# האוניברסיטה העברית בירושלים
# The Hebrew University of Jerusalem

# המחלקה לכלכלה חקלאית ומנהל
# The Department of Agricultural Economics and Management


**Discussion Paper No. 4.01**

## THE IDENTIFICATION OF ENEMY INTENTIONS THROUGH OBSERVATION OF LONG LEAD-TIME MILITARY PREPARATIONS

**by**

**Jonathan Lipow and Yakir Plessner** *

**P.O. Box 12, Rehovot 76100, Israel**

- Corresponding Author: Tel: +972 – 3 – 684 – 5004; Fax: + 972 – 8 – 946 – 6267

# THE IDENTIFICATION OF ENEMY INTENTIONS THROUGH OBSERVATION OF LONG LEAD-TIME MILITARY PREPARATIONS

Jonathan Lipow and Yakir Plessner *

*Department of Agricultural Economics and Management*

*Hebrew University of Jerusalem, P.O. Box 12, Rehovot 76100, Israel*

Abstract:

Intuitively, we would expect that an increase in the military preparations of potential enemies imply that the rival perceives an increase in the likelihood of future conflict. In this paper, we present a simple model that suggests that, surprisingly, the relationship in ambiguous. We find that (a) the specification of the social utility function; and (b) the rate of substitution between long and short lead-time preparations in the production of defense capability play a role in determining whether rivals respond to an increased future threat, by increasing or decreasing their long lead-time preparations.

Keywords: Military, R&D, Procurement, Threat assessment.

JEL classification: H56.

---

Email: lipow@internet-zahav.net (J. Lipow)

- Corresponding Author: Tel: +972 – 3 – 684 – 5004; Fax: + 972 – 8 – 946 – 6267
  Email: lipow@internet-zahav.net (J. Lipow)

## I. Introduction

Intelligence services are constantly searching for information that will provide a clearer picture of the long-term intentions of potential enemies. One important and obvious element of any threat assessment is the evaluation of rivals' physical preparations for war. For example, intelligence services place a great emphasis on monitoring "long lead-time" military activities, such as weapons research and development (R&D), that shed light on the potential enemy's perception of events likely to take place far in the future.

In this paper, we will seek to identify how intelligence analysts should interpret an intensification of the weapons R&D of military rivals. It is intuitively appealing to assume that increased weapons development implies that potential enemies believe that the likelihood of future hostilities has risen. Our analysis, however, suggests that this may not be the case. We find that the response of a potential enemy to a perceived increase in the likelihood of future conflict is ambiguous. There are two key factors that determine the R&D response to an increased long-term security threat. The first is the specification of the social utility function. The second is the rate of substitution between long lead-time investments and short lead-time investments in the production of defense capability.

In our analysis, we will ignore the game-theoretic aspects of enemy behavior. Obviously, potential enemies are well aware that their R&D efforts are being monitored. Hence, there may be a temptation to exploit R&D as a tool of signaling or signal jamming. Optimal behavior under full information must, however, be identified before issues of signaling and asymmetric information can even be considered.

To the best of our knowledge, the questions raised in this paper have heretofore not been analyzed. Several papers have, however, addressed other aspects of optimal defense procurement behavior. Gansler (1980) and Stubbing (1986) conclude, based on case studies, that U.S. military procurement decisions are biased towards the purchase of weapons of excessively high quality. Rogerson (1990) presents a model in which institutional arrangements could create such a bias. In Lipow and Feinerman (forthcoming), signaling behavior on the part of senior military officers leads to a similar bias towards high quality weapons. Finally, Feinerman and Lipow (2001) presents a model in which the timing of procurement decisions, combined with uncertainty regarding future security threats, lead to a greater allocation of resources to weapon quality than would take place under full information.

This paper has four sections. In Section II, we present a simple model of the R&D decision making process. In Section III, we conduct a comparative static analysis in order to determine how the optimal level of R&D changes as the perceived likelihood of future conflict increases. Section IV concludes the paper.

## II. The Conceptual Framework

Consider a country that in the first of two periods, designated $t_0$, has to choose the quality level Q of its weapons, to be procured at time $t_1$ in the future. The quality level is determined by long lead-time R&D activities. During period $t_0$, it is believed that the probability of war during period $t_1$ is p. No asymmetry of information is involved i.e., the choice of Q is not intended as a signaling device. Potential adversaries know that p represents the country's beliefs.

At $t_1$ the state of the system is $\theta$, where $\theta$=W means war actually comes to pass, and $\theta=\pi$ means that peace prevails. Following observation of $\theta$, the country chooses the amount of weapons $N_\theta$ to purchase.

The criterion for making the two choices involved is termed national security, defined by the function

(1) $H=h(Q,N_\theta,\theta)$.

It is required that

(2) $H=\overline{H}$, $\theta=W,\pi$.

This means that the country must preserve an adequate level of national security at all times.

The function (1) is assumed to satisfy the following restrictions:

(3) $\frac{\partial h(.)}{\partial Q}, \frac{\partial h(.)}{N_\theta} > 0,$

(4) $h(Q^*,N^*,W)<h(Q^*,N^*,\pi)$ *for all* $Q^*$, $N^*$.

The first condition states that defense capability is enhanced by both the quality and quantity of weapons. The second asserts that for a given level of quality and quantity, national security under war is less than it is under peace.

Let $c_0$ and $c_1$ denote, respectively, the cost of a unit of quality appropriately defined, and the cost of a unit of weaponry. Although it would seem that the cost of a unit procured should be an increasing function of quality, the simplification employed here is only slight. The reason is that much of the higher costs associated with advanced weaponry reflect R&D expenditures.

III. The Optimal Choices of Quantity and Quality

At $t_1$, quality is already given and the state of nature is known. Hence, because of the monotonicity of (1), the amount of weaponry may be solved from (2):

(5) $N_\theta = f(Q, \theta; \overline{H})$.

Based on (3), total differentiation of (2) implies that (5) satisfies

(6) $\frac{\partial N_\theta}{\partial Q} < 0, \ \theta = W, \pi.$

From (4), it follows that

(7) $N_W > N_\theta$.

We shall also assume that (5) cannot vanish. A natural restriction on (5) that is suggested by this assumption is that

(8) $\frac{\partial^2 N_\theta}{\partial Q^2} > 0.$

That is, (5) is a convex function of Q.

Consider first the special case where the government's objective is to minimize the discounted value of total expenditures on weapons. Assuming for simplicity that the discount factor is 1, the problem is

(9) $argmin U = bc_0Q + pbc_1f(Q, W, \overline{H}) + (1-p)bc_1f(Q, \pi, \overline{H}),$

where b>0 is a constant, whose role will be explained below. The first and second order conditions for minimum are, respectively,

(10) $c_0 + pc_1g'(W) + (1-p)c_1g'(\pi) = 0$

and

(11) $r \equiv pc_1h''(W) + (1-p)\ c_1h''(\pi) > 0,$

where g(W), g(π) are shorthand for f($Q, W, \overline{H}$ ) and f($Q, \pi, \overline{H}$ ), respectively. Because of (8), (11) holds for any value of Q, not just the values that satisfy (10).

To consider the impact of a change in the perceived probability of war on the country's choice of weapons quality, differentiate (10) with respect to Q and p to obtain

$$(12)\ \frac{dQ}{dp} = \frac{g'(W) - g'(\pi)}{r}.$$

There are now two possibilities. One is that, in addition to (7), we assume that

(13) $g'(\pi)<g'(W)$.

Equation (13) states that in response to increased quality, quantity falls under peace faster than it falls under war. In this case, (11) and (13) imply that (12) is positive. This means that quality is an increasing function of the probability of war. In this case a country that increases its R&D efforts may believe that the chance of war has risen.

If (13) does not hold, then (12) is either zero or negative. While (13) seems reasonable, it is not compelling. It therefore follows that observation of changes in the R&D efforts of a cost-minimizing country may not provide any information concerning changes in that country's perception of the future likelihood of war.

Let us turn now to the more general case and assume that the government's objective is a welfare function in which the alternative cost of defense spending is consumption. Let u(C) be the utility function, where C is what is left of income, y, after defense costs. It is assumed that

(14) $u'(C)>0,\ u''(C)<0$.

For simplicity, we assume that there is no growth of income over time, and that the discount factor is 1. The government desires, then, to

(15) $\arg\max U = u(y-c_0Q)+pu(y-c_1f(Q,W,\overline{H}))+(1-p)u(y-c_1f(Q,\pi,\overline{H}))$.

Before dealing with the solution to this problem, we show that cost minimization is indeed a special case of welfare maximization. For if the government is risk neutral, i.e., the welfare function is linear, then (15) may be rewritten as

$$(16)\ argmaxU=a+b(y-c_0Q)+p(a+b(y-c_1f(Q,W,\ \overline{H}\ ))+(1-p)(a+b(y-c_1f(Q,\pi,\ \overline{H}\ )),$$

where a, b>0, and b is the constant employed in (9), to which (16) clearly leads.

The first order condition for (15) is

$$(17)\ -u'(y-c_0Q)c_0-pu'(y-c_1g(W))c_1g'(W)$$
$$-(1-p)u'(y-c_1g(\pi))c_1g'(\pi)=0.$$

Equation (17) says that the marginal utility foregone for acquiring additional quality should equal the expected utility gained by avoiding the need to buy additional weapons.

The second-order condition for (15) is

$$(18)\ R\equiv u''(y-c_0Q)c_0^2+pu''(y-c_1g(W))c_1^2[g'(W)]^2+pu'(y-c_1g(W))c_1g''(W)$$
$$+(1-p)u''(y-c_1g(\pi))c_1^2[g'(\pi)]^2+(1-p)u'(y-c_1g(\pi))c_1g''(\pi)<0$$

for the values of Q that satisfy (17). Because of (8) and (9), R<0 everywhere, so that the solution is a global maximizer.

To see how a perceived change in the probability of war affects the choice of quality, we differentiate (16) with respect to p and Q to get

$$(19)\ \frac{\partial Q}{\partial p}=\frac{c_1[g'(W)u'(y-c_1g(W))-g'(\pi)u'(y-c_1g(\pi)]}{R}.$$

The sign of (19) is ambiguous. This is so because

$$u'(y-c_1g(W))>u'(y-c_1g(\pi)).$$

If (13) holds, then it is impossible to tell whether an increase in the perceived probability of war will lead to an increase or to a decrease in long lead-time activities aimed at enhancing the quality of weaponry. If (13) does not hold, however, then (19) is negative.

In other words, an increase in the perceived likelihood of war leads to a *reduction* in long lead-time activities.

## IV. Conclusion

As we have seen, observation of a military rival in respect to R&D and other long lead-time military activities does not provide any reliable information concerning the way that country perceives the future likelihood of war. This suggests that the emphasis placed on the monitoring of long lead-time military activities by intelligence agencies may be misplaced. In reality, little can be inferred regarding the intentions or perceptions of military rivals by observing their R&D efforts.

References

Feinerman, E. and Lipow, J., 2001. Is there a bias towards excessive quality in defense procurement? Economics Letters 71, 143 – 148.

Gansler, J., 1980. The Defense Indsutry. MIT Press, Cambridge, MA.

Lipow, J. and Feinerman, E., (forthcoming). Officer reputation and quality/quantity tradeoffs in defense budget decision-making. Defense and Peace Economics.

Rogerson, W., 1990. Quantity vs. quality in military procurement. American Economic Review 80, 83 – 92.

Stubbing, R., 1986. The Defense Game. Harper and Row, New York.