Sailors repairing computers at Naval Support Activity, Bahrain

U.S. Navy (Phillip A. Nickerson)

The Economics of Mobilization in the Information Age

By IRENE KYRIAKOPOULOS *and* DONALD L. LOSMAN

Mobilization—the marshalling of resources for defense—is a multifaceted and multidimensional process dealing with military, political, diplomatic, social, and financial components of national power. This essay focuses on the economic aspect of mobilization: the transformation of resources away from civilian to military uses, subject to budgetary, technological, and other constraints. Transformation implies choices; hence, it is essentially an economic process. Economics, in turn, is the study of trade-offs, with every gain coming at a cost and every goal ordinarily attainable through a variety of approaches. In any production process, economic choices must be made to maximize output from inputs used or to minimize the cost of producing a given level of output. Making such choices in the public sector is particularly difficult because there is no obvious way to gauge the economic or market value of national security services the government produces on behalf of the public. Even so, economic choices are made daily by legislators and government officials. Such decisions, whether they are made in peacetime or in wartime, always involve trade-offs.

In preparing for and prosecuting a war, the materiel dimension is critical; troops without weapons and vehicles without fuel are useless.

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2005		**00-00-2005 to 00-00-2005**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
The Economics of Mobilization in the Information Age	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **National Defense University,Institute for National Strategic Studies,Fort Lesley J. McNair,Washington,DC,20319**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**9**	

Preparation effectiveness is largely a function of intelligence, makeup and location of stockpiles, industrial mobilization capabilities, and logistic capabilities. There are clear trade-offs among these variables. If critical defense requirements have been properly identified and appropriate stockpiles are strategically prepositioned, industrial surge capabilities are less critical—the required inputs are already there. If intelligence is effective and provides accurate and timely prediction of future attacks, surge capabilities are again less critical since manufacturing efforts can begin well before the conflict. Similarly, effective logistic capabilities make the need for prepositioned materials less pressing. In allocating resources toward material preparedness and sustainability, each of these dimensions and their interrelationships must be recognized. Reductions of effort in one arena can be compensated for with increased efforts in another; without such compensation, however, defense capabilities will be degraded. This essay examines definitions, concepts, and policy alternatives that help frame the role of economics in mobilizing the defense industrial base as an element of national power in the 21st century.

marshalling resources to defense purposes always generates frictions and encounters bottlenecks

Mobilization: Definition and Concepts

From an economic perspective, mobilization is neither a single act nor one accomplished on a specific date; rather, it is the process of allocating resources to defense purposes. Mobilization affects the manner and speed with which all resources are utilized and distributed. The proportion of national resources allocated from the civilian to the military sector provides a static measure of the degree of mobilization. The lower the degree to which a country routinely devotes resources to defense, the lower its level of mobilization; conversely, the greater the proportion of resources routinely allocated to the defense sector, the greater the economy's degree of mobilization. Although such statistics do not describe the presence or absence of military conflict or the efficiency of defense outlays, they do indicate the kinds of economic choices associated with maintaining defense and military potential.

Demobilization is the reversal of the process: the reallocating of resources to the civilian sector. For example, during World War II, the economy was highly mobilized, with roughly 40 percent of economic activity in 1943 devoted to the war effort. After the war, real military spending "hit a postwar low in calendar year 1947 at $10 billion . . . or 4.3 percent of GNP."[1] That decline was only temporary; Cold War realities soon evoked a 25 percent increase in outlays. The demobilization reversal intensified during the Korean War: real defense spending more than doubled from 1950 to 1951.[2] As a percent of gross domestic product (GDP), defense spending rose roughly from 5 percent in 1950 to 11 percent in 1955, gradually falling to 7 percent by 1965.[3] By contrast, American defense spending as a share of GDP during the Vietnam War did not exceed 10 percent. This pattern of increased and lessened defense outputs and efforts—mobilization and demobilization—has continued, generally conforming to perceived threats in the international security environment. Not surprisingly, since September 11, 2001, both real outlays and the defense share of GDP have been rising.

All mobilizations are characterized by resource reallocations and often by increasing production capacity for defense materiel. *Surge* is that stage of mobilization in which greater defense outputs can only come from existing economic capacity.[4] Major mobilizations seek to attain higher defense production as quickly as possible. Speed and time thus become important variables, yet the process of marshalling resources to defense purposes always generates frictions and encounters bottlenecks that impede the pace of mobilization.

The term *capacity* suggests precise limits or calculable maximums, but in reality the concept is far more ambiguous. Frequently, economic capacity is described as the level of production at which average costs are lowest. The U.S. Bureau of the Census defines full production capacity as "the maximum level of production an establishment could attain under normal operating conditions."[5] However, plants can almost always be run "harder"—assuming additional human and material inputs are available—pushing production to higher levels, though often at higher unit costs. Indeed, the maximum output of one 8-hour shift will obviously be less than that of a double shift; triple shifts are also possible and have been common in major mobilizations. Accordingly, the actual levels of output associated with full production capacity are less quantifiable than the expression suggests. The Bureau of the Census uses an empirical approximation of "national emergency production," which is broadly defined as "the greatest level of production an establishment can expect to sustain for 1 year or more under national emergency conditions."[6] However, capacity utilization information is highly subjective since it is provided by manufacturing establishments

U.S. Air Force (Kevin J. Gruenwald)

ScanEagle UAV being tested for Marine Corps

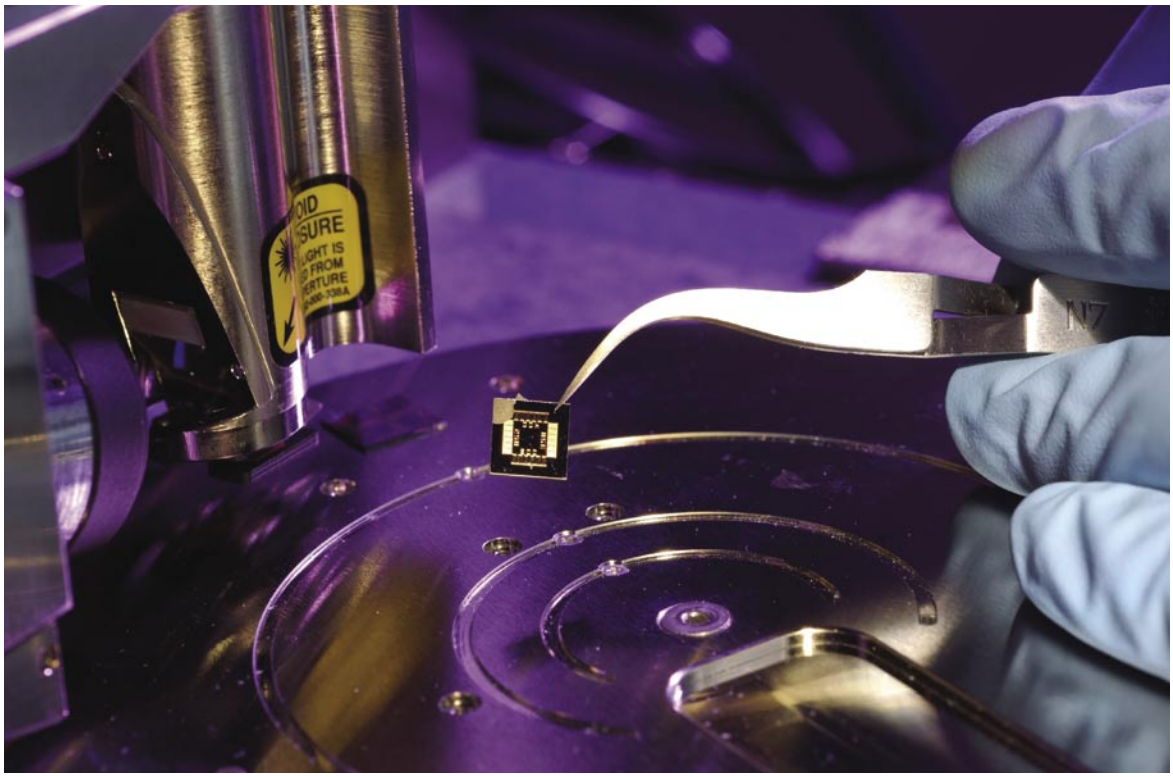
in response to mail questionnaires sent by the Bureau of the Census.[7]

Nor is the capacity concept necessarily limited to facilities alone. Today there is increasing reliance on human capacities, which also can be strained severely under surge conditions. Reports of overtime fatigue and increased security burdens during the Afghanistan campaign are a clear example.[8] Of course, under surged production, unit costs are likely to rise substantially as there is increased downtime for repair and maintenance and because fatigued workers and less experienced labor perform at lower productivity rates. These frictions, coupled with the likely utilization of either more expensive or reduced quality material inputs, will be reflected in higher unit costs.

The ability to surge production also depends on the amount of relevant raw material and supply inventories on hand or readily obtainable. In the past, metal castings, bearings, fasteners, automated test equipment, and materials such as titanium and cobalt were significant pacing items in short supply. For decades, the Department of Defense (DOD) spent considerable amounts on industrial preparedness, much of which went to fund contractors' maintenance of adequate materials inventories to enable surged production. The guidelines used, which often required companies to maintain spare capacity as well, were dropped at the end of the Cold War. The subsequent declines in defense spending resulted in a substantially downsized defense industrial base and a correspondingly lower surge capacity.

Production bottlenecks—clogs at significant points in the overall industrial process—critically impact downstream production. Bottlenecks generally result from suppliers' inability to obtain long lead-time inputs or to further expand output because production maximums have already been reached. The latter is commonplace in major mobilizations, particularly when the defense industrial base shrinks and reliance upon sole-source suppliers is generalized. For example, following the attacks of 9/11, almost all major defense contractors were asked to surge production of spare parts, precision munitions, and electronic equipment, while some major programs were simultaneously accelerated. In October 2001, orders from defense industries, which had been shrinking for over a decade, surged 206.3 percent over those in August.[9] By December, defense orders stood 40.5

Nanotechnology chip developed by Dupont



Dupont

percent higher than a year earlier.[10] A significant mobilization surge was clearly the order of the day. Since the prime contractors depend on a limited number of smaller contractors for key components, such as specialty computer chips, a backup at sub-tiers can produce bottlenecks for many purchasing firms, both at the prime and sub-prime level. And such a backup indeed occurred among lower tier parts suppliers.[11]

Changing Structure of the Defense Industrial Base

Defense analysts, planners, and economists have traditionally used the phrase *defense industrial base*, an expression that sounds precise but is actually empirically inexact and fuzzy. Conceptually, it can encompass those firms, organizations, and industries that directly or indirectly produce national security outputs. The defense industrial base may describe a part of the industrial sector, large or small, depending on the specific context, circumstances, policy approach, and orientation of the analyst. In this essay, the phrase is used to describe all output, regardless of industry origin, that is purchased directly or indirectly by DOD. For example, the acquisition of radars and telecommunications equipment, all of which embody semiconductors, would constitute an indirect purchase from the semiconductor sector. This definition of defense industrial base is conceptually clear, but obtaining precise data for analysis is not easy.

The Department of Commerce standard industrial classification system does not include an industrial grouping called "defense industrial base," nor does it contain a suggested industrial grouping with its own numerical code. The conventional (or institutional) approach treats the defense industrial base as "the combination of people, institutions, technological know-how, and facilities used to design, develop, manufacture, and maintain the weapons and supporting defense equipment needed to meet U.S. national security objectives."[12] But this approach is not helpful for data collection purposes since some important components, such as *institutions* or *technological know-how*, are impossible to measure.

Jacques Gansler and others take a similar approach; Gansler defines the U.S. defense industry as including "aerospace contractors as well as producers of small electronic microchips and manufacturers of tanks as well as engineering services contractors hired for the independent testing and evaluation of advanced weapons systems."[13] Producers include prime contractors, subcontractors, and parts suppliers; ownership of the means of production is both public and private. Another

approach relies on a more restrictive definition, referred to as *high-tech defense*. This consists of four manufacturing industries: aircraft and parts; guided missiles and space vehicles; ordnance and accessories; and search and navigation equipment.[14] But this approach ignores supplying sectors as well as critical but low-tech items such as meals ready-to-eat, parachutes, and tires.

The Industrial College of the Armed Forces (ICAF) has developed a much more comprehensive approach. It focuses on the industrial base as a whole and considers industrial linkages in the context of domestic as well as international interdependence.[15] The result is a range of industries representing both goods-producing and service-producing sectors. Representative sectors include advanced manufacturing, aircraft, biotechnology, construction, electronics, energy, information technology, land combat systems, munitions, shipbuilding, space, strategic materials, strategic supply, and transportation. Such an array of industrial sectors, comprising the backbone of the U.S. economy, is examined in terms of structure, conduct, performance, and international competitiveness. Insights gained in the course of the study are used to develop strategic assessments of the condition and outlook of industrial sectors considered vital to national security. The broader ICAF approach considers the defense industrial base to include any and all industries that produce output, directly or indirectly, for purchase by DOD. Clearly, the defense industrial base is a subset of the overall economy that changes in size and structure over time; accordingly, issues and policies dealing with it should not be treated in isolation from the larger national economy. And to complete the analysis, the defense industrial base should also be examined in an international context.

ICAF considers industrial linkages in the context of domestic as well as international interdependence

In the 1980s, analysts of the American manufacturing sector disagreed on the extent to which de-industrialization threatened the economic health of the defense industrial base. It has since become evident that the perceived process of de-industrialization was largely a shift from smokestack industries to high-technology industries. The relative defense orientation of an industry can be measured by the extent to which it depends on DOD for output purchases and, therefore, for employment. For example, an industry that directly and indirectly sells half of its output to DOD has a far greater proportion of its industrial capacity tied to the prevailing level of mobilization than an industry that sells only 5 percent of its output to DOD. Similarly, an industrial sector selling only 5 percent of its output to defense will cater to other customers and be relatively unresponsive to defense needs and requirements. In 1991, the defense share of output ranged from 99 percent in shipbuilding and repair to 18 percent in engineering and scientific instruments.[16] Employment directly or indirectly attributed to production destined for DOD purchase also varies across industries. For example, defense-related employment was roughly 2.3 percent of total employment (excluding Armed Forces personnel) in the U.S. economy in 1996. But the figure was as high as 54.7 percent in ordnance and ammunitions, 46.8 percent in search and navigation equipment, and 18.6 percent in research and testing services.[17]

To assess the state of each industrial sector, the competitiveness of the industries that comprise the defense industrial base must be analyzed. At the competitive end would be industries that function effectively in the world market, such as aircraft and telecommunications. At the noncompetitive end would be industries with little export potential, such as shipbuilding. The critical questions are: Which industries must be maintained, at what cost, and in what manner in order to preserve a healthy industrial base? Should government intervene to maintain or augment capacity in the less competitive industries? What constitutes an acceptable rationale for intervention? If intervention is warranted, what form should it take? Should government assume full responsibility, as is the case with depots, or partial responsibility, as is the case with government-owned/contractor-operated facilities? If taxes, subsidies, and trade interventions are used to maintain domestic defense production capabilities or surge potential, they are likely to contribute to further erosion of competitiveness.

Laser event recorder to warn aviators

U.S. Navy

Such is the price of maintaining defense production capabilities that no longer possess a comparative advantage in the marketplace. Finally, when economic capacity increases are warranted, how much reliance should be placed on market forces and how much on policy intervention?

Economic Capacity in the Information Age

Under ordinary circumstances, the market effectively responds to increased demands for output over time. In the long run, market-driven resource allocations, through the price mechanism, are the most efficient means of reordering economic processes as society's demands change. In a major mobilization, however, time is of the essence. Successful resource reallocation via the price mechanism evokes output adjustments over a variety of time frames. But time itself may become a critically scarce input. The relevant military forces must be speedily positioned with the right weapons, communications equipment, and supplies of expendables. Accordingly, the need for a quick response is the main justification for government controls and interference in market allocations to support a war effort, although such interventions always bring about their own problems.[18] In supporting Operation *Desert Storm,* for example, 135 special priorities cases were invoked under the Defense Priorities and Allocation System (DPAS). From its implementation by the Department of Commerce under Title I of the Defense Production Act of 1950, the purpose of DPAS is to "assure the timely availability of industrial resources to meet current national defense and emergency preparedness program requirements [and] to provide an operating system to support rapid industrial response in a national emergency."[19] Nonetheless, for *Desert Storm* the price mechanism was extensively relied upon; DOD paid above-market rates for shipping and insurance to obtain expansion of cargo capacity through commercial shipping firms.

whereas just-in-time inventory practices reduce operating and other costs, they also reduce surge capabilities

A second important justification for government controls is the need to alert the body politic to the economic costs of the war and assure the public that sacrifices will be fairly shared by all economic classes and groupings. If, for example, workers perceive that corporations are benefiting at their expense, strikes and work stoppages may disrupt critical production. If some groups appear immune to wartime inflation while others are vulnerable, both public support for the war effort and morale in general may be harmed. Under such circumstances, wage and price controls, corporate profits surcharges, and related measures may be used to promote equity and unity of effort, thus garnering maximum public support, albeit at some possible loss in economic efficiency. An alternative is to avoid explicit market intervention, which could result in "guns and butter" policies like those of the Vietnam War era. In choosing among alternative policies, it is imperative to estimate the stream of net economic and political benefits likely to accrue to society at large. Here again, trade-offs must be assessed.

Is government better prepared to interfere explicitly with the market processes at work in the so-called information age? Not necessarily. The laws of economics have not been repealed. Increased demand for output without corresponding increases in industrial capacity will ultimately generate bottlenecks and higher prices. If idle capacity exists in the form of underutilized plants and equipment and unemployed workers, or if the economy in general is operating below its potential, price increases will take longer to register and shortages may be avoided. By contrast, in a fully employed economy, an increase in defense orders may easily lead to shortages, price increases, and bottlenecks. Further, to the extent that increases in the defense budget bring about rapid changes in the level and structure of relative prices, they can lead to macroeconomic instabilities.

But the environment in which economic laws operate may well have changed, in part due to information technology. The information revolution has transformed both the goods-producing and service-producing sectors of the industrial production system around the globe. Electronic trade in real and financial assets has revolutionized the conduct of business for producers, consumers, and governments. The relationships between the industrial world and financial markets have become much more interlinked, seamless, and internationalized. Real-time information affects how market participants react, decisions are made, and equilibria are attained. In an age of instant communications and globalization, to what extent are the transmission of economic shocks faster and the resulting volatility more pronounced? This is an open question that needs to be modeled and empirically tested.

Another contributing factor involves structural changes that have reduced the degree of idle capacity in the economy; these same technological and economic adjustment forces will operate during periods of higher defense spending. In the 1980s and even more in the 1990s, companies relied on extensive applications of information technology to reduce the costs of doing business across the board. But whereas just-in-time inven-

tory practices reduce operating and other costs, for example, they also reduce surge capabilities because stockpiles (inventories) are smaller. While the continuous application of information technology and other cost-saving techniques generate peacetime cost benefits, will this trend begin to dangerously degrade industry's surge and mobilization capabilities due to reduced idle capacity and minimal inventories?

Finally, a third factor concerns structural change in the patterns of economic life. The labor force participation rate among women has increased dramatically since the 1970s, reaching nearly 70 percent. Mobilization might entail large increases in employment and, therefore, in the labor force. In the past, the number of nonworking married and unmarried women who were potentially available to join the labor force was much greater. Today's high participation shows that the reservoir of potential female workers has all but disappeared. In a major mobilization, there most likely would be meaningfully increased frictions and dislocations since defense employment growth would come at the expense of private sector positions rather than housekeeping and domestic activities. This is an important, relatively new constraint to rapid expansion of industrial capacity. However, if recent history is a guide, this trend may speed future capital-for-labor substitutions across all industries, including the defense sector in general and the Armed Forces in particular.[20]

In view of these realities, the question of what constitutes optimum policy for output expansion during mobilization is a topic of debate.[21] The strongest argument in favor of narrowly targeted government support relates to those defense-related sectors whose future capacity is expected to fall short of desired levels to meet defense orders. This is a sufficiently narrow policy goal that it may be safely pursued through the defense budget, independent of the specific level of funding involved. But how can those critical gaps be identified? One way is to use recent data to rank industries by the proportion of output they sell to DOD. As a next step, it is possible to project DOD purchases of output, by industry, at higher levels of defense spending.[22] This approach is sensible in the short run, but it may not be appropriate in the long run. Rapid technological change leading to efficient resource substitution works well in the market economy but can cause serious resource misallocations in a centrally controlled system such as DOD's requirements determination process.

Even so, estimation of desired capacity depends on assumptions about future demand for increased defense orders, given that industrial sectors can be correctly identified. When such

Global Hawk UAV developed by Northrop Grumman and other contractors, Beale Air Force Base

U.S. Air Force (John Schwab)

U.S. Air Force (Dave Ahlschwede)

Soldiers transporting injured Iraqi to combat support hospital in Baghdad on John Deere Gator

estimation is possible, a range of policies can be considered for capacity augmentation purposes. These policies should address defense requirements to be met through stockpiling, reliance on foreign or non-U.S.-based capacity (including U.S.-owned capacity abroad as well as allied capacity), and requirements that ought to be met by domestic U.S. capacity. Costs and benefits are associated with each option. Stockpiling continues to be used where storage makes technical and economic sense, as in the case of petroleum, but it is not an effective option for resources affected by rapid technological obsolescence. Similarly, foreign-based capacity would subsume industrial capacity and production available in allied countries, including all North Atlantic Treaty Organization member states. Overseas suppliers often offer the most price-competitive sourcing for many systems or components, thus promoting the objective of low-cost peacetime procurement. But reliance on offshore suppliers may degrade reliability because of political and economic uncertainties overseas or possible transportation bottlenecks. Above all, reliance on offshore supplies or on allied capacity presupposes that they cannot or will not be withheld or curtailed by a foreign government. In the absence of permanent overseas alliances, total dependence on offshore production capabilities may be imprudent. For those sectors where foreign sourcing remains or becomes an unacceptable option, capacity expansion can be achieved by trade restrictions, by explicit use of the defense budget to subsidize domestic production, or by establishing government arsenals. Use of the defense budget for subsidies can be justified on grounds of transparency and equity: subsidies spread defense costs across all taxpayers and are less difficult to reconcile with U.S. commitments to a liberal trading regime.

if some foreign action is deemed unacceptable, diplomatic negotiations can be supported with partial mobilization

Mobilization as a Strategic Tool

The ability to rapidly effect and sustain a mobilization is not only a critical operational imperative for warfighting, but also can be an integral strategic tool. Mobilizations are a form of muscle-flexing that can reveal both intentions and capabilities. If some foreign action is deemed unacceptable, diplomatic negotiations can be supported with the option of partial mobilization, a policy demonstrating seriousness of intent. Mobilization capabilities can thus be an integral portion of a deterrent strategy; the ability to quickly marshal resources for defense purposes presents a deterrent to would-be aggressors. And if deterrence fails, a nation with substantial industrial mobilization capabilities can more easily prevail. Similarly, a nation that can sustain a prolonged military effort can render aggression against it far more costly and therefore less likely. However, every reduction of risk entails mobilization resource demands. There is no such thing as a costless mobilization.

A larger question is whether the nature, speed, and industrial dimensions of economic transformation from peace to war will acquire different characteristics in the information age and especially in the era of asymmetric warfare. Economic evolution is likely to continue producing movement away from the traditional industrial sectors and toward new sectors of the information economy, but at what pace? What are the implications for the demand for highly skilled personnel and specialists in information processing and management? How will excess demand for such personnel be handled domestically when jobs and work responsibilities can be contracted out across the globe? And how relevant is the notion of a national industrial base in a globalized world? These questions suggest the need for rethinking traditional models of economic transformation and adapting them to the conditions and technological realities of the information age.

Mobilization of resources to meet national security needs can be approached as a macroeconomic problem associated with the national budget in general and the defense budget in particular. It can also be approached from the microeconomic perspective since it affects resource allocation decisions at the level of the firm, agency, or organization. Issues of macroeconomic stability

and trade-offs between inflation and unemployment arise at any level of mobilization but can become especially acute in some sectors as the economy approaches full employment. Resource allocation, utilization, and distribution problems become more difficult to resolve as mobilizations intensify because social and political constraints are more intense and speed of response becomes a critical variable. The defense industrial base is an evolving subset of the larger national and international economic space within which most industries must function. Global applications of information-age technologies have led to efficiencies in plant, equipment, and facility utilization, generally via reductions in inventories or underutilized industrial capacity. For those defense-oriented industries that are not likely to survive or maintain adequate production capabilities when exposed to market forces, policy proposals to support capacity should address reliable estimates of gaps between actual and desired output. Alternatively, government production is another option. Finally, it is imperative that in the information age traditional approaches to achieve output and capacity expansion be reexamined with respect to cost effectiveness and consistency with principles of equity. JFQ

NOTES

[1] Robert Higgs, "U.S. Military Spending in the Cold War Era: Opportunity Costs, Foreign Crises, and Domestic Constraints," *Policy Analysis #114* (Washington, D.C.: Cato Institute, November 30, 1988), 2.

[2] Ibid., appendix.

[3] U.S. Bureau of the Census, *Statistical Abstract of the United States,* 103d annual edition (Washington, D.C.: U.S. Department of Commerce, 1983), 350.

[4] For a detailed analysis of surge dynamics, see Rolf Clark, "Surge Dynamics," in *Readings in the Economics of Strategy and Resources Management* (Washington, D.C.: Industrial College of the Armed Forces, 2002).

[5] U.S. Bureau of the Census, Economics and Statistics Administration, *Current Industrial Reports* (Washington, D.C.: U.S. Department of Commerce, September 2001), 1.

[6] Ibid.

[7] Capacity utilization estimates, published by the Bureau of the Census, are based on information collected from a sample of 17,000 manufacturing establishments. The estimates are subject to errors.

[8] For example, 70 security guards had a work stoppage at a high-security military installation; the union president stated, "There's been too much overtime since September 11. . . . Overtime on top of overtime." See Keith Rogers, "Security Guards for 'Nowhere' Strike for Contract, Higher Pay," *Las Vegas Review-Journal,* December 11, 2001.

[9] "Defense Boosts Durables Orders," *Investor's Business Daily,* November 30, 2001, 1A.

[10] Charles Oliver, "Solid 2% Rise in Durable Goods Orders," *Investor's Business Daily,* January 30, 2002, 1A.

[11] See "Industry Surge Hampered by Parts Suppliers, Air Force to Help Speed Rampup," *Defense Daily,* October 15, 2001, 6.

[12] U.S. Congress, Office of Technology Assessment, *Redesigning Defense: Planning the Transition to the Future U.S. Defense Industrial Base* (Washington, D.C.: U.S. Government Printing Office, July 1991), 3.

[13] Jacques S. Gansler, *Defense Conversion* (Cambridge, MA: The MIT Press, 1995), 21.

[14] Ron L. Hetrick, "Employment in High-Tech Defense Industries in a Post–Cold War Era," *Monthly Labor Review* 119, no. 8 (August 1996), 1. Along the same lines, the designation *defense technology and industrial base* has been proposed; see Gordon Boezer, Ivars Gutmanis, and Joseph E. Muckerman II, "The Defense Technology and Industrial Base," *Parameters* 27, no. 2 (Summer 1997).

[15] See Industrial College of the Armed Forces, *In Touch with Industry* (Washington, D.C.: National Defense University Press, 1999).

[16] Congressional Budget Office, *The Economic Effects of Reduced Defense Spending* (Washington, D.C.: Congressional Budget Office, 1992), 2.

[17] Hetrick, 17–20. By contrast, some traditional defense industries had lower shares: 10.4 percent in nonferrous foundries and 8.8 percent in engines and turbines.

[18] See Donald L. Losman, Irene Kyriakopoulos, and J. Dawson Ahalt, "The Economics of America's World War II Mobilization," in *The Big L: American Logistics in World War II*, ed. Alan Gropman (Washington, D.C.: National Defense University Press, 1997), particularly 170–175.

[19] Office of Strategic Industries and Economic Security, Bureau of Export Administration, "Defense Priorities and Allocation System" (Washington, D.C.: U.S. Department of Commerce, August 1998), iii.

[20] The military services identified the reservoir of women workers as a source of recruitment and expanded job opportunities for women joining the enlisted and officer corps beginning in the late 1970s. Also, they proceeded with capital-for-labor substitution as the relative cost of manpower continued to rise faster than the cost of defense capital. Greater reliance by the military services on unmanned systems is sure to follow.

[21] Irene Kyriakopoulos, testimony before the Subcommittee on Defense Industry and Technology of the Committee on Armed Services, United States Senate, Washington, D.C., May 14, 1992.

[22] The Department of Defense used this approach through the 1980s. Specifically, the Defense Economic Impact Modeling System (DEIMS), which was developed and maintained by DOD in collaboration with DRI, Inc., was used to estimate disaggregated industry measures of the economic impact of defense expenditures. See U.S. Department of Defense, Office of the Under Secretary of Defense for Research and Engineering, Office of Industrial Base Assessment, *Defense Purchases: An Introduction to DEIMS* (Washington, D.C.: Department of Defense, 1984).