. Tishler, and A. Weiss. 2008. "Evaluating Strategic Arms Limitation Agreements, with Applications to the Israeli-Syrian and the North vs. South Korean Conflicts." Forthcoming in *Defense and Peace Economics*.

Levine, P. and R. Smith. 1997. "The Arms Trade." *Economic Policy*, Vol. 12, pp. 336-370.

Levy, M.A. 1985. "Mediation of Prisoners' Dilemma Conflicts and the Importance of the Cooperation Threshold." *The Journal of Conflict Resolution*, Vol. 29, No. 4, pp. 581-603.

Mantin, B. and A. Tishler. 2004. "The Structure of the Defense Industry and the Security Needs of the Country: A Differentiated Products Model." *Defense and Peace Economics*, Vol.15, No. 5, pp. 397-419.

Mendez, R. 1997. "War and Peace from a Perspective of International Public Goods," pp. 307-336 in J. Brauer and W.G. Gissy, eds. *Economics of Conflict and Peace*. Aldershot, U.K. and Brookfield, VT: Avebury Press.

Niksch, L.A. 2007. "North Korea's Nuclear Weapons Development and Diplomacy." Report. RL33490. Washington, D.C.: Congressional Research Service. http://assets.opencrs.com/rpts/RL33590_20080121.pdf [accessed 29 November 2008].

Panagariya, A. and H. Shibata. 2000. "Defense and Welfare under Rivalry." *International Economic Review*, Vol. 41, No. 4, pp. 951-969.

Ploeg, van der F., and A.J de Zeeuw. 1990. "Perfect Equilibrium in a Model of Competitive Arms Accumulation." *International Economic Review*, Vol. 31, No. 1, pp. 131-146.

Plous, S. 1993. "The Nuclear Arms Race: Prisoner's Dilemma or Perceptual Dilemma?" *Journal of Peace Research*, Vol. 30, No. 2, pp. 163-179.

Richardson, L.F. 1960. *Arms and Insecurity*. Pittsburgh: Boxwood.

Sandler, T. and K. Hartley. 1995. The Economics of Defense. Cambridge, U.K.: Cambridge University Press.

Setter, O. and A. Tishler. 2006. "Introduction: Defense Research and Development in the 21st Century." *Defense and Peace Economics*, Vol. 17, No. 3, pp, 65-167.

Simaan, M. and J.B Cruz, Jr. 1975. "Formulation of Richardson's Model of Arms Race From a Differential Game Viewpoint." *Review of Economic Studies*, Vol. 42, pp. 67-77.

Smith, R., M. Sola, and F. Spagnolo. 2000. "The Prisoner's Dilemma and Regime-Switching in the Greek-Turkish Arms Race." *Journal of Peace Research*, Vol. 71, No. 6, pp. 737-750.

Snyder, H.G. 1971. "'Prisoner's Dilemma' and 'Chicken' Models in International Politics." *International Studies Quarterly*, Vol. 15, No. 1, pp. 66-103.

Wallace, M.D. 1982. "Armaments and Escalation: Two Competing Hypotheses." *International Studies Quarterly*, Vol. 26, pp. 37-56.