COWLES FOUNDATION FOR RESEARCH IN ECONOMICS

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COWLES FOUNDATION DISCUSSION PAPER NO. 789

DEFENSE ECONOMICS AND ECONOMIC WARFARE REVISITED

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April 1986

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DEFENSE ECONOMICS
AND
ECONOMIC WARFARE REVISITED*

by

Martin Shubik with J. Hoult Verkerke

I INTRODUCTION

Economics has been called the "dismal science." Its application to war will not lighten the epithet. Yet the failure to apply economic reasoning to war makes it an even more damaging occupation than it otherwise might be.

This paper covers two related topics which sometimes are confused. They are the economics of defense and economic warfare. The economics of defense consists in applying economic analysis to national defense issues. As economics is a science of choice, so defense economics is a systematic study of choices from among competing alternatives. Examples of these choices include: the level of defense spending, the mix of public and private weapons production and the attention paid to the macro-economic effects of defense activities.

Economic warfare is the use of economic weapons for strategic purposes. This topic can be divided into two parts. The first is economic warfare for private economic purposes. This type of economic warfare is studied in the literature on oligopoly, on monopolistic competition and on bargaining and other aspects of competition among the few. (See, for example, Zeuthen, 1930.) We do not deal with this topic. The second type of economic warfare is that undertaken by a government to promote its national objectives. This type of economic warfare, seen as one element of a national strategy, is, along with the broader topic of defense economics, the subject of this paper.

While defense economics encompasses any application of economic analysis to defense, the study of economic warfare focuses more narrowly on the use of economic weapons. These weapons certainly include sanctions, embargoes and cartels. But do they also include industrial mobilization, arms races and stockpiles of strategic

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* The authors gratefully acknowledge helpful discussions with Paul Bracken and the research assistance of Anant Sundarum and Lisa Brandes. This work relates to Department of the Navy Contract N00014-84-K-0429 issued by the Office of Naval Research under Contract Authority NR 274-352. However, the content does not necessarily reflect the position or the policy of the Department of the Navy or the Government, and no official endorsement should be inferred. The United States Government has at least a royalty-free, nonexclusive and irrevocable license throughout the world for Government purposes to publish, translate, reproduce, deliver, perform, dispose of, and to authorize others so to do, all or any portion of this work.

materials? These latter topics occupy a gray area which prior authors have excluded from economic warfare. (See, for example, Hitch and McKean, 1963.) And yet each of them involves important economic decisions. We also may question whether attacks on economic targets constitute economic warfare. Such attacks undoubtedly influence the ability of a country to wage war. Though they achieve this influence through military means (e.g., sabotage, mining, blockade, bombing), the attacks aim to reduce the economic potential of the enemy.

We adopt the narrow definition of economic warfare with a caveat. The category is arbitrary. We will have to look elsewhere for strategically meaningful divisions of defense economics. One useful distinction among various types of analysis in defense economics is the degree to which the analysis considers the enemy response. We may identify three classes of analysis: 1) assumes no response, 2) considers local response, and 3) considers global responses. The first category characterizes engineering-type studies of the least cost method of production or transportation. This type of analysis is relevant to technical questions where our choices are unlikely to affect enemy strategy.

The second category, while still employing the method of constrained maximization, introduces explicitly the enemy's reaction to our choices. Such studies consider only the local response, where "local" has both a spatial and temporal meaning. They are analogous to partial equilibrium analysis in economic theory.

The third category considers overall strategic action and cannot be treated as a strictly economic problem. In this mode of analysis, quantification becomes increasingly difficult. Sociopolitical considerations may predominate. At best it may be possible to describe the important strategic interactions and to rank them according to their relative importance.

There have been considerable changes in the configuration of the world economic system and military capabilities in the past twenty-five years. It is our belief that the necessary updating of economic thought as applied to defense analysis has not kept pace with the change. The legacy of the Vietnam war is to be seen in the missing generation of defense analysts and the gaps in our knowledge and analysis.

The approach here is primarily via economics and political economy. In the field of defense economics, there is a spectrum stretching from almost pure economics (e.g., the cost of feeding troops in peace time) to grand strategy with economic implications (e.g., a decision to attack economic targets). The damning but possibly accurate remarks of Hedly Bull (1982) where he suggests that the scholar may have not much to contribute to strategic policy-making should serve as a warning against the overreliance on economic thought in strategic matters.

In this paper we paint with a broad brush. Our purpose is to present an overview, a status report, and by implication, an indication of what needs to be done at this time. We devote Sections II and III to providing a survey of topics in the economics of defense and in economic warfare. In Section IV, we conclude and comment on some naval aspects of these topics.

II PROBLEM AREAS IN DEFENSE ECONOMICS AND ECONOMIC WARFARE

Since World War II many of the economic problems of defense have remained more or less the same. But the technologies of weaponry and of communication have changed dramatically during this period. The implications of explosives measured in megatons, communication times in nanoseconds and weapons costs in billions of dollars force us to reexamine conventional wisdom on both defense economics and economic warfare.

War always has been an expensive business. The phrase "winning the war decisively" has a clear and morally imperative meaning to the military. But the clarity of mind and unity of purpose needed to destroy an enemy often produces a mindset, if not opposed to, at least not consonant with the views of auditors, economists and politicians in a democratic society.

Unfortunately, along with the advances in technology, maintaining peace by being adequately supplied with the means to wage war has remained a considerably expensive part of the modern economy. Table 1 shows the GNP of a selected group of nations in the period 1950 to 1980 and the percentage of GNP reportedly devoted to defense.

Table 1

Country	1965	1970	1975	1980
France	314.9	400.3	486.9	575.1
	(5.2)	(4.2)	(3.8)	(3.9)
U.S.A.	1800.2	2102.9	2390.1	2868.3
	(7.1)	(7.4)	(5.4)	(5.0)
U.S.S.R.	819.8	1129.0	1392.0	1558.3
	(>10)	(12.1)	(14.9)	(15.0)
W. Germany	418.6	521.6	577.9	688.7
	(4.3)	(3.3)	(3.6)	(3.3)

(Source: U.S. Central Intelligence Agency, 1982 and U.S. Arms Control and Disarmament Agency, 1984, 1978, 1976)

The accurate measurement of defense expenditures are notoriously difficult for at least three reasons: 1) secrecy, 2) conceptual definitions, and 3) empirical measurement of costs of production. (See Treml and Kostinsky, 1982; Wolf et al, 1983; Rosefielde, 1982.) The secrecy aspects of Soviet and other military expenditures need little elaboration.

The conceptual problems pose deep difficulties especially because the political discourse in a democratic society depends heavily on the perceptions of the public and their political representatives of trends and magnitudes. A busy legislator has little time or patience to consider the details of whether a scientific research project with military application supervised by a member of the Academy of Sciences should be

imputed to defense expenditures or pure science. Yet, when discussing "missile gaps," science gaps, civilian defense differences, and other economic efforts closely related to overall military strength, the reclassification of costs and activities can produce trends in any direction. Technical difficulties, such as selecting an exchange rate for the rouble or imputing a price where no open market exists, are enough to reverse a trend.

The economic problems of costing major weapons systems are complex. A Nimitz class carrier may take on the order of ten years to complete, especially when one includes the planning and paperwork needed prior to actual construction (Livne and Shubik 1982). But with some construction times in the range of five to ten years and weapons systems design and production cycles stretching out ten to twenty years (with frequent change orders imposed on the production process) the clashes among the length of bureaucratic job tenure in the military, the political cycles of two, four and six years (House, Presidency and Senate) in the United States, and the weapons procurement process produces difficult coordination problems.

Table 2

Position	Date of Assignment	Tenure
Commander-in-Chief	1956	26
First Deputy	1974	8
Chief Main Naval Staff	1981	2
First Deputy	1976	6
Chief Political Administration	1981	2
Chief Shipbuilding & Armaments	1966	16
Chief Technical Readiness	1970	12
Chief Naval Aviation	1982	1

(Source: Soviet Armed Forces Review, 1982-83.)

Table 2 shows the time in post for some senior Soviet naval personnel. From August 16, 1949 until 1984 the United States has had ten chairmen of the Joint Chiefs of Staff (Defense, Sept. 1984, p.11) giving an average time in office of three to four years. It is an open question as to what are the benefits and drawbacks in the tradeoff between fast and slow turnover in high command positions. But the indications are that there are considerable differences in length of tenure in the Soviet and U.S. systems.

We now turn from our concern with political and military control to the economics of the production of weapons. In the domain of the economics of specialized production with indivisibilities, the set up costs of manufacturing facilities for items such as tanks or planes makes it highly desirable to engage in coproduction and to promote a vigorous international trade in order to reduce unit costs. An industry that is, at best, oligopolistic, at the forefront of innovation, intimately involved in international trade and that depends almost completely on the political

process poses great challenges to economic analysis.

The study of Peck and Scherer (1962) applies industrial organization economics to the problems of weapon development and procurement. They demonstrate the importance of and difficulties with the economics of the defense industry. The more recent, but less analytical, work of Gansler (1980) provides examples illustrating the many difficulties in comprehending the economics of the defense industry.

Autarky has a lengthy history in the economics of defense. Adam Smith (1776) noted the special duty of the sovereign to defend the state and the attendant costs of providing this defense. Ausspitz and Lieben argued for autarky. Alexander Hamilton (1791) favored protection to promote an industry capable of supplying military needs and weighed whether armaments should be supplied by a governmental industry or by private firms. The great light arms industry of New England at the time of the Civil War was a product of individual entrepreneurship and government interest in standardization with the Harper's Ferry establishment playing an important role (Hounshell, 1984).

It can be argued that the American Civil War was the first modern war where the dull and pragmatic economic consequences of industrial power, the Northern railroad communication system plus the naval blockade of the South, overwhelmed better generals. It is suggested here that, in a world with the threat of nuclear war, where at least two countries operate, at great cost, vast command and control systems involving tens of thousands of individuals with twenty-four hours a day of surveillance (Bracken, 1983; Blair, 1985), deep consideration need be given to the delicate balance of bankruptcy that accompanies the delicate balance of terror.

Kanter (1984) offers a brief overview of defense economics from 1776 to 1983. The conclusions he reaches are that it has only been in the twentieth century that massive mobilizations have dominated the industrial economies in wartime. He then offers two mutually exclusive beliefs that either economic growth can or cannot be sustained with a heavy military expenditure. Although he notes the advent of strategic analysis there is little if any attempt in this otherwise useful article to distinguish and link the problems of defense economics and economic warfare. Sharfen and Ball (1983) have recently considered economic warfare yet their conclusions reinforce the observations of Kanter (1984) and Shubik (1979) that the concern for both defense economics and economic warfare in the recent past has been small.

The domain of economic analysis relevant to war ranges from the most detailed mundane technical assessment of the costs of moving a ton of food from point A to B, up to the cost-benefit analysis of alternative scenarios of nuclear war. For obvious reasons, a prime concern for all is the consequences of a nuclear war.

The implications of Herman Kahn's (1962) warning do not appear to have been fully appreciated, even in current thought. He warned of the effects of a failure to estimate and analyze the potential effects of nuclear war. In Thinking the Unthinkable, his message was that to invoke a scenario of utter horror is an unsound psychological device to rationalize this failure. The approach of sticking a "minus infinity" into nuclear war payoffs helps to justify the value of a massive retaliation threat. But, by the same line of reasoning, no sane individual or group would carry out a massive retaliation unless it were an act of revenge or desperation. For a threat to be plausible the magnitude of the transgression matters. In particular, the general

economic mode of reasoning makes policies such as massive retaliation suspect from the start.*

A blanket policy of massive retaliation without linking the punishment to the level of aggression may be a logically feasible threat, but the plausibility that it will be carried out may vary with the magnitude of the aggression. Putting aside the technological barriers for a moment, the Strategic Defense Initiative raises the interesting question: How should we expect a defensive arms race to differ from an offensive one? Our analysis lends support to the argument that a defensive arms race would be more stable and predictable. The relative deterrent effect of a defensive shield versus a retaliatory strike capability against "irrational" enemies (e.g., Islamic fundamentalists) also favors defensive weapons.

In a complex system loaded with errors, time lags, misperception and loose linkages among many decisionmakers sharp distinctions quickly blur. Situations which have been static and apparently well defined for decades may become fluid and ill-defined for a brief window of time. Thus there are several "traditional boundaries" between France and Germany any one of which is stable for some period until a moment of opportunity opens up. At this time the situation in Hungary and Czechoslovakia may be regarded as stable. When matters change the critical feature which will determine what results from the period of fluidity will be the preparations by all parties to handle conflict at every level without having to dichotomize between peace and nuclear holocaust.

It is important to bear in mind that the first postwar reliance on nuclear weapons was to some extent for economic reasons (Dyson, 1984). The weaponry promised war on the cheap or more bang for the buck. But this hope proved illusory. The need for the foot soldier or the policeman on a horse has not disappeared even though each has become considerably more expensive and new needs calling for sophisticated weaponry have appeared.

The economic problem of defense calls for the evaluation of the absolute level of defense expenditure and the tradeoff of expenditures at all levels. Thus rescue missions in Lebanon, insurgency in Angola, liberation movements in Afghanistan or Cambodia, small wars in Africa, coups in the Caribbean, adventures in the Falklands, intervention in Iran in the post-Khomeini interregnum, war in Central Europe and all-out thermonuclear war must all be considered in terms of an integrated defense posture which counts both political and economic costs.

III THE ECONOMIC ASPECTS OF DEFENSE: TOPICS AND PROBLEMS

In order to appreciate the breadth of the context in which defense economics and economic warfare must be considered, a breakdown into five broad scenarios appears to be useful. These are: 1) peace and cold war, 2) proxy or client war, 3) limited war, 4) full conventional war and 5) nuclear war. No claim is made that these categories do not overlap on occasion. Table 3 below uses these categories to portray the variety of

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* Or, alternatively, it can be argued that economic reasoning is suspect when applied to fear, revenge and nuclear attack.

economic problems which appear and vary from scenario to scenario.

Although most of our comments emphasize the overall economic viewpoint of the United States, there are several key distinctions called for. They are the politico-economic interface in defense decisionmaking as well as the different ways in which economic problems are encountered and perceived by the Soviet Union, the United States and by third parties. Symmetry assumptions (e.g., assuming that the Soviet problems are like ours) may be dangerously misleading. Equally dangerous is the penchant to view potential conflict as only bipolar. (For example, the best friends of China and of France, appear to be China and France respectively.) We attempt to avoid both of these errors.

In the remainder of this paper, we present a brief sketch of the various topics noted in Table 3 together with an assessment of the potential value of further investigation and planning. In this section, general comments are made on each of the major topics. These are followed by more specific observations made in the context of the war scenario contemplated.

Table 3

Topic	Peace and Cold War	Proxy/Client War	Limited War	Conventional War	Nuclear War	General Comments
Logistics and Convoys	1.1 Contingency plans Intelligence Covert operations Terrorism Boot on the ground deterrence Non-client small wars	1.2 Surreptitious vs. overt supply (Afghanistan, Pakistan) Covert operations against enemy supply lines (Afghans attack w/heat seeking missiles, mining Nicaraguan harbors)	1.3 Harassment Refueling, coaling stations	1.4 Points of vulnerability Choke points War length Rate of resupply (Yom Kippur War)	1.5 Limited vs. Armageddon Communications and transport Supply from unaffected areas? Third parties War length	Logistics and transportation economics Role of marine vs. air supply routes Institutions and authority (esp. interservice) Basing problems
Mobilization	2.1 Contingency plans Exercises Sizing surge capacity Public vs. private tradeoff Mobilization war triggered by a crisis	2.2 No mobilization Reserves and readiness as a deterrent to hostile entry	2.3 Partial mobilization Increase reserves Improve readiness Public control of production?	2.4 Total mobilization Full manpower Maximum readiness Public control of production? Allied supply to U.S.	2.5 Mobilize for a conventional war after nuclear recovery What will be left? How does war end? Who wins?	Role of marine vs. air supply routes Institutions and authority What kind of economic control? Intelligence Industrial policy
Sanctions Sabotage & Embargoes	3.1 Harassment Financial, industrial and military sabotage Illicit trade	3.2 Harassment Economic threats to trading partners	3.3 Seige warfare	3.4 Seige warfare (Pnom Penh, Beirut Pusan and Leningrad)	3.5 Food embargo could cripple major powers in post-attack world	Damage exchange Effectiveness Preemptive buying Export controls
Strategic Materials	4.1 Stockpiling Autarky	4.2 Denial of materials to enemy and his clients	4.3 Denial... Attacks on economic potential Short-term elasticities	4.4 Relative value of attacks on economic potential Short-term elasticities	4.5 Are supplies inaccessible or destroyed?	Lack of materials may limit surge capacity
Blockade	5.1 Is this still a strategic option? (e.g. Cuba)	5.2 Mining operations	5.3 Mining Fleet blockade	5.4 Seige warfare Control of SLOC and military economic conseqences Mining Fleet blockade	5.5 Primitive blockade could cut off food supplies from unaffected areas	Sabotage Permeability Could impede convoys and mobilization

Table 3 (continued)

Topic	Peace and Cold War	Proxy/Client War	Limited War	Conventional War	Nuclear War	General Comments
Cartels	6.1 Cartels have coercive power in disputes	6.2 Some coercive power	6.3 Military power predominates through the threat of invasion	6.4 Cartel members subject to invasion	6.5 New relative power of unaffected nations	Political aspects Economic aspects Role of corporations in international disputes
Bilateral Arms Races	7.1 Choice of force structure (e.g. nuclear triad) Offensive vs. defensive weapons (e.g. S.D.I.) "Peace" movements Alliance politics	7.2 Choose level of weapons technology supplied to proxy or client	7.3 Cost and value of slow, long client war (e.g. Vietnam Afghanistan)	7.4 Economics of countermeasures	7.5	Damage exchange Indices of damage Political will Role of domestic and international politics
Arms Industry	8.1 Production, R & D for arms races Increasing returns to scale and international arms trade	8.2 Arms sales and supplies in "little wars" Issue of control	8.3 Arms sales... Surge capacity Lead time in a crisis	8.4 Role in mobilization and resupply cycle	8.5 Speed of reconstitution and amount of resiliency	Political economy of arms industry Procurement in markets with one buyer and a few sellers Bureaucratic incentives for weapons evaluation
Finance	9.1 Use of debt to gain political leverage Sabotage	9.2 Financial support of proxy Hindrance, denial for enemy	9.3 Blocking accounts Freezing assets Runs and panics Financial conseqences of mobilization	9.4 Financing mobilization Control of inflation Sabotage and esoteric financial warfare	9.5 EMP on the banking system Can the government tax or borrow? Culpeper switch	Strategic default Bureaucratic difficulties International financial control Costs of using the financial system for political purposes Effectiveness of financial sanctions

1 Logistics and Convoys: General Comments

The traditional object of logistic operations is to enable military forces to engage in combat, occupation or deterrent deployment with the minimum possible material constraints. Logistics capabilities also can exercise a deterrent effect. We may distinguish between military logistics and national logistics. The former refers to the specific ability of the military services to transport and support their forces. (A sample of the bibliographic references is given in Abstracts of LMI Reports (1962-1982), Logistics Management Institute, Washington D.C. 1983.) The latter refers to the ability of a nation to assist the military services. National logistics often is called industrial mobilization. We prefer to emphasize the theoretical and practical similarities by using the term national logistics.

Important determinants of logistic difficulty are:

a) distance of operations from national territory.
b) geographical barriers.
c) political barriers.
d) military barriers.
e) availability of forward support bases.
f) type of operations required.
g) urgency of logistic operations.
h) overall scale of logistic requirements.
i) level of advance preparation.
j) size and location of available inventories.
k) availability of transportation.
l) security of supplies of raw materials.
m) surge production capacity of industry.

The importance of each of these factors will vary according to the type of conflict. We begin with some general observations on the nature of each of the determinants of logistic difficulty and discuss the ways in which they may interact. The varying importance of the determinants within each class of conflict is then examined.

Clearly, the distance of operations from national territory is an exogenous variable. And yet in two ways it can be controlled. First, we may examine our strategic commitments in an effort to consolidate these commitments close to our territory. This consideration has produced the strategic doctrine of spheres of influence. Second, we may attempt to acquire bases and rights to use foreign bases. These bases become an extension of national territory for military purposes. Our last option is to configure our forces so that they are sufficiently mobile over long distances to project force where it is needed. This option does not control the distance; it simply adapts to the parameter.

Geographical barriers between supply points and the theater are simply an extension of the distance. Likewise they are susceptible to the same controls and adaptation.

Political barriers again are an extension of the concept of distance. They are also susceptible to the expedient of technical adaptation and the strategic choices outlined above. In addition we may invest in geopolitical capital as a means of reducing these barriers before the fact. These efforts may involve seeking streamlined

procedures for securing permission to enter a country's airspace. Or we may resist extension of territorial waters under international law (e.g., the new Law of the Sea). Furthermore we may conduct extensive contingency analysis of supply routes for potential conflict zones. While it is a common practice to consider distance and geographic barriers, we have often neglected the fact that the geopolitical landscape is far less stable.

Military barriers are again subject to frequent change. They are not generally negotiable. They may be avoided or overcome by technical means. The selection of an appropriate strategic choice may also avoid a confrontation. As with political barriers there may be a great deal of uncertainty about how a nation will react to our efforts to move troops and equipment. The uncertainty in the military realm is likely to be even greater since military contingency plans are less likely to be made public. Thus our own plans for logistic contingencies require us to consider a large number of possibilities. This fact suggests that our plans will be most successful when they allow last minute information to influence a choice among prearranged alternatives.

Forward support bases are essential to any logistic strategy which seeks to economize on transportation costs. Some obvious transportation costs are ships, planes, trucks, railroads and fuel. But one must also consider the cost of relying on long, vulnerable supply lines. A delay in military operations caused by waiting for supplies is a cost which may be attributable to our failure to maintain forward bases. If our only logistic option is a ten day sea journey to the battle theater, then we certainly will find a firmly entrenched enemy. In fact, our narrow range of logistic options will encourage potential aggressors. This failure to deter aggression may prove far more costly than maintaining forward bases. In short, forward bases and permanently stationed troops and ships are a powerful conventional deterrent. An awareness of the power of proximity is the foundation of gunboat diplomacy.

The recent U.S. Naval exercises (in the vicinity of Libya) demonstrate the subtle tradeoffs involved in the modern use of gunboat diplomacy. One crucial difference in its use today is the role of the news media in covering and even creating events. One can be quite certain that Qaddafi's widely covered ride on the deck of a patrol boat would not have occurred without the presence of the electronic media. Although the presence of a significant American naval force undoubtedly made some impression on the Libyans, the net effect of the exercises may have been to give Qaddafi the publicity he wanted. In Middle Eastern politics, an Arab state which succeeds in confronting the United States may believe that it becomes, at least temporarily, more influential. Even in decisive military defeat, a charismatic despot often may salvage a domestic political victory.

The logistic requirements of a heated battle differ markedly from those of an occupation force even if the number of troops involved is identical. Thus logistic contingency planning must consider the most likely roles of our military forces in a region. Our attention to this matter will highlight the tradeoffs involved in making strategic commitments in remote places. This concern for the type of conflict naturally will influence our decisions concerning forward bases, landing rights and the type of combat units we create. If interservice political maneuvering determines our force structure, then there will be little, if any, correspondence between strategic objectives and our combat capabilities. In extreme cases, we simply may lack the required forces. But any divergence between objectives and capabilities will make war fighting and even deterrence much more costly. When you need a screwdriver, a

hammer will not do.

The urgency of logistic operations is a key element in our advance planning for conflict. It is almost always the logistic requirements of a given strategy which delay its implementation. In rare circumstances, the delay of logistic preparation for battle provides an interval for diplomatic maneuvering (e.g., the Falklands War). But even in this type of situation, one can argue plausibly that the expectation of a delayed response helps to provoke the conflict. For a fine description of the role of logistic limitations in provoking the Falklands War, see Hastings and Jenkins (1983).

Logistic operations may vary from minuscule to enormous. And there is substantial correlation between the scale of operations and the time required to complete them. In this sense, military planners who value immediate response to aggression must discover means to maximize the military potential of the smallest possible force. This trade off between scale and rapidity of response illuminates the appeal of tactical nuclear weapons. Their high yield to weight ratio minimizes the logistic requirements to project a given amount of force. We must also consider the role of unusual defense strategies in overcoming logistic obstacles. Perhaps a credible threat to attack a nearby target in retaliation for a distant act of aggression could deter that aggression. One must balance carefully the economy of such a strategy against the political and diplomatic vulnerabilities which it can create.

Advance preparation is a form of logistic expense and it must be carefully managed. Above all, preparations for logistic operations need to support strategic objectives. If we have a few overriding strategic objectives, then we may realize substantial returns from concentrating our logistic resources in support of these objectives. The cost of preparing for every contingency may be that we will not be prepared properly for any of them. Given that our logistic resources are limited, our strategic commitments can be evaluated in part on the basis of their logistic requirements. We may find that some of these commitments make unacceptable demands on our logistic resources. In this case, a fundamental rethinking of policy is required.

The size and location of inventories is a strategic decision which influences every succeeding phase of logistic operations. We may construe "inventory" in the most general sense of any prepositioned military asset. These inventories besides playing the rather obvious role of buffering the initial demands of military operations, may also exercise a significant deterrent effect on potential aggressors. This deterrence arises in part because prepositioned military assets enhance the credibility of a threat to retaliate. When weighed against the costs of making threats credible through the actual exercise of force, the cost of these prepositioned assets may be relatively small. But like the nuclear deterrent force it may be difficult to convince the electorate of the need for forces which we hope never to use.

Inventories at forward bases also raise the stakes in the event of an invasion. A potential aggressor may not wish to risk the provocation inherent in overrunning a base manned by U.S. personnel. Thus widely stationed U.S. military personnel may exercise a deterrent effect out of proportion to their actual firepower. Terrorists, in the absence of a credible policy of retaliation, often are not deterred. Thus we must weigh the strategic benefit of these forces against the new vulnerabilities they create.

The classic example of an apparent failure to assess these costs correctly is the

decision to deploy U.S. troops as part of the multinational "peace-keeping" force in Lebanon. One might argue that the prior probability of an attack was low and that the value of stabilizing the situation was high. But such an analysis neglects the important question of alternative strategies. In point of fact, the shelling from the big guns offshore proved to be the only effective sanction against factional violence. This naval strategy involved negligible exposure to loss, and avoided the risk of wholesale sacrifice inherent in the onshore deployment. The fundamental point is that troops deployed in proximity to terrorist enclaves must have the means to defend themselves.

Logistic operations primarily consist in the transportation of troops and materiel. Thus the logistics planner must be concerned especially with the availability of the means of transportation. Contingency planning for transportation requirements requires substantial information about strategic and tactical plans. (And strategy and tactics which ignore the number and size of available ships, planes and trucks are doomed to failure.) Logistic plans also must consider whether to maintain large, relatively idle inventories of ships, planes, trucks and trains or to rely on the rapid adaptation of commercial vehicles.

In the related area of national logistics, there is an optimal strategy for maintaining the so-called "infrastructure." The policy recommendations of such a strategy may include subsidized construction and maintenance of roads, airports, railroads and ship terminals. But current policies seem to have been adopted with little attention to their specific military benefits or to potential alternatives. In Pfaltzgraff (1983), several authors offer unusually careful and insightful essays on mobilization issues. While the literature is full of assertions on what constitutes a strategic industry and prescriptions for strategic economic strength (e.g., Fabrie, 1985), it is rare to find analytic rigor. Among the many subjects deserving further inquiry is the role of political appropriations in distorting decisions regarding mobilization infrastructure. And an analytic framework for assessing the strategic importance of various industries and materials would be an immensely valuable contribution.

Obtaining secure supplies of important raw materials is a vital national security objective. Food, petroleum and minerals for alloying are some of the supplies which are essential both in peacetime and during a war. Again the options are to maintain massive inventories and/or productive capacity or to plan for a secure supply from abroad. In choosing the second option for any material, one must prepare for or insure against shifting political and military alliances. Protecting the sea lanes is useless if one's supplier refuses to sell the commodity in question. Wu (1973) provides a sober view of the complications in securing raw material supplies in a "multipolar world." His work represents an excellent starting point for further analysis in this area.

Policy in this area trades off the certainty of an inventory with its relatively high cost against the uncertainty of foreign supply at a lower direct cost. In principle, one can evaluate the expected values of alternative schemes, but the estimates of risk and return for foreign supply are tenuous at best. This issue presents an interesting challenge to the conventional wisdom about the supposed risk neutrality in public decision making. When the risk involves the very existence of the nation, does the state resemble the risk averse individual?

National logistic requirements include the ability to sustain a surge in industrial production. Military hardware and munitions naturally take precedence, but

shipbuilding, truck, plane and other transportation equipment manufacture could be crucial in a protracted conflict. This industrial capability could be reduced by a lack of plant capacity, insufficient supply of raw materials, financial disruption or a shortage of trained personnel. Each of these problems requires careful analysis. In some cases, government action may be able to guarantee the necessary plant, material, finance or manpower. But, in other areas, an attempt to politically direct investment or encourage production may prove counterproductive. We are concerned particularly about the potential for introducing defense related subsidies or tariffs which can be manipulated for private ends. This potential is part of the prospective cost of any economic intervention for national defense purposes. A strategy to minimize the potential for manipulation would be a significant contribution.

The determinants of logistic difficulty discussed above also interact. One may tradeoff widely dispersed inventories against readily available transportation. But if one wishes to rely on centrally located inventories, then he must be able to supply transportation as well as the political, diplomatic and military leverage to secure the supply route to the theater. Similarly, large inventories of strategic materials are a substitute for secure supplies from abroad. But some source of supply is an essential input to the surge production capacity of industry.

Last, but far from least in our general observations on logistics and production we stress the importance of understanding the elasticity of supply and demand of all materials to changes in price, technology and military urgency. An example of these concerns is the dramatic difference between the short-run and long-run elasticities of supply for oil. Policies devised in response to the perceived short-run elasticity, which is very low, will over time become ill-matched to the long-run elasticity, which is relatively high.

1.1 Logistics and Convoys: Cold War

In cold war, the superpowers engage in so-called "peaceful competition." And yet this competition involves the production, deployment and maintenance of vast arsenals of weapons as well as the enlistment, training and supply of large standing armies. The Soviet and American navies operate in every ocean. Both the U.S. and the U.S.S.R. have thousands of troops permanently stationed far from their national territory. And superpower nuclear missiles are based in NATO and Warsaw Pact countries. Each of these cold war activities involves significant logistic operations. We discuss briefly six topics related to logistics during a cold war.

First, we advocate academic and military research into questions of logistics. The field is not considered as glamorous as strategy and tactics, and thus it has not attracted much scholarly attention. There are abundant studies answering the practical questions of how best to maintain a fleet of trucks or to schedule an airlift. (See, for example, Bureau, 1972.) But there is a dearth of work identifying the key concepts of logistics and their relationship to strategy and tactics. The appropriate time for research is before the war begins. And peacetime offers ample opportunity to reflect on the problems encountered in exercises.

Contingency plans allow us to make realistic preparations for the most probable military operations. These plans also provide a realistic assessment of the logistic costs of different strategies. In this sense, logistic contingency planning is a perfect

complement to strategic deliberation.

The role of intelligence information in logistic planning and operations cannot be overestimated. Especially political and military barriers can be anticipated only when accurate and timely intelligence is available. As an ounce of prevention often is worth a pound of cure, so a little intelligence can prevent logistic catastrophe. Investments in logistically useful intelligence should be very cost effective. A plan which correctly anticipates important logistic obstacles may realize substantial economies by prepositioning inventories using the least expensive means of transportation. And early warning of political and military barriers also should reduce any delay in military operations which they cause.

Terrorism, which is a form of undeclared war, usually is not considered a challenge to logistic plans. But logistic operations are among the most vulnerable of military activities. Although patrols and barracks have been favored targets of terrorists, troop transports, supply vessels and ammunition dumps also are vulnerable. (See, for bibliography Smith 1980) The threat of terrorist violence must be considered a cost of prepositioned military assets. We should weigh the strategic advantage they provide against the additional exposure to loss.

Logistic support for covert operations is a topic which is neglected completely in the open literature. This is unfortunate. Covert operations are one of the few means available to accomplish traditional military objectives during a cold war. They also are essential to counter-terrorist efforts.

Could we launch an Entebbe-style raid? The abortive attempt to rescue the hostages held in Iran demonstrates how ill-prepared we are to launch and support covert operations. In this area we may have much to learn from the Israeli Army which has the advantage of having performed such operations relatively recently. However, the crucial lesson which one can glean from the Israeli experience is the value of adapting the techniques of one's operations to the local conditions. In this regard, attention to logistics can pay handsome dividends. It will often be logistic problems which point the way to appropriate adaptations. (See, for example, Luttwak and Horowitz, 1984)

The deterrent effect of logistic capabilities often is neglected. Conventional deterrence hinges on three factors: (1) possession of necessary troops and military hardware, (2) the ability to transport and support forces and (3) the political will to use the capabilities in (1) and (2). In this scheme, logistic capacity is an equal partner with the requisite forces and national will. Bellicose rhetoric, a massive arsenal and a large standing army are impotent without the logistic support needed to project force rapidly. In many small scale conflicts the speed of deployment is the decisive issue. However, our judgment is that the factor limiting U.S. conventional deterrence during the past two decades has been a lack of political will. Our logistic capabilities may have deteriorated, but the deterioration is more the result rather than the cause of our comparative restraint.

1.2 & 1.3 Logistics and Convoys: Proxy/Client & Limited War

The unique logistic problems of Proxy/Client wars include the delicate balance often struck between respecting conventions of international law and achieving one's

objectives. Thus we might wish to reward the Pakistanis for covert cooperation in helping to supply the Afghans, but nevertheless maintain the stance that the letter of the law is being obeyed even though the spirit is not.

When the war is limited, as in Vietnam or the India-China border dispute, then, at least for some parties, the normal inhibitions against openly interdicting lines of supply is removed. An example of this level of escalation is provided by the threat to interdict Soviet ships en route to Cuba during the missile crisis. But this event shows the fuzziness of categorization as there was really no limited war at the time although there was a danger of transition from cold war to nuclear.

The perceptive articles of Maurer (1981) and Kemp and Maurer (1982) on the importance of coaling stations as a preliminary to entering into limited or conventional war stress that both in a historical and analytical context the lack of secure lines of supply are an invitation to disaster. In the outbreak of a war, a lack of proper facilities is a signal of basic weakness as well as a source of fundamental miscalculation prior to hostilities. This problem can best be viewed as a failure of deterrence. And the disastrous consequences of severed lines of supply highlight the often neglected role of conventional deterrence in keeping the peace.

1.4 Logistics and Convoys: Conventional War

A theme that we wish to emphasize is that the threat of nuclear war does not provide an excuse for a failure to plan how to handle a conventional war. All of the logistic problems discussed above apply to conventional war with the addition of the need to study points of vulnerability and choke points. For example, what are the key elements in a supply plan for taking military action in the Arabian Peninsula given revolution or invasion in Saudi Arabia? Hanks (1980) provides a useful survey of the importance of maritime choke points at the strategic level, but his comments apply equally to logistic planning. He argues that the dramatic expansion of the Soviet Navy can be interpreted only as a shift from a pure sea-denial strategy to a much more ambitious sea-control strategy.

War length and resupply problems may also be of critical importance in a conventional hot war. Both the Falkland Islands and the Israeli Six-Day War are cases in point. If an attack can overwhelm the opposition in a sufficiently short time, supplies may be regarded as inelastic to demand. A single all out effort may enable an inferior force to obliterate a superior enemy primarily due to slow logistics reaction time. It is likely, given the small size and distance of Israel from the United States, that if there is another war in the Middle East involving Israel its outcome may depend critically upon the United States logistics resupply program (e.g., Yom Kippur War). This program, in turn, is influenced greatly by the availability of landing and intermediate refueling bases between the United States and Israel.

1.5 Logistics and Convoys: Nuclear War

In a discussion of nuclear war, it is worthwhile distinguishing among at least three possible scenarios: 1) the limited use of tactical nuclear weapons in an essentially conventional war which we believe to be an unlikely possibility, 2) the use of one or two strategic nuclear weapons followed by the cessation of hostilities, and 3)

the outbreak of or escalation to an all out nuclear war. Even in the worst of these scenarios there are some fundamental logistic problems of concern.

The conventional war case has been discussed above. What is new when we add an exchange of one or two strategic nuclear weapons? Following the scenario of General Sir John Hackett (1978), who had a single exchange between the Soviet Union and the United Kingdom, with Birmingham and Minsk destroyed, the logistics questions are of two types. We must be concerned with: 1) civilian post attack recovery, and 2) maintenance of a logistics system strong enough to be prepared for a conventional war if either side chooses to resume the conflict.

All-out strategic nuclear war poses a qualitatively different set of problems. Here is where the tendency for horror and desperation scenarios predominates. Setting aside the nuclear winter and full Armaggedon scenarios there are some legitimate questions concerning pre- and post-attack civilian defense. In particular, we must analyze the economics of deep shelters such as the Moscow subway system extensions and of placing reserve supplies and means of transportation in such a manner that they would be unlikely targets.

A barely discussed topic, except in global nuclear winter or other disaster scenarios is the importance of third parties. Suppose that the Soviet Union and the United States were to devastate each other taking along China for good measure. What roles would the possibly undamaged Brazil and Argentina have to play? Are these roles such that post recovery contingency plans should involve them? (See, for further discussion of this problem, Section 4.)

2 Mobilization: General Comments

The basic distinction between democratic and one party societies in peacetime mobilization comes in the political realities of defense budgeting. In wartime, for almost any level of war which has major public support, the economic flexibility of an open society may more than offset the political inhibitions on mobilization. An example of the political economic interplay is provided by the lease-lend program in World War II.

However, during a period of cold war, western democracies, which cannot exert very much control over news media and political discourse, are at a disadvantage. The Soviets are able to feed misleading and self-serving disinformation to open western news media while they maintain tight control over their own state run media. (See, for example, Schultz and Godson, 1984) The net effect of this asymmetry is to erode public support for military spending in democracies while carefully indoctrinating Soviet citizens. We should add to this the fact that citizens of Western countries lobby and vote in contested elections. Soviet citizens, in stark contrast, exert little if any meaningful pressure on Soviet policy. Completely peaceful, but "unauthorized," demonstrations and groups are violently disbanded. Thus the Soviets exercise reasonably effective control over internal dissent.

There also is a tendency in a representative democracy to overrepresent concentrated, vocal interests and to underrepresent diffuse interests. Every American receives the benefits of citizenship, which necessarily includes the valuable protection of the U.S. Armed Forces. However, few Americans consider the debate over a

specific item of military spending worth the high cost of political lobbying. Most people have better things to do. By funding so-called "peace" groups in the West, the Soviets subsidize the activities of disarmament ideologues. Their funding activities tend to increase the effective representation of anti-military interests relative to the diffuse interest in national security.

2.1 Mobilization: Cold War

Mobilization comprises both manpower mobilization and industrial mobilization. These issues are quite distinct. Manpower mobilization involves the ability of military and civilian authorities to transform troops, reserves and new conscripts into an effective fighting force. Industrial mobilization consists in directing production and distribution to support war aims.

During periods of cold war, when war fighting is excluded by definition, war preparation, of which mobilization is an important facet, is for deterrent effect. The importance of this deterrent effect best can be seen by a counter-example. The Israeli defense strategy prior to the Yom Kippur War was based on the Bar Lev Line. They also planned for a very rapid mobilization of reserves in the event of strategic or tactical warning. In the actual event, the thinly garrisoned Bar Lev Line was overrun quickly, and the hoped for mobilization was delayed by inadequate transport (especially for tanks which drove to the front on their own tracks arriving with exhausted crews and low fuel supplies). (See Luttwak and Horowitz, 1975.) Admittedly, the Israelis faced a formidable mobilization problem, but surely the NATO mobilization in the event of war in the European theater dwarfs it. And we should note that even small-scale operations like Operation Toylift (Grenada) involve the rapid mobilization of specific fighting units.

There are varying degrees of mobilization. Since the Korean War, the U.S. and the Soviets have maintained what we might describe as imperial scale armed forces. Both countries have strategic commitments around the globe. The scale of these commitments requires a substantial peacetime military establishment.

Thus when we speak of mobilization in the nuclear age, we are referring to the final stages in preparation for war. This fact arises because of the sacrifices which mobilization requires. Production of consumer goods is curtailed because of: 1) increased demand for military equipment, and 2) reduced supply of labor as reserves are called up. This redirection of resources from private to military purposes generates substantial political pressure to justify the sacrifices.

The state of full mobilization is one in which there is a relatively high probability of conflict escalation. Thus we are unlikely to be able to remain mobilized for a long time without entering a shooting war. World War I is an historical example of the risks of mobilization warfare.

In a democracy, the political dynamic requires swift, decisive action or no action at all. A totalitarian state can ignore popular discontent far longer. This asymmetry allows the Soviets a peacetime mobilization surge capacity which, at the political level, differs fundamentally from that of the United States. We perceive greater economic inefficiencies in the Soviet system, but a key question is are they offset by a speedier political maneuver time?

2.2 & 2.3 Mobilization: Proxy/Client & Limited War

Mobilization problems in a proxy war hardly differ from the cold war scenario, except, as the progression of involvement increases, the political feasibility of increased levels of mobilization is dependent upon public perceptions and pressure on political decisionmaking. It is here that one of the dangers in the interaction among military, economic and political factors is at its most error prone. When international instability increases, political dissension in a democracy can be interpreted as a sign of weakness. Misestimation of the country's resolve, speed and ability to mobilize forces can introduce new instability.

2.4 Mobilization: Conventional War

The study of high levels of mobilization was of considerable concern during and shortly after World War II. Studies were made of the level of mobilization and its speed for several of the major combatants. It can be argued that among the more surprising aspects of the war was the inefficiency and incompleteness in the Nazi industrial and other economic mobilization (Speer, 1970).

Possibly among the major changes to be expected in comparing mobilization for a future conventional war as contrasted with World War II concerns surveillance and the change in the vulnerability of sea, land and air transportation. These problems primarily involve the future roles of convoys, logistics and blockade and other forms of transportation interdiction. Few analysts have gone as far as Admiral Fioravanzo (1979) who, in his book on naval tactics suggested that convoys in a third world war might call for submarine cargo carriers.

2.5 Mobilization: Nuclear War

The literature on mobilization for conventional war is concerned with total mobilization, surge times, substitutability, complementarity and the speed of change of various elasticities of supply and demand in an economy. In the context of a strategic nuclear war, both the time frame and the nature of the potential damage are so fundamentally different from conventional war that our first problem involves changing our mindset. In contrast with conventional war, the major mobilization features in a nuclear war involve prewar positioning and postattack organization.

Do hostilities cease after a strategic nuclear strike and counter strike? Or is it feasible that "victory" goes to the survivor who can recuperate and mobilize sufficiently to fight a post nuclear conventional war? The Armageddon school would say no. But, as the macabre doggerel of Samuel Hoffenstein (1939) suggests, the invocation of Armageddon is not necessarily an adequate substitute for thought.

> Fear not the atom in its fission
> The cradle will outwit the hearse.
> Man on this earth has a mission,
> To survive and keep on getting worse.

3 Sanctions, Sabotage & Embargoes: General Comments

Economic sanctions and embargoes are often considered to be primary elements of the traditional view of all levels of economic warfare. They denote the ability to deny resources to an enemy by restricting or cutting off supplies usually derived through normal trade. Sabotage in contrast involves the covert use of low levels of violence for economic purposes and for effects upon morale.

Unlike blockades, embargoes need not be supported by military forces, although the implicit or explicit threat to use force may have a powerful effect. Sanction and embargo activities are similar in some dimensions to cartel activities as success depends upon the ability to restrict alternative sources of supply or other means of evasion. In much of the literature (see, for example, Milward, 1984) sanctions refer to the suspension of normal trade. The definition is sometimes expanded to include preclusive buying or destruction of goods, limitation of capital flows, or suspension of foreign aid.

Economic sanctions broadly defined can be viewed as a form of strategic damage exchange. They seek to impose costs upon the target nation for its behavior, actual or anticipated. Included and of increasing importance in a world of high technology are sanctions involving "brain drain" components. The countries involved attempt to hinder the exportation of high technology goods and highly trained individuals. The United States ban on sales of high technology to the Soviet Union provides an example. The Soviet ban on emigration of highly skilled professionals, in spite of appearing to be solely a question of human rights, involves a technology transfer component.

Economic sanctions are essentially political responses to international events (for example U.K.-Italy, 1930s; U.S.-Iran, 1979), or for reasons of domestic or international political significance (OPEC-U.S., 1973; U.S.-U.S.S.R., 1980). As such they tend to be weak or unsuccessful. Their strategic or damage exchange potential is discounted by policymakers and analysts.

It would be useful to have a measure of effectiveness of economic sanctions. This would involve constructing an appropriate index or even qualitative assessment. It must account for factors such as the size and value of trade involved, the substitutability of other goods and services, the availability of other willing suppliers, and the overall flexibility of the economy under attack. (See, for example, Doxey, 1971; Knorr, 1977; Losman; 1973, Porter, 1978).

Political and economic strategic motivations underlying the imposition of various types of sanctions may be in opposition. Thus an action could be judged as successful in terms of its influence on international opinion even though, in economic terms, it was relatively ineffective. It has been suggested that the imposition of the oil and steel embargo on Japan in 1940 was a politico-economic act which hastened the entry of the Japanese into the war.

It must also be noted that the very nature of sanctions requires that the damage exchange calculations take into account both the costs to the threatening nation and the fact that a threat carried out may destroy further threat power. Brams and Hessel (1984) discuss threat power in situations which can be modeled as sequential games. The paper applies their model to the Polish situation in 1980-81.

A case could be made for placing sabotage in a category separate from sanctions and embargoes. However, the transition from overt to covert and from nonviolent to somewhat violent is subtle and is on a continuum. Embargoes bring with them as reaction, smuggling and other economic measures to overcome the embargo. These responses, in some instances, may require covert attempts to interdict the sources of alternative supply.

3.1 Sanctions, Sabotage & Embargoes: Cold War

During periods of cold war, where the major powers are avoiding outright military confrontation, it appears that they cannot inflict serious damage on each other without high costs to themselves in terms of foregone trade. When there are large disparities in size, the larger nation may be able to affect the terms of trade for a small nation without disrupting its own trade patterns. But perhaps the issue is not size but rather strategic vulnerability. It would be exceedingly useful for the U.S. to rank the strategic vulnerabilities of the Soviets in order of the U.S. resources required to frustrate Soviet aims. In economic terms, the cost imposed on the Soviets by our own countermeasures may be a very effective way of waging war. We caution, however, that trade as a weapon is a very blunt instrument. It often will misfire for unforeseen reasons (e.g., the grain embargo resulted in the dramatic expansion of Canadian and Argentinean grain sales to the Soviets). In trade warfare it is crucially important to have accurate estimates of both the short- and long-run elasticities of supply and demand. Neglecting the market response to changes in prices is probably, along with the inability to get even allies to cooperate, the most common reason for the failure of sanctions.

Given the permeability of western economies it is even questionable whether technology bans can be effective when the costs of guarding against smuggling, espionage, bribery and third party dealings are taken into account. The Soviet-European gas pipeline dispute reveals both the high political costs of restricting technology transfer and the facility with which key components of a high technology venture can be obtained from other sources. (See Adler-Karlsson, 1968, for a discussion of trade restrictions during the period 1947 to 1967.) The political and real resource costs of policing such bans can be substantial. And a marked increase in the use of international cross-licensing and patents held by foreign subsidiaries makes control of technology flows even more problematical.

Another potential problem is that imposing sanctions may cause the sanctioned nation to adapt in a way which results in a serious deterioration of the strategic balance. For example, the current pressure on South Africa could lead to a Soviet and South African accord on strategic resource supplies.

Sanctions and economic disruption can come from within as well as from without. Thus outside sponsorship of "peace movements", anti-nuclear power or even environmental protection groups offer a means for manipulating perfectly legitimate and even morally attractive causes for international political purpose. We might term such activities "political sabotage." (See, for example, Schultz and Godson, 1984)

In the cold war prelude to the outbreak of nuclear war, attempts have been made to use embargoes and trade interdictions to prevent, or to at least slow down, the growth of the number of nuclear powers. The critics of such policy are quick to point

out its failure. Yet one must be careful in phrasing the appropriate questions.

An analogy serves to illustrate this problem. In essence, there is no such thing as a lock which cannot be penetrated or a secret code which cannot be broken. These devices are designed to make certain actions costly and time consuming, but not to make them impossible. It was perfectly evident that once the nuclear bomb had been invented it was merely a matter of time for the diffusion of knowledge and special resources to take place. At best a policy of embargo or sanctions can slow, not stop the process. Thus it may not be possible to stop an unfriendly (or friendly) power from obtaining high technology, but it may well be in our interest to make it costly and time consuming to do so, provided that we can impose these constraints with little extra cost to ourselves.

3.2 & 3.3 Sanctions Sabotage & Embargoes: Proxy/Client & Limited War

Sanctions and embargoes are somewhat less significant for the conduct of proxy or client warfare. All the difficulties of one-on-one conduct of sanctions are now compounded by a client structure. More leakages are present. Some economic threats to trading partners are feasible such as Soviet warnings to Pakistan concerning Afghan trade, but it requires detailed knowledge of ad hoc situations to assess the likelihood of obtaining a positive damage exchange rate.

Sabotage and low level violence such as the "accidental bombing" of border supply points or explosions in supply depots are possibly more cost effective. In fact, Soviet strategy in this area seems to place great emphasis on training and support for international terrorism and "indigenous" dissent in democratic countries and in autocratic ones sympathetic to Western views. (See, for example, Pilgrim, 1982; Livingstone, 1982; Alexander, 1982; Halperin, 1982; de Borchgrave, 1982)

Essentially the same remarks hold for limited war, but, at this level, forceful interdiction such as submarine sinking of third party merchant ships or blockade is more relevant.

We also observe that there can be serious political repercussions from imposing sanctions. The imposition can be used by an otherwise unpopular regime to rally the people to the defense of the nation. National pride is at stake, and this pride is often stronger than partisan loyalties. The unexpected dynamic of rallying behind the flag is, at least partly, analogous to the economic concept of the compressibility of an economy. When foreign influence presses on domestic politics, unexpected alignments result.

3.4 Sanctions, Sabotage & Embargoes: Conventional War

In examining the conduct of conventional war we find roles for economic sanctions, embargoes, preclusive buying, exclusive tying up of resources etc. Historical case studies, especially from World War II, provide illustrations. (See for example, Gordon & Dangerfield, 1947). But it must be stressed that, in a full scale war, the sanctions and embargoes are essentially a side show directed at third parties or neutrals whom you wish to have tow the line.

Given the nature of international business connections and multinational enterprises, it is even relatively hard to enforce an embargo on trade with the enemy by one's own corporations with dual nationality. Cross licensing and international trade secrets and patent exchanges make this even more problematical.

Possibly the best satire of the clash between defense concerns and the virtues of "the free play of the markets" has been provided by the activities of Milo Minderbinder in Catch 22 (Heller 1961) summed up as follows:

> Milo shook his head with a weary forbearance. "And the Germans are not our enemies," he declared. "Oh, I know what you're going to say. Sure, we're at war with them. But the Germans are also members in good standing of the syndicate, and it's my job to protect their rights as shareholders. Maybe they did start the war, and maybe they are killing millions of people, but they pay their bills a lot more promptly than some allies of ours I could name. Don't you understand that I have to respect the sanctity of my contract with Germany? Can't you see it from my point of view?

3.5 Sanctions, Sabotage & Embargoes: Nuclear War

As the duration of the major spasm of a strategic nuclear war is estimated by most to be relatively short, questions concerning the role of sanctions and embargoes during a nuclear war verge on the frivolous (Yet it must be noted that it is probably a good policy, in scholarly and analytical works, to ask questions which appear frivolous and have the analysis reject them, rather than suppress them by invoking ridicule).

In a post nuclear attack world, sanctions and embargoes could play a major role. Those undamaged countries with resources such as a food supply could be in a position to dictate many of the postwar terms. For obvious political and sociological reasons, post attack recovery and international trade and negotiations is not a particularly pleasant or even high priority topic. But, as with many of the unpleasant aspects of human existence, it is of sufficient importance to survival that it requires some attention. (See, for example, Katz, 1982)

The next three topics are covered only in general comment for the sake of brevity, not to indicate a lack of importance.

4 Strategic Materials: General Comments

The economic and strategic implications of policy with respect to strategic materials pose several key and inadequately answered questions. These include: 1) appropriate definition of which materials are strategically essential and when they are, 2) consideration of the "compressibility" of an economic system, and 3) the idea of unusual scenarios such as a conventional war fought after a nuclear exchange.

What is meant by a strategic material depends heavily upon the time scale involved. It also depends upon the short and long term elasticities of supply and demand not merely to price but to other factors as well (e.g., the development of

substitutes). The Department of Defense keeps track of some forty odd strategic materials. But the economic and military views of strategic materials can easily be confused and often appear to be at cross purposes. The implicit assumptions concerning the time scale permitted for substitution must be made explicit. Furthermore, one must evaluate the cost-benefit tradeoff in light of available and prospective technological fixes around dependency on specific materials (e.g., high grade plastics substitute for some alloys). Perhaps investments in research and development of alternatives is more cost effective than stockpiling -- taking the benefits of the private spinoff effects into account.

Morgenstern and Thompson (1976) developed the concept of the compressibility of an economy. The basic idea was to try to characterize the irreducible links in the economic system beyond which it begins to collapse. These links are analogous to choke points in naval communications. History appears to teach that economies are far more robust than casual theory would have us believe. Shubik (1979) has noted an amusing example of misplaced faith in finding the strategic weak point of an economy. When analyzed as a Leontief system, the bicycle industry of Cuba appeared to be essential. But such a static model cannot capture or predict the economy's potential for adaptation to external shocks. But this adaptation is the essence of compressibility. The unexpected adaptive dynamic is analogous to the effect of sanctions on national pride. Note that currently employed economic models cannot capture these effects.

The experience with the bombing of the German economy and the bombing of the British in World War II shows surprising resiliency and considerable substitutability. The debate on the value of attacks on economic potential in local or conventional war must be reconsidered. On the whole the evidence seems to be that it has not been particularly successful. (See, for example, Ruggles and Brodie, 1947) But it is not clear that this is a case that can in some sense be proved just because history supports this proposition to date. There will be undoubtedly circumstances in which the strategic benefit of destroying a particular economic asset will far outweigh the military and political costs of destroying it.

Given a scenario of nuclear war, we must take into account that the strategic materials in a post-attack reconstruction or even war continuation might be far different from those in the pre-attack state. Medical supplies and uncontaminated food could be worth their weight in titanium. Unfortunately, post-nuclear attack scenarios are highly speculative and range from the blithely optimistic to the wildly overdrawn and exaggerated (Nuclear Winter). Perhaps the best approach to contingency planning when faced with such uncertainty is to compress the salient features of the various scenarios into the smallest possible number of contingencies. A cautionary note is that we must prevent psuedo-scentific pronouncements like the nuclear winter "model" from gaining respect. (See National Review, November 15, 1985.)

5 Blockade: General Comments

The use of blockade provides an act of overt willingness to engage in violence without necessarily going to war. Thus the Cuban blockade was an exercise in brinkmanship. The siege of Berlin and the Berlin airlift, the mining of the harbor at Haipong, and the sieges of Leningrad and of Tobruk provide examples in cold, limited and full war respectively.

The Berlin airlift is possibly a case apart in illustrating the power of logistics and planning in the face of blockade. It offers one of the few instances of a technological, logistic, organizational fix to an otherwise apparently insurmountable problem. (See Section 1 for consideration of this issue.)

Naval blockade may sound somewhat old fashioned. But, short of a nuclear war, it is probably underrated as an important component of our defense posture. The need for appropriate naval and air bases to project force quickly and for a dependable communication and logistics network to allow rapid resupply should not be underestimated. Where do mines, submarines, surface ships and aircraft figure in blockade and interdiction in a less than nuclear war? In the past thirty years, we have seen a revolution in mining (Hartmann, 1979). A key defense economics question is: What are the economic means of the delivery of supplies in a less than nuclear war, and what are the current optimal means of interdiction?

The convoy sinking rates achieved by German submarines in the 1940s almost destroyed the British. Short of nuclear escalation what would NATO's "Atlantic Bridge" look like in a new European war? Would the sea lines of communications (SLOC) be maintained by convoys being sunk by better submarines being pursued by better ASW devices with superior communications; an updated version of WWII or is there a radically better alternative. Till et al (1982, p.198) note that "the modern convoy has at least as many defenders as it does detractors."

To provide an adequate review of this question, an understanding of new naval technology and doctrine alone is not enough. The answer must consider the operations research and economics of logistics delivery in the presence of blockade and other forms of interdiction.

Some critics have gone as far as to question the future for above surface transportation, envisioning large and possibly slow submarine cargo delivery (Fioravanzo, 1979). Is this science fiction together with bad economics? Is air supply a viable alternative for much of the materiel which was sent by ship in WWII? There is little doubt that the Exocet and modern communications have changed the nature of surface warfare. But obsolescence of one style of surface battle does not rule out a new form.

6 Cartels: General Comments

It is our belief that the most important consideration in the study of the strategic economic aspects of cartels involves cold war trade between centralized and enterprise economies. The small firm, the large national firm, the large international, the private cartel, the international governmental cartel, and the government trading organization are all distinctly different players. It is critical to form a balanced assessment of the asymmetry in negotiations among these different actors.

We suspect that the large multinational and the government trading organizations pose more problems than do international cartels. Politics and public opinion are subject to fashion shows. Thus even a year or two ago OPEC appeared to be six miles high. At this time its power appears to have melted. At the start of OPEC as a force, the popular press and magazines were full of articles on food cartels, metal

cartels and other resource cartels. While it may be the case that cartels such as the raw diamond suppliers have done reasonably well for many years, the interesting fact of economic life is the relative scarcity of major cartels not their abundance. Independent nation states do not organize and coordinate well unless there is an enormous commonly perceived threat or mutual gain which can only be achieved by rigid cooperation.

The cartel problem faced by the United States is primarily of the Milo Minderbinder variety noted above. Where are the loyalties and responsibilities of the multinational corporation to be located? Do their duties to their stockholders precede their duties to the country where their headquarters are located?

In some ways, the drive towards co-production of complex weapons systems may be regarded as a quasi-governmental quasi-private cartelization of parts of the arms industry. The problems of divided loyalties and joint products have only begun to show, they could grow exponentially with co-production. A particularly interesting problem in international joint ventures is the political pressure to earmark certain parts of production for domestic industry. This pressure will often be a binding constraint in the search for efficient and secure co-production. Ashcroft (1969) presents a useful discussion of some of these problems in a paper which is now rather dated.

7 Arms Races: General Comments

Arms race studies have been the subject of historical, economic and mathematical research. They tend to be treated as two power competition, although when interlinked with technological and trade aspects of the armaments industry the need to consider more than two countries for many of the pertinent questions appears.

At least to the mathematician and economist the study of defense to a certain extent implies the study of offense and the study of arms races also covers the study of peace or disarmament races. Or could it be that de-escalation is qualitatively different from escalation with a negative sign?

7.1 Arms Races: Cold War

The central question considered in the mathematical treatment of arms races is: Can or will an arms race in general lead to an outbreak of war? The works of Richardson (1960a, 1960b), Rapoport (1961), Intriligator and Brito (1984) and O'Neill (1985) provide simple mathematical models of spirals, zones of stability and instability with conflicting conclusions depending delicately upon the underlying simplifying assumptions.

Possibly the central unanswered empirical and theoretical question (which may well depend heavily upon context) is: If arms pile up on all sides will they eventually be actively employed? In general, the mathematical models tend to consider armament build up in terms of a one dimensional measure such as money or percent of GNP spent. A different and more directly operational question concerns the choice of force structure. For example, a major feature in the current debate on deterrence is the value of the nuclear triad (Freedman, 1981) as a means of providing optimal defense. Yet the SDI approach adds a completely different viewpoint based upon fundamentally

new assumptions concerning deterrence theory, technology and the economics of arms races. (See also section II.) Dyson (1984) suggests that one should expect changes in technology to invalidate the basic assumptions, even of nuclear warfare, in a surprisingly short time.

It is well known that a concern for maximizing damage exchange ratios converts a two-person nonconstant game into a constant sum game. Thus one way of viewing the economics of SDI is as a damage-exchange fight between the United States and the Soviet Union in terms of financial drains on their economies. But although the conceptualization of the spending race is fairly clear, a useful study calls for the scientific assessment of the defense value of the expected product and some estimates of the relative spinoff values of scientific developments to the civilian economies. It is here where opinion in the United States diverges to the point that professionals of stature can be either opponents or proponents in good faith given the difficulties of assessment. (See, for an example in the Soviet context, Ofer, 1975.)

7.2 & 7.3 Arms Races: Proxy/Client and Limited War

From the viewpoint of the United States, Afghanistan is a proxy or client war; viewed from the Soviet Union it is also a limited war with Soviet troops in the front lines. In Vietnam, the situation was reversed, with the United States involved in a limited war. In both of these instances, the economic questions relevant to arms races involve damage exchange rates and optimal force structure. These questions tie in directly with logistics (1.2), sanctions (4.2) and blockades (5.2).

In both proxy and limited wars, a choice must be made concerning the level of technology to employ in combat. There are several major considerations involved. The dangers of escalation dependent upon the effectiveness of new weaponry must be assessed, as well as the dangers of reverse engineering of captured weapons by the enemy. These must be weighed against both the military advantage to the client and the research and development advantage of being able to test new weapons and doctrine in limited combat.

Another question to which economic theory, military practice and public opinion will produce divergent answers is the cost to the economy of supporting a proxy or client or of fighting a limited war. The true costs of Vietnam to the United States or Afghanistan to the Soviet Union or the support of Israel or Syria are difficult to define. The problem is not with the gathering of statistics but with the conceptual framework adopted in the analysis.

A military establishment must accept as part of the military realities the socio-political factors of its nation state. In particular, even if reasonably meaningful figures could be assigned to the costs of supporting an undeclared or semi-war, the problem of determining the meaning and value of a victory in a proxy or limited war remains.

The problem of ascribing value to victory is one that is key to net assessment in general and to some of the major problems in the evaluation of doctrine and overall weapons system procurement. The technical needs of weapons evaluation programs make it attractive to select a zero-sum scenario where many of the more imponderable factors required to comprehend the value of a strategic posture are implicitly removed.

Offering a morally appealing goal which unfortunately can provide misleading advice for the overall selection of a weapons system. To a commanding general the observation that his goal is to win or beat the enemy is a precept or moral imperative rather than a reasoned analysis. It serves his immediate purpose. The full meaning of winning can be left to the politicians and philosophers. This reasoning does not extrapolate to the design of armaments programs where the meaning of "win" melts into the complex realities of the management of an ongoing society.

7.4 Arms Races: Conventional War

Like the Potlatch of the Northwest Coast Indians the arms race aspects of a conventional war involve staying power. If the war lasts and is static its economic appetite will become enormous whether or not the growth of the casualty lists is commensurate. The costs of the stalemate in the trenches in WWI and the current drain of resources both in casualties and relative shares of GNP in the Iran-Iraq war serve as examples.

Five thousand years ago Sun Tzu warned against involvement in long wars as being too costly for the state. The advice still stands. But there are open analytic questions. Is there an analogy between the breaking point phenomenon noted in battle (see Weiss, 1980) and the breaking point in a war economy? How must arms races end either in peace or war? At a highly simplified level, Shubik (1971) has suggested the dollar auction game as an illustration of escalation. Only one side wins the prize but both pay. Even in this simplified context there is no natural solution unless one introduces considerations of limited resources and a relative evaluation of losses (O'Neill 1984).

7.5 Arms Races: Nuclear War

It is somewhat difficult to conceive (but not logically impossible) that the production of new strategic nuclear weapons would be of much concern in a strategic nuclear war. The major presumption is that such a war would be fought from inventory. The problems would arise after the interchange not during it. The post-attack competition might be better described as a peace race than a war race if both sides were sufficiently damaged to make their post war recovery the prime goal.

8 Arms Industry: General Comments

In virtually every aspect the arms industry poses special technological, procurement, contracting, bidding and industrial organization problems. When international co-production and third world competition are added to the complications faced in dealing with the United States industry alone the likelihood of developing simple guidelines and estimates for new weapons system procurement becomes slim.

The design of incentive and bidding systems alone raise deep problems in naval and other procurement. Engelbrecht-Wiggans, Shubik and Stark (1983) and others have outlined some of the problems encountered in bidding and the allied process of estimating. Livne and Shubik (1982) have considered bidding and incentive systems in relation to nuclear powered carriers and submarines.

Possibly one of the most serious gaps in defense economics analysis today is that of our understanding of the structure of the armaments industry. In spite of the inclinations of many to praise the free market, the demand and technological aspects of the industry require a market structure that does not fit in with the conditions needed for the benefits of simple price competition. The number of shipyards capable of constructing a Nimitz class carrier will remain few. The planning horizons for new systems will be on a cycle that outlasts both the initiating admirals and politicians. And the needs for change orders are facts of a changing environment even if we were in a position to eliminate all of the changes attributable to fad or whimsy.

9 Finance: General Comments

Although financial crises have been with us for some time it has been only recently that explicit thought has been given to the employment of financial weapons as an addition to the means of war. The financial system is the command and control mechanism of much of the economy. The growth of technology in communications has revolutionized the mechanisms and the speed and interlinkage of financial systems. Even at this time the interplay among technology, economic process and government control is simultaneously producing great forces for centralization and decentralization of the financial system.

Some fifteen years ago with the growth of computer time sharing it appeared as if the future for individual enterprises was to be bound into computer networks with central timesharing systems playing the same role as major utilities. It appeared that the economics of the technology might bind the individuals into centralized rather than decentralized networks or stand alone centers. The amazing growth of the personal computer has gone in the other direction. But the currents and countercurrents have both increased. Thus the centralized tax systems and records grow. The possibilities for big brother activities which enable bank A to check or ruin individual X's credit rating by obtaining an accurate or inaccurate dossier on his credit rating from bank B six thousand miles away have grown considerably.

Electronics fund transfers enable financial institutions to move billions of dollars in a matter of minutes across continents and the very concept of money becomes more abstract as a series of messages can move enormous credits which once they have been received cannot be reclaimed or frozen or blocked without great effort. It has been noted that the fish gets on the hook one way, but it usually gets off it in another way. This analogy is of relevance to complex financial transactions. Undoing them is not the mere inverse of carrying them out in the first place.

As the financial systems grow in size and complexity the tax collectors can extend their abilities, the files of the credit raters grow. Aggregate indices for evaluating credit risks appear. Special details concerning depreciation allowances, rebates or the assignments of overheads can be automated so that computer systems spew forth accounting reports which may contain hidden assumptions which require the highest level of trained accountant to "backward engineer."

Yet in spite of the communication and information flood some simple verities of the economic system remain. Once the netting out of paper written on paper has taken place the remaining paper is an ownership symbol for real assets and as in a

military command and control system so it is with the economic command and control system. You can sooner or later figure a way to fire a gun or launch a missile without an electronic impulse from Washington. You can also convert wheat into bread and eat it without an electronic pulse from a bank hundreds or thousands of miles away.

Maintenance of high productivity depends delicately upon the sophistication of the financial command and control system. The sophistication of this system depends upon technology, national law, international law, accounting conventions and business practices. As these systems grow, banks, credit granting facilities, fund transfers and stock markets all link more and more internationally. But from the viewpoint of international financial warfare certain basic elements emerge. It has been said that possession is nine tenths of the law. In dealings among nations crossing jurisdictions and depending upon the flimsy structure of international law, a more accurate estimation might be that possession is ninety-nine one hundredths of the law.

A game theoretic observation is in order. In spite of the apparent noninstitutional abstractly general virtues of the price system in a modern economy, even the most untrammeled and apparently free economic system is a creature of national law and habit. The most abstractly free markets are those for which the rules of the game have been most clearly specified and enforced. The New York stock market provides an example. But the rules of the game are the laws and commercial practices of the society involved. They describe and delimit the strategic actions of the individuals. The economic and financial process is carried on through the financial institutions of the society involved. It is the society which sets the laws and controls its own institutions. When matters get out of control, the society, if prepared, can change the rules and modify the game. If it fails to act with despatch the complexities of a highly sensitive and complex feedback system offer considerable possibilities for magnification, instability and eventual destruction of parts of the control mechanism. Thus, for example it is only in the last three hundred years along with the growth in the connections and sophistication of the national and international economies that the concept and the understanding of the importance of central banking has emerged.

The lesson to be learned concerning the possibilities of financial warfare should be clear. As financial instruments are creatures of law and custom the way they can damage the economic system can be controlled by national law and custom. Prompt response by a government agency, be it to close the banks, freeze accounts or change the interest rate is within the scope of a nation state acting within its own jurisdiction. The efficacy of an attack by an outside state using financial weapons is a function of the competence or incompetence of the state being attacked. If your treasury or central bank does not know where the deposits or assets of Iran are during a hostage crisis it may not be able to freeze them in time. It appears that the important consideration in financial warfare is to be prepared against attack because if an attack comes from the outside onto your jurisdiction you can change the rules of the game and nullify most of its effect if the actions are decisive and fast.

The damage that can be done to a large country by financial warfare depends upon how much time is given for transient shocks to amplify through the feedbacks of the system. In several papers specific aspects of financial warfare have been discussed. These include an array of "dirty tricks" such as flooding an economy with counterfeit money, sabotaging clearing houses, perpetrating credit card fraud on a large

scale, loan default strategies and others (Shubik 1979, Shubik & Bracken 1984, Altman & Sametz 1977). But in virtually all instances it appears that it is relatively hard to do much damage to a well prepared target in its jurisdiction. The operational and conceptual problem lies in taking the steps and understanding well in advance what it means to be well prepared.

IV CONCLUDING REMARKS

Table 3 in Section III has been presented to provide an overview in context of the array of problems involving defense economics, offense economics and economic warfare. It is designed to serve three purposes.

The first purpose is to stress that the same questions concerning the use of means must be considered under at least five highly differing war scenarios. The concentration on a single scenario may be highly desirable to provide the specific context for a single study. But a net assessment of the economic component of defense must present an evaluation in the context of all scenarios weighted for their relative importance and plausibility. The prime lesson to be learned from considering the alternative scenarios is that a concentration of attention on the spectacular such as nuclear warfare can lead to insufficient attention being paid to the mundane such as naval blockade and logistics. Capacity for massive retaliation cannot be bought at the cost of a lack of capacity to deal effectively with low intensity crises requiring speedy delivery of men and materials over great distances.

The second purpose in attempting a research overview of the economic aspects of defense is to present in a single document a juxtaposition of major instruments and activities (such as procurement of strategic materials) and an indication of research problems which are raised in understanding their roles in different levels of conflict. This menu of research problems may help to clarify the relationship between perceived research topics and operational assessment of the importance of these research activities.

The third purpose is possibly the most important. That is to stress the interconnection and linkages between different problems and different approaches to the same problem. Good research administration requires that research programs be as clearly defined as possible so that both purpose and scope be sufficiently constrained that in depth work can be carried out within the resource constraints. But there is the danger that in the process of dividing research problems and approaches that key interlinking factors go unstudied. This is particularly true here. The technological, economic, military, political, bureaucratic and psychological viewpoints differ radically in their views of critical factors such as the future importance of the convoy and its defense, or the cost and value of redundancy in a command and control system.

In the overview of defense economics presented here, the stress has clearly been on economic analysis. But war is not economics alone (or vice versa). For example the economics of logistics support, convoys and blockades in the 1990s cannot be fruitfully discussed without establishing a common set of perceptions of the performances (or variability in performance) of new marine and air technology. Similarly psychology, operations research and technology appear far enough apart that a research program involving one rarely involves a high level of expertise in the other

topics. Yet our ability to plan for the redundancy needed in man-machine systems operating under stress depends directly upon our knowledge of how human decisionmaking changes under stress. How relevant is the operations research and game theory view of optimizing behavior under risk? How valuable is it as a norm that should be followed?

The change in the nature of the technology of war both in the nature of weapons and the structure of communication has been so radical in the past thirty years that the need to combine technological economic and strategic military studies has increased substantially. The Soviet Union appears to face similar problems to those of the United States. To some extent on the surface, at least, more stress is placed in the Soviet Union on the role of operations research, game theory and other mathematical methods in the study of defense as is indicated by publications such as Concept, Algorithm, Decision (Druzhinin and Kontorov, 1972) with a foreword by General Shtemenko and Game Theory for the Naval Officer (Suzdal, 1976) with a review by Vice Admiral V. Babiy. Yet a close perusal of these books and other Soviet operations research literature shows few Soviet references and the impression is given that, in spite of considerably more lip service being paid to decision theory and to military operations research education, either joint studies involving an intermix of economic analysis, operations research, technology and strategic military analysis do not exist or are highly classified.

Some Key Issues in Naval Economic Warfare

Although the open problems in the economics of defense stretch across all services and many parts of the economy, the Navy has played a central role in the implicit protection of world trade during peace and the explicit protection of the sea lines of communication (SLOCs) and the vital logistics support that has been a central factor in virtually all wars to date. Thus a critical set of questions in planning for the contingencies of a future war are how will the roles of convoys, blockades and mining change as contrasted with historical experience. In the future, will overseas bases play as vital a role as previously in bolstering the defense of the SLOCs?

In setting the context in which to answer these questions, should we consider the possibility of the use of nuclear weapons at sea which do not necessarily lead to the use of nuclear force elsewhere, or do we take it as an axiom that the use of nuclear weapons at sea is a guarantee of escalation on land. Or is reality somewhere in between?

One of the lessons of the proliferation of long range planning, contingent forecasting and massive computation of alternative futures is that the critical step is in picking the correct few controlling factors. This far outweighs the elaborateness of the large scale computer runs (See Ascher 1978). Orders of magnitude of costs and danger hinge upon basic assumptions such as: Does the use of nuclear weapons at sea imply escalation, or can Norway be held long enough to guarantee a high enough attrition of the Soviet submarine fleet within the Iceland-Greenland-Norway gap.

Formal models and analyses depend critically upon basic assumptions which are meant to be supplied by those who use the analysis. But often the analysts provide their own assumptions by default. Thus, for example, it may be evident to the Naval strategists that the Soviets would not dare to send a major part of their submarine fleet well beyond the Iceland, Greenland Norway gap before hostilities started. And

the economics of resource allocation to the defense of Norway depends considerably upon the evaluation of the location of the Soviet submarine fleet at the start of hostilities.

The defense economic analyst must not lose sight of the irony of the nuclear age. The first appeal of the postwar nuclear armament race was economy (Dyson, 1984). But this appeal was based upon a one-player illusion of a two or more player nonconstant sum game. The realities were ever escalating costs and dangers.

It is not the role of the policy analyst or basic researcher to propose policy. But with policy as given it is desirable that the defense and cost implications of the policy, its premises and alternative premises be examined. When public estimates indicate the daily variable operating costs of a carrier at between $500,000 and $600,000 and a battleship at $250,000 (Wall Street Journal, August 29, 1985 p.1) the value of an alternative to a 15 aircraft carrier group navy must be calculated and examined under several basic assumptions. The study of Grotte (1983) provides an example of an operations research analysis where the costs and values of alternative force structures faced with low and high threat missions is discussed. This study provides a nice blend of economic analysis, operations research and modeling where the critical assumptions are made explicit concerning key factors such as the vulnerability of a carrier battle group to attack under high or low threat conditions. The selection of a few basic assumptions in one way or the other can bias such an analysis in virtually any direction, but that enhances rather than destroys its value as it clarifies and exposes the key assumptions which must be made.

The speed of change of naval warfare is suggested by noting that mines were first introduced in 1854 (the Crimean war), the torpedo in 1868, torpedo boats in 1885, submarines in 1895 with the Twentieth century bringing a whole new technology in mines, torpedo boats, destroyers, naval air, missiles, nuclear propulsion, nuclear weapons, radar, ASW and general communication and surveillance. The submarine, convoy and blockade aspects of World Wars I and II in the Atlantic were to some extent similar. Under what scenarios could this similarity stretch to a new European war?

It is common for those concerned with naval strategy with a scholarly bent to make obeisance to Admiral Mahan whose book The Influence of Sea Power Upon History 1660-1783 (Mahan, 1890) caught the imagination of the naval staffs of his day. Mahan's writings must be interpreted in the context of the technology and economics of his time. Till (1982) provides a careful discussion of Mahan and his relevance to the current naval situation. In spite of the reassessment of much of Mahan's work his concept of "fleet-in-being" is possibly at least as relevant today if not more so than previously. It is highly analogous to the economist's concept of "liquidity". What counts is not actual presence or direct investment, but the ability to manifest a presence and produce needed resources in an instant.

Once resources are committed their liquidity is lost. Thus as noted by Wood and Hanley (1985) the premature deployment of a mobile force such as a Marine Amphibious Brigade detracts from its value prior to commitment. Until deployment it may pin down as many forces of the enemy as its potential presence is widespread. But after commitment it is relevant only to the immediately opposing forces.

The role of the fleet-in-being together with the modern technology of mining

raise new possibilities for the blockade.

In many of the functions of the modern navy in future conflict the importance of the economic aspects of the naval role is great. But in virtually all instances the economic aspects of convoys, blockades or logistics support are all directly connected with strategy. Thus the analysis must be highly influenced by the assumptions concerning the strategic environment. It is at this point that we must acknowledge the gray zone in which the intuition and political sensitivity of the policymaker must be reconciled with the modeling assumptions of the operations research analysts and the analogies of the historians.

Defense economics, with stress on costs and production, is a safer and more institutionally acceptable topic for study than offense economics or economic warfare. The explicit link to policy brings the latter two far closer to strategic studies than say a cost estimate for the design of a new piece of ordnance.

The wise policymaker is and probably should be skeptical of highly formal mathematical methods applied to the type of "squishy" problems he deals with. Yet the formal methods of economics and game theory have a crucial role to play if used with care. In particular the attempts to build even oversimplified models force key critical assumptions and simplifications out into the open. The decision to guess the strategic value of a base in the Philippines is a policy decision, but its costs and the sensitivity analysis of alternative assumptions involve a large component of research.

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