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Prospects and Risks of Technological Dependency

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Creating and executing a coherent strategic vision for the United States in the post–Cold War world is only half of the task that confronts strategists today. It will be at least as important to have a strategy that is both politically achievable and systematically efficient. These are not "either-or" propositions, they are necessary elements of sound strategy. For the United States to define and protect its interests in the new world order, we must generate and effect a strategy that is at once expedient and methodological. The hard part of matching ends to means is in maintaining the optimum balance among these often competing requirements. In assessing the prospects and risks of technological dependence the right balance is especially troublesome to effect as the very process of technological advancement is so poorly understood. Our very economic life depends on continual improvement in technology, yet nowhere is there either a model to explain and predict it or a corpus of the art to guide its development. Yet, in spite of this intellectual mélange, strategists have ascribed to technology a preeminent position both as an end and a means. A proper assessment of the prospects and risks of technological dependence will therefore not only consider the impact of U.S. dependence on *foreign* technology, the issue currently in vogue, but it should also consider the very premise on which it lies, namely whether technology should be depended on as an element of, and goal for, our national security strategy.

This chapter develops a framework for the consideration of technological dependence, both foreign and domestic. It then examines the risks inherent in a strategy dependent on technology before moving on to a more thorough investigation of the opportunities and risks of foreign technology dependence. Finally, some implications will be drawn as guidelines for the approach to technology in our national security strategy.

THE DEFENSE TECHNOLOGY AND INDUSTRY BASE

The U.S. defense technology and industrial base[1] is defined as the aggregate ability to provide the manufacturing, production, technology, research, development, and resources necessary to produce the material for the common defense of the United States. This definition captures the essence of the defense technology and industrial base as it is, rather than as one might wish it to be. The definition also presumes that there is a market mechanism at work that results from the interaction of government policy, defense budget demand, and corporate decision making. The market mechanism produces the U.S. defense technology and industrial base.

This definition of the defense technology and industrial base presumes that any firm that provides—or potentially could provide—goods for the national defense (whether it is commercially owned and operated, whether it is completely or partially owned and operated, or whether it is domestic or foreign based) is part of the U.S. defense base.

As a matter of policy choice, what is observed in the analysis of the defense technology and industrial base may not be what is desired in regard to government control over critical defense technologies and production capacity or the amount of foreign intrusion into critical sectors. The definition itself, however, does not presuppose any particular mix of type or source of ownership.

The defense technology and industrial base must contribute to strategy in three fundamental ways: peacetime efficiency, technological competitiveness, and crisis flexibility. These form the criteria for assessing the health of the defense technology and industrial base. These contributions are the basis upon which to judge the current performance of the defense technology and industrial base and for recommended policy solutions for the future.

First, U.S. strategy presumes that peace will be the normal state of U.S. relations and that peace will be sustained by demonstrated readiness and willingness to fight to protect national interests. The primary vehicle that demonstrates this intent is the set of programs administered by the Department of Defense that man, equip, maintain, train, and operate U.S. forces around the globe. The defense technology and industrial base must respond to the demands of these programs with cost-effective, reliable, and capable systems. These demands shift over time both in the magnitude of the demand, as expressed in the changing defense budget top line, and in emphases of programs, as expressed in the allocation of resources to such defense functions as force structure, manpower, readiness, procurement, and research and development (R&D). The defense technology and industrial base must provide the goods required by the defense budget in an efficient manner.

Second, the defense technology and industrial base must provide U.S. forces with technologically superior material. Maintaining a technological advantage over potential adversaries, particularly the former Soviet Union, has been an explicit part of U.S. national security strategy since the end of World War II. Because it would be prohibitive in cost and alien to the U.S. democratic culture, the United States could not match the number of Soviet deployed forces during the Cold War. Recognizing the danger to U.S. national security from the massive Soviet military machine, the United States opted to respond to quantity with quality. This required the United States to maintain a significant margin of superiority over the Soviet Union in its ability to develop high performance, high quality, and cost-effective products and processes so that the United States did not have to match the Soviets soldier-for-soldier or gun-for-gun. Unquestionably, it was in the U.S. defense technology and industrial base that this lead was developed and maintained.

Finally, because deterrence may not always preserve the peace and because there is the risk that low-level threats may bring the United States into conflict, the defense technology and industrial base must retain some flexibility to convert from peacetime R&D and production to expanded levels of production and development required for anticipated forms of future conflict. If post–World War II history is a guide, then the defense technology and industry base must be capable of short-term surge, long-term expansion, and postwar recovery. The surge requirement was demonstrated in the 1973 Arab-Israeli War when U.S. war reserve stocks in tanks and anti-tank guided missiles, for example, in a very short time were so severely depleted that weapons in the hands of U.S. active forces were taken and given to the Israelis to prevent the utter defeat of a valued U.S. ally. The Vietnam War required U.S. industry to gradually develop a production capacity for many combat items not stocked in sufficient quantity in peacetime, such as small arms and artillery ammunition.

Achieving these three criteria is problematic because efforts designed to achieve one goal may be counterproductive in preserving another. For example, if the United States spends large sums of defense budget dollars to build excess production capacity for anticipated surge requirements, it would be building an inherent economic inefficiency into the peacetime production of the military goods. Unit costs for peacetime requirements would carry an exorbitant premium to amortize the investment in the excess—but idle—capacity set aside for anticipated surge production. Indeed, the failure to recognize such fundamental trade-offs and to devote adequate resources and analysis to these issues have led to disarray in current defense technology and industrial base policy.

DEPENDING ON TECHNOLOGY

In the context of the strategic framework for understanding the technology base, there may be an opportunity to maximize the payoff from investments in resources for security by an emphasis on technology. A resources strategy that can minimize the needs for efficiency and flexibility can afford to make its major investments in technological superiority. But a strategy that pursues technological advancement as a principal end must provide some kind of insurance against the future need for efficiency and flexibility, and that insurance will certainly not be free; it may not be cheap.

Efficiency

If the defense technology and industry base is not efficient it will not generate political support for any investment. We need not review the literature of the 1980s on the inefficiencies in the U.S. defense acquisition system; it is replete with documentation on the phenomenon.[2] The American taxpayers paid about a 25 percent inefficiency premium on U.S. defense investment because of the way business was done and, as a result, research, development, and procurement programs became favorite targets of political opposition even when support for the defense spending top-line was widely favorable. The pursuit of military technology must be perceived to be at least not wasteful in order to elicit broad support in our political system.

Efficiency is of course valuable in its own right in support of technological advancement since it can be defined as the greatest value for the least cost. In the systems analysis world of the Cold War, efficiency took on a rather rigorous meaning. Ultimately, the justification for an investment in a particular technology for a weapons system was based on measures of effectiveness that related capability to unit cost. The key to the precision of the measurement was that capabilities could be defined in relation to a specific threat—the military capabilities of the Soviet Union, or a Soviet-equipped surrogate. Thus, a fleet of approximately 130 B–2 bombers, for example, was judged to be a cost-effective solution to the need to penetrate Soviet airspace and deliver nuclear bombs to a specific set of strategic targets in the Soviet Union.

In the new strategic era, however, the old measures of effectiveness evaporated with the dissolution of the Soviet Union. Although we know that there is inherent value in the investment of billions of dollars in the unique military technologies for stealthy, long-range, manned, heavy-payload, precision-bombing aircraft, we cannot be as precise as we once were as to how much capability we can expect from those kinds of investments. Unit cost will no longer suffice as the measure of effectiveness, neither politically, where the costs of few-of-a-kind systems will likely be above the famous Augustine Curve,[3] nor in systems analysis terms, where the need will be for measures of scientific advancement rather than battle effectiveness against a definable enemy force. A challenge presently facing the analytic community is to derive new measures of effectiveness with which to judge efficiency for the new strategic era in the absence of an overarching threat upon which to base such calculations. We must begin to learn how to measure capabilities purchased, rather than threats defeated.

Even with such scientific tools, however, there is no escape from the fundamental historical experience in military technology; it is not cheap. Alan S. Milward has observed:

> Even the most ardent economic critics of warfare frequently concede that in one respect war brings economic benefit in its tendency to promote technological and scientific innovation.... The tendency of modern fighting is to become increasingly capital intensive. One measurement of this is the amount of capital expended on killing one enemy; this has been estimated as roughly ten times as much in the Korean war as in the Second World War.[4]

The dilemma facing strategists in the new era is that while the requirements for investments in new technology will continue to grow, the pool of capital from which those investments can be made—the defense budget top-line—will decline for the foreseeable future. As a result, the public policy consensus supporting such investments will demand a demonstrated level of efficiency out of the technology base, multiplying the need for new analytical measures of efficiency.

Flexibility

The other criterion of the strategic effectiveness of the base is the flexibility of the system to respond to changing strategic needs. As U.S. national security strategy comes to rely more on quasi-mobilization concepts such as reconstitution, the ability of the base to return to military development and production will be a new need in the system. Market forces will neither preserve defense technological capability for unique military applications, nor maintain production capabilities for rapid, or even deliberate, surge requirements.

Although some industrial specialists hope for greater integration of commercial and defense technology and production capacity,[5] a full measure of skepticism is in order here based on the post–World War II experiences of defense firms that have tried to achieve economies of scope by transferring their military expertise into commercial applications. Most such attempts were unsuccessful.

In the Cold War era the defense technology and industrial base maintained an inherent level of flexibility because of the size and scope of defense acquisition efforts. Separate investments in surge production capacity were not needed when, for example, the Army's tank fleet of over 7,000 vehicles was replaced on the order of once every twenty to twenty-five years. Even if production in a given year was below minimum economic levels, the unused capacity did not go away because there was the prospect of future production. On the technology side of the base, promising new applications could generally find a programmatic champion without having to identify a so-called bill-payer from which to take funding.

In the new strategic era, not only will maintaining flexibility require new investments to replace robust acquisition programs, but it will require new bureaucratic approaches. The entire defense program and budget process has become a negative-sum game. New program initiatives must not only provide justification on the merits of the military capability purchased, they must also convince decisionmakers that other programs already slated for cuts should be cut further or terminated. As new technologies are created, new military flexibilities can be gained, especially if the innovations are in process technology as well as product applications. But to the extent that technology competes for declining budget resources, flexibility may be sacrificed to technology development priorities. A lack of flexibility becomes a calculated risk in pursuing a technology-based strategy. That risk can be minimized by maximizing the response time available to apply new resources to technology development and production expansion, given necessary political decision making under conditions of sufficient warning. The record of the past in making such decisions and in obtaining such warning time illustrates the kinds of policy choices that face strategists today.

Prior to World War II, the manufacture of weapons systems was limited primarily by the structure of the machine tool industries among the combatants. The United States and Germany were the world's leaders in machine tools, but they followed opposite technology strategies. German industry had been manufacturing so-called universal machine tools during the reconstruction of Germany's heavy industry after World War I. Such tools were able to be switched rapidly from commercial production to military production because they had built-in adjustability features. During the war, Germany therefore had no need to surge production of new machine tools, as did the United States. Of course, such machines were more complicated and expensive than those made with the special-tools approach followed by the United States, the other machine tool giant of the 1930s and 1940s, which again illustrates the inherent trade-off between efficiency and flexibility.

During World War II, Germany did not increase its machine tool capacity utilization, it mostly switched from one type of production to another. But the United States—with Great Britain and Japan following suit—had to go through a period of innovation and expansion in the machine tool industries to develop new kinds of tooling to make new weapons and to create new capacity for manufacturing.[6]

The inherent size and potential strength of the underlying American heavy industries provided the flexibility to shift into wartime technology and production, while German industry had purchased that flexibility by investing in a more adaptable industrial structure.

Given the strategy adopted by the Roosevelt Administration of steady expansion of military industrial capabilities beginning as early as 1939, the U.S. industrial approach proved to be quite effective indeed. Acting on sufficient warning, the U.S. defense industrial and technology base became the "arsenal of democracy," producing 296,000 aircraft; 1,201 major naval vessels; 64,546 landing craft; 86,333 tanks; and 41.585 billion rounds of small arms ammunition between July 1, 1940, and July 31, 1945.[7] But this great feat was accomplished by government action initiated well before the outbreak of the war. The process began with the U.S. providing material to allies under various assistance programs and ultimately required direct government control over large segments of the economy. It included the outright construction of 1,600 new defense plants and direct financing for the expansion of many others.

It is highly unlikely that future regional contingencies of the types anticipated by strategists today would engender a public consensus for mobilization of the magnitude achieved for World War II. Thus, we will have to provide for industrial and technological flexibility as a hedge against the risks that the Base Force will not be able to handle the short-term situations we anticipate, or that we will have insufficient warning time to act on the emergence of greater threats, or that political leaders will equivocate or err in judging the nature of future threats. These risks will require investments in some near- and mid-term flexibility as an insurance policy beyond the need to invest in the flexibility needed to secure industrial and technological capability to reconstitute the base to meet the unforeseen global threat for which we expect to have five years or more to plan. Again, investments in flexibility will compete with investments in technology in the defense drawdown. So the first element of risk inherent in a strategy that depends on technology is that the application of resources guided by that strategy, an inherently imprecise process compared to the systems analysis approach of the Cold War era, may result in insufficient investment in the two other dimensions of industrial and technological capability, namely efficiency and flexibility. There is a second element of risk at work as well. The technological superiority approach may be wrong.

Quantity versus Quality

For decades during the Cold War, U.S. national security strategy has explicitly relied on technological superiority to overcome acknowledged quantitative shortcomings. We have never intended to match our potential opponents man-for-man or gun-for-gun. We have instead opted to apply the creative genius of the American character to the design and development of better weapons, both for the defeat of the enemy and for the protection of American fighting men and women. This approach served us well during

the Cold War and was vindicated by the low casualty rate of the Gulf War. But will it be the best way to apply limited resources for the future?

One hazard in continuing to pursue technological approaches is that if the total U.S. defense technological effort declines, we may lose our relative advantage over potential adversaries. Already, the diffusion of technology has brought a number of Third World states into advanced technology bases of their own in various fields including electronics, nuclear weapons, precision guided weapons, command and control systems, missiles, and others. The U.S. military technology policy and investments must be directed to ensure that we stay ahead of potential opponents (in terms of greater capabilities and countermeasures) and must also help dampen, or at least provide some control over, the proliferation of advanced military technologies.

A second consideration has to do with the evolution of the art of war. Having just come through a military technology revolution, have we reached the limits of the leverage we can get from technology for the present era? While it may be somewhat un-American to suggest that we might not be able to create new breakthroughs in military technology in our lifetime, history teaches us that such technological revolutions occur neither at a steady state nor at regular intervals. Preeminent military historian Trevor Dupuy has observed:

> The dates of the significant advances of the age of technological innovation are curiously bunched. The conoidal bullet, an effective breech-loading rifle, and breech-loading rifled field artillery appeared between 1841 and 1849. The modern machine-gun, the high-explosive shell, the Mauser bolt-operated magazine rifle, smokeless powder, and quick-firing modern artillery appeared between 1883 and the mid-1890s. The tank and fighter bomber appeared in a two-year period in World War I (1916–1917). Ballistic missiles and the atomic bomb were introduced within a year of each other in World War II.[8]

It is premature to eulogize the passing of the current military technological age, but a strategy that counts on the continuation of the current revolution must hedge against the historical probability that we are near the end of the current "bunching" period.

Finally, dependence on technological superiority might not work. Although it did work under the circumstances of the Gulf War, it did not work under the less favorable conditions of the Vietnam War. In many ways, World War II German military technology outclassed American systems. But America's superior ability to produce greater numbers of good weapons was instrumental in overcoming the limited numbers of advanced systems the Germans could bring to bear during the war. Even in the Gulf War it was not the technology alone that caused the defeat of the Iraqi forces in the field; "people" factors were more important. The combination of a highly motivated, well-trained force under superb leadership employing combined arms operations doctrine that exploited the technology was decisive.[9] Again, history teaches that superior technology does guarantee victory in battle.

Technology Bust

The third task of pursuing a technology superiority strategy is that technology may fail to continue to progress. It has become an article of faith that the United States is the engine of technological advancement. We have become accustomed to an ever accelerating pace of improvements in our ability to apply science to improve productivity and to solve new problems. But we do not understand the process very clearly, and there is no guarantee that we will continue to reap the benefits of technological change.

Economist Frederick M. Scherer has argued from a Schumpeterian perspective that:

> It should not be concluded that there is a necessary correlation between the magnitude of research and development expenditures and the importance of inventions produced. Many major advances in science and technology have been brought into the world at relatively little expense.... On the other hand, the enormous outlays made to create many of our very complex new products and processes frequently contribute little in the way of basically new technology.[10]

Joseph Schumpeter held that technological change is indeed the engine of prosperity in capitalist economies, but that it was not competition that stimulated technological progress. Instead, he believed that the expectation of a monopoly position was the motivation behind invention, which in turn produced technological innovation and economic growth. Schumpeter wrote, "In this respect, perfect competition is not only impossible, but inferior, and has no title to being set up as a model of ideal efficiency."[11] Scherer takes the argument a step further to point out that in the creation of basic inventions it is the intangibles that dominate:

> Physical resources allocated to the support of basic research, or simply to bringing scientists and engineers into contact with the unsolved problems of technology, provide the institutional setting where these intangibles operate. But when, where, and how a basic invention will occur is difficult if not impossible to predict.[12]

The fact that it is the expectation of monopoly profits that stimulates innovation was confirmed in a more recent work by Eric von Hippel. Von Hippel surveyed innovations in a cross section of industries to determine if there was a relationship between the source of innovation and the type of industry. He found that the functional source of innovation varies widely and cannot be predicted:

> In some fields, innovation users develop most innovations. In others, suppliers of innovation-related components and materials are the typical sources of innovation. In still other fields, conventional wisdom holds and product manufacturers are indeed the typical innovators.[13]

But he also concluded that those firms that did successfully innovate could "reasonably anticipate higher profits than non-innovating firms."[14] In the industrial sectors that are important to defense technology, the record of financial performance has not been favorable for meeting such expectations.[15]

American companies are becoming increasingly unwilling to do business with the Defense Department (DoD). There was in the 1980s a virtual stampede of producers out of the defense business. In 1982 there were more than 188,000 companies providing manufactured goods to DoD. In 1987 there were fewer than 40,000. Some that left went out of business altogether, including 20,000 small companies. But most companies have simply quit doing business with DoD and have opted for more reasonable customers. This is remarkable, because at the same time the defense procurement budget grew from $54.9 billion to $87 billion in constant fiscal 1989 dollars.

Defense business simply is not being pursued by profit-seekers. In fact, many companies that are highly dependent on defense business for survival are engaged in behavior (such as predatory pricing) that in other sectors would be illegal or suicidal. In the sometimes perverse world of defense contracting, such behavior is often the only way to survive.

The reason is that defense is, comparatively, not a profit-making business. Return on sales in defense has been about the same overall as in commercial manufacturing, falling from 4.9 percent in 1980 to 3.8 percent in 1986. But many defense sectors posted precipitous declines in this time; and, remember, those profits had to go to pay the 25 percent defense inefficiency premium. Return on fixed assets (ROA) was higher in defense manufacturing (44.7 percent) than in commercial manufacturing (11.3 percent) in 1986. But those apparently favorable ratings mask some troubling basic trends.

Defense is one business in which a company does not own all its production facilities. Many are owned by the government. Much of the capital equipment that defense companies do own is old and has been depreciated well beyond zero in present value. Thus, the book value of the assets held by defense contractors is artificially low. ROA is thus not a good measure of profitability in the defense business. At any rate, ROA in defense sectors declined by over 4 percentage points from 1980 to 1986, including huge drops in small arms, aircraft, and shipbuilding.

The drop in profitability in the defense industrial base is reflected in the investment climate surrounding the military manufacturing sector. In U.S. manufacturing as a whole, the ratio of capital spending to value of goods shipped was 3.8 percent in 1980 and 5.4 percent in 1985. The defense industrial base performed worse, actually falling from 3.9 percent in 1980 to 3.5 percent in 1985, while capacity and productivity in defense sectors were no better than in manufacturing overall.

One of the most important national security aspects of industrial performance is import penetration into the domestic industry. In total, the import penetration grew between 1980 and 1986 in 104 defense sectors out of 122 sectors for which data were available.

Who is to say that our explosive technological progress experienced since the end of World War II will continue? Even if it does, can we count on always being ahead of our potential military opponents in relative terms? Already, the Defense Department has identified a number of technologies critical to national security in which foreign countries either have a lead or could soon gain it.[16] Even if our potential adversaries cannot soon match all or most of our military technologies, they may be able to deny us the advantage of those technologies by developing countervailing technologies in other fields. The risk of reaching "technology bust" in pursuing our strategy of technological superiority is at once the least understood and potentially the most dangerous.

A strategy of depending on technological superiority served us well during the Cold War. It went a long way toward deterring conflict in the first place, and when properly employed by skilled military organizations operating within clear and achievable political mandates, it was instrumental in winning the wars that did occur. It served to compensate for the unbearable burdens that would have been necessary to accomplish the same ends with a large standing armed force capable of meeting our principal opponents in quantitative terms. It was, in fact, a force multiplier.

For the future, technology may well continue to deter potential threats to U.S. interests. Although it may be difficult to determine how long a shadow U.S. technological dominance casts,[17] there is some leverage to be obtained from maintaining our technology lead. In fact, there may be new strength for conventional deterrence from the dramatic demonstration of U.S. military technology during the Gulf War.[18]

But a continuation of the strategy of technological dependence should not go unquestioned as we move into the new strategic era. There are risks inherent in the strategy, and those risks are not well understood at present. Much more analysis must be put into efforts to assess the nature and magnitude of the risks and to develop affordable insurance policies to hedge against those risks.

PROSPECTS AND RISKS OF DEPENDENCE ON FOREIGN TECHNOLOGY

A subset of the question of technology dependence is the question of foreign technology dependence. Depending on foreign sources for technological advantage in military systems compounds both the potential benefits from technology and the inherent jeopardy associated with such dependence.

Foreign technology dependence is an inevitability in the new strategic era, although in past times autarky seemed to be the most desirable strategy. The globalization of military technology has been well argued.[19] But the full extent of this global integration is not fully known.[20] It is very difficult to know with much certainty the exact national origin of all the various components and parts of a given weapon, although a number of systems have been documented.[21] To the extent that dependence maintains U.S. access to foreign sources of technology not otherwise available to the United States, such dependency need not be detrimental and indeed may be a net benefit.

But there are risks associated with foreign technology dependence. A good framework for understanding those risks was developed at the now-disestablished Mobilization Concepts Development Center (MCDC) at the National Defense University in 1987.[22] A foreign source is defined as a source of supply, manufacture, or technology outside the United States or Canada.[23] A foreign vulnerability is a dependency on a foreign country whose lack of reliability and substitutability jeopardizes national security by precluding the production, or significantly reducing the capability, of a critical weapons systems. The MCDC project examined case studies based on conflict scenarios embodied in then-current contingency plans and existing weapons systems priorities as detailed in the defense acquisition system.

In precision-guided munitions (PGMs) the study found that only 1 to 2 percent of the value of PGMs comes from overseas sources, but the foreign content was concentrated in a few vital components and a cutoff in a crisis would result in cessation of production. For petroleum and nonfuel minerals in an extended war, the project found that provable domestic reserves or alternatives would probably increase under the price pressures of wartime and that strategic stockpiles would serve to provide sufficient time to bring new or alternative sources on line. For integrated circuits, the project found that there was no recourse to the loss of technology for integrated circuits other than a peacetime industrial strategy to recapture that technology for national security purposes. It found similar situations potentially developing in a number of other critical technologies. That crisis situations could disrupt the availability of militarily relevant technology for U.S. armed forces was hinted at during the Gulf War when the Department of Commerce had to engage in jawboning procedures to get Japanese suppliers to provide certain computer electronic components on short notice.[24]

Although this framework is widely accepted for understanding the nature of the foreign dependency problem, there is little consensus on how to approach the problem. The MCDC study identified four policy approaches. The first was a continuation of the present haphazard market approach of attempting simultaneously to emphasize the preservation of the domestic base, cooperating with allies, and maximizing our competitive position globally. This seems to be the approach favored by the Department of Defense at the end of the Bush Administration.[25]

There are advocates of a "Buy American" approach that would provide maximum protection against disruption. But such an approach would be costly in terms of maintaining idle capacity in peacetime and duplicating the technology efforts of foreign partners. It would probably mean that we would not have access to the world's best technology, and it might risk a trade war. At another extreme, the United States could pursue a "Buy World" strategy in which we count on being able to participate as a buyer, if not as a seller, in any sector of the global technology market regardless of what those market forces do to the development of those sectors on U.S. soil. This would pose the greatest risk of foreign vulnerability as the twin processes of technology diffusion and industrial integration continue.

Rejecting all these approaches, the MCDC authors suggest a strategy of managed risk wherein some rational combination of market competition is pursued to a point, at which the worst risks of foreign vulnerability would be managed by optimal solutions of protection of domestic sources, enhanced access to foreign sources, and allied cooperative agreements. There would not appear to be a rational method of optimizing such politically loaded policy approaches.

Recognizing the inherently political nature of the managed approach, more recent academic study has concentrated on economic solutions to the problems of foreign technology dependence. Georgetown University Professor Theodore Moran has suggested an approach that assesses foreign dependence in terms of the global concentration of industries in the militarily relevant technologies.[26] He borrows from industrial organization economics[27] the notion of a concentration ratio, which is the share of the total output of an industry captured by the top few—usually four or eight—firms. Industrial organization economists hold that market concentration does not result in the opportunity for monopoly profits unless a few firms control a majority share of the market and can exert control over pricing behavior of all the other firms or potential entrants. An elaborate body of theory has been held up as legal basis for antitrust action based on market concentration measures developed under this branch of economic theory.

Moran argues that the threat of foreign control is similarly a function of the degree of external concentration in the industries upon which the defense effort depends, not solely the nationality of the firms. Moran suggests that the United States should follow a 4–4–50 rule in allowing foreign participation in the U.S. defense technology and industry base. If any combination of four firms in four countries has 50 percent or more control over the world market, then those firms or countries could place U.S. access to those industries or technologies at risk. If it takes more than four firms or more than four countries to reach the 50 percent control threshold, then it would be highly unlikely that any combination of opponents could deny U.S. access without a suitable alternative source, including a domestic U.S. source, being available.

For strategic policy purposes, Moran believes that diversification and multiplication of companies and locales from which the nation can draw is the most dependable method of providing insurance to minimize the threat of foreign control. If the 4–4–50 rule is violated, Moran suggests voluntary application of a domestic U.S. location requirement for production and technological development as a prerequisite for foreign firm entry. If such arrangements cannot be made voluntarily, Moran argues that the most effective enforcement mechanism would be a tariff or countervailing duty. He argues strongly against strategic trade policies that would attempt to combine protection with promotion of select high technology sectors. He also opposes propelling national champions into a commanding global lead, citing examples—such as the British Nimrod program—of achieving national champion status but at unacceptable cost.

More recently, a group at the RAND Corporation[28] has taken Moran's "insurance policy" notion a step further and has argued that the foreign vulnerability question is really a problem of the marginal cost of providing adequate insurance. The policy question, according to the RAND researchers, is not whether the insurance policy is complete or perfect, for it will never operate in a globally integrated economy. Rather, they believe the policy issue is one of adequacy, and it should be judged in terms of the marginal cost of obtaining it versus the marginal benefits thus obtained.

They point out several factors that lead private sector participants in the defense industry and technology base to have inadequate insurance including an expectaton of price controls, public sector monopsony, corporate income tax rates, regulatory policies, contracting policies, and poor information about conflict contingencies. On the government side, inadequate insurance is brought on by short time horizons, political pressure from concentrated interests, foreign government policy, and the potential for interdiction. The researchers found inadequate insurance in the Tritium (government) and High Definition Television (private) industries, while the Surface Acoustic Wave and Dynamic Random Access Memory chips sectors seemed to have adequate insurance. Such economic approaches as proposed by Moran and the RAND group, as sensible as they may seem to the analytic community, may not have the political appeal necessary to find their way into national security strategy and policy. But there is a window of opportunity opening for a time after the 1992 presidential election. We would serve the country well to attempt to explain these approaches in understandable fashion and to insert them into the public debate over the national security strategy for the new era.

STRATEGY AND TECHNOLOGY IN THE NEW ERA

There is no question that technology will continue to be a major component of U.S. global security strategy for the future. The important questions are how great a role technology should play, how much the nation can afford to invest in technology, and how to organize the application of technology to protecting national interests. The basic requirements of efficiency, superiority, and flexibility still apply, but as the defense drawdown continues into the 1990s it will become increasingly difficult to optimize the balance of investments to achieve these goals.

The United States must begin to explore new approaches to strategic technologies. Finding new ways to evaluate both the risks and opportunities presented by foreign dependencies and foreign investments will be an increasingly important dimension of this policy area. At the same time, there will remain requirements for defense-specific investments in critical military technologies that will not be supported by commercial market forces.

It may also prove to be more cost-effective to abandon the Cold War approach of pursuing the most advanced technologies in all areas of military significance in favor of a more selective approach. In some cases it may be cheaper to pursue quantity over quality in military technologies in which strategic assessment would prove the approach to be prudent. In such cases, maintaining production capacity may be more important than pushing forward the envelope of technology. In some cases, our technological lead may be so far ahead of potential adversaries that we can afford to maintain large existing inventories, already paid for during the Cold War, while pursuing only a modest level of investment in the pursuit of new technologies. Where we do choose to invest, we would be wise to exploit our opportunities to have access to foreign developments rather than maintaining high walls of protection around our own laboratories and factories.

NOTES

1. The following discussion is taken from the framework developed in: Center for Strategic and International Studies, *Deterrence in Decay: The Future of the U.S. Defense Industrial Base*, The Final Report of the CSIS Defense Industrial Base Project (Washington, DC: Center for Strategic and International Studies, May 1989).

2. See *A Quest for Excellence: Final Report of the President's Blue Ribbon Commission on Defense Management*, David Packard, chairman (Washington, DC: The Commission, June 1986); Center for Strategic and International Studies, *U.S. Defense Acquisition: A Process in Trouble* (Washington, DC: CSIS, 1987).

3. Norman R. Augustine, *Augustine's Laws* (New York: Viking, 1986).

4. Alan S. Milward, *War, Economy and Society, 1939–1945* (Berkeley: University of California Press, 1977), p. 169. Data from secondary source, see footnote 1.

5. See, especially, Center for Strategic and International Studies, *Integrating Technology for National Security* (Washington, DC: CSIS, May 1991).

6. The discussion of machine tool industries in the World War II period is taken from Milward, *War, Economy and Society*, pp. 181–185.

7. CSIS, *Deterrence in Decay*, p. 11. For a more detailed historical summary of industrial mobilization in the United States, see Roderick L. Vawter, *Industrial Mobilization: The Relevant History*, An Industrial College of the Armed Forces Study in Mobilization and Defense Management, rev. ed. (Washington, DC: National Defense University Press, 1983).

8. Colonel Trevor N. Dupuy, U.S. Army, Ret., *The Evolution of Weapons and Warfare* (New York: Bobbs-Merrill, 1980), p. 299.

9. The most credible of the "lessons learned" studies and after action reports make this point. See Department of Defense, *Conduct of the Persian Gulf Conflict: An Interim Report to the Congress* (Washington, DC: U.S. Department of Defense, June 1991), pp. 7–1 to 7–7; Center for Strategic and International Studies, *Military Lessons Learned from the Persian Gulf War* (Washington, DC: CSIS, p. 37; and James Blackwell, *Thunder in the Desert: The Strategy and Tactics of the Persian Gulf War* (New York: Bantam Books, 1991), pp. 213–230.

10. F. M. Scherer, *Innovation and Growth: Schumpeterian Perspectives* (Cambridge, MA: The MIT Press, 1984), p. 3.

11. Joseph A. Schumpeter, *Capitalism, Socialism, and Democracy* (New York: Harper, 1942), p. 106.

12. Scherer, *Innovation and Growth*, p. 6.

13. Eric von Hippel, *The Sources of Innovation* (New York: Oxford University Press, 1988), p. 3.

14. Ibid., p. 5.

15. The following data are taken from CSIS, *Detterence in Decay*, pp. 33–44.

16. *Department of Defense Critical Technologies Report* (Washington, D.C.: Department of Defense, 1990).

17. On the notion of an explicit strategy of conventional deterrence based on technological superiority, see Theodore S. Gold and Richard L. Wagner, Jr., "Long Shadows and Virtual Swords: Managing Defense Resources in the Changing Security Environment," unpublished paper provided to Undersecretary of Defense for Acquisition, U.S. Department of Defense, February 1, 1990.

18. For an early discussion of the relationship between technology and conventional deterrence, see chapters by Michael Gordon and Michael Brown in *Conventional Deterrence: Alternatives for European Defense*, eds. James R. Golden, Asa A. Clark, and Bruce E. Arlinghaus (Lexington, MA: Lexington Books, 1984).

19. See, especially, DoD Critical Technologies Report; OTA report ITA-ISC–449, *Arming Our Allies: Cooperation and Competition in Defense Technology*, May 1990; OTA report OTA-ISC–374, *The Defense Technology Base: Introduction and Overview*, March 1988; OTA report OTA-ISC–460, *Global Arms Trade*, June 1991; US GAO report NSIAD 91–93; "Industrial Base Significance of DoD's Foreign Dependence," 1991; OTA report, *Holding the Edge: Maintaining the Defense Technology Base*, 1990; OTA report, *Adjusting to a New Security Environment: The Defense Technology and Industrial Base Challenge*, February 1991; OTA report, *Redesigning Defense: Planning the Transition to the Future U.S. Defense Industrial*

Base, July 1991; and The Defense Science Board, *The Defense Industrial and Technology Base*, October 1988.

20. See various reports identifying this deficiency, especially, CSIS, *Deterrence in Decay*, pp. 53–54; and the GAO 1991 report.

21. A noteworthy example is the Joint Logistics Commanders 1987 Precision Guided Munitions Study.

22. Martin Libicki, Jack Nunn, and Bill Taylor, *U.S. Industrial Base Dependence/Vulnerability: Phase II—Analysis* (Washington, DC: National Defense University, November 1987).

23. The notion that Canada is not a foreign country when it comes to consideration of defense technology base analysis is in fact embodied in law and is supposed to be governed by a joint U.S.-Canadian watchdog agency called the North American Defense Industrial Base Organization (NADIBO).

24 Blackwell, *Thunder in the Desert*, p. 9.

25. See the November 1991 Defense Department Report, *The Defense Industrial Base.*

26. Theodore H. Moran, "The Globalization of America's Defense Industries: Managing the Threat of Foreign Dependence," *International Security* 15, No. 1 (Summer 1990), pp. 57–99.

27. The basic text is F. M. Scherer, *Industrial Market Structure and Economic Performance* (Boston: Houghton Mifflin Company, 1980).

28. Benjamin Zycher, Kenneth A. Solomon, and Loren Yager, *An "Adequate Insurance" Approach to Critical Dependencies of the Department of Defense* (Santa Monica, CA: RAND Corporation National Defense Research Institute, 1991).