

**The Place of the Defense Industry
in National Systems of Innovation**

Judith Reppy, ed.

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PREFACE

Military research and development programs are a substantial component of many countries' public spending for new technology, but their contribution to innovation processes remains a contested issue. Whereas the debate used to center around the question of whether military R&D programs provided useful spin off to the civilian technology base and enhanced economic growth or, conversely, exacted a net cost in terms of missed opportunities, the end of the cold war and the changes associated with globalization have recast the terms of the argument. The lines between military and civilian technology have been blurred by the increased importance of information technologies—an area in which the military lags behind the civilian sector—and by changes in government policies that aim to increase procurement from civilian sources. In most of the major arms-producing countries, mergers between defense firms have produced a sharp reduction in the number of major contractors. Globalization, variously defined, has opened up the borders of national defense industries to cross-country flows of information and weapons technology that go far beyond the traditional exchanges embodied in state-to-state arms transfers. These changes co-exist with (and are, in part, a reaction to) secular trends in the complexity and costs of weapons systems, as well as declining defense budgets.

One way of talking about these issues is to consider the place of defense industries in national systems of innovation (NSI), where the national system is taken to be the totality of institutions and practices that interact to produce and diffuse new technology. What is the effect of government funding and regulations on the production of new technology? How do defense firms relate to their major customer or to civilian-oriented firms in their industrial sector? What is the nature of the transnational links and technology flows among defense firms and markets? How have the changes outlined above affected the patterns established in the past? The value of the NSI approach is that it focuses attention on the networks or systems that are involved in innovative activities and at the same time problematizes the boundaries of those systems and the roles of their constituent players.

The papers collected here are the product of a workshop on “The Place of the Defense Industry in National Systems of Innovation,” held on October 16-18, 1998 at Cornell University in Ithaca, New York. The workshop brought together specialists in defense industry issues from the United

States and Europe to discuss the changes taking place in the industry and to debate the utility of the NSI approach in a world in which globalizing trends may be undermining the basis for such an approach. The authors chart various national responses to the changes affecting the defense industry and military technology programs, and they reach different conclusions about the ability of the state to retain control over defense technologies. One obvious source of these differences lies in the valence assigned to the military sector, something that varies with a country's role in the international system and its individual history, as Claude Serfati's chapter on France and Etel Solingen's on newly industrializing states make clear. Variation in the degree to which different states have embraced market liberalization and in the strategies followed by individual firms in response to market changes also affect the emerging configurations of state power over the industry. The case studies range from advanced industrial economies of Europe and the United States to examples of transition economies (Russia) and industrializing countries (China). Opinions at the workshop differed on whether globalization has already spread to the defense sector, is certain to do so in the near future, or will be blocked in leading countries by the state's interest in maintaining a strong, nationally-based defense industry.

The rich discussion and debate during the workshop are reflected in the arguments presented in the following chapters. The authors benefitted from that discussion—particularly the contributions of our named discussants, Susan Christopherson, Rachel Weber, and Adam Segal—in revising their papers for publication. We have grouped the chapters under three main themes: Competing Institutional Paradigms; Case Studies of Advanced Industrial States; Examples from Transition and Industrializing Economies.

The workshop was sponsored by Cornell's Peace Studies Program, with funding from an institutional grant to the Program from the John D. and Catherine T. MacArthur Foundation. Judith Reppy and Susan Christopherson organized the workshop, with help from Rachel Weber. Elaine Scott and Sandra Kisner provided essential administrative support for the workshop, and Sandra Kisner contributed significantly to the editorial task of producing this publication.

I. COMPETING INSTITUTIONAL PARADIGMS

Conceptualizing the Role of Defense Industries in National Systems of Innovation

Judith Reppy

Background

The concept of national systems of innovation first emerged in the work of a network of scholars based at the Science Policy Research Unit (SPRU) at the University of Sussex, notably Chris Freeman's studies of Japan's system of innovation (Freeman 1987) and in related work by Bengt-Åke Lundvall and his colleagues at the University of Åalborg in Denmark. Now, more than a decade later, the concept has become well established as a leading paradigm for analyzing innovation processes; it has also come under attack for being both too broad and insufficiently theorized (e.g., Radosevic 1998). In this essay I summarize briefly the main elements of a national system of innovation approach and discuss its utility in analyzing the role of the defense industry in innovation.

The NSI Approach

A national system of innovation (NSI) can be defined as “the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies” (Freeman 1987, 1). This definition takes for granted that the network is bounded by national borders, an assumption that may or may not be warranted. Other noteworthy features of the definition are the systems approach, here expressed as a network; the emphasis on institutions; and the inclusive definition of innovation to include technology transfer and diffusion. Each of these features is problematic in some applications, but the definition nevertheless captures the essential features of the NSI approach.¹

¹ See Edquist (1997), “Introduction” for an extended discussion of variants to the Freeman definition.

NSI approaches gained popularity in the late 1980s in the context of rising “techno-nationalism” in western countries, a phenomenon that was, itself, a reaction to the increased competition in world markets for high technology goods from Japan and the newly industrializing states of East Asia (Nelson 1993, 3). Another factor was the end of the cold war, and with it a shift in emphasis from military competition to economic rivalries. No longer was the East-West confrontation the most important competition; instead, in a spate of books and reports, analysts debated the advantages of free market strategies versus various types of state intervention.² There was, however, consensus about the goal: the wealth of nations, which was seen to depend on success in innovation and diffusion of new technologies. This debate was largely framed in terms of cross-national comparisons and attention to the multiple institutions influencing innovation—that is, in terms of national systems of innovation.

Advantages and Disadvantages of the NSI Approach

The first strong advantage of the NSI approach is the weight it gives to institutions. Whereas conventional economic theory locates innovation in the firm, depicted as an optimizing machine running on automatic pilot, and seeks to construct general models of technology diffusion across firms, the NSI approach provides space for the role of government policy, legal institutions, educational and training institutions, and even norms and regimes. Interactive processes and feedback loops are emphasized; no room here for linear models of innovation. Success or failure in innovation can be affected by any of the constituent elements of the system, and weaknesses in one area may be compensated for by strength in another. Human resources get particular attention, and the contributions of well-trained and motivated technicians may be as important as those of Ph.D. scientists.

The naming of a multiplicity of actors and their complex patterns of interaction generates points of contact between a NSI approach and related theories of innovation, from developments in the new institutional economics, to evolutionary economics, to network theories in science studies.³

² See for example, the large literature on Japanese success in world markets (e.g., Samuels 1994; Friedman 1988; Freeman 1987) and the numerous reports from the U.S. Office of Technology Assessment on U.S. performance and policy options in the high technology sector (e.g., OTA 1988; 1990; 1992; 1994).

³ Standard references include Douglass North (1986); Richard Nelson and Sidney Winter (1982); John Law and Michel Callon (1992).

In evolutionary theories, in particular, there is a great emphasis on learning and on search patterns as the mechanisms that generate new solutions and bypass bottlenecks in the innovation process. Outcomes are path dependent, and national differences may be explained in part by national histories: for example, different regulatory regimes, whether the country is a technology leader or follower, or even geographical differences can all play a role in shaping technology.⁴

The NSI approach is particularly well suited to analyses of technology policy, where it focuses attention on elements beyond government R&D funding and support for education, the topics that have dominated the discourse on “policy for science” in the past. By drawing attention to the systemic features of the innovation process and their variation across countries, the NSI approach cautions against simple policy prescriptions that do not take into account cross-national differences among competing systems. For example, if the strength of Japanese manufacturing lies in the attention given to continuous innovation in industrial processes, it does not follow that that success can be replicated in other countries simply by providing funds for investment in improved manufacturing technology. The status accorded to engineers working on the shop floor and the supply of trained technicians may be equally important. Conversely, increased funding for basic research in Japan may not be effective in increasing the stock of fundamental science if traditional norms of extreme deference to senior scientists are unchanged.

The weaknesses of the NSI approach are the obverse of its strengths. It casts its net widely, with a resultant loss of analytical bite (Radosevic 1998; Whitley 1998). Where so many factors may play a role, assigning relative weight to particular institutions or relationships is difficult. What are the limits to the system? Are national borders really the appropriate boundary? What about regional systems, which may or may not lie within national borders, or the increasing globalization of major industries? Which institutions within the innovation systems are most important? How can cross-national comparisons be sustained, when the constituent elements of the national systems of innovation may have little in common? Although attempts have been made to address these problems by imposing more restricted definitions, or shifting the boundaries from national systems to regional systems, business systems, or technologically defined systems or sectors, they are still at an early stage. We must conclude that the NSI approach at present is not a formal theory, but rather a conceptual framework (Edquist 1997, 28-9).

⁴ For a classic study of these factors, see Hughes (1983).

Even a mere framework has its uses, however, when the goal is a discussion of policy options. Although we may not be able to predict outcomes with any precision, the elements of the NSI approach draw our attention to the important factors that should be considered in government policy for innovation. In particular, the NSI approach suggests that interconnections among policies are important, as are secondary impacts; that the traditional focus on governmental funding of basic research may not be enough; and that the boundaries of the system, and hence the range of relevant policy options, may not be easy to define.

The Defense Industry in NSI: The U.S. Example

Given this picture of innovation systems that vary according to particular features of their institutional settings, it follows that the importance of the defense industry as a source of innovation will vary across countries. In some countries the role played by the military as funder and customer for new technology may be negligible. In other countries, the defense sector and its constituent institutions have been a central site for innovation. In countries like the United States, the former Soviet Union, France, and Britain, military R&D has dominated government spending for R&D, and many developing countries have also assigned a leading role in technology development to their nascent defense industries (Ergas 1987; Gummert and Reppy 1988; Ball 1988, ch. 9).

To assess the place of the defense industry in these countries' systems of innovation, one should look at the systemic features of the defense sector and its connections to other sectors; the ways in which the national boundaries for technology flows are policed; and the extent to which spending for military R&D actually results in innovations that are diffused into the broader economy. In other words, each element of the NSI rubric deserves scrutiny.

System?

The defense industry in the United States has long been understood in systemic terms: to wit, as a military industrial complex (MIC) or "iron triangle" (e.g., Cooling 1977; Kaufman 1972; Adams 1982). The main features of the MIC are the interlocking and self-reinforcing interests of the military, the defense contractors, and members of Congress, who all have reasons to support high levels of government spending on new weapons development. Although the MIC has been repeatedly attacked by would-be reformers, it has proved remarkably robust precisely because—however costly to the taxpayer—it has been highly functional for its constituent members. Protected by its role in

national security and nourished by generous budgets, the MIC has produced a continual stream of new weapons and related innovations for close to half a century.

The institutions and practices that have held the MIC network together include supplier chains that link subcontractors to prime contractors; the IR&D program, which combines government funding for inhouse R&D at major contractors with a system of technical evaluations that has provided a flow of information about new technological directions to military laboratories; the so-called “revolving door” or movement of people back and forth between positions in the defense department, Congress, and the defense industry; tacit understandings about how the budget game is played; and secrecy practices that protect important aspects of military programs for new technology from public review. In addition to government laboratories and large research divisions in defense contractors, the network includes university researchers, federally-funded R&D centers such as RAND’s Project Air Force, and a large number of consulting businesses that specialize in technology assessment and program analysis, all interacting with other elements in the system.

These features are well established in the United States, and—appropriately modified to allow for differences in governance institutions and the size of the defense industry—they are present in other countries with large military R&D budgets as well. In France, for example, the close ties between government procurement officials and engineers working on defense contracts are extensions of bonds formed during their shared experiences at the elite *écoles polytechniques*, which graduate a large fraction of the engineers and civil servants in the French system (Chesnais and Serfati 1992, 69).

With the end of the cold war, however, an important prop supporting the MIC was removed: it is no longer credible to argue that the United States and its allies face a powerful foe with technologically advanced weapons that must be countered with continuing high levels of military spending. The dangers of the new world disorder lie in more amorphous threats, many of them emanating from nonstate actors. New technology may still be an important source of state military power, but it is far from clear what form that technology should take. We can say unequivocally that the older symbols of military hegemony—the tanks, battleships, and bombers—are less relevant to security than they once were, and the technologies that are replacing them are rooted in the civilian economy rather than the military.

In the years since the fall of the Berlin Wall, military budgets in the United States and other NATO countries have been cut; new weapons programs have been stretched out or canceled outright

(the latter a violation of one of the old rules of the game, which decreed that programs in trouble would be reshaped and/or delayed but rarely, if ever, shut down); and in the United States, at least, the industry has undergone a massive restructuring that has reduced the number of major contractors to only four companies: Lockheed-Martin, Raytheon-Hughes, Boeing-MacDonald, and—a distant fourth—Northrop-Grumman. With the exception of Boeing, which has a large commercial aircraft business, these companies have chosen to concentrate almost entirely on the defense market. They have sold or spun off many of their civilian subsidiaries and in the process become substantially more dependent on defense business than they were previously (see Ann Markusen's chapter in this publication). In addition, as a response to budget pressures and the reduced number of new programs, prime contractors have trimmed their subcontractor networks and moved to a system of pre-certified suppliers. In short the U.S. defense industry is smaller (as measured by the number of significant players) and more concentrated now than at any time since the start of the Korean War.

The end of the cold war and falling defense budgets have exacerbated long standing trends of increasing complexity and cost, trends that had already sharply reduced the number of different new weapons systems and the length of production runs. At the same time technological leadership in important technologies, particularly electronics technology, has been shifting from the military to the civilian sector. The Pentagon has responded with renewed efforts to reform defense procurement practices by eliminating many regulations and encouraging defense procurement officers to buy off-the-shelf commercial items rather than special purpose military products. In the first Clinton administration there was also a substantial increase in funding for dual-use programs intended to benefit both military and civilian users.

These changes, taken together, amount to a substantial restructuring of the MIC system. The number of major players on the industry side is much smaller; new links to the civilian sector have been encouraged, even as the prime contractors have become less diversified; some of the rules of the game have been rewritten; and the involvement and attention of members of Congress is less, now that defense business has shrunk in many members' districts. Nevertheless, the MIC is still recognizably a system, one that to a great extent stands on its own bottom, despite its many links to other parts of the economy, and one that still oversees the expenditure of very large sums of money in pursuit of new military technology.

National?

National boundaries are the obvious choice for delimiting an analysis of the role of the defense industry in innovation systems. Security is the primary function of the state, and it is the primary—if not the only—justification for military R&D programs and new weapons procurement. Thus, in the name of self-sufficiency and security of supply, countries have long protected their defense industries against foreign competition whenever possible, even when the result was higher costs or less advanced equipment. For example, “Buy American” clauses in the United States legislate against using foreign suppliers for many systems, and they are supplemented by unofficial, but no less powerful, military preferences for dealing with U.S. companies over foreign ones. This is one of the reasons that attempts to create a two-way street in arms flows within NATO, i.e., to increase substantially U.S. purchases of weapons manufactured by its NATO allies, have been unsuccessful. Similar preferences for domestically produced arms prevail in other countries and have proved resistant to change. The Anglo-French agreement on opening up public tendering in each country to bids from the other country’s firms, for example, has had little effect on who actually wins the contracts (Cobble 1998).

National states also put considerable effort into controlling flows abroad of information about military technology. They maintain elaborate systems of export controls on weapons and technological information; they supply their allies with equipment that has been “dumbed down;” they place restrictions on mergers or acquisition of their defense companies across national lines; and they restrict access by foreign nationals to some kinds of advanced training and employment. Although these efforts to police transfers of military technology are not always successful, they testify to the importance that national boundaries have for defense systems of innovation.

A case can be made for redrawing the boundaries of the defense system to allow for trends towards globalization. In response to rising development costs and shrinking markets for major weapons systems, there has been a marked increase in the number of strategic alliances between defense firms across national borders (Reppy 1994). In Europe the project of a European defense industry has been perennially discussed, although progress was for many years glacial. The example of (and the threat posed by) the large-scale mergers in the U.S. industry, however, has propelled the European industry toward consolidation, both at the national and European level, as exemplified by the merger of British Aerospace and Marconi into BAE Systems and the proposed merger of Aero-spaciale Matra and DASA to form a European Aeronautic, Defense and Space Co. (EADS). Trans-

atlantic partnerships are also on the rise. These new relationships challenge national borders and governmental controls on the flow of technology because R&D and production activities may move internationally between subsidiary units and internal transactions among the units are largely hidden from view.⁵

The trend towards an increasingly globalized defense industry, while taken for granted by many analysts, is, however, still largely prospective. To the extent that globalization is identified with the emergence of transnational defense firms, we can note that effective consummation of a merger requires development of a shared corporate culture; thus we can expect that transnational mergers will face special difficulties (Sparaco 2000). Short-term collaborations around specific projects are less ambitious, but even here difficulties abound (Malone 1980). On the one hand, cross-national links between some firms and between some governments have existed for a long time—for example, the special relationship between the United States and Britain has always included cooperation on defense technology, and several of the European consortia have stayed together through multiple versions of a weapon systems.

Globalization involves more than foreign trade, international collaborations, or transnational corporations and capital mobility, however: it speaks to a deracination of consumers and markets as well as producers. I would argue that in the defense industry the essentially national character of the national industries remains quite strong for the United States and most European countries, and that this is generally the case where defense industries have been important components of national systems of innovation.⁶ Thus, whether the current restructuring moves of defense firms will create a *de facto* global industry remains speculative at this point. An alternative future might be “Fortress America” countering “Fortress Europe” or even a retreat to nationalism and job protection if economic conditions turn sour.

⁵ A recent report from the DOD’s Defense Science Board (1999) underlines the tension between the assumed inevitability of the globalization process and security concerns raised by that process.

⁶ The same can be said for industrializing countries, which for better or worse often give defense technology a leading role in strategies to promote the development of a national technology base (Ball 1988; Molas-Gallart 1998; see also the chapter by Etel Solingen, this publication).

Innovation?

What role does a nationally-based defense industry play in innovation? With this question we are on the familiar ground of debates over spin-off, spin-on and spin-away (Samuels 1994), not to mention the justification that national security gives otherwise liberal states to pursue mercantilist policies. To many observers, the obvious explanation for U.S. dominance of high technology markets in the post-World War II period was the cross-subsidization of its civilian technology by investments in military R&D. Aircraft design, space technology, nuclear power, and solid-state electronics are examples of areas that benefitted from large-scale military spending, either for R&D or procurement or both. We can also trace management and accounting innovations to developments within the U.S. defense sector, especially the techniques for managing large-scale, complex programs. The Soviet Union, France, and Britain also pursued national policies based on investment in military-related technologies, whereas Japan nourished a strong civilian technology base that has had spin-on benefits for military technology.

Whether we regard the outcomes as a by-product of security policies that emphasized technological supremacy or as the result of a conscious policy to base industrial policy on investments in military technology, the privileging of the defense sector produced innovation systems that were simultaneously enlarged by high levels of government spending and distorted by the demands of military procurement. Mary Kaldor, for example, has argued that the defense innovation systems of the United States and Britain are biased towards trend innovation, ever more baroque and ever more isolated from civilian needs and markets (Kaldor 1981). These defense innovation systems do not, therefore, present models that other countries would be wise to emulate. There is little doubt, however, that they have produced technological innovations and that over time many of these innovations have found their way into civilian products.

National innovation systems that rely heavily on the defense sector provide another kind of resource for their governments when the political environment is hostile to government intervention in the economy. Thus, during the Thatcher government in Britain and the Reagan-Bush years in the United States, industrial policy initiatives for the civilian sector were routinely disparaged as doomed to failure and ideologically incorrect. Government spending for innovation under the rubric of national security, however, was exempt from these criticisms, and government programs such as Sematech and the Very High Speed Integrated Circuits (VHSIC) program in the United States—

programs clearly intended to bolster the civilian micro-electronics industry in its competition with Japanese firms—were funded from the DOD budget.

Even under the Clinton administration, which came into office with a declared intention of revitalizing the U.S. industrial base, the practice of linking technology programs to the DOD budget continued, and dual-use programs have emphasized military applications of civilian technologies rather than the reverse (Stowsky 1999). Technology transfer programs designed to transfer defense technologies into the civilian economy have had only limited success.⁷ Thus, the importance of the defense sector to the national innovation system goes beyond its technological contributions, *per se*, to include the shaping of structural and rhetorical dimensions of government policy.

Conclusion

The case for a national system of innovation approach in analyzing defense technology is a strong one, at least for those countries that have maintained large military R&D programs. In the defense sector the difficulties with defining appropriate boundaries and naming constituent elements that bedevil some other applications of the NSI approach are diminished by the strong identification of military innovations with state security and the interest of the state in maintaining a fence around military technology. Any analysis of the national systems of innovation for these defense-intensive countries must give pride of place to the military programs that absorb so many budgetary and real resources. At the same time, the language of systems draws our attention to the interlocking elements and processes that make up the defense innovation network, including their connections to the rest of the economy, national and international. While it clearly would be desirable to have more refined theoretical propositions to employ in our analyses of the role of the defense industry in national systems of innovation, the current NSI approach provides a workable framework in which to begin our task.

⁷ For example, in Ham and Mowery's (1998) study of five cooperative R&D agreements (CRADAs) between Lawrence Livermore National Laboratory and commercial firms, the most unambiguously successful CRADA was one in which the principal customer for the technology was the laboratory itself.

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The Defense Industry as a Paradigmatic Case of “Actually Existing Globalization”

John Lovering

Introduction: The Reconstruction of the Defense Industry

A review of current and forthcoming developments in the European defense industry (which here means mainly Britain, France, Germany, and Italy) would lead, I believe, to some fairly clear conclusions. The relationship between sectoral and national (including regional) economic development is changing profoundly. This is above all because the defense industry currently represents a major and extremely significant instance of globalization. However, this is not the kind of globalization described in many summaries.

This chapter begins by addressing the question, “What are the appropriate paradigms for thinking about defense and innovation systems?” It focuses mainly on Europe, although it would be impossible to make sense of this without taking into account the fundamental influence of the U.S. defense industry. I argue that the dominant version of two influential paradigms that are widely used in studying other sectors—Globalization and National System of Innovation—leave much to be explained in the case of the defense industry. Instead, the most illuminating perspective is offered by a “critical” conception of Globalization as a strategy implemented by, and on behalf of, powerful industrial and political interest groups.

Globalization?

Globalization is held to be a world-embracing process with several dimensions—social, cultural, political, and economic (Waters 1995). In most summaries, the emphasis is on the economic dimension, which in turn is generally presented as a historic culmination of the drive to efficiency in the use of resources. This is seen as a consequence of the increased mobility of resources, especially capital, consequent upon the reduction of national protectionism, signified not least by the demise of the autarkic “Soviet model” and the emergence of an international economic policy consensus in all but a shrinking minority of “deviant” states. Some commentators add an emphasis on the revolutionary—and irreversible—nature of new technologies, especially those based on electronics, and on biotechnologies (Castells 1997).

This portrayal of globalization—as an irresistible historic process giving rise to new geographical outcomes—is widely endorsed by official agencies, most notably the World Bank (1995, 1997). Numerous social analysts have drawn out the implications for national socio-economic change and for policy. In Britain, Dahrendorf (1995, 38), for example, has argued that Western governments have no choice but to seek to raise “national competitiveness,” and that this means they have to choose between social cohesion and political freedom. In Europe they have mainly opted for the latter (while the appointment of Putin in Russia is seen as signifying a turn towards the former). Dahrendorf is one of a large cohort of sociologists for whom the Western orthodoxy of political freedom plus globalization is posing new problems of managing widening economic inequalities. To tackle these, governments are advised to consider a “Third Way” between traditional social democracy, with de-facto protectionism built in through the effects of public subsidy, etc., and the equally traditional “laissez-faire” model (Giddens 1998). Quite what this Third Way amounts to remains obscure, although enthusiasts claim that traces can be seen in the United States and in Britain.

This conception of globalization as unavoidable, but eventually benign, is founded on both abstract arguments and empirical observations. The theoretical arguments tend to invoke an economic conception of the way economic forces operate and a dualistic conception of the relationship between the “global” and the “local,” in which the former is the domain of world-historical economic forces, symbolized by the transnational corporation and international financial flows, while the latter is the domain of responsivity, adaptation, or resistance, more often than not resulting in failure (see Lovering 1996). The running is made by the Global, where economic forces reign supreme—or at least should be allowed to do so.

As a description of the decision-making processes that lie behind globalization this is seriously inadequate. Giddens may insist that “Globalizing processes have transferred power away from nations and into depoliticized global space” (1998, 141). But the idea that globalization is somehow free of politics is quite mistaken. That globalization is deeply political, albeit often at the “micro-political” rather than formal electoral State political levels, is the gist of some of the Critical Globalization literature that has exploded over the past few years (Gordon 1988; Glyn 1995; Eatwell 1995; Amin 1997; Hirst and Thompson 1996; Weiss 1998). “Actually Existing Globalization”—I choose the term to hark back to debates about the difference between what Socialism might have been, and what it really was—is shaped by, and reproduces, shifting configurations of power. Within

these, traditional nationally accountable entities, such as elected polities, have declining influence. The defense sector is an outstanding case in point.

For this reason, I suggest that Chomsky's (1998) recent breezy overview is pertinent here. Noting that only perhaps 15 percent of all trade is truly "free" (p.19), and that 40 percent of U.S. imports are actually within-firm transfers, Chomsky writes (p. 27) of globalization as the creation of:

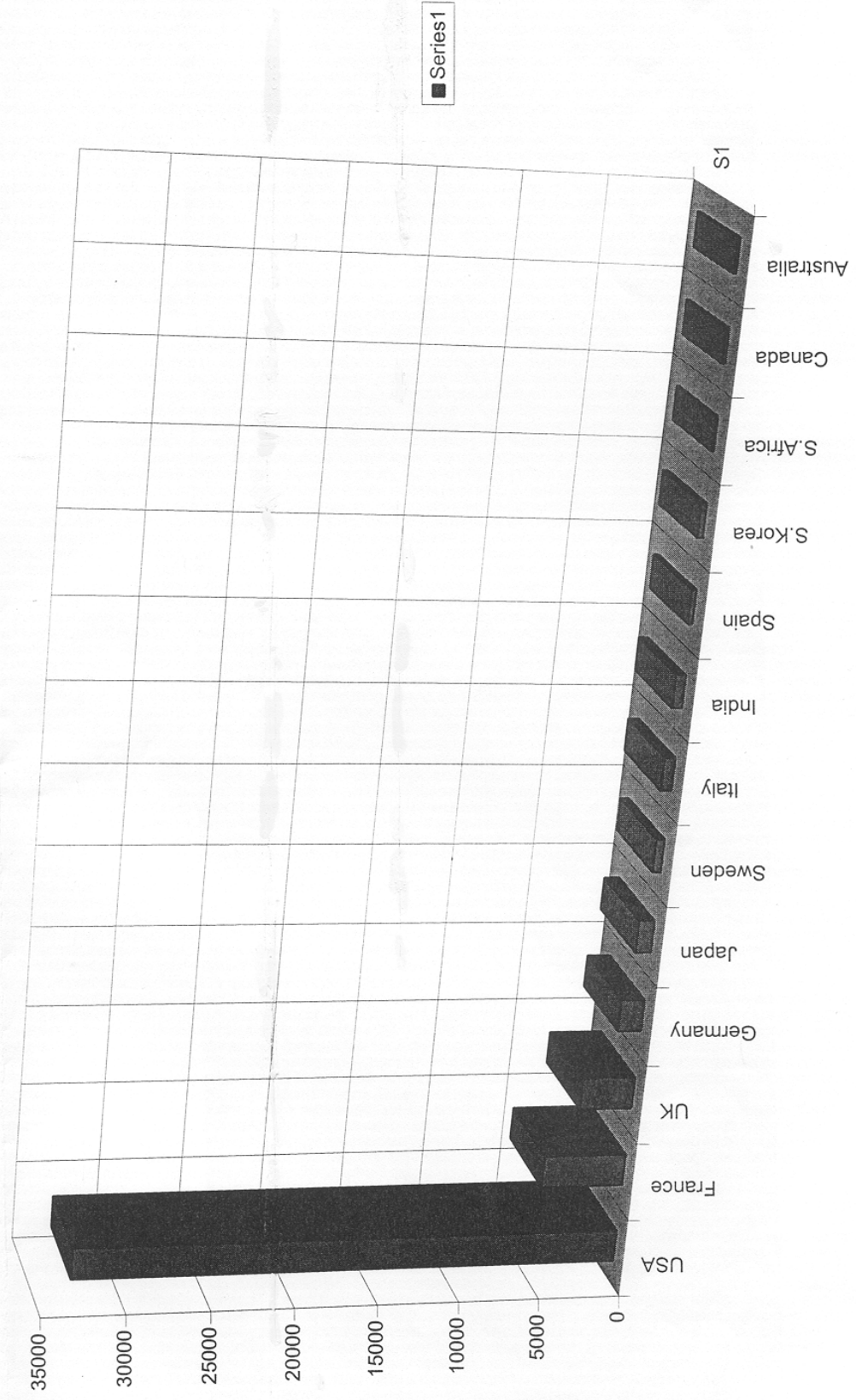
. . . an international political economy which is organized by powerful states and secret bureaucracies whose primary function is to serve the concentrations of private power which administer markets through their own internal operations, through networks of corporate alliances, including the intra-firm transactions that are mislabelled 'trade.' They rely on the public for subsidy, for research and development, for innovation and for bail-outs when things go wrong . . . In such ways, they seek to ensure that the 'prime beneficiaries' . . . are the right people; the smug and prosperous [minority of] 'Americans'. . . and their counterparts elsewhere [notably in the corporate elites of Britain, and soon Germany, Italy, and even France—JL]

Outside the United States, and to a degree within it, the defense industry is being "denationalized" according to the priorities and strategies of a tiny group of decision makers. While many economists, defense scholars, and writers on science policy continue to talk of the defense industry as an arm of the national state (e.g., Sandler and Hartley 1995; Edgerton 1991, 1998), this is becoming an increasingly misleading description of the way it really works, especially in Europe. The industry is increasingly becoming privatized, and even where it remains in formal public ownership, its behavior is increasingly "marketized" (Gansler 1995; Lovering 1998a, b, 1999a). It is also increasingly interwoven with finance capital—this is new. "The City" or "Wall Street" played only a minor role in the Cold War years, when the industry was essentially financed by the state. The globalization of defense is not evidence of the much-discussed "decline of the nation state" (Ohmae 1993), but rather of its reorientation and increasingly closed nature and partisan behavior.

Globalization or "Americanization"?

Most of the "globalization" in the defense industry is in fact "internationalization." It is premised on the survival, rather than the transcendence, of national states. Since the key state on any dimension is the United States, this means that "globalization" in defense is to a large degree a matter of "Americanization." The simplest way to indicate the overwhelming influence of the United States is in terms of spending on military R&D. As shown in Figure 1, U.S. spending is roughly

Figure 1
Government Defence R&D Spending 1994



equivalent to the combined total of the rest of the world, and if company spending is added in to the equation, almost certainly exceeds it.

This is but one dimension of the “Americanization” of the world’s defense industries. It is perhaps more importantly evident in the conscious strategic choices of all major defense companies to get into the American market, which is both enormous in itself and a key stepping-stone to exports to third party customers. All the major British and Germany defense companies, for example, have U.S. sales at the top of their list of priorities. Companies such as British Aerospace (BAe) have made it clear that their aim is to become a “global” company, but only in the sense that many U.S. transnational corporations are global: “[W]e wish to appear as British company in Britain, a Japanese one in Japan, and an American one in the USA’ (British Aerospace Strategy Director 1997).”

The substance of the push to globalize, as interpreted by key actors, is thus profoundly shaped by the uniqueness of the U.S. defense market, and the unique scale of its major defense corporations. There is another dimension to this, just as there is in the earlier successful globalization of U.S. civilian companies, amongst which Coca-Cola is perhaps a paradigmatic case: in order to be constructed as a market for U.S. products, buyers in other countries must adopt American styles of consumption. We can thus observe an “Americanization” of defense markets around the world, symbolized by the ubiquity of American-style military uniforms, the influence of U.S. (and British) military technical advisors, and not least the adoption of the characteristically American emphasis on air power as *the* key military technology. This is having some bizarre effects. In Central-East Europe, for example, three relatively poor countries are being asked to invest huge sums in purchasing new aircraft as part of the “ticket” for entry to NATO and the European Union.

This in turn has profound implications for the political-economy of the defense industry within Europe, and the circuits of flows through which it operates. The pressure for Globalization-Americanization in the defense industry varies in detail from country to country, but some common themes are evident. The defense sector is becoming “de-nationalized” not only through international trade (arms exports), but also and more importantly through the proliferation of cross-border collaborative development and production deals of various forms. Current examples in which European producers are involved include just about every sub-sector, including ships, radar, combat aircraft, troop-carrying aircraft, helicopters, missiles, and guidance systems. The ammunition sector has perhaps been the most “autarkic,” and even this is changing, with the prospective merger of British and

French capacities (Royal Ordnance and—subject to clarifying the role of state ownership and the costs of de-manning—GIAT).

Cross-border collaborations, joint ventures, etc. are not merely technical industrial arrangements, they are also inextricably *political* because they involve the construction of enduring networks that tie in companies, government departments, and armed services over many years. The ties consist not only in the financial penalties built into contracts, but also the weightier if less tangible constraints of foreign policy agreements. One important effect of these arrangements, and the new networking circuits they involve, is thus to reduce the susceptibility of a program to national political influences. Once established, as a British Minister approvingly noted at the beginning of this decade, collaborative programs imply “less and less political surveillance over defense production” (cited in Hayward 1990, 39). They help to insulate the companies involved from what they see as the disinterest, short-term thinking, or active opposition that characterizes politicians’ attitudes to defense spending in the post-Cold War era. In so doing they create a new domain within which corporate decision-makers exert sway unfettered by the kind of interference to which the Cold War defense industry was subject. This is presented as an efficiency gain, but it clearly has another side. In a nutshell, it creates a new arena, one that is chronically prone to corporate capture. And from the point of view of companies, this indeed is precisely the point (see Lovering 1999a).

For these reasons the defense sector is, I suggest, an outstanding example of the kind of politically engineered Globalization described in Chomsky’s conception cited earlier. This bears little connection to either the “abstract” models set out by neo-classical economists or the “inevablist” scenarios of sociologists such as Dahrendorf and Giddens.

National Systems of Innovation?

The growth of globalization-Americanization in the defense industry has yet to be given adequate consideration in that stream of literature which draws on the concept of National Systems of Innovation (NSI) (Nelson 1993; Lundvall 1992). The defense industry has often been cited as the key instance of NSIs. Chenais (1993) in France and Walker (1993) in Britain, for example, have identified the defense sector as a key—if not the primary—channel through which national research and development resources impact upon national industrial and economic performance (see also Gummatt and Stein 1994).

The NSI literature brings together in a new paradigm a number of observations that have long been familiar in the defense field. It is useful in that it focuses attention on the relations between publicly-provided or underwritten capacities and the defense sector in a comparative perspective. However, the globalization tendencies noted above suggest that the NSI approach is severely limited in that—at least to date—it lacks an adequate historical dimension.

The changes associated with Globalization-Americanization in defense suggest that the defense sector is in general ceasing to be such a straightforward exemplar of a National System of Innovation. Put another way, they show that the NSI must be seen as historically as well as geographically specific. The other side of the coin of Globalization-Americanization in defense is that the relationship between the defense sector and national science and technology investment is changing. In short, defense is ceasing to be a major window through which national innovatory capacities are projected into the national economy in those states that increasingly pattern their militaries on American technology.

I suggest that this is the predictable consequence of the privatization of the defense industry that accompanies “Actually Existing Globalization.” In Europe—where since 1997 governments and industry have been discussing ways to form a cross-border defense giant as the next convulsive phase of restructuring—the benefits spilling over from the defense sector to other industries, firms, and employees within the nations are shrinking. Subcontracting linkages are becoming closer, and the number of firms involved is declining, but this does not follow a national (much less a regional) pattern. In sum, the net benefits of national inputs of skills, public resources, etc. to defense are being channelled more exclusively into the private (corporate) networks outlined above.

The Dilemmas of National R&D Support to an Increasingly Globalized Industry

The “globalization” of defense-related R&D and production in Europe poses new problems for the formal agencies of national innovation, most prominently the defense research establishments. These problems have been particularly acute and visible in the United Kingdom, where the Defense Evaluation and Research Agency (DERA) has been in a state of near crisis for some years. The root cause of the dilemma is simple: the agency used to provide public-funded inputs at no or minimal cost to the users on the rationale of promoting the national defense industrial base. Its mission was revised in the mid-1990s to become “providing the MOD (Ministry of Defense) with expert information to assist in procurement on the global level.” On the one hand, it is unable to access

lavish public funds to pursue the kind of “blue skies” research in which it engaged in the past (resulting in some important technological gains, such as vertical take-off and landing aircraft and infra-red technology, which were then transferred to British companies and remain vital to their profitability and competitive footholds). The decline of public funding for DERA has been a *cause célèbre* in the British defense industry, which although now privatized, still wants to be able to draw upon R&D inputs provided by the public sector. In 1995 the effects of the rundown were such that it was claimed that necessary defense aerospace R&D was making unsustainable demands on companies, which were spending 130 percent of their profits on R&D (OST 1995; Lovering 1995). Defense R&D fell four times as rapidly as civilian R&D did. The new Labour government has begun to address this problem, with the Strategic Defense Review of 1998 promising more public spending on demonstrator programs guided by the companies. Meanwhile, the proportion of R&D in the British defense industry accounted for by “overseas” resources continues to rise.

For DERA to fulfil its mission of providing expert advice to the MOD, it needs to adopt an impartial posture. But, as its spokespersons have pointed out, they are increasingly dependent on the companies themselves for the requisite technical expertise. Public defense research, in short, is increasingly bound up with the construction of “specialist knowledge” in which private interests are increasingly dominant actors. Globalization, together with neo-liberal public policies, have created an almost insuperable dilemma for the official repositories of the public interest.

From National to Regional Systems of Innovation?

It is worth noting here that the restructuring of defense shows tendencies that run precisely counter to those that many economic geographers claim to have identified as the emergent paradigm of economic geography—namely the economic empowerment of “regions” (Storper 1995; Scott 1998). A new sub-theme in this literature—at least in Europe—is the historical and normative claim that competitiveness is related less to the existence of national than of *regional* systems of innovation (the term “region” is not defined with any clarity). This idea is popular in Europe in those political, administrative and academic circles most closely associated with the regional policy activities of the European union.¹

¹ For example, see Braczyk, Cooke, and Heidenreich (1998). Two of the authors are European bureaucrats, while the third is an academic who has worked closely with the Commission, and with regional agencies.

However, the regionalized versions of the NSI literature is much less substantial than its National elder brother. Indeed it relies on assertion, generalization from abstract propositions, and extremely loose empirical work. It shares many of these weaknesses with the wider new literature on “Regional Resurgence,” which is coming under increasingly critical scrutiny (see Lovering 1999b). There is virtually no empirical content to the claims of the RSI writers. Insofar as there is any evidence of the regional flows of R&D within the United Kingdom, for example, it suggests that there exist several “islands of innovation” in UK aerospace that are as closely embedded in networks stretching overseas as in networks indigenous to the United Kingdom (Hickie 1991). Similarly, such evidence as is available on R&D connections within the United Kingdom shows a national rather than a regional pattern (Goddard et al. 1994). In short, the notion of the RSI, at least in Britain, is best described as not very accurate.

The “globalization” of the defense sector would seem to be living proof that if they exist at all, regional systems of innovation have little influence on the leading edge of modern high-technology industry. The impact of “globalization” on the geography of the European defense industry would seem to be clear in general terms: the consolidation of high-level activities within a shrinking number of existing established locations (such as Warton, Lancaster—military aircraft; Munich, Bavaria—military aircraft; Hengelo, Netherlands—naval electronics; Cherbourg, France— naval ships), alongside a radical decline of employment in lower-tier companies and in labor-intensive production and assembly activities. A sign of the future in this context is British Aerospace’s recent agreement with PZL Mielec of Poland to make parts of Hawk airframe, parts that at present are made at Hull and at Hamble. While some high-level professional jobs remain in Western Europe, and others decline, the companies are also engaged in proliferating small “buy-local” initiatives that help to sustain their local image and legitimacy as key employers and important actors in the new regional structures of economic governance, especially in the labor market (e.g., BAe Warton). The real action, however, is elsewhere, as a result of increasing *de facto* corporate and labor market integration linking sites and elite labor forces in British and other European towns to their collaborators and intended customers in St Louis or Seattle. BAe has long had most of its software provided by wire from India. The search for wider markets and lower labor costs is leading to the rapid establishment of new outposts in Capetown, Beijing, and elsewhere. In short, the phrase “globalization-localization” in the defense sector entails very different effects under each of its terms.

Conclusion: Defense Globalization *versus* States and Their Regions

We are faced with a curious paradox. The defense sector is “de-nationalizing”—and even more radically “de-localizing”—just at the time when governments are emphasizing the need to promote national competitiveness, and are stressing the role of policies and networks at the regional scale to achieve this. Spokespersons for government departments and industry and many academics are claiming that a new “regionalization” of economic activity, including innovation, is the key process in the world economy, and the appropriate focus of policy. The thrust of this chapter is that—at least in the defense sector—this influential academic and policy discourse is, in a nutshell, wrong (see also Lovering 1998a).

In order to understand the defense sector, and its relationship to innovation, we need to add both a new “political” dimension to the globalization approach, and a new historical dimension to the National Systems of Innovation perspective. The combined effect would be to see the transformation of defense in a new light. From the point of view of the impact of current changes on national (and regional) economic development and employment, and equally from the point of view of a Peace Studies focus on the public control of the technologies of violence, the result will not be very cheering.

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Should We Welcome a Transnational Defense Industry?

Ann Markusen*

Introduction

In the 1990s, as defense budgets plummeted, nations scrambled to rationalize their defense industries, with less than salutary results. In the United States, for instance, the Pentagon twice altered its policy towards defense industry restructuring. The Bush administration maintained a Cold War tradition of staunch opposition to full-scale mergers among large defense firms. The Clinton administration encouraged the implosion of dozens of contractors into just four firms, only to reverse itself by opposing the Lockheed Martin bid for Northrop Grumman in 1997. The policy did not produce the savings anticipated, and surprisingly few production lines have been closed down. More troubling, mergers diminished competition in some weapons lines, undermined defense conversion and civil/military integration, and produced fewer, more politically powerful defense-specialized firms.

Now weapons-producing nations face a new development—the proliferation of transnational mergers and alliances. American contractors, emerging from a decade of deep and abrupt domestic military spending cuts, are actively seeking foreign, chiefly European, partners. European firms, long disadvantaged by the small size of their national markets, are trying to merge with each other, while their governments engage in a politically-embattled privatization process to pave the way. The defense industry is belatedly doing what its commercial counterparts have done for decades—gone global—not just by exporting arms but by establishing design, production, and marketing operations in foreign locales.

But the defense industry is not just like any other industry. Its character and operations pose technological, economic, political and security problems not present in a Chrysler/Daimler-Benz

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merger. Traditional issues of cost, quality, and innovation in a market already marked by considerable concentration will become even more formidable. Governments already find it difficult to adequately oversee the industry, and coping with transnational suppliers will be just that much more difficult. In addition to these micro-economic concerns, it will become more difficult to ensure that government investments in military R&D result in spin-offs that are captured within the national economy. Transnational defense firms, in other words, pose large challenges to the notion of a national system of innovation.

There are also security issues. Nations might have to compromise on weapons design, as other buyers loom larger in the strategic plans of transnational companies. Supply lines could be more easily disrupted in times of crisis. Sophisticated weapons technologies could move more easily from country to country, quickening the pace of proliferation. Within the confines of a single firm or strategic alliance, people, ideas, and technologies, rather than weapons, would move more readily across national borders, making it difficult for governments to monitor cost, pricing, possession, and re-export of arms. Lead nations could risk their competitive edge in weaponry altogether, as know-how diffuses to other centers of expertise.

The military industrial conundrum demonstrates just how deeply economic imperatives have become intertwined with security policy. There are good economic and political reasons to encourage transnational mergers and partnerships. They could speed the elimination of redundant capacity and lower the cost of designing and producing weaponry. They might also undermine the pork-barreling that keeps military spending high and crowded into inappropriate activities. But these gains must be weighed against a fundamental fact—that a transnational defense industry would entail fewer sellers facing a greater number of buyers, shifting market power on balance from governments toward private industry.

In this chapter I review these multiple aspects of the transnational defense industrial challenge. The analysis is based on twelve years of interviews and discussions with defense firm managers, investment bankers, government defense industrial base managers, policymakers, and scholars. It has been subjected to the “vetting” of three years of scrutiny by a broad-based expert study group at the Council on Foreign Relations in New York. I also draw upon my own published empirical work and that of others. The discussion focuses on the United States, but the implications are quite similar for other weapons-producing countries. I speculate briefly at the end on the consequences of transnational mergers for weapons-poor countries.

I conclude that global industry restructuring should be welcomed, but only if nations coordinate their defense industrial and arms export policies, matching the global reach of transnational defense firms. Such coordination will be easier to the extent that cooperative security strategy and multilateral arms export controls supplant “go-it-alone” security postures. Without the former, political pressures will mount on individual governments to support their own domestic companies, even when owned by or paired with transnational firms, and to compete in export markets, speeding proliferation. Ironically, then, economic realities may force a rethinking of security policy. Citizens of all countries—both weapons producers and weapons buyers—deserve full debate on the economic and security consequences of transnational military industrial alliances before they become a fait accompli.

Defense Industrial Strategy in the 1990s

Former adversaries faced a formidable adjustment problem following the end of the Cold War. The cessation of cold war hostilities meant that defense spending could be cut dramatically and the resources tied up in it—labor, industrial plant, military facilities—released into other activities. Some countries were able to cut military spending rapidly. Germany, whose investments were principally in personnel, quickly closed military bases and shifted public spending to the re-integration of eastern Germany into the national economy (Brömmelhürster and Markusen 1999). Russia also cut spending dramatically, but for a number of reasons was unable to easily transfer capabilities into other sectors (Gonchar, Kuznetsov, and Ozhegov 1995). The United States was slow to cut defense spending and France even more reluctant, in both cases because of domestic political resistance and the significance of defense spending as industrial policy (Markusen and Serfati 2000). Overall, world military spending has fallen by more than 30 percent in real terms since 1989, and with the Asian financial crisis, it is apt to continue to decline, albeit more slowly (Table 1).

The American case illustrates the remarkable range of options available to policymakers at the cold war’s end and the pitfalls of choosing among them. Arguably the most transparent and well-staffed defense industrial base management agency in the world, the Pentagon did not do a particularly good job guiding the downsizing of the American defense industry in the 1990s. Because procurement spending—the share of the defense budget spent on purchases from the private sector—had increased disproportionately in the 1980s, the Pentagon planned deep cuts in a relatively short period of time. From the military point of view, the challenge was to slash spending without

damaging the industry's ability to design and build weapons and without unduly eliminating cost-containing competition (Gansler 1995). For some, the challenge was also to preserve the government's historic ability to ensure American civilian technological leadership through a quiet industrial policy at the Pentagon (Alic, Branscomb. et al. 1992). For yet others, the strategic sea change offered the possibility for large-scale conversion of redundant military industrial capabilities and a definitive shift to a civilian-led technology policy (Markusen and Yudken 1992; Stowsky 1999). The peace dividend was also seen as an opportunity to fund infrastructure, education, and social spending priorities that had taken a back-burner to the Reagan military build-up (Bischak 1991).

Table 1
Military Expenditures, 1985, 1990, 1996
Selected countries (Index, 1996 = 100)

Region	1985	1990	1996
United Kingdom	141	135	100
China	62	74	100
France	106	111	100
Germany	159	129	100
Russia/Soviet Union	783	584	100
United States	138	116	100
Developing Countries	101	117	100
Industrialized Countries	161	138	100
World Total	146	133	100

Source: BICC *Conversion Survey 1998*, Appendix A1.

Responding to the challenge proved difficult, not the least because of conflicting agendas. Even within the Pentagon, controversy arose over the distribution of spending cuts. One option was to shield research and development contracts from the budget knife while cutting operations and production contracts. But military leaders concerned with readiness (i.e., funds for personnel and operations) fought the modernizers, who pressed for spending on new weapons systems. Meanwhile, the defense industry pushed for procurement contracts (especially for existing systems), closing bases, and privatizing depot and other functions. Peace groups, environmentalists, and other constituencies pressed for lower defense budgets altogether, citing studies that suggested the United States could mount a credible defense for only a fraction of current spending (Forsberg 1992; Bischak 1999).

Those defending military budgets found it impossible to hold the line on Reagan era spending. It was hard to defend new R&D spending, slated mainly for Cold War systems, as it became clearer that security policy was itself in question. Threats are more diffuse, while terrorism, biological and chemical warfare, and nuclear proliferation pose greater risks than those anticipated in current modernization plans. Then, too, negotiated settlements, peacekeeping, and preventive strategies have emerged as important new foreign policy activities, with quite different implications for defense policy and thus for procurement. The upshot has been that American military R&D funding, while less hard hit than orders for existing weapons systems, fell 26 percent in real terms since 1987. The significance of overall military spending cuts of nearly 40 percent in the United States is still quite controversial. The industry laments procurement cuts of 60 percent or more, but critics point out that procurement in real terms is still higher than in the cold war 1970s and accounts for a larger share of the defense dollar now. Furthermore, they argue, the need for high levels of defense spending has diminished dramatically.

In the 1980s, when defense dollars were easy to come by, the Pentagon had little reason to fret about industrial structure and performance. But faced with the squeeze from binding budgets on the one hand and concern with readiness on the other, the Pentagon had to redouble its efforts to get the best return on its shrinking modernization dollar. It crafted three new defense industrial base approaches in the 1990s—a dual-use strategy to break down barriers between military and civilian sectors, a merger policy to right-size the industry, and a liberalized arms export policy. What did each of these achieve?

Dismantling the Wall of Separation

The dual-use strategy, articulated most powerfully by John Alic, Louis Branscomb, and colleagues in their book *Beyond Spinoff* (1992), and by current Pentagon acquisitions chief Jacques Gansler in his book *Defense Conversion* (1995), held the United States could no longer rely on defense-dedicated firms, cordoned off from the commercial sector, to provide the innovative edge. Civilian electronics and communications, once bred on defense R&D and procurement contracts, had outpaced military applications for two decades, forcing the Pentagon to turn to Silicon Valley firms for critical technologies. Alic, Branscomb, and Gansler counseled a major procurement overhaul, buying off-the-shelf commercial components wherever possible and inducing firms to become integrated civil/military producers, right down to the shop floor.

The Bush administration instituted procurement reforms in this vein, and President Clinton accelerated them, also funding a \$2 billion plus Technology Reinvestment Program (TRP) with grants to firms who would move technologies either way across the border between defense and civilian sectors. Procurement reform has proceeded slowly. It confronts a deep structural problem: because innovation is the basis of military superiority, a fair degree of secrecy and close Pentagon oversight over research, design, and production of leading edge weapons will remain essential, discouraging civilian/military integration, especially at the systems integration level. But the Pentagon is buying more off-the-shelf commercial components. The TRP, despite a promising start, was cut heavily by the Republican Congress elected in 1994, as part of its general repudiation of technology programs and it disappeared in the FY1997 budget request, to be replaced by the Dual-Use Applications Program (DUAP) (Stowsky 1999; Oden, Bischak, and Klock-Evans 1995).

The Merger Flip-Flop

No Pentagon policy initiative was more unexpected than the Clinton administration's sudden reversal of a half century of opposition to defense mergers among large contractors. For five decades, the Pentagon engaged in often contorted efforts to maintain a plurality of contractors who could compete on major weapons systems in each major sector: aircraft, missiles, satellites, submarines, destroyers, tanks, and so on. As James Kurth (1973, 1990) demonstrated in his two "follow-on imperative" articles, this consistently involved awarding contracts to the corporation most in need of a new system rather than to the one with the best design. The Bush administration maintained this vigilance against diminution of competition, going to court to stop the pairing of ammunition manufacturers Olin and Alliant.

But in 1993 Under Secretary of Defense William Perry, at what defense contractors later dubbed "the last supper," announced that some of those present would not be there in five years and that this was, in the view of the Pentagon, a good thing. The merger impulse had already begun, led by the rapid acquisition of second-tier contractors by Loral CEO Bernard Schwartz, who stressed financial rather than engineering priorities in the corporate suite. The Pentagon change of heart set off a flurry of mergers that imploded the ranks of the largest American defense contractors, from more than fifteen with Pentagon sales over \$1 billion each in 1993 to just four by 1997, with those four racking up combined sales of more than \$56 billion (Korb 1996; Dowdy 1997; Markusen 1998).

The merger wave undercut incipient diversification efforts. Companies had begun using accumulated cash reserves and defense-bred technologies to enter commercial markets, a development anticipated in the trade press and congruent with dual-use policies (Oden 1999). Diversifying companies like Hughes, Raytheon, Rockwell, Texas Instruments, and TRW were subsequently pressured to spin off their military from their civilian operations and/or to merge, and by 1997 all but TRW capitulated. The preoccupation with finding mates and consolidating marriages crowded out diversification, as retained earnings were diverted to cover purchases prices and retire new merger-related debt. Wall Street investment banking firms played an important initiating role in this process, as they will in the international acquisitions now in the planning stages (Markusen 1998).

The consolidation slide was greased with Pentagon dollars. In an unprecedented policy decision, the Pentagon permitted contractors to write off their costs of realizing the mergers, plus a rate of return, against current contracts, on the presumption they would save the government money in the future. Although the GAO has confirmed savings in some cases of completed mergers, these have been far below the levels promised and in the aggregate, below the threshold allowed by Congress (U.S. General Accounting Office 1995).

Surprisingly little capacity was actually retired in the wake of the mergers. MIT's Harvey Sapolsky and Eugene Gholz, in a careful census of actual production lines, confirm the retention of most of them, albeit at reduced levels of capacity utilization (Sapolsky and Gholz 1999). University of Texas economist Michael Oden has shown that most mergers were of the market-extension type, in which the largest firms expanded their portfolios of offerings to the Pentagon. Most of the savings resulted from real estate liquidation and layoffs of relatively well-paid, unionized workers, some of whom were replaced by lower-paid workers in the subcontracting sector and others by relocation to cheaper, more military-friendly Congressional districts in the South and Southwest (Oden 1999).

Disappointed with progress on dual-use policy and alarmed at the persistence of defense-specialized giants and the diminution in their numbers, Defense Secretary William Cohen and Acquisitions Chief Gansler sharply reversed the merger policy in 1997. Although late in the game, they opposed the absorption of Northrop-Grumman by Lockheed-Martin, on grounds it would eliminate effective competition in a number of weapons lines. Stunned, the industry protested, but to no avail. Persistent opposition convinced Lockheed-Martin to drop its merger bid in July of 1998, ending five years of industry-altering mergers and leaving four large system-integrating defense contractors in the American market (Figure 1).

Why the Flip-Flop?

Why has the Pentagon been so inconsistent in its stance towards large contractor mergers? One possible answer is simply changeovers in leadership. Bill Perry was relatively unique as a Secretary of Defense, having started a defense electronics firm and later, a Silicon Valley venture capital firm, before taking on the top Pentagon job. He may have felt more comfortable with investment banking initiatives that promised to produce substantial savings by subjecting large defense firms to the same restructuring pressures most other large companies endured in the 1980s.

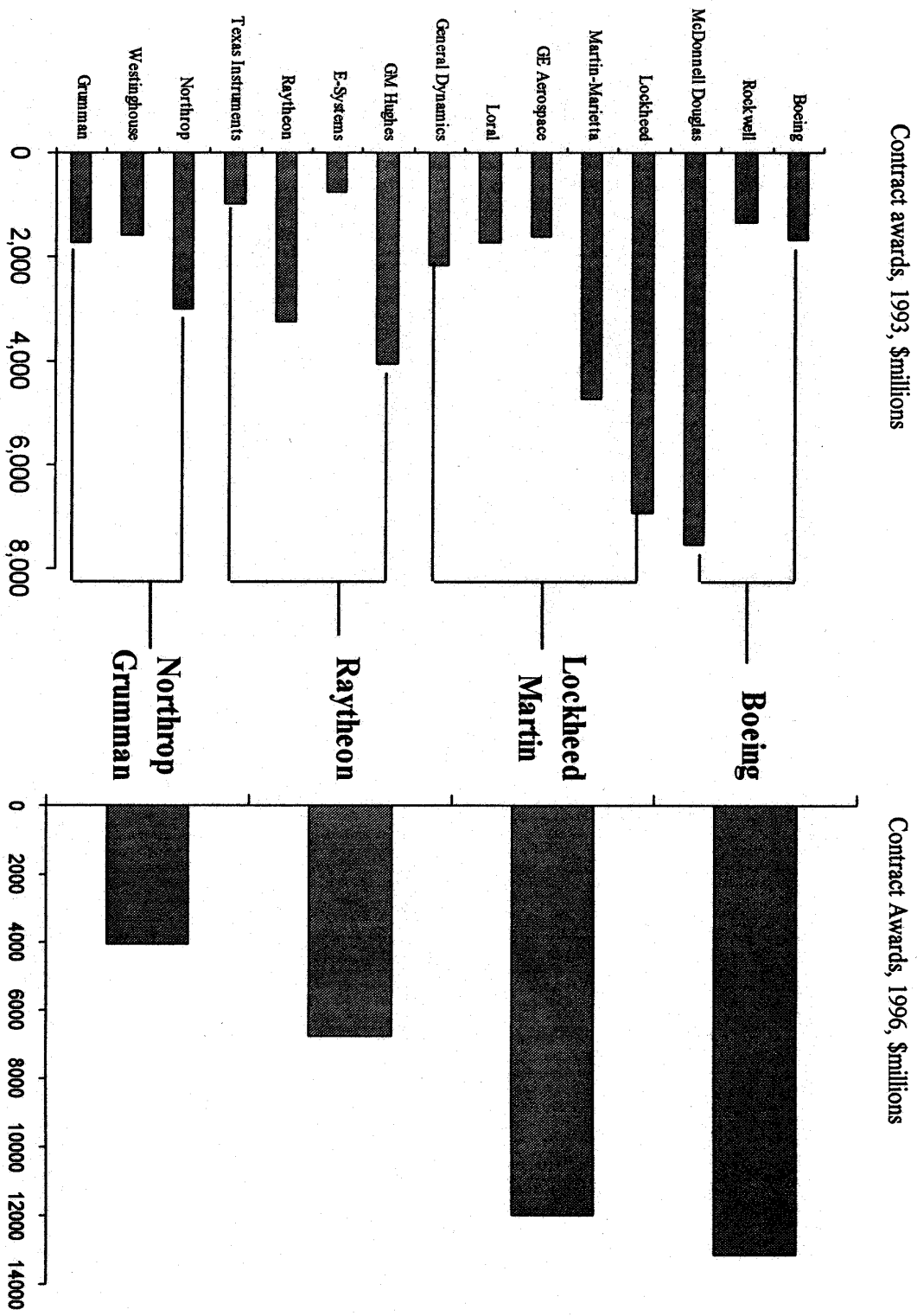
But a more satisfying answer is that the Pentagon simply does not have adequate analytical capacity to project what different configurations of the industry might mean for weapons innovation, costs and prices, an argument pressed by Kenneth Flamm (1999). Secretary of Defense Les Aspin set up an Office of Economic Security (OES) early in the Clinton years to conduct this type of analysis and answer questions such as the following: What precisely are the economies of scale in various weapons systems? How many competitors in each line could the Pentagon be capable of supporting over the coming decades? If the numbers were to shrink to two or less, how could the Pentagon guard against excess profit-taking, shoddy product, and below-par new designs? These are not new issues, but their salience has grown with the industry's shrinkage. Aspin's OES never really had time to do much more than preliminary work before its status was downgraded under Secretary Perry.

Few experts outside the Pentagon have the access and know-how to conduct such analyses. The arguments for mergers rest on assumed economies of scale and increasing returns. But legal protections of corporate proprietary information make it difficult to know just what the cost functions really look like. Furthermore, economists find it difficult to prescribe optimal solutions when there are small numbers of players. Nevertheless, William Kovacic and Dennis Smallwood (1994) advised the Pentagon in 1994 that certain mergers would be more appropriate than others. They argued, for instance, that mergers between Lockheed and Northrop, Northrop and Grumman, or Boeing and McDonnell-Douglas would destroy significant rivalries, while other configurations, even if only two firms survived, would preserve them. Their advice was ignored.

Liberalized Arms Exports

In this drama of choice between a more heavily populated industry consisting of relatively diversified firms and a more thinly populated one of defense-specialized firms, arms export policy

Figure 1.
U.S. Defense Merger in the 1990s



Source: All data are from the Department of Defense publication (P01), 100 Companies Receiving the Largest Dollar Volume of Prime Contract Awards from the Fiscal Year of 1993 and 1996.

played a supporting role. Early in the decade, the industry leaders argued they needed to export more units of existing weapons systems to compensate for shrinking domestic orders. International sales would help lower the cost of each fighter craft, communications satellite, or missile to the American military, saving taxpayers money and/or releasing funds for military modernization. They would also keep production lines “hot” in lieu of domestic orders. The industry pressed for an arms export policy which would explicitly take defense industrial base issues into account.

The Clinton administration was sympathetic. Election year competition between Bush and Clinton had already scotched promising conventional arms export control talks. Bush, under pressure from Clinton, overruled the State Department and approved the sale of F-16s to Taiwan, a move that angered the Chinese. Arms control advocates began to hear from State Department officials that although certain sales might be problematic on other grounds, economic factors justified them. Early in 1995 the White House issued two policy briefs stating that industrial base concerns would henceforth be weighed in the permit process for arms exports (1995a, 1995b). Liberalized exports to countries like Indonesia and more recently, Latin America, are credited to this policy shift. President Clinton appointed an Arms Export Task Force chaired by Brookings’ Janne Nolan, but ignored its emphatic conclusion that economic concerns should not govern export policy. An all-out competition among allies to serve remaining growth markets—chiefly the Middle East and East Asia—ensued.

The Clinton administration backed its new mercantilist arms export policy with hefty financial commitments, as did its major competitors—Russia, France, the UK, and Germany. It redoubled its efforts to market American weapons through its trade attachés and armed forces participation in military air shows around the world. In a move that undercut the cost savings rationale, it eliminated fees on arms sales that had previously recouped the development costs footed by the American taxpayer. The World Policy Institute’s William Hartung (1996) estimates that annual American arms export subsidies reached into the billions. United Nation’s economist David Gold (1999) concludes that on economic grounds alone the gains from arms sales do not appear to justify the public costs of promoting them. The enthusiasm for arms exports as an industrial base policy is perplexing, especially when the Pentagon’s own study (U.S. Department of Defense 1994) showed that arms were unlikely to make much of a dent in American excess capacity. Indeed, U.S. arms exports fell by 10 percent in real terms between 1989 and 1996 even though U.S. contractors’ world market share rose by nearly 50 percent (Table 2).

Table 2
Arms Exports: Britain, France, U.S.
 millions of 1990\$, 1989-1996

Nation	Arms Exports			Share of World Market			Exports/Procurement		
	1989	1996	% Change	1989	1996	% Change	1989	1996	% Change
Britain	2541	1733	-30.2	6.8	7.7	14.2	28.32	25.49	-10.0
France	2788	2101	-24.6	7.4	9.1	23.4	15.26	15.8	3.5
United States	11366	10228	-10.0	30.2	44.5	47.3	14.02	17.44	24.4

Sources:

SIPRI Yearbook. 1997. *Armaments, Disarmament and International Security*. Stockholm: SIPRI
 SIPRI Yearbook. 1994. *Armaments, Disarmament and International Security*. Stockholm: SIPRI.
 1996 Arms Exports and World Share from 1997 Yearbook, Table 9.1, p. 268.
 1989 & 1996 Exports/Procurements from 1997 Yearbook, Table 13.8, p. 484.
 1989 & 1996 Exports/Procurements from 1997 Yearbook, Table 9.1, p. 268; and Table 6A.1 & Table 6A.2,
 p. 186-88.

The American liberalized arms export policy is costly and contradictory. On the one hand, it does not seem to have produced the economic results promised. It has kept production lines open, as in the F-16, but the United States is not going to be ordering any more anyway. It has produced and retained few jobs, since to sell overseas, defense contractors must agree to offsets sometimes as high as 100 to 150 percent. These offsets take the form of either final assembly or component production in the buyer country, or they displace American workers in other sectors. Wisconsin Senator Russell Feingold was outraged to find that to meet its offset commitments McDonnell Douglas was marketing European paper at a discount, forcing a Wisconsin firm into bankruptcy. The export policy enabled defense contractors to make higher profits in the 1990s, unprecedented in a period of deep military spending cuts (Trevino and Higgs 1992; Pint and Schmidt 1994; Oden 1999).

On the other hand, liberalized exports have undoubtedly decreased national security. Sophisticated weapons are now in the hands of some regimes that may prove to be unstable in the longer run—Saudi Arabia, Egypt, Indonesia among others, as well as those to whom the French, Russians, and Chinese have sold under the worldwide free-for-all. And they have created pressures for costly new weapons innovation. The Federation of American Scientists' Lora Lumpe (1999) has shown how Lockheed-Martin used the possession of F-16s by potentially unstable regimes as a rationale

in lobbying for the F-22. American arms export policy, in other words, has set off a parody of the Cold War arms race in which the nation is engaged in an arms race with itself.

The Transnational Impulse

This recounting of post-Cold War defense industrial policy suggests that American leaders are not particularly well-prepared for incipient, transnational developments. Frustrated by the evaporation of opportunities in the domestic market—the Pentagon has made it clear that it will scrutinize carefully any further mergers—the industry is now exploring formal and informal global partnerships (Muradian 1997; U.S. Department of Defense 1997). Lockheed-Martin is actively seeking European partners, and transatlantic buyouts of smaller firms have already taken place. Former Defense Secretary William Perry and CIA Director John Deutch recently formed a firm to advise investment bankers on global deals.

Why the transnational thrust? For the four largest American contractors, the calculus is clear. Since markets aren't growing, the target is market share. American firms make most of the best weapons in the world, thanks to decades of public R&D investment. Other countries have confirmed the superiority of American weapons, preferring them even over those from their own domestic defense complexes. There are pervasive increasing returns to scale, but the Pentagon is discouraging further large marriages. Domestic market growth is constrained, and the pressures on other governments to "buy domestic" are still fierce. Access to foreign markets will be considerably easier if contractors can couple up with counterparts operating in buyer and competitor nations.

In Europe, the calculus is considerably more complex. Although EU partners are committed to creating a common security strategy under the guise of the Western European Union, they have not yet succeeded in doing so, leaving NATO as the chief transnational security arrangement (Brzoska, Wilke, and Wulf 1999; Lovering 1999). Progress towards an integrated European arms industry has been glacial—there is ongoing talk of a joint procurement agency, but to date national arms industries remain exempt from the EU free trade regime. No joint rationalization program of the sort that worked remarkably well in iron and steel has emerged. Concern over loss of high-tech capacity and fear of political backlash from firms and workers has kept governments invested in their domestic industries and in arms export promotion, even on joint projects. Despite enormous excess capacity in fighter jet production, for instance, British Labour's Tony Blair and German

Christian Democrat Helmut Kohl recommitted in 1998 to joint development of the pricey Eurofighter, an aircraft analysts believe will be inferior to American offerings.

Yet European firms have no viable choice but to team up with someone. European nations cut procurement spending abruptly and deeply in the 1990s. With budgets already much smaller than that of the U.S.—Britain, France and Germany spend 6 percent, 12 percent and 23 percent respectively of the American level—the Europeans know they must abandon their autarkic defense industries. Many already buy equipment from the United States and from each other. Europeans viewed the American mergers, which exacerbated the trans-Atlantic scale gap considerably (Table 3), with alarm and in 1998 redoubled their efforts to create a pan-European industry.

Table 3.
Major Defense Contractors by Nation, Sales 1995

Company	Country	Defense revenues \$bn
Lockheed Martin	United States	19.39
Boeing/McDonnell Douglas	United States	17.90
Raytheon/Hughes/Texas Instruments	United States	11.67
British Aerospace	Britain	6.47
Northrop Grumman	United States	5.70
Thomson	France	4.68
Aerospatiale/Dassault	France	4.15
GEC	Britain	4.12
United Technologies	United States	3.65
Lagardere Groupe	France	3.29
Daimler-Benz Aerospace	Germany	3.25
Direction des Constructions Navales	France	3.07
General Dynamics	United States	2.90
Finmeccanica	Italy	2.59
Litton Industries	United States	2.40
Mitsubishi Heavy Industries	Japan	2.22
General Electric	United States	2.15
Tenneco	United States	1.80
TRW	United States	1.71
ITT Industries	United States	1.56

Source: "A Survey of the Global Defense Industry" *Economist* June 14, 1997.

But intra-European partnerships have proved difficult. The French, with more of their science and engineering workforce tied up in defense sectors than any other country, are reluctant, despite palpable failure, to give up a decades-long industrial policy grounded on defense innovation.

Tiring of waiting for the French, British firms began to partner with Americans; British Aerospace, for instance, has paired up with Lockheed-Martin on the Joint Strike Fighter. The disarray in the European military industrial complex beckons to American firms, and some European officials believe this may be the only way to overhaul a poorly configured and highly inefficient defense industrial base.

The impulse towards a transnational industry is unlikely to wane, and it will reach beyond the United States and Europe. American firms already help the Taiwanese, Koreans, and Turks assemble fighter jets, and they partner with Japanese firms on important high-tech components. Lockheed Martin has bought up the remains of the Argentinean aircraft industry, transforming it into maintenance facilities for a military fleet comprised of American craft, and Russian capacity is being selectively bought out by U.S., European, and Japanese firms for commercial as well as military purposes. Although design and innovation will remain the province of the rich countries able to pay for it—principally the United States and Europe—military production will increasingly replicate the international division of labor of commercial sectors.

A New International Arms Division of Labor?

Transnational consolidation could facilitate the retirement of considerable excess capacity, especially in Europe, Russia, and some developing countries. It might alleviate pressures to export weapons at bargain basement prices, although private sector contractors will rationally seek to export as long as increasing returns to scale hold sway. Linked to privatization in many countries' industries, it could produce greater transparency in procurement policy and contracting, though that requires good state sector management. Anyone who has tried to discern the decisionmaking calculus inside the French military industrial complex, where the DGA (the procurement agency) is more or less fused with large portions of the publicly-owned industry, understands how utterly frustrating this can be (Markusen and Serfati 2000).

A transnational industry will not, however, guarantee military industrial jobs and incomes. Even if populated by smaller numbers of transnational firms, this sector will remain a buyers' market far into the future, simply because of excess capacity. American weapons may dominate and American firms may secure the lion's share of the contracts, but the associated economic activity will not necessarily take place within American borders. Buyers, even with few choices, will be able to bargain with contractors for production and jobs concomitant with the size of their purchases. In fact,

weapons procurement may serve as a convenient means for some buying regimes to command and control a hefty increment of jobs within their own economies, used to political advantage. (When asked recently why Chile, friendly to its neighbors, would want to buy expensive new fighter aircraft, the Chilean Finance Minister is reputed to have exclaimed, “because we have the money!”)

The result will be a patchwork of specialization spread across the globe. A future generation fighter, for instance, might be designed in the United States, its prototype built in Britain or Italy, and the first units tested in France. Once in production, it might be assembled in the United States, Turkey, Korea, and Taiwan, as the F-16 now is, with unique high-tech componentry from Japan, Germany, Russia, and Israel and more cost-sensitive and commercially available components from Spain, Poland, Brazil, and South Africa. A world weapon could look a lot like a world car on a wall map, but its implications are far, far different.

A Lopsided Market?

Despite the fact that buying nations will be able to extract jobs and chunks of weapons-producing capacity with every weapons purchase, the implosion in the number of major weapons makers and their increasingly international orientation constitutes a shift in the balance of power in the arms market, away from governments and toward contractors. Less than a decade ago, the U.S. Pentagon, for instance, could count on three or more firms to compete in most weapons lines. Today, only two domestic competitors survive in most large weapons lines, and in some, only one. Economic theory predicts that heightened oligopolistic power on the supply side will curtail innovation and raise prices above actual costs, concerns that induced Secretary William Cohen and his acquisitions chief Jacques Gansler to hold firm on their opposition to the Lockheed/Martin Northrop/Grumman merger. One solution would be to buy from the Europeans, an option that Gansler cautiously favored in his book, *Defense Conversion* (1995). Buying foreign would reverse decades of “buy America” habits and would undoubtedly attract strong Congressional opposition. Furthermore, transnational mergers and partnerships would whittle down this option.

For sellers in the arms market, meanwhile, things are improving structurally—there are now more buyers, and any one country, the United States included, accounts for a smaller portion of the big contractors’ sales. To be sure, the Pentagon is still by far the single largest customer for American contractors, as their own governments are for European firms. The share of exports in American firms’ output rose only modestly in the past decade, from 14 percent in 1989 to 18 percent in 1997

(Table 2). But if transatlantic mergers occur on anything like the scale of domestic mergers in the 1990s, we could witness an altered market in which a relatively few international firms sell to dozens of major buying nations.

Under these circumstances, the ability of any one government, even the United States, to develop weapons appropriate to its security needs, enjoy technological superiority, or limit the diffusion of technology would be greatly curtailed. Other nations have suffered under these circumstances for some time. The French Air Force, for instance, was impelled to compromise on its fighter jet designs to satisfy Middle Eastern customers, whose purchases were needed to cover development costs (Kolodziej 1987). The U.S. Air Force is now facing the same prospect. For its next-generation fighters, it has been asked to specify which other countries might be expected to buy the craft and whether those countries' defense needs might require alterations in the design.

Private Arsenals?

The trend toward private sector provisioning of arms poses new problems that impinge on national security and require creative solutions, especially as the defense industry goes global. Outsourcing has made slow but steady inroads on public arsenals, from the rise of the private naval shipbuilder Vickers in the 1880s, described in Mary Kaldor's *The Baroque Arsenal* (1981), to the momentous decision of the incipient American Air Force to rely on private aircraft companies rather than government facilities for the fighters, bombers, transports, and ballistic missiles that transformed twentieth century warfare. A larger share of the military dollar now goes for procurement from private sector firms (and less for military manpower, bases, and DOD civilian employees) than the Cold War average (Figure 2). This shift reflects the rising significance of remotely-delivered destructive power, reliant on aircraft carriers, fighters, bombers, missiles, precision-guided munitions, and the paraphernalia required to gather intelligence, communicate it, coordinate decisionmaking, and provide for battlefield management from afar (Markusen and Yudken 1992, ch. 2).

There were good reasons for going this route in the past. The competition among youthful aircraft companies served the Army Air Corps and subsequent Air Force well, as they churned out a wide array of designs that either stood or failed the market test. The relative superiority of the Air Force ballistic missile program in the 1950s, spread among competing firms, over the Army's in-house effort at Redstone Arsenal confirmed the advantages of competition and an arms-length relationship between a public sector buyer and private sector suppliers (Markusen, Hall et al. 1991).

But as the number of suppliers shrinks, the Pentagon and its European counterparts may be confronting what Sapolsky and Gholz (1999) call “private arsenals”—huge firms with more or less monopoly positions in various weapons lines. As limited liability corporations, these organizations operate with entirely different motivations than do the armed forces, the Pentagon, or public sector agencies in general. Their loyalties are first and foremost to shareholders, whose priorities increasingly stress short-term returns (Weber 1998).

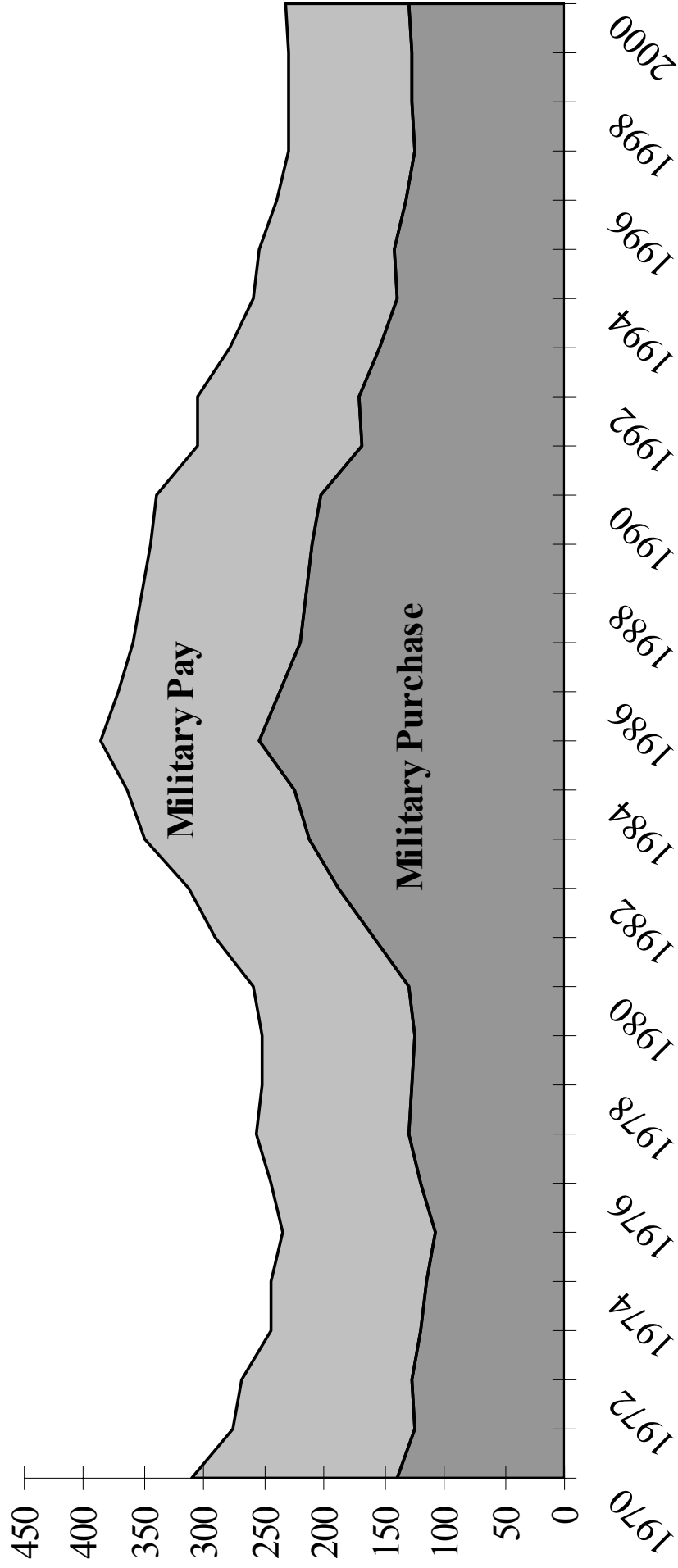
Governments have always relied on two features to keep private sector contractors in line: competition among firms, and regulation to curb potential and punish actual abuses (McNaugher 1989). But today domestic competition is considerably diminished, and regulation is under attack, as budget-conscious legislators and privatization advocates favor a smaller, more business-friendly Pentagon. As contractors become transnational and form international oligopolies, the oversight challenge will become considerably more difficult. There is no substitute for well-informed, vigilant government oversight of the private sector defense industry and for a coordinated policy that anticipates and shapes international restructuring of firms.

A Transnational Defense Industrial Base Strategy

It may seem Pollyannish to call for an internationally coordinated military industrial base strategy among allies when individual nations have not been able to chart a wholly effective course on their own. But the changes about to take place in the industry, driven by market forces, will not wait for governments to get their act together. If the major weapons-producing allies do not act to optimally restructure the industry, private sector firms will do it on their own. Contractors’ obligations to their shareholders are unambiguous, and partnering is the right thing for them to do for market access, market dominance, and scale economy reasons. But there is no reason to believe that what serves short term stockholder interests well is congruent with ensuring efficient defense outfitting or national security in the 21st century.

Oft-cited security problems—compromise on weapons design, supply disruption in times of crisis, accelerated proliferation of sophisticated weapons, and loss of national technological leadership—would seem to argue for a continuation of an autarkic policy (Moran 1993; Pages 1996). Some envision a Fortress America facing a competitive Fortress Europe, each supporting a complete line of domestic defense industrial capabilities, ensuring that its national champions stay in business, and competing to supply the rest of the world (Coffman 1998). But such a standoff is unlikely to

Figure 2. Military Procurement, Pay, 1970-2000 (Billions 95\$)



Source: DoD data

hold in the longer run. Dual-use technological applications have already made national borders quite permeable, and a number of important partnerships and acquisitions have already taken place. Furthermore, fiscal pressures clash with the extravagant cost of the Two Fortress outcome. Restive under the budget knife, procurement chiefs in many countries have strong incentives to buy, from whomever, the best weapon at the most affordable price. The British under Margaret Thatcher did just this in the 1980s, cutting military spending faster, with less debilitating effects on readiness, than other Cold War protagonists.

We are apt to see a transnational industry develop regardless of government reticence. Of the security issues posed, the third—proliferation of conventional weapons—is by far the most worrisome to the world community, and the fourth—loss of technological leadership—serious enough to induce countries to rethink their security strategies. To date, defense contractors principally design and make weapons within their home countries' borders and sell some portion of them abroad, affording their respective ministries of State and Defense ample opportunity to monitor the appropriateness of foreign sales. But as transnational or allied firms, they will increasingly allocate their design, development, and production activities among nations in response to buyers' demands for offsets. Personnel, ideas, and technologies will move more freely from one corporate unit to another heedless of national borders. Under these circumstances, governments will have a more difficult time monitoring cost, pricing, and proliferation. But their role as overseers will be more important than ever.

Such fluidity would also undermine security policies rooted in the possession of a clear technological lead in weapons and delivery systems. For purely technical reasons, maintaining technological superiority is increasingly difficult, because the edge is shifting away from platforms per se towards sophisticated electronics, communications, and guidance capabilities, heavily rooted in "dual-use" sectors of the economy. While arms control advocates contend that it is still possible to slow the spread of these technologies, economists increasingly argue that it is impossible to do so and oppose efforts to restrain dual-use exports. If transnational firms supplant domestic firms, it will be just that more difficult to ensure pre-eminence, even though certain governments—the United States, the Europeans—will remain the largest investors in military R&D.

How would a transatlantic defense industrial base strategy work? First, initiating nations—at a minimum the United States, Britain, France, and Germany—could agree to create a common data and knowledge base about their defense industries, firms, and production lines. This would include

analyses of existing and potential economies of scale, an evaluation of excess capacity, and profiles of the technical and business strengths and weaknesses of major contractors. This may sound “ho-hum,” but it is amazing how little is known about the shape of the defense industrial base, even in the most sophisticated and “open” nations (cf. Kudrle and Bobrow 1998).

Second, these nations along with other suppliers would jointly develop an industrial base strategy that would ensure sufficient competition to keep prices close to costs but ensure innovation where it is desirable. The strategy would distinguish between desirable and unacceptable transnational partnerships among firms, and it would target particular segments for closing. In implementing the latter, partner states would chip in to support worker adjustment programs and alternative economic development strategies for exiting sectors and regions, much the way the EU Konver program has done for European military base and shipyard closings.

Third, governments would engage in joint procurement programs where domestic and transnational firms are invited to compete and where R&D in particular is jointly agreed upon, with provisions for disseminating the results so that additional firms might compete for production contracts. When buying already developed systems, nations would be guaranteed a modicum of economic activity corresponding to their level of ongoing financial and military commitment, though this need not be in the defense industry. Governments, rather than firms, then, would negotiate offset policy.

Such a transnational industrial base strategy would work best if it were linked to a cooperative security policy along the lines suggested by Kaufman, Steinbruner, and Forsberg (Steinbruner 1994; Kaufman and Steinbruner 1991; Forsberg 1992). Indeed, the pursuit of unilateral military strategy and the ability to count on one’s own military superiority seem incompatible with an evolving transnational industry. A clear and shared vision of the nature of contemporary threats, appropriate military response, burden-sharing in readiness and war, stabilizing forms of deterrence in the conventional weapons sphere, effective arms export restraint, and “fair sharing” of the costs of military industrial downsizing would facilitate the fashioning of an affordable and efficient defense industrial base.

It would be foolish to underestimate the obstacles facing such a coordinated industrial base strategy: parochialism, legitimate fears of loss national sovereignty, unwillingness to countenance job loss, and high start-up costs, to name a few. But anything short of this will be suboptimal on both economic and security fronts. The United States could lead such an effort, as the world’s largest

weapons buyer and major exporter. America's lively history of relatively transparent, arms length relationships between contractors and the Pentagon is much admired in Europe. So is its historic commitment to competition among multiple suppliers for designing and producing weapons systems. And American data on defense contracts and arms exports are better than most. A relatively more peaceful albeit confusing security environment, fiscal austerity, and a troubled world economy should propel allies into partnering on military industrial base strategy. The payoff would be substantial.

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II. THE PLACE OF THE DEFENSE INDUSTRY IN ADVANCED INDUSTRIAL ECONOMIES

U.S. Defense Industry in the Post-Cold War: Economic Pressures and Security Dilemmas

Kenneth Flamm

During the last 50 years, the single largest category of discretionary spending for many Western governments was the national defense. That allocation came about in the course of the Cold War in a context in which rapid technical development and immediate preparedness were considered more important than economic efficiency. Redundant capabilities and inefficient practices were tolerated. The analysis of efficient defense production was not intensively pursued.

In the very different circumstances that now prevail, the industrial infrastructure (the “defense industrial base”) that currently builds the systems used by Western military establishments is in the midst of a painful transition. In the United States, deliveries of major defense systems are currently, in real terms, about sixty percent of the mid-1980s cold war peak.¹ A determined push to reform the acquisition process is slowly gaining momentum. If successful it will lower barriers that have sheltered those willing to invest in mastering the very arcane rules of the defense acquisition process. In technologies once driven by defense, commercial applications now lead the process of technical innovation. Recent American policy has been encouraging the use of commercial technologies and products in defense systems wherever possible. This initiative promises to erode the boundaries between defense and commercial production even more and to open an already shrinking market to a larger set of commercial competitors.

In this new environment, major investments in systems and technology may be developed and demonstrated in the form of prototypes. They will have to be produced and deployed on a lim-

¹ See Kenneth Flamm, “Defense Industry Consolidation in the 1990s,” in G. Susman and Sean O’Keefe, eds., *The Defense Industry in the Post-Cold War Era*, (New York: Pergamon, 1998) for a more thorough discussion of real spending levels. Unless otherwise noted, all statements made in this chapter are drawn from a research project that will be published by the Brookings Institution.

ited scale to work out operational issues. Even where it is clear that new large scale weapons platforms must be procured, the production and fielding of such systems may stretch out over years, even decades, into the future.

The U.S. defense industry has some formidable strengths as it faces these necessary adjustments. It is the premier global producer of a variety of defense systems, the clear world leader in key systems integration skills and specialized technologies. It accounts for roughly half of world exports of military equipment. Its domestic market is by far the largest in the world—more than triple that of Japan which has the second largest procurement budget among the Western allies. The United States' weapons procurement budget exceeds the combined total of all its European NATO allies. As a consequence, the formidable volume of U.S. military equipment exports amounts to only about 20 percent of procurement by the Department of Defense (DOD), and in few cases is the fundamental viability of a U.S. defense industry critically dependent on success in export markets. Furthermore, despite a continuing decline in military budgets around the globe, U.S. foreign defense sales have remained roughly constant, and U.S. export market share has therefore increased.

The same cannot be said for the U.S. allies' defense industries. Japanese companies are prohibited from exporting military equipment, and flat defense budgets—combined with uneconomic volumes and fantastically high costs—have thrust Japan's defense industry into a deepening crisis. In response, both Japan's industry and its promoters within the Ministry of International Trade and Industry (which controls defense procurement) have begun to publicly advocate a controversial legalization of military exports. European governments have long recognized the importance of exports to the survival of their defense industries: in France, for example, exports exceeded 40 percent of arms industry sales in the mid-1980s. Despite aggressive promotion efforts, European export sales dropped with the continued decline in global defense spending (in France, by the early 1990s, to 25 percent of a falling industry output), and European defense industries today are in a state of turmoil. Responses to these developments—initially championed by France, and supported strongly by Germany—have included the formation of a Western European Armaments Group under the political aegis of the Western European Union, the first embryonic steps toward a European defense procurement agency, proposals to restrict European defense procurement to European-only suppliers whenever possible, and a renewed emphasis on export promotion. But despite repeated public calls for consolidation of a fragmented European defense industry into a smaller number of producers

(responding to a major consolidation that has occurred with U.S. defense industry), until recently there had only been slight movement toward real industrial restructuring in Europe.²

For the United States, in contrast, the issue has not been industrial survival, but how and where to reduce the industrial capability primarily dedicated to defense to a level appropriate to a new, post-cold war force structure. Despite an ebbing wave of mergers and acquisitions in America's defense industries, existing capacity in the current defense industrial base may still exceed the investment requirements of tomorrow's military forces. What those investment requirements are, and what set of industrial capabilities are needed to meet them, is, unfortunately, a complex set of issues that so far has largely defied a crisp conceptualization or a clear answer.

With defense downsizing in full swing around the globe, every major producer of high-tech armaments other than the United States now faces a virtual economic crisis in its defense industries. The economics of defense production, this chapter will argue, are dominated by various flavors of economies of scale—in assembling and sustaining essential design capabilities, in systems R&D, in start-up costs, in lumpy production capacity, in learning curves. This means that unless they are willing to give up maintenance of a national capability to produce advanced military systems as a national security objective (exceedingly unlikely), America's allies will be pushed to (a) close off their national markets to foreign-built systems and (b) dramatically increase exports. Both developments would raise significant problems within the coalition of allies built during the Cold War.

Thus economic pressures seem destined to push the defense industry against restraints on the proliferation of advanced conventional military capabilities. In many cases, the best customers for sophisticated capabilities will be in precisely those regions where sales are likely to feed existing tensions, where old disputes may blossom into new wars. In other cases, now dormant rivalries could be exacerbated by the aggressive salesmanship of strapped companies fighting to stay competitive.

If higher walls around national defense markets are a component of the response to these economic pressures, a different but equally painful source of divisions within the alliance will emerge. The allies are still highly dependent on the liberal transfer of American defense technology

² The 1999 merger of British Aerospace and Marconi Electronic Systems into BAE Systems and the projected establishment of the European Aeronautic, Defense and Space Co.(EADS) in June 2000 from Aerospatiale Matra, DASA and CASA have changed the European picture dramatically. These two large firms will rank among the five largest defense firms in the world.

to their defense industries. Barred from access to foreign markets, the American taxpayer—who ultimately foots the bill for these technology investments—is likely to ask why a policy of easy technology transfer is being continued, and express those doubts through the U.S. political system.

Finally, if economic pressures spawn easy access to advanced military capabilities by marginal customers, the United States is certain to press even harder to accelerate its “Revolution in Military Affairs” (RMA) to maintain its current technological advantage over potential adversaries. Large U.S. investments in new technology are already beginning to spur talk that a “technology gap” between the U.S. and its allies exists, and threatens the interoperability of American forces with those of its friends.³ The likely response is greater pressure on the allies to buy advanced information and sensor systems like those fielded by the Americans. Given the enormous costs of developing these systems, already tight European and Japanese defense budgets are unlikely to have room for either domestic production of compatible indigenous versions or purchase of American equipment.

The predictable outcome of these developments would seem to be rising dissent within the Alliance. While it might not be sufficient to rupture the fabric of our security ties, it will certainly stress them and leave us less prepared to deal swiftly and decisively with crises as they develop.

This chapter proposes to dissect these economic forces in some detail, discuss their implications for Alliance security, and examine some possible responses. We first look at the dynamics of changes in defense procurement budget. We then define the concept of a “defense industry,” and examine the contours of defense industry in the United States. Looking at the economics of designing and building an advanced fighter aircraft illuminates the economic pressures driving consolidation within the defense industry. A final section of the chapter analyzes likely outcomes and possible solutions.

Declining Budgets and Industry Consolidation: The American Example

In recent years, discussions of downsizing and consolidation within the U.S. defense industry have typically begun by observing that in real terms, American military procurement is down by almost 70 percent from its Cold War peak in the 1980s. It is therefore self-evident, continues the logic,

³ See Bryan Bender, “U.S. Worried by Coalition ‘Technology Gap’,” *Jane’s Defence Weekly* (29 July 1998). The problems NATO faced in Kosovo have increased these worries. See John D. Morrocco, “Transatlantic Links a Crucial but Elusive Goal,” *Aviation Week & Space Technology* 150 (24 May 1999): 28-29.

that there is excess capacity in the industry, and that—given pervasive scale economies—this excess capacity is manifested in too many firms competing for too few defense dollars. Therefore, recent consolidation within the U.S. defense industry has been a much-needed step toward rationalization.

At first glance this is a plausible chain of logic. But when scrutinized more closely, there are a number of points where the assertion is misleading, if not incorrect. To begin, while procurement appropriations may indeed have declined by close to 70 percent from a Cold War peak, procurement outlays—disbursements of those funds to industry, which may take a decade or more, smoothing out budget peaks and valleys—has declined somewhat under 60 percent. Even this may be a misleading figure. The Defense Department procures all sorts of goods and services, from paper clips and toilet seats to fighter jets and tanks. Arguably, when discussing the condition of the defense industrial base, we are less concerned about the paper clips and more concerned with the fighter jets—and other specialized, defense-unique products and systems that cannot be quickly and easily procured from commercial suppliers. DOD investment in military equipment—aircraft, ships, vehicles, missiles, electronics, and other defense equipment—might be considered a better measure of trends in government purchases from the industries that we tend to think of as making up the “defense industrial base.”

The national income accountants at the U.S. Bureau of Economic Analysis have constructed an index of real spending on defense equipment investment measured in 1992 dollars. This index shows a substantial drop from a calendar year 1987 peak—about a 40 percent decline. But this is considerably reduced from the 70 percent drop in procurement budgets with which we started. And while total procurement outlays sank well below a previous 1976 low before stabilizing around 1995, real equipment spending in 1995 remained at a much higher level—above 1982 levels.

The considerably less steep decline in equipment investment may in part reflect the fact that sophisticated defense systems take much longer to produce and deliver than the more ordinary goods and services that DOD also procures. Cutbacks would therefore be stretched out in outlays over a longer time period, and the industrial impacts felt in a more gradual fashion. But it is also true that in relative terms, the U.S. military has spared the specialized systems and capabilities it is most concerned about protecting and maintaining—sophisticated, high-tech equipment—from the sharpest relative cuts in the procurement budget. There was considerable unevenness in the way this overall 40 percent decline was distributed. Some sectors faced large cutbacks, others small adjustments, so the impact on industry may have been enormous, economically, in some cases. Nonetheless, on aver-

age, defense equipment spending in real terms was about where it was in 1982. How does this relate to the argument for consolidation?

Pressures to consolidate in the U.S. defense industry can be viewed through two alternative lenses. First, one could think of defense as a business like any other, and argue that competitive pressures force change. Given significant economies of scale in defense systems (based on the economics of fixed investments in R&D and plant, as well as learning economies), fewer competitors will be able to “fit” into a smaller market in the long-run and maintain a market rate of return on their capital investments, as they compete with one another. The “natural” pressures of competition as the market shrinks will therefore force some out.

The alternative view is that the usual story about competitive markets does not fit defense well. In the real, cost-plus world of administered pricing of defense contracts by a single large customer bearing the risk of designing and building products to meet its unique needs, the defense department will simply pay whatever overhead costs exist within those defense-oriented firms it chooses to maintain through the awarding of contracts. Therefore, it is the defense department itself, in its quest to achieve greater bang per buck of procurement spending, that must create pressure on its contractor base to reconfigure to reduce overhead. The pressure can be in the form of positive carrots—like agreements to share overhead savings with contractors when they take steps to reduce costs through mergers and acquisition—or negative sticks—like letting companies go bankrupt when they don’t receive sufficient contract awards to keep themselves profitable. In both views of the world, government will play a key role in determining the defense industry configuration, through both its policies toward mergers and acquisitions and its contracting practices.

There is little doubt that there was major shift in American policy toward defense industry mergers when a new crop of top officials entered the Pentagon in 1993. The Bush Administration had effectively signaled its willingness to block major defense mergers when it torpedoed a big consolidation deal in the ammunition and ordnance industry in the early 1990s. Under Defense Secretary William Perry’s leadership in 1993, this course was unequivocally reversed.

But did shrinking budgets really made a new policy toward the defense industry inevitable in 1992? The data suggest that in 1992 we were at about the same level of real defense output as in

the early 1980s. Contrary to what an economist might presume,⁴ the evidence suggests there was effectively no increase in the numbers of competing defense producers during the massive Reagan defense buildup of the 1980s, and even an increase in concentration in a small number of defense sectors (like aircraft). This raises an important question. If the amount of output and the number of producers involved in manufacturing it were about the same in 1992 as in 1982, why was a reduction in the number of companies producing this output newly desirable? Or to put it another way, if the problem was so apparent in 1992, why was there no pressure to undertake (or at least discuss) consolidation and restructuring of the defense industry back in 1982? One logically consistent answer would be to argue that the industry was facing an imminent crisis back in 1982.⁵ Only the knowledge that an incoming Reagan administration was likely to vastly increase defense procurement, it might be argued, kept restructuring of the defense industry off the policy agenda. The problem with this argument is that it flies in the face of the facts of profitability in the defense industry. Simple calculations of returns on equity or investment for aerospace firms⁶ or more complex methodologies designed to estimate economic profits in defense firms⁷ show that the early 1980s were a period of high levels of profitability for defense companies. Paradoxically, defense contractors' rates of return and profitability fell steadily after 1983 through the remainder of the decade, even as defense procurement soared.

A more compelling argument hinges on an increase in the soaring costs of R&D for new, higher-tech military platforms. A typical fighter aircraft R&D program, for example, ran about \$6

⁴ Based on the notion that, all else being equal, with some fixed entry costs even imperfect competition will generate larger equilibrium numbers of firms in an industry in response to an increase in demand.

⁵ In fact, this was precisely the answer that Bernard Schwartz, former CEO of defense giant Loral (now for the most part absorbed into Lockheed-Martin) gave when asked this question in October 1997, at a presentation at the Johns Hopkins University's School of Advanced International Studies. Schwartz's prepared remarks, calling for prophylactic policies to discourage further vertical integration within the defense industry, have been published as "Defense Industry Consolidation: Where Do We Go From Here?" (brochure, ca. 1998).

⁶ For example, using data from the Census Bureau's Quarterly Financial Survey of Manufacturing.

⁷ See James Lewis Field, "Economic Profit in United States Government Defense Contracting: Theory and Practice of a Fair and Reasonable Return." Ph.D. diss., Graduate School of Business Administration, Harvard University, 1993, pp. 264-68.

to \$8 billion 1990s vintage dollars in the late 1970s and early 1980s.⁸ Today, the price tag on R&D for a new stealth fighter has roughly tripled, to \$20 billion or more (current estimates for the F-22 and Joint Strike Fighter, for example).⁹ This makes it much more expensive to have a large number of programs. With a decline in the number of new defense programs also comes a reduction in the number of producers that can be sustained on an ongoing basis. Exploding price tags for investments in new technology needed to develop advanced platforms—not a reduction in the overall size of the procurement pie, but an increase in the size of the minimum slice needed for a new system—seem a more persuasive argument for why 1992 was so different from 1982.

Note, incidentally, that this argument—which focuses on having too many firms shouldering the fixed costs required to maintain the capability to design and develop a new defense system—is a little different from what is normally meant, at least by some, when they refer to “excess capacity,” i.e., underutilized factories and equipment. Data from U.S. guided missile and space vehicle factories, for example, suggest that over a period in which there was little change in industrial concentration and output was dropping sharply, defense managers nonetheless removed excess capacity and sharply improved capacity utilization. Suggestions that no Cold War production lines have been closed down in the United States are not only wrong on the facts—they also err in implying that excess production capacity was the main problem for U.S. defense industry efficiency. From the perspective of the firm, the real “excess capacity” is the cost of maintaining and sustaining a minimum critical mass of skilled people with design skills and experience, not buildings and tools.¹⁰

Thus conventional wisdom most likely comes to the right conclusion, but for the wrong reasons. It is a massive increase in the R&D investments required to design leading edge military equip-

⁸ In the 1970s, R&D costs for 3 fighter jets with R&D started in that decade (in FY 91\$) were for the F-16 (\$3.3 billion), the F-15 (\$8.2 billion), and the F/A-18 (\$7.4 billion). See J.A. Drezner, G.K. Smith, L.E. Horgan, C. Rogers, and R. Schmidt, “Maintaining Future Military Aircraft Design Capability,” Rand Report R-4199-AF (Santa Monica: Rand, 1992), p. 24.

⁹ See Congressional Budget Office, *A Look At Tomorrow's Tactical Air Forces* (Washington, DC: Congressional Budget Office, 1997), pp. 83-87.

¹⁰ Indeed, much of the physical plant and tooling used in at least some U.S. defense production lines continues to be owned by the government, supplied to the contractor at little or no cost, and operated by the contractor. There would seem to be few incentives for a contractor not to use these “free goods,” even if the number of firms operating these plants were to be reduced.

ment (and possibly management overhead), not excess factory capacity, that leads one to focus on reducing the number of producers.

Whatever its rationale, it is certain that the process of consolidation unleashed in the United States in the early 1990s has had a profound impact on the contours of industry. Table 1 displays the reduction of the number of producers supplying selected types of weapons systems from 1990 to 1998. (The numbers in brackets show the number of producers that would have existed had the proposed Lockheed Martin-Northrop Grumman merger not been blocked.) The numbers are striking: in tactical missiles, from thirteen to four companies; in fixed wing aircraft, from eight to three firms. Space launch has gone from six to two, and satellites from eight to five. In tracked combat vehicles, strategic missiles, and torpedoes, three producers dropped to two. In helicopters, the military has gone from four to three suppliers, and in tactical wheeled vehicles, from six to four. In surface ships we now have five contractors, compared with eight in 1990.

Table 1
Prime Contractors in U.S. Defense Market Sectors

Sector	Number of Contractors	
	1990	1998
Tactical Missiles	13	4 [3]
Fixed-wing Aircraft	8	3 [2]
Expendable Launch Vehicles	6	2
Satellites	8	5
Surface Ships	8	5
Tactical Wheeled Vehicles	6	4
Tracked Combat Vehicles	3	2
Strategic Missiles	3	2
Torpedoes	3	2
Rotary Wing Aircraft	4	3

[with Lockheed Martin-Northrop Grumman merger]
Source: General Accounting Office

These counts of companies make it clear that, at least among prime contractors for major weapons platforms, the process of mergers and acquisitions within U.S. defense industries is nearing its logical end point. (One glaring exception is in surface ships, where pork barrel politics has forced the Navy to continue to support a number of shipyards that by all accounts is wildly mismatched to plans for future ship procurement.) For cost is not the only issue when the Defense Department

contemplates its industrial base. The number of producers available to bid on new procurement may have at least some competitive impact on the margins negotiated by contractors, and ultimately, the price actually paid by DOD. And competition is also presumed to have an impact in providing contractors with an incentive to innovate, to aggressively introduce new ideas and technology.

Magic Number Theory

One way to think about how slackened competitive pressures—the downside of cost cutting through consolidation—might come into play is to think about “magic numbers.” Two is clearly a very magic number: with fewer than two producers, no competition is possible by definition. This is not to say it is irrational to have fewer than two producers—the fixed cost of sustaining a second competitor might be so high that some regulatory or incentive-based contracting scheme might be a more attractive route to maintaining some discipline on costs and some pressure for innovation. But with an economic culture sold on the discipline of competition and a still (relatively) vast defense market, settling for fewer than two producers will clearly be an exceptional case in the United States.

Rand Corporation analysts, in briefings to the Department of Defense, have argued that in fact three is the magic number for the minimum number of producers that will maintain real competitive pressures. With only two producers, goes their argument, the incumbents know that they will not be permitted to go out of business, and the loser in a competition will always know that it will be given enough work to stay afloat. With three, on the other hand, there is a credible threat that someone might actually be permitted to go out of business and some degree of competition maintained.

This pragmatic argument for three can be challenged. If the threat to drop a contractor were actually carried out, there would then only be two. If that is known to be an undesirable outcome for DOD, it might be argued, firms would realize that a certain amount of slackness will be tolerated, and enough work dispensed to maintain what all know to be the magic number, three!¹¹

¹¹ For this and a variety of other reasons, there is little obvious basis in economic theory for choosing three as a magic number. The number may be greater than five: see Louis Philips, *Competition Policy: A Game-Theoretic Perspective* (New York: Cambridge University Press, 1995), ch. 2; Stephen Martin, *Advanced Industrial Economics* (Oxford: Basil Blackwell, 1993), ch. 5.

In any event, it is clear that the United States is in most sectors now approaching the minimum number of producers it can choose to sustain, yet still claim it is benefitting from competition in defense procurement. It is small wonder that the defense department opposed the merger of Lockheed Martin and Northrop Grumman, which would have dropped tactical aircraft producers to two, and missile makers to three. (Issues of concentration in electronic warfare gear and radar were also raised.) A theme we shall return to below is whether it is possible to introduce additional competition into defense procurement without supporting additional numbers of national producers, through international cooperation or the creation of “virtual” companies.

Some argue that even though the process of consolidation among prime contractors may be reaching its limits in the United States, an equally needed consolidation among subcontractors has yet to unfold, and is the logical next step in rationalization of the defense industrial base. While the enthusiasm of Wall Street dealmakers for this argument is understandable, its empirical underpinnings seem weak. At least one survey of subcontractors to U.S. defense primes found that for the vast bulk of these subcontractors, defense sales are only a relatively small part of their business.¹² These firms are mainly focused on commercial sales, with defense as a sideline, and any drive to consolidate in a quest for efficiencies should clearly be primarily driven by non-defense factors. To the extent that DOD worries about its subcontractors, it is a very small group of specialized producers of defense-unique items that are of concern.

One final point that emerges from Table 1 is the relatively large numbers of primes that continue to produce satellites (five) and wheeled vehicles (four). These sectors are not obviously benefitting from high levels of political interference. Because their products share much in common with commercial items, this raises the interesting question of whether these are now truly defense sectors, or instead commercial industries that happen to produce some particularly important, specialized products for defense applications. Put another way, are satellites really a defense industry today, and if not, where do they fit into our concerns about the defense industrial base?

¹² See Maryellen R. Kelly and Todd A. Watkins, “Are Defense and Non-Defense Manufacturing Industries Really All That Different?” in Susman and O’Keefe, eds., *The Defense Industry*. Fewer than one in five plants doing defense work in 1991 sold more than 50 percent of their output to DOD or primes. Interestingly, a 1994 LMI survey of small prime contractors to DOD found only 30 percent of these firms did more than half of their business with the defense department. D. Peterson, C. Webster, E. Gentsch, and M. Myers, “Capital Availability for Small Businesses with Dual-Use Applications,” Report EC404R1, Logistics Management Institute, 1994.

Dependency, the Defense Industrial Base, and Defense Industry: A Taxonomy

When analysts discuss the defense industrial base, they typically are concerned with policies that aim to promote the health or vitality of sectors that produce either essential inputs that go into armaments or the weapons systems themselves. Glancing at an input-output table—or just relying on common sense—suggests that just about every good produced in a modern industrial economy winds up in some form within defense systems. Thus, if “defense industry” is to be taken as a meaningful description of something narrower than the entire economy, there are two intuitively appealing ways to parse the term.

The first is to define defense industries as those industries that produce defense-unique products, items that have no commercial application. This is still overly broad, because an industry that is overwhelmingly oriented toward commercial markets may still produce a few specialized items for military use. In such cases, where defense-unique items are a specialized sideline for firms that mainly deal with commercial markets, the issue of maintaining access to the capability to produce these items is really no different from the issue of maintaining needed access to inputs that are general purpose, commercial products, and is, therefore, not defense-unique. There may be a problem worth worrying about, but it is really not a question of maintaining a specialized defense-oriented industrial capability. The problem of maintaining access to military-grade, high-strength steel for submarine hulls, for example, may really be the problem of maintaining access to a high-tech commercial steel industry with the capability to produce the most technically advanced products.

In today’s globalized economy, where commercial supply chains for all sorts of vital inputs are dispersed internationally, the decision to take some special action in this kind of situation probably ought to hinge on two questions. First, one might want to classify the input or component either as a “commodity” or as a “strategic differentiator.” A commodity might be defined as an input needed for use in military systems, but where the item need not be superior, or our access better, than that faced by potential adversaries in order to maintain a strategic military advantage. In this case, the only real potential problem is whether “dependency” on an unreliable supply chain is likely. If the item in question is of significant military importance, a policy maker might then wish to ask whether the geographic and industrial concentration of suppliers is sufficient—under some at least remotely likely threat scenario—to undermine some significant military capability in a time frame, and in a way, of major concern for national security. Given an affirmative answer to this second question,

a defense industrial policy in such circumstances might sensibly take action to ensure needed access to an industrial capability that was primarily commercial in nature.

Thus, if advanced steel available to our military need not be significantly better than that available to our rivals, the problem of access to advanced steel is really not qualitatively different than the problem of access to oil. Problems of access to capabilities and resources that are either commercial, or defense-unique but “commodities” (in the sense we have just defined) we shall define as a *dependency* or general industrial base issue, and distinguish it from a defense industrial base issue.

If on the other hand, the availability of special, advanced steel is critical to important performance advantages of U.S. submarines, it is what we are calling a strategic differentiator. Even if only a small part of a mainly commercial industry’s sales are involved, our taxonomy will label the item a *defense industrial base* issue. Heuristically, we make this distinction on the grounds that industry’s ability to supply this product makes a unique and important contribution to a military’s strategic or technological advantage against potential adversaries.

The second approach to defining a defense industry applies this label to sectors that sell (or historically have sold) a large share of their output to military users. This definition is also not entirely satisfactory as it stands, because some products that are arguably commodities—like uniforms, or anchor chain—may be given special protection by political authorities that effectively creates a domestic industry that can only compete and sell within a protected military market. In some countries, a state-owned enterprise may even exist for the sole purpose of producing a commodity for military use. Intuitively, we should not want to let pork barrel politics shape our analytical notion of a defense industry.

Therefore, we shall define a defense industry as an industry that sells a large share of its output to military users, and produces at least some products or services that are strategic differentiators. Thus, according to the taxonomy we have just created, problems in access to commodity products or services—whether commercial or defense-unique—may create a dependency issue, but will not be a defense industrial base issue. Problems in access to strategic differentiators, on the other hand, will be labeled a defense industrial base issue. That subset of the defense industrial base that largely or mainly sells to military customers is what we will call *the defense industry*.

A final definitional issue about which we will not worry much is at what level of statistical disaggregation we define an industry. Is aircraft a defense industry, or is a piece of that—military

aircraft—the defense industry? We propose to finesse this question by simply taking the lowest level observational units that are available—whether factories, divisions or groups, or enterprises—and applying the general concepts outlined above to the available data.

Defense Industry in the United States

A convenient way to examine what constitutes the defense industry—as defined above—is to look at what meets the criteria for defense industry in the United States. The lowest level at which a broad array of industrial data are available is the 4-digit level of the standard industrial classification (SIC) code. Table 2 presents total sales of industries that are commonly labeled as “defense-related” sectors by U.S. statistical agencies for 1982-1992. These sectors also conform fairly closely to the definition of defense industry developed above.

There are twelve 4-digit defense industrial sectors, which can be grouped into six broader sectors: aircraft and aeroengines, ordnance and ammunition, tanks and armored vehicles, shipbuilding and repair, space and guided missile systems, and defense electronics. Table 2 also provides an estimate of the share of each industry’s output that went into defense-unique products or to military customers.¹³ The largest single sector, by far, is defense electronics (search and navigation equipment), accounting for roughly \$30 billion in defense sales in 1992—more than fifty percent larger than military aircraft, the next largest sector. More detailed data (available at the 5-digit level) show that in 1992, 122,000 employees labored in U.S. military aircraft manufacturing plants, compared with 228,000 in search, detection, navigation, and guidance equipment establishments (with the great bulk of their sales going to defense). The preeminence of electronics in defense industry lends statistical weight to the observation that defense systems are evolving into platforms that carry payloads largely comprised of electronics and information technology.

Note that some growing high-tech sectors that originally might have qualified as defense industry in the 1950s and 1960s, “graduated” into the defense industrial base in the 1970s and 1980s, as technologies originally developed for military application spun off into widespread commercial use. For example, most of the American computers sold in the early 1950s went to military users,

¹³ We have estimated military output in search and navigation equipment by counting all defense-unique products (reconnaissance and surveillance electronics, IFF, proximity fuzes, sonar and ASW, electronic warfare equipment, and underwater navigational systems) plus radar, which is dual use, but where the military accounts for the bulk of sales.

Table 2
Military Output in U.S. Defense-Related Industries
selected years, 1982-1992

	Military Products, % of sales			Military Product, value \$x1000		
	1982	1987	1992	1987	1992	note
Heavy Ammo	100.0	100.0	100.0			1
Other Ordnance	100.0	100.0	100.0			1
Ship Building & Repair	62.1	83.7	84.0	6985	8732	2
Aircraft	57.9	61.5	38.3	22,138	21,969	3
Aircraft engines	NA	46.8	36.6	8812	7541	4
Aircraft parts	49.8	60.5	229.6	11,796	6552	5
Missiles and Space Vehicles	71.2	76.5	85.0	12,255	11,754	6
Space Propulsion	74.1	76.5	58.4	2652	3162	7
Space Vehicle Equipment	70.1	70.7	68.3	2372	3086	8
Tanks & Tank Components	100.0	100.0	100.0	3017	2503	1
Search & Nav Equipment	79.0	85.0	86.3	28,898	29,708	9
Optical Inst. & Lens	35.5	37.7	34.4	750	787	10

1. All products assumed military.

2. Self-propelled ship building and ship repair for military as share of total for all customers.

Share of covered products in total industry sales: 1982, 85.7 1987, 95.3 1992, 91.6

3. Aircraft sold to or designed for military customers, R&D for military customers or designs, conversion or overhaul of military aircraft, other services for military aircraft as share of totals for conversion or overhaul of military aircraft, other services for military aircraft as share of totals for both military and commercial.

Share of covered products in total industry sales: 1982, 99.9 1987, 98.9 1992, 96.6

4. Military engines (built for military aircraft or to military specs), R&D on military engines, other services for military engines.

Share of covered products in total industry sales: 1982, NA 1987, 97.0 1992, 91.7

5. Mechanical power transmission, hydraulic subassemblies, pneumatic subassemblies, landing gear, R&D on aircraft parts, other subassemblies for military aircraft as share of totals for military and commercial.

Share of covered products in total industry sales: 1982, 94.5 1987, 91.5 1992, 87.3

6. All guided missiles and services assumed military. Guided missiles plus space vehicles, R&D on space vehicles, other services for space vehicles for U.S. government military customers as share of totals for all customers. (1987 only: R&D on complete space vehicles allocated to U.S. military and all other customers on basis of 1982 ratios.)

Share of covered products in total industry sales: 1982, 100.0 1987, 99.8 1992, 89.9

7. Complete missile and space vehicle propulsion units, R&D on propulsion units, other services on propulsion and other propulsion unit parts for U.S. military customers as share of totals for all customers.

Share of covered products in total industry sales: 1982, 100.0 1987, 98.8 1992, 74.8

8. Airframe, space capsule and other space vehicle, and other parts and accessories, and R&D, for U.S. military customers as share of totals for all customers.

Share of covered products in total industry sales: 1982, 71.9 1987, 98.1 1992, 88.9

9. Search, detection, navigation, and guidance equipment (SIC 38122) share of all search, detection, navigation, and guidance equipment and aeronautical, nautical, and navigational instruments x share "military or mainly military" in 38122.

Share of separately classified products in total industry sales: 1982, NA 1987, 97.5 1992, 97.5

Share of "military and mainly military" in SIC 38122: 1982, 85.4 1987, 91.2 1992, 86.3

10. Sighting, tracking, and fire-control equipment share of all optical instruments and lenses.

Share of classified products in total industry sales: 1982, NA 1987, 95.3 1992, 96.4

and over half of computer R&D in that decade was paid for by the U.S. military. As late as the mid-1960s, over half of the integrated circuits sold went to American defense and space users.

Subsets of these same industries probably pose more of a dependency issue today than a defense industrial base problem. In general, microelectronics and computers—using the definitions developed above—probably belong in the defense industrial base, given the centrality of specialized systems based on customization of advanced information technology to the much-heralded RMA. But DRAM chips or Windows-based personal computer systems—if access issues were to develop—would probably qualify today only as dependency issues.¹⁴

Beyond the surprisingly large share of defense output accounted for by electronics, three other trends are worth noting. First, through the late 1980s, military sales accounted for over half of total sales of aircraft by U.S. producers. It wasn't until 1992 that the military accounted for less than half of sales, and the U.S. aircraft industry finally made the transition from a defense industry to a primarily commercial sector embedded within the defense industrial base. Second, the shipbuilding industry has suffered a continuing decline that, today, leaves it essentially a ward of the U.S. navy. Little commercial industry remains in the United States. Because it has strategic capabilities—stealth designs, nuclear-powered propulsion, submarines, etc.—as well as military customers, shipbuilding is clearly a defense industry in the United States. Finally, with the explosive growth in space-based commercial communications systems over the last decade, one might have expected space systems to be edging toward the same sort of commercial transition as in aircraft. Indeed, we see precisely that sort of trend in space propulsion, i.e., the launchers used to boost space-based payloads. Surprisingly, however, the military share of missiles and space vehicles has increased substantially in recent years. The most likely explanation for this contrarian trend is an increasing role for large, sophisticated, space-based sensors and communications systems in the U.S. force structure. To answer a question raised earlier, satellites remain primarily a defense industry.

¹⁴ In the mid-1980s, the Pentagon's Defense Science Board argued that memory chip dependency was a defense industrial base issue, mainly because of the key role of DRAMs in developing leading edge semiconductor production technology. Today, in the age of the mass-market microprocessor (logic) chip, it is clear that the most advanced chip manufacturing technology can now be sustained without having any presence at all in mass-market memory.

America and the Allies

In the aggregate, how do defense industries abroad compare with America's defense industrial capabilities? By any standard, and despite large cutbacks in U.S. military spending, one must conclude that the U.S. defense industry dominates the global market. American industrial hegemony in armaments is easily visible in 1997 defense sales data compiled for the 100 largest defense suppliers worldwide, shown in Figure 1. U.S. suppliers accounted for almost 60 percent of \$141 billion in global sales within this elite set of companies, compared to roughly one-third for European suppliers, 4.5 percent for Japanese companies, 2.0 percent for Israeli firms, and about 0.2 percent for Russia.¹⁵

The numbers tells a similar story on the demand side. U.S. spending in 1997 on R&D and procurement of weapons systems appears to have been roughly equal to that of Europe, Japan, Russia, China, Iraq, Iran, and North Korea combined.¹⁶ Similarly, data for 1994 show the American share was roughly half of total procurement spending by the United States, its NATO allies, Japan, and Australia taken together. By contrast, the U.S. share of alliance R&D was about 70 percent of the total. This raises an interesting question: why was it necessary for the U.S. to spend so much more, in relative terms, on R&D, than on procurement? Is the U.S. acquisition system that much more inefficient? Are the performance advantages of American systems that much more costly at the margin?

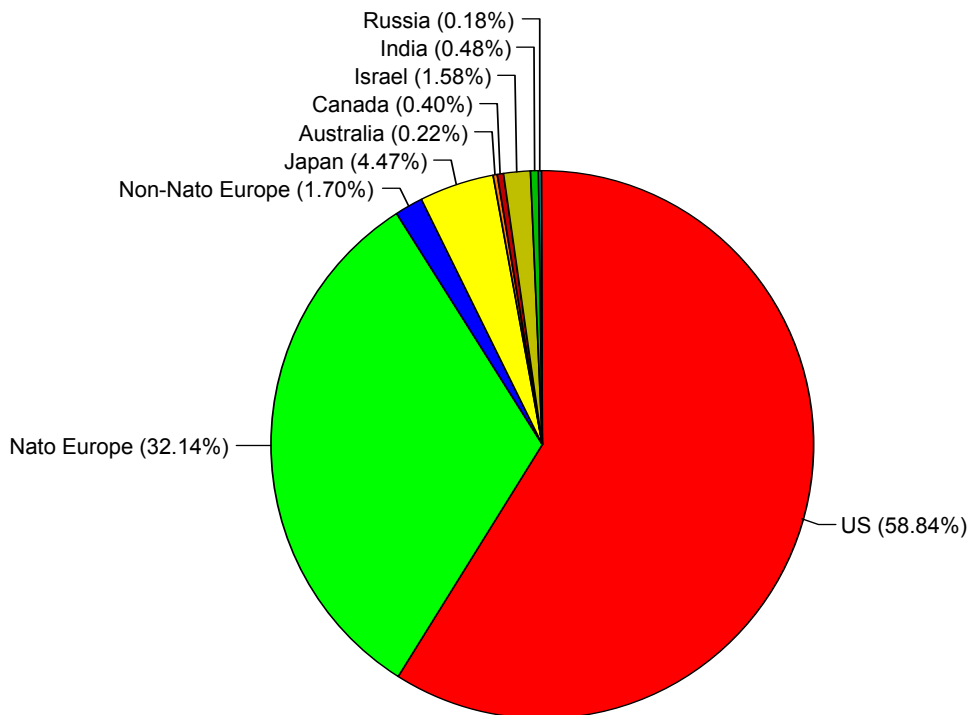
Casual observation suggests the United States is not grossly less efficient than its allies, and while squeezing out marginal performance advantages on the bleeding edge of the technological frontier may be disproportionately costly, this too seems unlikely to explain the bulk of this gap. Rather, the United States, through a variety of policy choices, has in effect subsidized the development of high-tech weapons systems by its closest allies. The mechanisms have included a deliberate policy of liberal transfer of technology, on the cheap, to allies through coproduction, licensed production, and codevelopment programs, and a variety of policies (like waiver of recoupment of R&D charges on export sales of components and systems, intellectual property policies, etc.) that

¹⁵ Because of a fragmented Russian industrial structure, these data certainly underestimate the Russian presence in global defense markets. The data include both goods and services.

¹⁶ Based on data in International Institute for Strategic Studies, *The Military Balance 1997/98* (Oxford: Oxford University Press, 1997).

make it possible for our allies' defense industries to acquire some of the key components of high-tech weapons systems at prices that may approach their marginal cost of production. In this sense the U.S. national system of innovation spills over to our allies as a matter of national policy.

Figure 1
Share of Defense Sales by Top 100 Defense Firms Worldwide
by National Origin of Company



Source: *Defense Week*

The Economics of Consolidation: The Case of Fighter Aircraft

The overwhelming role of scale economies, derived from the high development costs for weapons, in creating economic pressures for rationalization is well illustrated by a stylized model of the costs of developing and building a leading-edge fighter aircraft. I start by assuming the United States wishes to maintain a stock of 3000 fighter aircraft, with a new fighter aircraft introduced every 24 years. Both production of the current model and development of the next one are spread evenly over this 24 year cycle in the “steady-state” world I am imagining, so that in year 24 the very

last batch of 125 of the last vintage fighter are replaced with the last production lot of the current fighter, and R&D on the next generation aircraft is finally completed. In year 25, the first batch of the new fighter is delivered, replacing the oldest models of the fighter model closed out in year 24, R&D on a still newer fighter is begun, etc.

I assume that the cost structure for this archetypal fighter looks a lot like the numbers now being vetted for the Joint Strike Fighter (JSF): \$21.5 billion to develop, \$134.5 recurring production costs on a production run of 3300, \$11.2 billion in non-recurring costs.¹⁷ I also assume a 10 percent learning curve,¹⁸ and a simplified set of pricing rules that provide an approximation to how contractors' output is actually priced and paid for in the U.S. acquisition system. Absent from these calculations is the possible benefit from increased competition among additional producers.

How do unit production costs change when our total fighter requirement of 3000 is divided up among varying numbers of producers? With all production concentrated in a single producer, the recurring cost per fighter, averaged over the life of the program, is about \$45 million. Adding in non-recurring costs, the total "flyaway" cost is a little less than \$49 million. With 2 producers building 1500 aircraft, costs rise, but not dramatically: the recurring unit cost is \$46 million, total flyaway cost is \$54 million. Increasing the number of contractors to 6, with a production run of 500, however, is most definitely not cheap: recurring unit costs only inch up to \$49 million, but the total flyaway cost for the jet is now over \$71million! The non-recurring costs—the fixed costs of tooling up to produce any aircraft at all—simply kill the affordability of the aircraft, when spread over significantly fewer producers.

This last comparison is especially significant because 500 is close to the numbers that are being projected for total program size for European aircraft like Rafale and Eurofighter. If only 300 are produced, total flyaway cost in our hypothetical example jumps to a horrific \$88 million.

Another interesting calculation involves the total annual cost (including R&D) of maintaining the procurement program producing a steady-state force of 3000 fighters. The cost of a single contractor producing all these aircraft is about \$7 billion annually—not insignificant, even for the

¹⁷ Estimates of non-recurring costs for the JSF are a much larger share of total production cost than is typical for a fighter program. Some cost analysts have suggested to me that, because this is a multi-role fighter, specialized mission equipment not standard with every aircraft is being lumped with non-recurring costs in data given to Congress.

¹⁸ That is, every doubling in cumulative output drops recurring production cost by 10 percent.

U.S. procurement budget. Adding an additional producer, with whom production is shared equally, adds a whopping \$1.5 billion, an incremental cost that remains roughly constant if even more producers are added.

Some have suggested that “design houses” could maintain industrial capabilities, and competitive pressure for innovation, by simply designing, building, and flying prototypes, then partnering with an established airframe integrator to form a “virtual contractor” if a design is produced. RAND analysts estimate that to sustain a full development and prototyping effort would cost about \$500 million annually, split evenly between airframe integration, and avionics and engine work. Others have countered that the full experience of moving a design through from development into actual production is needed to maintain needed technical skills, and a company working only on upgrades and prototypes lacks needed experience. If the design bureau/upgrade specialist could somehow be combined with a small number of full service aircraft producers to generate greater competitive and innovative pressure, however, the potential savings could be large: the difference between \$250 to \$500 million annually for a design house, and \$1.5 billion to add an additional producer.

Another cut at the same issue is to ask how much is saved when the steady-state force (and production) is halved, from 3000 to 1500. With only a single producer, total program costs drop by a little less than 40 percent; with two producers, costs drop by about a third. With five producers, expenditures fall by only 23 percent. Keeping a large number of firms going winds up consuming most of the possible “peace dividend” from reducing force sizes. Viewed from this angle, the consolidation kicked off by the Clinton administration in 1993 might be interpreted as a way of guaranteeing that any future cuts in forces would wind up resulting in real savings, rather than being absorbed in an oversized and inefficient industrial base.

The message of this exercise is that maintaining an industry that designs and produces only small numbers of advanced aircraft is going to yield a product that is virtually unaffordable, and at a substantial cost disadvantage when exported. Huge economies of scale will push smaller producers—in Europe and Japan—to merge, and even after that, to export just as much as is humanly possible. Given their severe cost disadvantage relative to higher volume American producers, smaller competitors will also be forced to turn to those export markets where cost—and possibly performance—is less important. Such “marginal” customers are likely to be located in “problem” regions, where sales may generate frictions with the United States.

Gray Threats and Technology Gaps

In short, increasing pressures to export advanced weapons seems likely. In the long run, because retention of a significant technological advantage over adversaries is critical to American military strategy, exports of weapons by our allies may ultimately force the U.S. to substantially increase its own defense spending and accelerate development of new generations of systems.

One excellent example of this phenomenon is use of the so-called “gray threat” (as a RAND study described it) to justify rapid development of the F-22 fighter. With the imminent production of European fighters (Eurofighter, Rafale, Gripen, etc.) comparable to current U.S. front-line fighters, and the necessity for Europeans to export these aircraft to reduce their unit cost, American forces will need to deploy even more advanced fighters in the not-too-distant future to guarantee a substantial margin of superiority over aircraft in the hands of potential adversaries. Indeed, once it seems likely that U.S. allies will be willing to sell a relatively potent system to a foreign buyer, there is a considerable momentum to instead support the sale of an equivalent American system, on the grounds that the political and economic benefit, and the advantages of a closer military relationship, might as well be captured domestically. In effect, given sufficient competition from U.S. allies, there is a perverse but compelling logic to America becoming its own “gray threat.”

If the outcome is increasing global proliferation of advanced conventional weapons, greater resources invested in the development of still more advanced U.S. systems will be needed. Ever newer technology aggressively deployed will lead to a “technology gap” with our allies, concerns over interoperability, and pressure on them to invest more in comparable new technology. As our allies respond with new investments, brute economics will drive still more exports of even more advanced technology. A complex, self-reinforcing dynamic is at work.

Three outcomes seem possible. The first scenario is a vastly more dangerous world, fed by spiraling exports of increasingly advanced weapons, accompanied by finger-pointing and complaints within the Alliance. A second possibility is much higher levels of defense spending by both the United States and its allies, to the point where the economic pressure to export the most advanced capabilities has subsided to more manageable levels. Finally, one can imagine the construction of a more cooperative regime for arms sales, where the handful of military powers with any realistic potential to develop the most advanced military systems agrees to some degree of mutual restraint on exports to third parties, perhaps in exchange for some program of industrial and technological cooperation that assures the survival of core defense industrial capabilities deemed essential to

national security. This last idea has gone by various names—a suppliers' cartel, an "inner circle," etc.—and is probably best viewed as an experiment to be pursued, rather than a crystal clear vision of a particular endpoint. One of the implications of such a system would be that transnational technology sharing in the defense sector would continue to be governed largely by the state rather than being simply the product of globalizing market forces.

An "Inner Circle" Approach

The most desirable by far of these alternatives is to work out some sort system of industrial and technical cooperation with major U.S. allies (Europe and Japan). This arrangement would open reciprocal access by defense producers to each other's markets, and permit the allies to maintain core defense systems capabilities without the export of advanced systems. The U.S.—as the only nation that can maintain an economically affordable advanced defense industry without relying on exports—must play a leadership role if this is to happen.

The formation of an "inner circle" of arms producers would focus on controlling diffusion of the most advanced capabilities, where there are really only a handful of producers (e.g., the United States, France, Britain, Germany) capable of producing and marketing sophisticated weapons systems. An inner circle of close U.S. allies would be given some access to parts of the U.S. defense market—and the United States access to parts of their markets—as part of an agreement to team on joint development and production of advanced systems for use within the limits of a narrowly defined "common market." In exchange for being given access to both the U.S. market and selected U.S. defense technologies, negotiated restraints on exports of systems and technologies developed within the "inner circle" to those outside would be defined and implemented.

In this way, two potent economic incentives (access to technology and markets) would be combined in a way that supported two major U.S. foreign policy objectives: restraint on exports of the most advanced weapons systems, and closer military cooperation and cohesion with U.S. allies. It is simply unrealistic to suppose that Europe will abandon efforts to maintain a high-tech defense industrial base. And Europe should realize that exports of advanced systems are likely to generate pressure to turn off the substantial U.S. technology flow from which—however inadequate in quenching its thirst—it still drinks. Furthermore, the inevitable consolidation of European defense industry, when it finally occurs, is likely to level the playing field and slow technology transfer to at least some who now have relatively privileged access. Without something like an "inner circle"

to guarantee the economic viability of European defense capabilities, the only alternative will be relatively indiscriminate exports to dubious buyers.

An additional advantage of the inner circle approach is that it can be defined and refined incrementally. In the beginning, its domain could be quite narrow, negotiated on a case-by-case basis. For example, we could initially experiment with this approach in very specific systems—for example, ballistic missile defense systems, or Stealth cruise missiles, or Stealth radar—with our most trusted allies. Given a track record of initial success, it could be then expanded to cover additional types of systems, and eventually, perhaps, become an integrated framework covering production and export of a whole range of advanced weapon systems.

Incremental expansion could also cover new categories of membership, so that instead of having a single inner circle, the system could be more like concentric circles. Close allies would share the greatest degree of access, and accept the greatest degree of restraint. The outermost circle would include virtually everyone, but also be associated with the least forceful restraints—an expansion and elaboration, perhaps, of current global agreements covering international export of sensitive military technologies and weapons of mass destruction. Intermediate levels of inclusion and restraint between these two limits could be negotiated where it made sense: bringing Russia into the fold, for example, or covering sensitive but somewhat more widely diffused advanced military technologies mastered by a larger number of players. In short, the inner circle idea could be viewed as an experiment rather than an endpoint: a graduated and progressive construction of an international regime blending restraint and cooperation in military weapons systems production and sales, using pragmatic and selective principles for inclusion of participants and technologies.

Some might argue that this is an impractical and utopian approach that would never survive in the rough and tumble of the real world. In fact, however, “impractical” restraints on export of components and systems for missiles and weapons of mass destruction—though far from perfect—currently serve us well in reducing the dangers from proliferation of these systems. And there are real examples where an incremental “inner circle” type approach has shown itself to be practical. When the United States, Germany, France, and Italy sat down and agreed to pool funding and technologies in a cooperative development program for a common theater missile defense system—MEADS, the Medium Extended Air Defense System—in 1995, all four partners agreed that no export sales could take place without common assent. True, France later dropped out of this program when it finally felt the pressures of defense budget cuts in 1996. But MEADS showed that export

restraints linked to a sharing of funds, technology, and production in a common acquisition program can be negotiated, and with strong-willed and independent partners. Out of such incremental first steps, an inner circle of armaments cooperation and export restraint can gradually be built, and later expanded.

One thing is certain. Weapons exports are at least partly driven by economics. Creating incentives to not engage in irresponsible proliferation of advanced capabilities requires global cooperation in constructing a regime which reconciles national security interests in maintaining defense establishments and curbing uncontrolled proliferation with the economic realities of a high-tech defense industry inexorably driven to seek the widest possible market. Security concerns provide a powerful argument for maintaining the special character of defense technology in the national system of innovation.

The Place of the French Arms Industry in its National System of Innovation and in the Governmental Technology Policy

Claude Serfati

Introduction

This chapter addresses the role of military R&D and defense-related innovation networks in the French national system of innovation. We find that this role has remained highly significant so far, despite profound changes in the geopolitical and world economy setting, despite strong domestic budgetary cuts in procurement and military R&D, and despite an outright decline of military innovation as a propeller for commercially oriented innovations. The resilience of the French arms industry can be explained by institutional and organizational factors and mechanisms. As we have long argued, the arms industry is organized as a “mesosystem,” with strong and interactive relations existing between the different “players”—companies, technical agencies, and the procurement agency, the *Délégation générale pour l’armement* (Chesnais and Serfati 1992). The priority given to military objectives for five decades has resulted in a pre-eminent role for defense innovation networks in the national system of innovation, as well as the pervasive role of the French *mésosystème de l’armement* (FMSA) in the government’s technology policy.

First, we present statistical data on French expenditures for military R&D and related major technology programs. An outstanding feature of these data is the strong concentration of expenditures on a small number of sectors, regions, and companies. Focusing our attention on the latter, we suggest that a handful of major defense contractors are at the nexus of R&D funding networks and of the national system of innovation. This situation can be traced back to the early 1960s, when military objectives were given top priority in the governmental technology agenda. That this situation persists illustrates that governmental policy is “path-dependent,” a fact that can be explained only if the role of structures, institutions, and organizations are taken seriously. Analysis of the restructuring process of the French industry reveals how attractive arms production remains. It also underlines the extent to which beefing up the arms industry has been at the top of the industrial policy agenda, giving no room for a debate on the future of commercially-oriented high-tech activities. Now, with the “europeanization” of the arms industry as the “new horizon” for the French govern-

ment and companies alike, the challenge is to reconcile the setting-up of a European industry with preserving the FMSA.

The Importance of Military R&D Funding

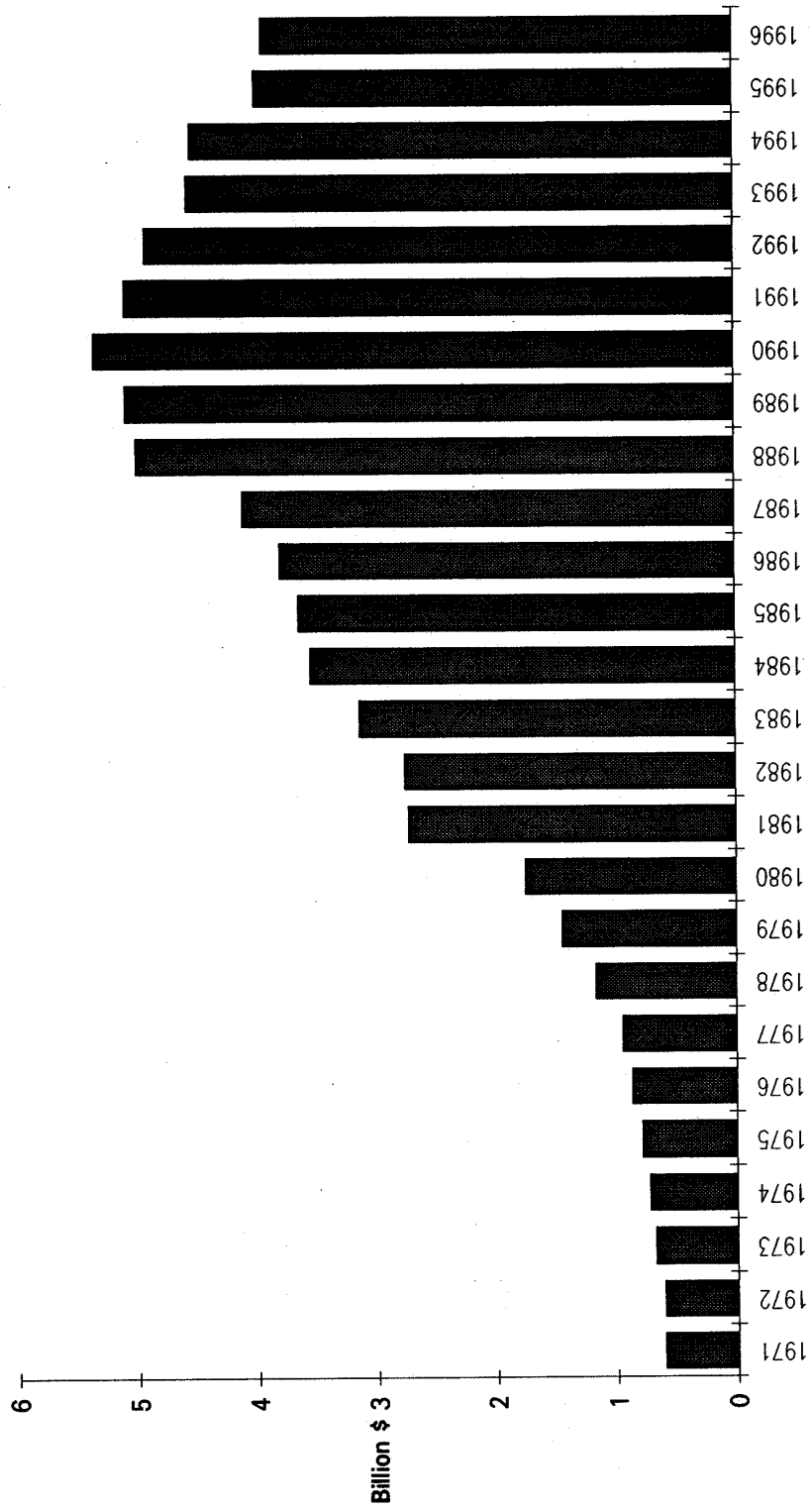
Steady Decline in Military R&D Funding

The high levels of French military R&D expenditures are clear from data provided by international organizations. SIPRI (1999), drawing upon OECD data, finds that between 1992 and 1996, aggregate military R&D spending in France in absolute terms was over 1.6 times higher than in Britain (\$33.8 and \$20.6 billion respectively, in 1995 US \$). It lagged, however, far behind American spending (by a margin of seven to one). As is true for most industrialized countries, France's Defense Budget Research & Development Expenditures (DBRDE) have declined dramatically over the past decade (see Figure 1). No data are available to investigate whether the fall in public R&D expenditures since 1992 has been compensated for by a rise in business spending on R&D, as seems to have been the case in the U.S. defense industry in 1997, when business R&D increased by 31 percent compared to 1996 (Mulholland 1998).

From a more long-term perspective, it is worth observing that the level of DBRDE in France in 1997, although down from the 1990 level, was still as high as in the mid-1980s, before the strong growth in DBRDE (an increase of 60 percent between 1983 and 1992) and procurement alike (Carpentier and Serfati 1997). To some extent, the trend in France is similar to that experienced by the United States, where, after a sharp rise during President Reagan's administration, government spending on military R&D fell to around the level of the 1970s, a level that was, however, viewed as very high by critics.

Falling government expenditure on defense R&D has led to a decline in the share of DBRDE allocated to industry in the total of Business Enterprise Research & Development expenditures (BERD), from 20 percent of total R&D performed by business at the beginning of the 1990s to 13 percent in 1996. However, DBRDE remained the spearhead of public funding to industry: its share in the total of budget R&D expenditures allocated to business (TBRDE) increased from 62 percent in 1983 to 69 percent in 1995, while the share of civilian budget R&D expenditures allocated to business (CBRDE) decreased. Table 1 indicates the long-term trends. Thus, so far as budgetary constraints on public outlays are concerned, the pinch has been felt more on the civilian than on the military side. This holds not only for R&D expenditures, but for other public budget capital spending

Figure 1
French Defense Budget Research & Development Expenditures (DBRDE) 1971-1996



Source: Adapted from French Ministry of Research data

as well. From the 1980s on, in absolute terms, the increase in military equipment expenditures has been much higher than expenditures for civilian equipment (e.g., transport infrastructure, hospitals, etc.). Despite strong cuts in the military equipment budget since 1992, it remains at a higher level than its civilian counterpart. This trend is not for France only—in most OECD countries cuts in DBRDE have been no greater than in CBRDE (OECD 1998). The downward trend in the French defense budget experienced during the decade was, moreover, reversed in 1999 compared to 1998, with an increase in the total defense budget (+2%), in procurement (+6.1%), and in R&D (+7.6%) (MacKenzie 1998).

Table 1
Defense and Civilian Budget R&D allocated to Business

R&D category	1985	1986	1987	1988	1989	1990
DBRDE (1)	1.455	1.413	1.615	1.670	1.828	2.120
CBRDE (2)	821	965	884	878	870	934
TBRDE (2+1)	2.276	2.378	2.500	2.547	2.698	3.054
(1)/(2+1) ratio	63.94%	59.42%	64.62%	65.54%	67.77%	69.42%

R&D category	1991	1992	1993	1994	1995	1996
DBRDE (1)	2.417	2.169	1.892	1.805	1.633	1.513
CBRDE (2)	1.033	988	1.024	896	736	839
TBRDE (2+1)	3.450	3.157	2.916	2.700	2.369	2.352
(1)/(2+1) ratio	70.06%	68.70%	64.87%	66.83%	68.93%	64.33%

In US\$ (1\$ = 6.5FRF)

DBRDE: Defense Budget Research & Development Expenditures allocated to Business

CBRDE: Civilian Budget Research&Development Expenditures allocated to Business

TBRDE: Total of Budget R&D Expenditures allocated to Business

Source: Adapted from French Ministry of Research data

Concentration on Major Programs¹

Data from the Ministry of Research (MoR) indicate that in 1994 total public contracts for R&D (military and civilian) allocated to industry amounted to \$3.5 billion, distributed between \$1.85 billion from the MoD and \$1.65 billion from civilian ministries.² The MoD funding is focused

¹ This section draws upon a 1997 research program, with C. Carpentier, for the *Observatoire des Sciences et des Techniques* (OST) (Carpentier and Serfati 1997).

² The exchange rates used throughout this chapter are the purchase parity power (PPP) exchange rates, 1US\$ = 6.5 FRF. Figures are rounded.

on Defense Technological Programs (DTP), while the civilian ministries' spending relates mainly to "Major Technological Programs" (MTP) in aeronautics and space, nuclear, telecommunication (\$1.55 billion). The remaining funding (\$0.3 billion) is less programs- and more incentives-oriented. Even though they are labeled civil-oriented, MTPs offer significant similarities to DTPs. They are very high in terms of costs, their lead time spans over years—sometimes decades—and in both cases the government procurement market accounts for a significant share of the firms' total output. Finally, by some standards, MTPs could be labeled as "strategic" in the triple meaning put forward by Freeman and Soete (1997, 341): technological (with learning and dynamic increasing returns); trade (with support policies dictated by comparative or potential comparative advantage); and industrial (with active industrial policies "best described with reference to the French notion of *filières*").

In a study based on MoR data, Carpentier and Serfati (1997) found that not only are public funds heavily concentrated on a few firms (120 out of the 3500 firms declaring an R&D activity), but also that the firms benefitting from military R&D contracts also receive the bulk (94 percent!) of the \$1.55 billion of R&D contracts allocated for MTP by civilian ministries. Public R&D contracts (military and civilian) are concentrated in two industrial sectors, the aerospace and the equipment sector (the latter being a broad category that includes telecommunications and defense electronics). The aerospace sector receives 46 percent of the military R&D contracts and 72 percent of the civilian contracts, while the equipment sector receives 42 percent of the military and 16 percent of the civilian contracts. Finally, geographical distribution is also strongly concentrated, with the "Greater Paris" region receiving 52 percent of the total amount of R&D contracts, while accounting for only 16 percent of the total domestic industrial output and 32 percent of the French arms production (de Penanrose and Serfati 2000). At the firm level, R&D contracts are also concentrated on a few "industrial groups" as discussed in the next section.

Defense Contractors at the Nexus of the French R&D Funding System

In our research agenda, we have adopted an approach at an "industrial groups" level rather than at the "firm" level. It should be made clear that "business firms and other formal organizations large enough to possess and exercise discretionary power are misperceived when viewed as if a 'single entrepreneur' or simply a 'production function'" (Bartlett 1994, 172).

This is a strong departure from the neoclassical way of thinking in economics. It has been suggested that, even as Keynes carried out a strong attack against neoclassical tenets, he did not

depart from the neoclassical view that competition is driven by market forces and thus fell short in not giving due account of the market power conferred upon the corporation by virtue of its size and organization (Peterson 1989). This is, obviously, not the case in the “Institutionalist” tradition, which, following Veblen’s analysis (1963), has a long record in studying how power matters and how big corporations shape the economy. This stream has been particularly useful as far as the role of military institutions is concerned (Melman 1997).

The Institutionalist tradition gives great weight to the fact that ownership is separated from control in large enterprises—see Veblen (1963) on “absentee ownership”—with opposition between “nominal” and “effective” ownership (the former referring to the right to receive an income in return for risking one’s wealth, while the latter reflects the actual ability to control the corporate assets) (Berle and Means 1932). It is fair to say, however, that case studies of industrial countries have found that the economic development of capitalism has been to some extent rather different from the picture painted by those asserting a strong opposition between managers and shareholders. Corporate directors and executives have been disproportionately numbered among the large personal shareholders (Scott 1997), a situation that has been reinforced in recent years by agency theory, which argues that if potential conflicts between managers and shareholders are to be overcome, stock options should be an important part of the top manager’s pay (Jensen and Meckling 1976).

Another theoretical school that has a longstanding interest in power and control issues is finance capital theory. Here, the emphasis is on the way that ownership control and market power can be brought together, thanks to the intercorporate networks created through interweaving of share participation. Based on a comprehensive investigation, Scott (1997, 16) has found that extensive networks of intercorporate capital relations have formed in all of the advanced capitalist economies, with, however, distinctive national patterns of development. This approach allows us to understand what we mean by industrial activities-oriented “groups.” These organizations are often designated in the Anglo-Saxon literature as “firms”—even when they comprise tens and indeed over a hundred affiliates and are owned and managed by holding corporations, which are the heart of the contemporary transnational corporation (TNC). These groups have dominant activities in given manufacturing and/or service industries, but their activities are managed as a particular type of asset, namely, the rate of return (RoR), which is measured against that offered by other types of assets—first and foremost, bonds and stocks. These industrial groups are becoming more and more what has been called in France “financial groups with industrial activities.”

Applying this analytical reading, it can be said that in France defense contractors rank at the top of the groups involved in industrial and R&D activities. While this chapter mainly focuses on the industrial and technological activities by defense contractors, the last section will comment on how the globalization process, in particular the changes related to the triumph of global finance, makes defense contractors act more and more as financial groups.

Strong “Agglutination” of Public Funding on Defense Contractors

In our analysis of the MoR data (Carpentier and Serfati 1997), we found that by taking into account the capital ownership control of firms all but a handful of the 120 firms receiving defense R&D contracts are owned by defense contractor groups. In fact, ten groups are the quasi-exclusive recipients (over 98 percent) of military budget R&D expenditures, where as only a tiny one percent of military R&D contracts goes to independent firms, which are exclusively small and medium-sized enterprises.³

Interestingly, the same situation can be observed as regards *civilian* public R&D contracts (\$1.8 billion). The bulk (87 percent) of civilian public funds accrued to 180 defense contractor-owned firms. Among these latter, there are 120 firms that are also benefitting from military R&D contracts. This contributes to a strong concentration of technical capabilities in a few industrial groups. In 1996, the top fifty groups accounted for 66 percent of the total R&D expenditures performed in France. Our findings suggest that the ten defense contractor groups perform as much as 35 percent of the total R&D performed by industry. This leading role played by the defense contractor groups is largely due to the huge amount of funds coming from ministries and governmental agencies, with only 52 percent of the groups’ R&D expenditures self-funded.⁴

There is little doubt that this “agglutination” of public R&D funds, i.e., their over-concentration in a handful of industrial groups, all of them with defense industry-related activities, has dramatic consequences on the shaping and dynamics of France’s technology policy.

³ This does not mean that only one percent of the R&D contracts from MoD goes to small and medium-sized enterprises (SMEs). SMEs that are subsidiaries of major defense contractors are also recipients. The “independent” firms mentioned here are firms having military activity that are not owned by the main defense contractor groups, but by commercially-oriented industrial groups.

⁴ It seems that the self-funded R&D-to-sales ratio of U.S. contractors is much lower than that of their French counterparts (Hitchens and Finnegan 1998) and European (EC 1996) counterparts.

R&D Funding and the National System of Innovation

From R&D Funding to Innovation Activity

The move from the analysis of R&D funding to the national system of innovation needs some qualifications. The latter has been defined by Freeman as the networks of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies (Freeman 1987). Even if we focus on the process of technical advance, as Nelson and Rosenberg (1993) do, clearly all innovation cannot be seen as an outcome of R&D activity. Organizations that play catalytic and interfaces roles, labeled “soft” organizations by Gally and Teubal (1996, 347)—such as technology assessment offices and organizations concerned with the design and implementation of patents, laws, etc.—are critically needed for innovation. Also, within firms, innovation occurs as a result of activities not included in R&D, such as know-how and design activities, the role of which are often underestimated (Walsh 1995). Conversely, only one part of research activity is motivated toward technical innovation. Finally, the whole notion of R&D is closely connected to a “linear” approach (basic, applied research, development, and in some industries testing and engineering), whereas a broad consensus exists that a “chain-link” model of innovation is closer to the real process, which takes place over some years with a critical role played by feedback effects (Kline and Rosenberg 1986).

We would suggest, however, that differences between R&D and innovation activities should not be too much exaggerated. The technical innovation process is not a “free lunch”; surveys made at the European level indicate that R&D activity is seen by firms as the primary source of innovation. Furthermore, R&D funding flows should not be viewed as mere monetary transfers. These flows connect organizations with each other and contribute to reinforcing the power of some of them and the marginalization of others. These funding flows could be viewed as the visible part of an iceberg: relationships set up by organizations with each other through funding flows are in general coexisting with other links, including non-market links.

A Hierarchical, Compartmentalized National System of Innovation

A basic thrust of our argument is that Defense Technological Programs (DTP) and Major Technology Programs (MTP) are shaping not only the government’s R&D system, but also shaping the French national system of innovation. Drawing upon previous research programs, our findings are that the French system of innovation (FSI) is strongly hierarchical and divided into compartmen-

talized sub-systems (Chesnais 1993; Serfati 1992). It is hierarchical because the core of innovation policy is “mission-oriented” and is set in motion by the State. This impetus is carried out by governmental agencies, which are in charge of procuring the programs, orienting technological trajectories, etc. The industrial leadership then goes down to defense contractor groups, whose role is to set up the network of hundreds of subcontractors (as seen above, most of those are subsidiaries of defense contractors) and to perform the work of the programs.⁵

Another feature of the FSI is that it is compartmentalized, and this for a series of reasons. Each governmental agency is keen not to lose its core competences to another agency; manager recruitment in each agency comes mainly from the different and rival *Polytechnique* high schools’ *grands corps* (e.g., *Ingénieurs des mines* for CEA, *Ingénieurs des télécommunications* for CNET, *Ingénieurs de l’armement* for DGA, etc.) (Serfati 1995); and finally, the core of the FSI is located in the aerospace, nuclear, and arms industries. These industries, which receive the bulk of governmental R&D funding, have rather poor records so far as their capabilities in terms of intersectoral technological diffusion are concerned.

Governmental Technology Policy: Why Such Inertia?

Technology Policy at the Crossroad of Technological and Institutional Dynamics

Examination of the content and objectives of governmental technology policy is closely tied, in ways too often not explicitly recognized, to what is understood by “the state.” In the dominant neoclassical approach, only market failure can justify state intervention. Since scientific activity and technical innovation can be said to a greater or less extent to be “public goods,” this approach provides a strong rationale for state support of such activities. Obviously, what constitutes market failure and when it occurs is a controversial matter. First, if governmental support to research and innovation is motivated by expected positive externalities, why should it not be extended to any physical investment aimed at generating specific assets and to any learning process? Further, it has been (in our view, rightly) argued that the distinction between private and public goods hinges less on their intrinsic and distinct attributes (i.e., their concrete or physical shape) than on the social conventions within which they are produced. This implies that the “externality-market” approach is concerned

⁵ Changes are under way in the procurement and R&D rules that could lead to an increase in the role and responsibility by defense prime contractors.

with the consequences of behavior of people in a market—a term with at least five distinct and sometimes opposed meanings, as listed by Boyer and Hollingworth (1997)—while the analytical background of this chapter is the study of innovation as a part of the process of production and reproduction of value. In that sense, our approach is in phase with Dalum et al., when they state that “the specific characteristics of each NSI are, so to speak, the ‘superstructure’ of its production system” (1995, 307).

Defining the state is important if one wants to depart from the understanding of governmental technology policy conceived as a corrective for “market imperfections.” First, the state is a political entity: it reflects a form of power organization in human society and can wield the “monopoly of legitimate violence” (Weber 1959 [1919]). This dimension of state responsibility is particularly relevant here, since as observed by Ergas (1987, 51), “Nation-states have long been major consumers of new products, particularly for military uses.” Second, the state should not be instrumentalized as a tool for managing externalities (as in the fundamentalist neoclassical approach) or, antithetically, as a simple agent used to solve “overaccumulation” difficulties (as in a fundamentalist marxist approach). The state is made up of institutions and organizations⁶ that have gained momentum and power by crystallizing definite types of socio-economic relationships and that have, over time, been able to gain momentum to develop on their own and to acquire autonomy. In a nutshell, the role and place of state institutions and organizations in any nation is strongly determined by history.

The variety of institutional configurations assumed by the state in the main industrialized countries is a major factor for explaining the diversity of their technology policies. To illustrate this point, we can refer to the new relationships emerging from WW II among science, technology, and the economy and the arrival of what has become known as “big science.” Even if these changes were in part the result of “technology- and economic-push,” few doubt that in a broad way they were “organization-pulled.” For example, Freeman and Soete (1997) remind us that overemphasis on “big science and technology” is in a large part due to the self-interest of the R&D and military establishments.

That the institutional setting plays a decisive role in the shaping of technology policy is illustrated by comparing the very dissimilar objectives and records in governmental policies for the same

⁶ Here it should be mentioned that differentiating between the two categories is a daunting task (see Edquist 1997).

technological domains in different countries. The first case is the very large differences in the outcomes of governmental policies related to laser technology in France and Germany, policies launched at the same time and with the same level of public funding commitment (Wolter et al. 1996). The second case relates to the biotechnology industry in the United States and Japan. A similar strong commitment by both governments has resulted in very different technology trajectories, because of the differences in their respective institutional settings (Callan 1997).

To sum up: a) the modalities, and not only the degree, of state involvement results in differences in governmental technology policy and outcomes; b) governmental involvement cannot be explained simply as aimed at correcting market imperfections—rather it is the result of active intervention by state organizations in the process of creating technological innovation, at least as regulators, producers, and users (Gregersen 1995).

Institutional Features of the French Model of Technology Governmental Policy: The Core Role of the Mesosystem of Armaments

Considering history is useful when one investigates to what extent science, technology, and the state have been intimately linked with each other in France (Papon 1978; Chesnais and Serfati 1992; Chesnais 1993). The type of technology policy set in the late 1950s reflects the lasting role of the state. The “major programs” launched were military- or strategic-oriented. Meanwhile, governmental agencies were created or strengthened, combining in an unusual way administrative, procurement, and technological responsibilities.

As explained above, we argue that major features of French technology policy and—beyond it—of the national system of innovation can be made more clear if this set of interrelations among organizations is taken into consideration. Regarding France, the pervasive role of state institutions and organizations should not be accounted for by an appeal to “market failure,” but rather by “entrepreneurship failure.” There is no space here to further develop the set of cultural and political factors explaining this kind of strange “failure” in a capitalist system. In any case, what began as “colbertism,” a term referring to the key role played by the Louis XIV’s prime minister in developing nascent capitalism, has lasted for over three centuries and gained further momentum after the second world war, a time when capitalism has become more than “mature.”

Hence, the large place of DBRDE and MTP-related funding in the national system of R&D that has been presented above is only the visible part of the iceberg. Behind the overconcentration

of resource allocations stands a handful of organizations that wield power and have the technical expertise to carry out those programs. All of these programs, and all of the organizations in charge of them, are fully or partly defense-related. They mainly include the DGA (Directorate General for Armaments), the state technical agencies (CEA, CNES, CNET, ONERA, etc.), and major industrial groups that are at the same time MoD prime contractors (Thomson-CSF, Alcatel, Aerospatiale, Dassault, Snecma, Matra, etc.). Extending the concepts of *filière* and *mésosystème* developed in the 1980s by French economists, we have proposed the term of *mésosystème de l'armement* (French Mesosystem of Armaments, FMSA) to describe the set of organizations, bound up with each other through market and—possibly more important in the defense industry—through non-market relationships (Serfati 1992; Chesnais and Serfati 1993). The cohesion of the FMSA is reinforced by the core role played by DGA's Engineers of Armaments (one of the *grands corps*), the pervasive influence of which is all the stronger because most of the *grands corps* are represented in the top jobs in the defense contractors. A noted American scholar has characterized the *grands corps* as the glue that holds the entire defense productions system together (Kolodziej 1987).

Arms Production and the Restructuring Process

The way the restructuring of the arms industry has been managed is a good illustration of the role of defense issues in governmental technology policy. Recently, France has undertaken a restructuring process of its arms industry. Similar processes are under way in other OECD countries endowed with a strong arms industry, but in France it has been a lengthy and rather tortuous process that is still not completed. Because of the magnitude of public funding channeled to defense contractor groups through DTPs and MTPs, we might have expected defense restructuring-related issues to be addressed in connection with an overhaul of the governmental technology policy. Instead, the defense restructuring process, which was launched by Président Chirac in January 1996 and is still far from over, has been exclusively grounded on the commitment to preserve the ability of the French industry to survive the global competition in this sector. As former Prime Minister Juppé declared when he announced his decision in favor of Matra (and Daewoo) before National Assembly members: “The decision we made has been based on a defense needs-oriented industrial logic” (*“Notre choix a été fondé sur une logique industrielle de défense”*) (*Journal Officiel* 16 October 1996).

The electronic sector is a case in point. The Juppé government decided to proceed with a total separation within Thomson S.A. (the parent company) between Thomson-CSF (military activities) on one hand and Thomson Multimedia (electronic appliances) and SGS-Thomson (electronic components) on the other. The government also announced that it would dispose of Thomson Multimedia by giving it free (allegedly because of its level of indebtedness) to the Korean conglomerate Daewoo. (This decision was called off by the Privatization Commission some months later.) The government's strategy reveals how large the gap is between what is happening in reality—i.e., erecting a “wall of separation” between military and commercial capabilities—and the official discourse made at length on the need to strengthen the links between military and commercial technologies, promote “dual-use technologies,” etc.

After years of indecision—it took over 30 months and an unexpected change in the parliamentary majority for the government to decide—and as a result of uphill lobbying from the firms concerned and their allies in the FMSA, Thomson-CSF and Alcatel's military businesses were merged in September 1997, with Alcatel becoming the biggest corporate shareholder in Thomson-CSF. Not surprisingly, the split of Thomson S.A. between its military and commercial divisions was confirmed, and no governmental comment on the future of Thomson Multimedia and SGS-Thomson was made by the Jospin government. Following its merger with Alcatel, Thomson CSF has speeded up foreign acquisitions, clearly keen to become a global company on its own. The company holds a significant defense market share in Europe, ranking number two in July 1999 before the Matra Aerospatiale-DASA merger. Since 1997 its strategy has been to focus on defense, or near-defense, electronics.

For Alcatel, gaining the Thomson-CSF acquisition bid for Matra-Lagardère marked an unexpected comeback in the defense industry. In 1983 an agreement, nicknamed by the parties “the Yalta of the electronic sector” (*Yalta de l'électronique*) was struck under the auspices of the government between Thomson S.A. (parent company) and Alcatel (parent company). This deal aimed at covering the whole scope of electronic products. A major point of this agreement was to evenly divide the state-oriented markets. Alcatel was to become the sole supplier for the state-dominated market in civilian products (public switching boards, telecommunications equipments, etc.), and Thomson-CSF (a branch of Thomson S.A.) was to become the sole supplier for the state-dominated market in military products (defense electronics, weapon systems, military telecommunications etc.) and commercial electronic business.

Alcatel's 1997 comeback in the arms industry through the take-over of Thomson-CSF reflects how attractive and lucrative the defense industry remains to French firms. The attraction of military R&D and procurement markets has been a driving force in the French restructuring process. Similarly, the military market proved attractive to dealmakers in the United States, raising concerns that the U.S. megamergers (Boeing-McDonnell, Lockheed-Martin, Raytheon-Hughes) could lead to further isolation of the defense industry in the economy (Markusen 1997). The comparison should not be overdrawn, however, as there are strong differences between the two countries: the role of financial markets in the restructuring process, the promotion of start-up companies, the importance and role of SMEs, and—obviously—the leading role played by the United States in international relations (Markusen and Serfati 2000).

In July 1998, a year after Alcatel acquired Thomson-CSF, the Jospin government announced that the state-owned Aerospatiale company would be privatized and merged with Lagardère's Matra Hautes Technologies. Then, in October 1999, Aerospatiale, Matra, and DASA announced the creation of EADS (European Aeronautics, Defense and Space Group). The new group will rank first in Europe, and third worldwide. Thus, the European aerospace industry will be dominated by two major companies of roughly equal size (\$22 billion). EADS and the new British Aerospace Systems are confronted with two options: merging their activities and risking the accusation that they are erecting "fortress Europe" or looking for transatlantic links with the risk of opening further avenues in Europe to American companies.

There is no doubt that the consolidation to two "national champions" (Thomson-CSF and Aerospatiale-Matra HT) is aimed at fortifying the French industry in order to prevent its marginalization in the restructuring process of the European aerospace and defense industry. The next section examines what is at stake if the French mesosystem of armaments is to be preserved.

Can the FMSA Survive in the New International Setting?

A Finance-driven Globalization Process

What we call the new international setting has to do with two distinct, but overlapping, processes: the globalization of the economy and the new situation created by the collapse of USSR and the entry into a post-cold war era. That globalization has become a driving force for two decades is challenged by some, who argue that the world economy (including production and trade) is less "open" than it was at the beginning of the century; i.e., that globalization is a "myth" (Hirst and

Thompson 1996; Kleinknecht and ter Vengel 1998). These analysts are right to put the actual process in a long-term perspective but, in our view, they underestimate the dramatic changes that have taken place in recent years. Using comparisons in the levels of Foreign Direct Investment to GDP or trade-to-GDP ratios between the pre-WWI and the current period to conclude that nothing has changed since the beginning of the century is hardly convincing, and does not pay sufficient attention to the key role actually played by TNCs, whose grip on the world economy is a compelling fact.⁷ Still more sweeping is the momentum gained by “global finance” and the re-emergence of a new kind of finance capital, not made up of rentier families,⁸ but of a variety of new institutional investors (pension, mutual, hedge funds) controlling over 10 trillion dollars.

Our understanding of the process is that this “global finance”—encapsulated as the “manic logic of capitalism” (Greider 1997)—is the very driving force of globalization and accounts for a large part of the difficulties of the current economic situation (Henwood 1998). Since the early 1980s, the high level of leverage by the borrowing⁹ and financial innovations that were relentlessly introduced on the markets have contributed to an unprecedented amount of credit creation, making it more and more plain that a large part of the capital swirling around the world is “fictitious” capital (Guttmann 1994) or to put in more conventional terms, “paper wealth” (*Business Week* 1998). For sure, owing to the Asian crisis this paper wealth “has already begun to vanish,” at least for Asian companies and households holding financial assets. More damaging, what is sometimes too narrowly called a “financial crisis” in emerging countries was transformed into a dramatic economic crisis on the “real side” of economy with resulting social backlash (*Business Week* 1998).¹⁰

Despite strong concerns, the American and, to a lesser extent, western European countries have escaped the devastating consequences of the economic crises that have been plaguing most of

⁷ Estimates are that the 200 top TNCs have a total turnover equivalent to over 28 percent of the world aggregate GDP and account for two-thirds of world trade.

⁸ At the turn of the century, 5000 British families and 20,000 continental European families provided the bulk of the capital on the bond and equities market.

⁹ See Plender 1998: “[I]t is not uncommon for hedge funds to borrow five or six times their investor’s funds in pursuit of high returns.”

¹⁰ The International Labour Organization estimates that the number of underemployed will be around one-third (750-900 million people) of the world’s workers. See Taylor 1998.

the world since 1997. At the turn of the century, “once again, North America and Europe are the global anchors of prosperity and stability, while the rest of the world struggles in economic limbo” (Warner 1999). At the close of 1999, Wall Street’s Dow Jones industrial average was 60 percent higher than in August 1996, a time when the Federal Reserve Board’s chairman, Mr Greenspan, said that the bubble reflected “an irrational exuberance.” That the U.S. economy has been enjoying good macroeconomic growth rates and low unemployment since 1993 is unchallengeable, as are the sky-rocketing foreign indebtedness (\$2 trillion at the end of 1999) and domestic debt used to finance household consumption and share buy-back by non-financial business.¹¹ And in the United States as well as in Europe, the pressures exerted by the financial markets through the reinforcing of “corporate governance” rules have negatively affected the level of firms’ capital accumulation along with the growth and orientation of their R&D expenditures (Chesnais and Serfati 2000). Financial market constraints, whether exerted at the macroeconomic level on social-oriented public expenditures or at the microeconomic level, have also meant increased social inequalities and poverty, as flexibility in labor markets translated into serious deterioration for workers in the United States (Appelbaum and Berg 1996) and Europe (O’Sullivan 1998). Once distributional issues and the situation of workers have been taken into account, it should become clear that the “Atlantic prosperity” is restricted to the upper income levels of the population.¹²

Even though the French industry was able, albeit with difficulty, to cope during the 1980s with the internationalization of production and trade (through a dramatic increase of FDI and technical interfirm agreements), the pressures exerted by global finance throughout the 1990s have posed a major threat to the French model of capitalism, including the French *mésosystème de l’armement* (FMSA), which is one pillar of this model.

¹¹ Over half of the \$400 billion debt increase by non-financial businesses was used to finance share buy-backs (*The Economist* 1999).

¹² Just to give an example, 86 percent of the Wall Street gains between 1989 and 1997 were captured by 10 percent of the households (Economic Policy Institute 1999). In France, reversing the three post-WWII decades, the 1980s saw in increasing inequalities: between 1979 and 1996, the income of the bottom 10 percent of the population fell by 3 percent, as the one of the top 10 percent increased by 9 percent.

The FMSA: Last Vestige of the French Model of Capitalism?

The unique features of the French model of capitalism are well-known. They include a closed system of recruitment of governmental and business elites, with most coming from the *Polytechnique* and *École Nationale d'Administration grands corps*¹³ (Bauer and Bertin-Mouroit 1995); an industrial system made up of cross-cutting participation, resulting in strong ownership autonomy vis à vis financial markets (Morin 1998); and innovation funding mechanisms based, as in Japan, upon “a credit financial system influenced by governments” (Christensen 1992).

The French model is threatened by the momentum of global finance, and the threat is perceived as operating through Anglo-Saxon financial institutions, mainly the pension and mutual funds, which have already had a presence on the boards of top French companies (e.g. Alcatel, Elf, Rhône-Poulenc, Saint-Gobain, Total) for some years.¹⁴ Table 2 provides data on the share of defense contractors’ stock held by Anglo-Saxon funds. There are few doubts that, due to the prominent role of these contractors in the French innovation system, technology policy could be seriously affected in the coming years by their further commitment to global finance.

Table 2
Degree of Capital Held by Foreign and Anglo-Saxon Institutional Investors
(% of company’s capital)

Company	Foreign shareholders	Anglo-Saxon institutional investors
Alcatel	49	30
Lagardère	47	36.7
Thomson-CSF	14.6	11.1

Source: *L’Expansion*, November 4-17, 1999

The restructuring of France’s arms industry should be analyzed in this context. There is no doubt that the arms industry remains in France, as in other major arms producing countries, a lucrative activity. The consolidation process has been used by the major companies to reinforce their

¹³ The number of managers recruited from the *grands corps* has continuously increased between 1986 and 1995, despite the privatization of firms and more free-market oriented policies, a fact construed by sociologists as the reinforcement of non-market links between government and firms.

¹⁴ Estimates are that foreign (mainly American and British) pension funds would control between 30 and 40 percent of the capital of the French “blue chip” companies.

presence in this sector. The privatization of ownership of major contractors—a process that has somewhat paradoxically been more active under the left-wing coalition government (*la gauche plurielle*, associating the Socialist, Communist, and Green parties) than between 1993 and 1997, under the right-wing government of Mrs. Balladur and Mr. Juppé—is expected to reinforce their competitiveness and free-market orientation, as privatization did in the United Kingdom (Dunne and Smith 1992). Meanwhile, another major objective of the restructuring process is to preserve the “cohesion” of the FMSA, through setting up capital cross-participation among the leading firms (Aerospatiale, Alcatel, Dassault, Matra Thomson-CSF). Figure 2 displays the financial links as of the end of 1998.

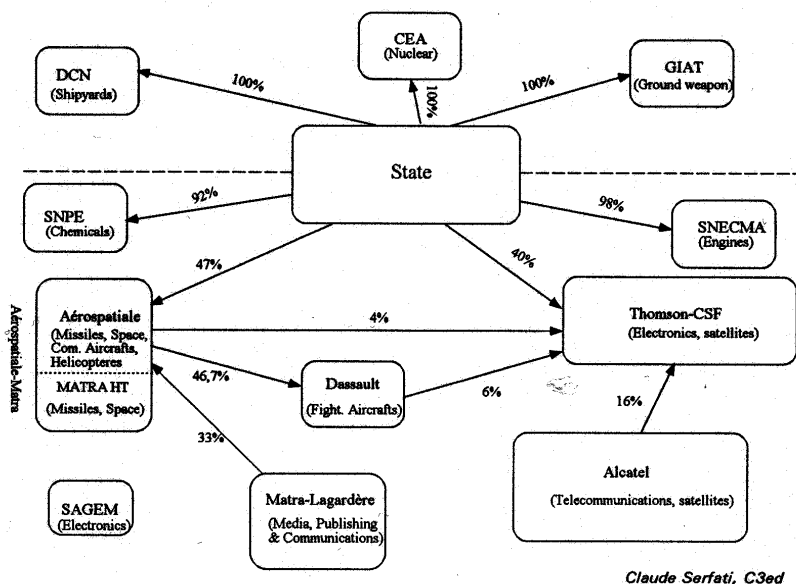
The redefinition of the DGA’s mission, which began in 1997, will probably weaken its role in arms production and the R&D process, by refocusing its administrative responsibilities and technical expertise and moving toward dropping its production activities (in shipyards). On the other hand, DGA could increase its influence, since it will be in charge of long-term strategy through the “foresight thirty-year plan,” aimed at identifying future technological breakthroughs. Also, the DGA’s arms engineers, one of the *grand corps* of the *Polytechnique* schools, possess unique expertise in defense technology, expertise that will remain critical in the design of complex weapons systems.

All in all, the industrial restructuring and financial reshuffling of the FMSA that has taken place may be seen as aimed at “locking in” control of the system and preventing would-be foreign institutional investors from having a leading role on the boards of the defense contractor groups. This strategy may be feasible in the arms industry, where protecting the capital ownership from foreigners can be grounded in sovereignty and security motives, but it seems more difficult to carry out in other industries. Consequently, the current restructuring process could be seen as an endeavor to preserve the arms *mésosystème* as one of the last building blocks of the French model of capitalism. But with europeanization of the arms industry is the new horizon for the French government and companies alike, how it can be reconciled with preserving the FMSA is anything but clear.

The European Defense Industry and the Persisting Role of Governments

We must also not forget the importance of the European and U.S. governments’ commitment to their arms industries, and their role—more or less active—in the restructuring of their domestic industries. In that sense, it is more accurate to speak of internationalization, rather than globalization,

Figure 2
Cross Participation in the French Mesosystem of Armaments



Note : arrows (and percentages) indicate the degree of control of companies or State on other companies at the end of 1998.

of the arms industry. The role of the United States and of the State (in the broad sense defined above) remain critical if we are to understand how the restructuring process is proceeding in other (mainly European) countries. The particular features of the U.S. arms industry create unique competitive advantages for U.S. contractors, including the size of their domestic market, firmly sheltered by procurement rules from the “winds of liberalization”; the momentum of geopolitical factors in the arms trade; and the strong commitment of the Pentagon to military R&D. Finally, even though Wall Street has been active in the consolidation of the industry, the role played by the DoD when confronted with budget cuts in the post-cold war era (e.g., the “last supper” meeting) should not be overlooked. Whereas it was possible to consolidate the U.S. industry at a fast pace, for years the consolidation the European industry has been a daunting task, haunting the “long dinners” that took place between industrialists and governments (let alone defense or civilian European- or Community-level bodies) in Europe.

Basically, the obstacles to further consolidation of the European industries come from the difficulty of disentangling the complex set of cross-links among the companies, public institutions,

ministerial departments, and political parties that have been at the very foundation of national defense industry-related networks for many decades. Even though TNCs have a major role in the globalization process, we should not imagine that globalization puts an end to the role of the state, conceived of in this paper as a set of institutions and organizations that are anything but disappearing. Even for those companies with a strong commitment to shareholder value, the government's involvement remains highly critical (Serfati 2000).¹⁵ This is why the strategy of preserving the domestic base should not be seen as only part of a "gallic" tradition. It is why, until recent years, the consolidation process in all countries was mainly based on mergers between companies of the same nationality.

That the role of governments in preserving the domestic base has remained critical is evident in the way the restructuring process has been proceeding. Even after the formation of national champions in the United Kingdom (British Aerospace and GEC-Marconi) and Germany (DASA), strong pressures are present in these countries to prevent domestic companies left out of these giant companies from falling into foreign hands.¹⁶ GEC-Marconi met opposition from the German government in its bid to take over the simulator manufacturer STN Atlas, and was allowed to acquire only 49 percent of the capital. Siemens' defense electronics facilities have been split between DASA and British Aerospace, which each acquired Siemens' defense assets in their respective countries. In the UK ground weapons industry, the three major firms (Alvis, GKN, Vickers) agreed on one thing: that consolidation would have to begin at home, a fact confirmed by the decision made by GKN and Alvis to merge their fighting vehicle lines. A similar concern exists in Germany, where armored vehicle firms are consolidating on a national basis (Krauss-Maffei and Wagmann). Similarly, the friendly cash offer launched by Saab for Sweden's other large manufacturer is aimed at creating a Big Nordic defense firm (Latour and Michaels 1999). So far, what is labeled European mergers have

¹⁵ See, for example, the BAe's chief executive's testimony before the Committee of the French National Assembly: "The challenge for the European industry will be to maintain a fair balance between its international dimension and the concerns of each nation to maintain its influence on the industry." (*Le défi à relever pour l'industrie européenne sera de trouver un équilibre entre son caractère international et les soucis de chaque nation de garder une influence sur l'industrie*) (Quiles and Chauveau 1997).

¹⁶ See, for example, the VSEL acquisition by GEC-Marconi. The European Commission was refused any say by the British government on the grounds of Article 223, as the fight to acquire VSEL was between the two leading British companies.

mainly concerned bi-national mergers, as if this kind of process offered guarantees to both governments and major contractors: to the former that they would be able to retain some control on their national firms and to the latter that their domestic market would be protected while they remained the main recipients of public funding of R&D (Lovering 1998).

It is in this context that the creation of a single European aerospace and defense company should be analyzed. More often than not, the obstacles to the creation of such a company are presented as epitomizing the opposition between globalization-minded firms and governments alike, and—the others. Table 3 suggests a more complicated story, with significant divergences among major players on several issues as to how the constitution of this company should be carried out. Such a company, if created, would be only a segment—albeit an important one—and not the entire defense industry, since shipyards, ground weapons, chemicals and nuclear establishments, all sectors with strong national vested interests, are left aside. Finally, some commentators are concerned with the monopoly situation that would be created if a Single Corporate Entity were to be set up. The recent creation of two European companies in this field (Matra Aerospatiale DASA and BAE Systems), the finalization of which has still to be confirmed, raises in new, not easier, terms the issue of the consolidation of the European aerospace and defense industry.

Table 3

The consolidation of the European aerospace and defense industry: a long way off?

Topics	Options	Examples
How to Proceed?	“big bang”? step-by-step	UK, Germany (more cautious) France, Italy
What role for Airbus?	Kernel of single aerospace and defense company? Focused on commercial activity?	France UK, Germany
Capital control: Based on (1)	Shareholder value? Market’s share?	UK, Germany France
Capital control: Based on (2)	Governmental “golden share”? Stock market sovereignty?	France, Germany: block of ownership UK: no shareholder >8%
How many members?	Enlarging the club (but how far)?	Consensus: enlarging to Spain, Italy, Sweden Under discussion: GEC, Thomson-CSF, American firms
Business lines “frontiers”	Full civil-military integration or Partial civil-military integration	Which business: fighter aircraft? helicopters? missiles? electronics?

Source: C. Serfati

Conclusion and Research Agenda

This chapter has underlined the strong role of military R&D and defense innovation networks in France's national system of innovation and governmental technology policy. If we are to understand why this role, even if declining, continues to be mightily felt as far as industrial and technology issues are concerned, we have to gain insight in the institutional and organizational background against which the defense industry has been built up.

This leads us to pay attention to the momentum of forces counteracting further cuts in military expenditures as well as to be cautious about allegedly "irreversible" trends in the use of commercial technologies to be integrated in weapon systems. Indeed, it can hardly be challenged that the number and the variety of commercial technologies integrated in weapon systems have increased over the past decade, and that modifications in procurement and administrative rules have begun to remove some obstacles to further transfers between military and commercial technologies. Nevertheless, one should observe that not only can the so-called "peace dividend" hardly be found (Markusen 1997), but also that some elements could signal that the downturn in military expenditures that has been a feature for the past decade or so could be over. Even before the 1999 NATO strikes against Serbia took place, it had become clear that U.S. procurement would rise by a significant margin by 2003. In France, the 1999 defense budget marked a reversal in a five-year downward trend. Increased tensions in various parts of the world, stirred up or aggravated by social consequences of the current economic crisis, provide some ground for those who argue that a new upward cycle in military spending is about to take place in developed countries. This cycle would occur against a quite different geopolitical background from that prevailing during the cold war and its arms race. At the turn of the new century, according to two experts in defense issues (Sandler and Hartley 1999), threats would become manyfold, some of them being: "Increased disparity [which] may breed the revolutions of the next millennium as hopelessness gives rise to violence" (16), and "conflicts over the property rights to disputed resources (air, water and natural resources)" (264). All of this would require a new role for NATO, which could be involved in projecting "power to trouble spots in these poverty-stricken countries, most of which are located outside of Europe" (197). As is evident from the strikes against Serbia, the United States holds the key role in NATO (Serfati 1999). Hence, it should not surprise anyone that the process of transatlantic collaboration, resulting from strategic, operational, technological, and financial factors (Gompert, Kugler, and Libick 1999) will be U.S.-dominated.

Were this trend confirmed, it would mean that a new kind of military-industrial system, “leaner and meaner” through consolidation and jobs downsizing, more internationalized, and with institutional investors holding a key role within it, will emerge in coming years. Keeping at the leading edge on technology innovation will continue to be the priority on the defense agenda in the coming years. Probably sourcing an increased portion of its technology in the commercial industries, these military-industrial systems will remain a core component of national systems of innovation in the countries with strong procurement and R&D budgets.

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The Place of the UK Defense Industry in its National Innovation System: Co-evolution of National, Sectoral and Technological Systems

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Introduction

A purely national perspective is no longer appropriate for the study of the UK defense industry. Indeed, it probably never has been. The institutions and relationships that contribute to the generation, application, and commercialization of technologies used in the UK defense industry are increasingly transnational in character, and they are likely to become more so in the decade ahead.

This chapter will argue that the UK defense industry is at the intersection of a number of distinct but overlapping innovation systems. The National Innovation System remains a key factor in the strategy and competitive performance of the defense industry. However, the co-evolution of National, Sectoral and Technological Systems increasingly shapes the context for innovation in the UK defense industry. This chapter will consider the place of the UK defense industry at the intersection of these innovation systems.

Innovation Systems Approaches

An important recent development in the study of the innovation process has been the emergence of a systems of innovation literature. The systemic approach emphasizes the collective character of innovation: in particular, it focuses attention on the interaction of firms with other institutions and organizations in the production, diffusion, and use of new knowledge. This approach is particularly associated with the work of Freeman (1988), Lundvall (1992), Nelson (1993), Carlsson (1995), and Edquist (1997).

* This chapter draws on on-going discussions on Systems of Innovation and the Defence Industry within the METDAC network. METDAC (Managing European Technology: Defence and Competitiveness Issues) is a thematic network funded by the Commission of the European Communities under its Targeted Socio-Economic Research (TSER) program. Thanks go to my colleague Philip Gummert for allowing me to use parts of our recent co-authored work as the basis of some sections of this chapter. I would also like to thank Stan Metcalfe for his extremely useful comments on earlier drafts and colleagues at the ESRC Centre for Research on Innovation and Competition, University of Manchester for their thought-provoking work on the innovation systems perspective.

Such an approach places particular emphasis on three principal components of the system: the *institutions and organizations* that contribute to the production, diffusion, and use of new knowledge, which may include firms (including suppliers, users and competitors), universities, public and private research organizations, and the government. The *relationships* among those elements and their interdependence and interaction within the system, which may be formal or informal and may be based on market or non-market means. The *boundary* of the system, which may be national but may equally be regional or international in scope.

Three major variants of the systems of innovation literature can be identified (Andersen et al. 1998); National Innovation Systems (NIS); Sectoral Innovation Systems (SIS); and Technological Systems (TS). I will (briefly) consider their main characteristics.

National Innovation Systems

The emphasis of the National Innovation Systems approach is on the interactions between institutional actors in creating, stimulating, and diffusing innovations within a specific country (Nelson 1993). The geographical boundary is taken as given, and the relationships between the actors involved in the innovation process—firms, universities, public research institutes and government—are analyzed. The NIS approach emphasizes the importance of existing national political and economic institutions in shaping the pattern of technical change and learning processes within a country.

Nelson and Rosenberg (1993) note that an important question is whether the concept of a *national* system is appropriate in an increasingly international economy. Scientific and technological knowledge is growing ever more international in its creation and dissemination, and the influence of transnational corporations are increasingly pervasive. However, as Edquist (1997) observes, there are strong reasons why we might wish to continue to talk about innovation in terms of national systems, not least because national differences persist in institutions and the relationships between them, and because national policies remain the central focus of public interventions in the innovation process.

Sectoral Systems

In response to some of the concerns about the national focus of much of the early innovation systems literature, another perspective has begun to emerge that focuses on Sectoral Systems

(Breschi and Malerba 1997; Andersen et al. 1998). Breschi and Malerba define a Sectoral Innovation System as:

... that system (group) of firms active in developing and making a sector's products and in generating and utilizing a sector's technologies; such a system of firms is related in two different ways: through processes of interaction and cooperation in artefact-technology development and through processes of competition and selection in innovative and market activities (Breschi and Malerba 1997, 131).

Note that, while the NIS approach takes the geographical boundary of the system as given, the SIS perspective sees it as endogenous and emerging from the specific conditions of each sector. Consequently, different sectors may have different boundaries that are not necessarily national but may spill over national boundaries through processes of cooperation, competition, and transnational knowledge transfer.

Technological Systems

A third approach focuses on specific technologies rather than the national or sectoral systems in which they may develop. Carlsson and Stankiewicz state that:

A technological system may be defined as a network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffusion and utilization of technology. Technological systems are defined in terms of knowledge/ competence flows rather than flows of ordinary goods and services. They consist of dynamic knowledge and competence networks (Carlsson and Stankiewicz 1995, 49).

As such, this Technological Systems approach is principally concerned with the knowledge and competence networks surrounding a particular technology, rather than the broader innovation process in which that technology is turned into commercial products. The boundaries of these knowledge and competence networks are likely to vary depending on the particular technology in question. However, with the increasing internationalization of scientific and technological knowledge, a Technological System may well be transnational in scope.

Co-Evolution Of Interlinked Systems¹

Most of the work on innovation systems has focused on one of these approaches. However, National, Sectoral and Technological Systems are clearly interlinked. Firms and other organizations may be members of more than one system, and changes in one of those system may influence the context for innovation for organizations in other systems. As such, the three approaches should be seen as complementary levels of investigation and pose they interesting questions about how the different systems interact (Edquist 1997; Andersen et al. 1998).

These interlinked systems can be seen as part of a *co-evolutionary process* that shapes the context in which organizations innovate and influences their strategy and competitive position. The process is co-evolutionary because the adaptive development of one element alters the innovative environment of its neighbors and may cause them to also seek to adapt. Where systems are interconnected, these changes within a system may alter the decision-making environment for organizations in other systems. The stronger the interconnection between systems, the greater the disturbance of a move or action in one system on organizations in other systems. These changes may take a number of forms and may include changes in organizations and their policies/strategies, changes in the relationship between organizations, and changes in the boundary around the system.

An Innovation Systems Perspective on the Defense Industry

The influence on National Innovation Systems of the scale and organization of technological activity directed at national defense is often noted but has rarely been a central focus of studies in the innovation systems tradition. Thus, a heavy commitment to defense technology has long been noted as a characteristic of the post-1945 National Innovation Systems of the U.S. and UK (Nelson and Rosenberg 1993; Walker 1993). This has been contrasted with the scale and organization of such activities in Japan (Samuels 1994).

Within the innovation systems literature, there is general agreement on the need for more cross-national comparative work. Edquist (1997) notes that without comparisons between existing systems it is impossible to argue that one national system is specialized in one way or another. Con-

¹ The notion of co-evolution as it might apply to innovation systems is discussed by Andersen et al. (1998).

sequently, Andersen et al. (1998) call for more comparative and historical work on similar Sectoral Systems operating in different national contexts.

The defense sector would seem an appropriate choice. It has framed the context for innovation in many countries in the post-War period. At the same time, we already know that there is considerable institutional variety between National Innovation Systems (Gummett and Stein 1997). The METDAC Network funded by the European Commission is engaged in some comparative work of this kind compiling a series of case studies of the defense industries in Europe, the U.S. and Japan. The Cornell Workshop is to be welcomed for taking the process of transnational comparison a stage further. This is clearly a rich vein for comparative empirical work.

At the same time, the innovation systems approach may contribute to an improved understanding of the nature of the defense industry and its relationship with National Systems. The perspective raises a number of interesting questions: How does the division of labor operate in the generation and application of knowledge for defense-related objectives? What are the relationships between National, Sectoral, and Technical Systems in the generation and application of such knowledge? What is the boundary around the system, and is a *national* perspective still appropriate when analyzing the defense industry?

The Evolving Structure of the Global Defense Industry

Thinking among European policy makers, company executives, and industry analysts has been dominated by the size of the leading U.S. companies that have emerged from the process of industry consolidation. This section describes the main features of U.S. defense industry consolidation and the European response.

Consolidation of the U.S. Defense Industry

The U.S. defense industry saw an unprecedented wave of mergers, acquisitions, and divestments during the 1990s.² This consolidation process was actively encouraged by the U.S. government with the aim of reducing procurement costs and sustaining a viable defense industrial base during a period of declining defense budgets. In response, companies either specialized in

² The drivers of this consolidation process and the main features of the U.S. defense industry structure that has emerged are described in greater detail in James (1998).

defense or exited the business altogether. The consolidation process has led to major changes in the structure of the U.S. defense industry and the industry structure that has emerged is characterized by considerable concentration. Thus, consolidation has seen the emergence of three giant defense companies—Lockheed-Martin, Boeing, and Raytheon—whose overall size and breadth of business activities dwarf their competitors in the United States and—until recently—Europe (see Table 1).

Table 1
Top 10 Firms in 1998 by Defense Sales (U.S. unless otherwise stated)

Company	Defense Sales in 1998 (\$ billion)
Lockheed Martin	16.60
BAE Systems (UK)	16.40
Boeing	15.60
Raytheon	14.80
(EADS)* (France, Germany & Spain)	6.70
Northrop Grumman	5.70
General Dynamics	4.95
Litton Industries	3.05
United Technologies	3.00
Mitsubishi Heavy Industries (Japan)	2.93

* European Aeronautic Defence & Space Co.

Source: Author's calculations based on *Defense News* (1999)

The Medium-sized Companies

Inevitably, most attention has focused on the leading three U.S. companies. However, there are a range of medium-sized U.S. defense companies that are also significant players in the U.S. defense industry. Thus, Northrop Grumman, General Dynamics, Litton Industries, United Technologies, TRW, Honeywell, and Newport News rank in the top 20 companies world-wide by defense sales.³ With defense sales of between \$2-6 billion in 1998, they are much smaller than the U.S.

³ In this classification, General Dynamics and Northrop Grumman present some problems. While considerably smaller than the three leading U.S. companies in terms of total defense sales, they are much larger than the next ranked U.S. company (Litton Industries). Indeed, it will be noted that in a previous FOA report by this author, Northrop Grumman was classified alongside Lockheed Martin, Boeing, and Raytheon (James 1998). Changes in the U.S. industry structure since that report mean that Northrop Grumman now has more common with the medium-sized companies than the three giants.

giants and the new BAe Systems, but they are considerably larger than European companies such as Finmeccanica, Smith Industries, and Saab-Celsius. In the defense industry supply chain, these medium-sized companies act as prime contractors and platform manufacturers, as well as tier-one suppliers of sub-systems.⁴ Thus, United Technologies manufactures helicopters and Northrop Grumman is a manufacturer of military aircraft. Litton Industries, Newport News, and General Dynamics manufacture naval combat ships. General Dynamics is also the only U.S. manufacturer of main battle tanks. Indeed, it is worth emphasizing at this point that these companies tend to be diversified defense contractors with a broad range of capabilities, and very few of them focus exclusively on defense electronics. Below these medium-sized companies are a range of smaller second- and third-tier companies who supply components and sub-systems to the prime contractors and tier-one suppliers.

European Response: The New Giants

The emergence of the U.S. industry giants has triggered a scramble to consolidate in Europe in an effort to create firms of a size thought necessary to compete in the new industry structure. The year 1999 saw consolidation in Europe leading to the emergence of two companies that will rival the leading U.S. companies in terms of defense sales. The creation of BAe Systems from the merger of British Aerospace and GEC Marconi Electronic Systems created a UK company with defense sales of more than \$16 billion, making it the second largest defense contractor in the world after Lockheed Martin. Equally, the planned merger of U.S.-German DASA with Aerospatiale-Matra of France and CASA of Spain to form European Aeronautics Defence and Space (EADS) will create a company with defense sales of almost \$7 billion. These recent consolidation moves mean that two of the five largest defense companies in the world are now European.

⁴ By tier-one companies is meant those who supply complete systems and integration skills directly to the prime contractors. Tier-two companies tend to supply sub-systems and components rather than integration services. Their customers are both the tier-one companies and the prime contractors. For a discussion of the defense industry supply chain, see James et al. (1998).

The UK Defense Industry

The UK has the largest defense industry in Europe and is the second largest arms exporter after the United States.

Background

The UK's defense industrial capabilities mean that it is one of very few countries that can design, manufacture, integrate, and market complete sea, land, and air-based systems: fixed and rotary wing aircraft, aero-engines, warships and submarines, air-to-air and air-to-surface missiles, low level air defense, field guns, and military land vehicles.

Since the 1980s, the defense industry has been privately owned. The two leading defense companies are British Aerospace and GEC. British Aerospace is the leading defense and aerospace company in Europe. A manufacturer of military aircraft, missiles, and munitions, it is the fourth largest defense company in the world, although considerably smaller than the leading U.S. companies. GEC, a large diversified industrial group, has major interests in defense electronics and warship and submarine building. In addition, the UK has a strong and diverse group of companies supplying sub-systems and components. These include aero-engine manufacturer Rolls-Royce as well as a sizeable number of smaller suppliers and sub-contractors (James et al. 1998).

The defense industry continues to represent an important part of UK manufacturing activity. In 1996, the industry employed 310,000 people (Bonn International Center for Conversion 1998). This represents roughly 7 percent of the UK manufacturing workforce and does not include indirect employment effects, which are estimated at about 300,000 jobs. The defense sector also makes an important contribution to UK exports. Exports in 1997 increased 10 percent on the previous year to stand at £5.5 billion (6.7 billion ECU) maintaining the UK's position as the second largest defense exporter after the United States (*Jane's Defence Weekly* 1998). Sixty percent of aerospace production is exported—the highest export ratio of any UK industrial sector—and British Aerospace, Rolls-Royce and GEC are consistently in the top five UK exporters (Cabinet Office 1995).

A Wall Of Separation

Historically, scientific and technological development for defense purposes has been organizationally (and often physically) separate from civil science and technology, both in terms of its institutions (with dedicated defense research establishments and defense divisions of multi-business

corporations) and a separate community of practitioners of scientists and engineers working on defense-related activities.⁵ An official report published in 1989 observed that Britain kept the development of defense technologies separate from civil technologies to an unusual degree. It argued that this

[C]oncentration on a mission of national defence contrasts markedly with the attitude of most other countries which recognise the national economic benefits to be obtained from exploiting the synergy between the defence and civil sectors (Advisory Council on Science and Technology 1989).

While most UK defense companies are in fact defense divisions of larger multi-business companies, military and civil production has historically been organizationally and physically separate. The “wall of separation” that has characterized many U.S. defense companies has been just as high in the UK (Markusen and Yudken 1992). Technology transfer between defense and civil divisions has been limited by security concerns, differences in organizational culture, but also (particularly in the case of GEC) internal accounting and budget procedures that have reduced incentives for interdivision knowledge sharing. The situation with regard to smaller suppliers is rather different, and there is considerable evidence of dual-use technological activity among first and second tier suppliers (James et al. 1998).

⁵ The influence of the scale and organization of UK defense technological activities on the innovative and competitive performance of the national economy has been the subject of considerable (and unresolved) debate. This is not the focus of this chapter. However, it is worth noting that the terms of the debate have been similar to that in the United States, with concerns about “crowding-out,” the extent (or lack) of spill-overs from defense to non-defense sectors and the implications for the international competitiveness of defense-dependent companies and sectors. A series of reports during the 1980s, including the 1983 Maddocks Report to the Electronics Economic Development Council, the 1986 report of the Council for Science and Society, and the 1989 report by the Cabinet Office’s Advisory Council on Science and Technology (ACOST), expressed concern at the limited civil benefit obtained from defense R&D spending. The ACOST report estimated that less than 20 percent of the Ministry of Defence’s R&D expenditure was likely to have any applicability in the civil sector, which was attributed to the defense-specific nature of many of the technologies funded, combined with the low spin-off potential of much of the work conducted during the costly engineering development of military systems albeit carried out under the heading of R&D. At the firm-level, the literature on the defense industry has long noted that the relationship between defense companies and their customers has had an important influence upon the character of those companies and, in particular, their competitiveness in non-defense sectors.

The UK Defense Industry In Its National Innovation System

The character of the institutional actors and relationships that comprise the UK National Innovation System remains a key factor in the strategy and competitive performance of the country's defense industry. In this section, I will focus on four aspects of the NIS that are of particular significance: government policy towards the defense industry; expenditure on defense-related science and technology; defense equipment expenditure and procurement reform; and the role of the defense research establishments.

Focusing on these policies and institutions emphasizes the central role of government in shaping the context for innovation in the UK defense industry. This is inevitable in the UK case, partly because of the government's responsibility for national defense and as the defense industry's principal customer, but also because of the continuing importance of its expenditure on defense-related R&D and its policies towards the consolidation of the European defense industry and arms exports.

There are other facets of the National Innovation System that could be considered, such as the defense industry's relationship with UK universities, the financial capital markets and so forth. These have been the subject of comment in recent official reports (House of Commons 1993; Cabinet Office 1995; House of Commons 1995). However, within the constraints of time and space, I have chosen to focus on the four aspects that are generally regarded as being of most direct relevance to the UK defense industry.

Relationships between the defense industry and the National Innovation System have undergone important changes over the last decade. Such changes have had an impact on the strategy and competitiveness of defense companies and have, to some extent, driven their growing internationalization. The changes have also prompted a series of official reports to express concerns about the UK defense industry's position relative to other countries.

Government Policy Towards the Defense Industry

Government policy towards the defense industry is clearly of central importance both in determining the ownership of defense companies, and their relationship with the European industry and in regulating exports. However, it ought to be noted that, historically at least, the Ministry of Defence has not seen itself as having an industrial sponsorship role. Consequently, the UK has not had an explicit defense industrial policy. This has been the subject of considerable debate during the

1990s, with criticism of the Ministry of Defence for its failure to recognize its responsibility to ensure the health of the defense industrial base.

One of the key legacies of the Thatcher era, as far as the UK defense industry is concerned, was the privatization of state-owned defense companies. I have already noted that the leading defense companies were privatized during the 1980s, making the UK defense industry very different from many others in Europe where defense companies remain in state ownership. There is little doubt that this has placed the UK defense industry in a strong position in the European context. Privatization has meant that UK companies have been freed of many of the political constraints on national level rationalization that have limited restructuring in some other European countries. Consequently, restructuring of the UK defense industry began rather earlier than in most other European countries. Most significantly for European restructuring, in France, the consolidation process has been inhibited by the structure of the defense sector and in particular the role of social, industrial, and economic considerations. This has resulted in what Hébert has described as “contained conversion,” with the French state seeking to delay key decisions on the defense industry for as long as possible (Hébert and de Penanros 1995).

At the same time, privatization decisions and competition in the procurement process have also made UK defense industry more competitive than some other parts of Europe, and UK defense contractors such as British Aerospace are generally regarded as being at the leading edge of organizational and process innovation in such areas as supply chain management. Thus, a 1998 *Aviation Week and Space Technology* survey identified British Aerospace and Smiths Industries as being among the best managed companies in the industry (Velocci 1998).

The UK has also been a prime mover at the government level in encouraging the consolidation of the European defense industry. In part, this is based on a belief that the combination of profitable private sector companies, strong export performance, and access to both European and U.S. markets, means that the UK is well placed to benefit from European restructuring.

To some extent, the dynamics of European rationalization match UK market power against the political power of France through its relationship with Germany and the portrayal of the UK defense industry as a “Trojan horse” for U.S. interests. Certainly, as a 1998 policy document from the Society of British Aerospace Companies makes clear, UK defense companies recognize the importance of the UK government in ensuring the outcome of the rationalization process is to the benefit of UK companies and in blocking any emergence of a “Fortress Europe” that would inevitably

damage UK companies with their strong transatlantic relationships (Society of British Aerospace Companies 1998a). At the same time, the UK defense industry is also pressing hard for government support for European Union level funding of aerospace technology and the development of a common European weapons acquisition process and a more open and competitive European defense equipment market.

The UK government has long supported defense exports both through financial support and diplomatic efforts. Such support increased markedly in the 1980s. However, the election of the new Labour Government in 1997, with its commitment to an “ethical foreign policy” and stricter controls on the arms trade, has caused some tensions with the defense industry. While the new Government has made it clear that it continues to support arms exports, some defense exporters have claimed that new regulations have slowed the export licensing process and threaten UK competitiveness in some export markets.

Government Expenditure on Defense-Related Science and Technology

The defense industry has always had a privileged position with regards to government science and technology funding and a heavy commitment to defense technology, and the unusually high proportion of funds spent on defense R&D has long been a characteristic of the UK’s National Innovation System (Walker 1993). From the late 1960s until well into the 1980s, half of government expenditure on research and development (R&D) went on defense, and the percentage was even higher in earlier years.

Indeed, despite recent cuts, the UK continues to spend, by international standards, an exceptionally high proportion of public research and development funds on defense-related objectives (James and Gummett 1998). Among the leading industrial countries, only the United States devotes a higher proportion of public R&D expenditure to defense, and government-funded defense R&D as a percentage of GDP is higher in the UK than in Germany, Japan, or Canada—but lower than in France or the United States and, in recent years, Italy.

Nevertheless, a number of recent official reports have noted that UK expenditure in absolute terms is falling behind that of France, Germany, and the United States. While government funding for defense R&D in the UK fell by 25 percent in real terms in the period 1985-1992, it increased in France (up 36 percent), Germany (up 24 percent) and the United States (up 7 percent) (DTI/OST 1996b). At the same time, industry expenditure on R&D is declining, not least as a result of the

reform of the Ministry of Defence's procurement process and, in particular, a shift towards more competitive Commercial Off-The-Shelf (COTS) procurement of defense equipment.

Consequently, the 1995 Defence and Aerospace Foresight Report noted that declining government and industry R&D expenditure threatened UK competitiveness and called on industry and government to reverse the decline in UK spending on research and technology demonstration.⁶

Defense Equipment Expenditure And Procurement Reform

The Ministry of Defence is the main customer for the UK defense industry. Consequently, the size of the defense equipment budget and the mode of procurement of that equipment is of key significance to the UK defense industry. The defense equipment budget has fallen substantially during the 1990s. Defense procurement expenditure in 1996/97 was £9.052 billion, compared to £9.86 billion in 1990/91—a decline of 8 percent in cash terms, and considerably more in real terms.

At the same time, the Ministry of Defence's approach to defense procurement has changed, with significant implications for the strategies of UK defense companies. During the 1980s, the Ministry of Defence introduced a number of initiatives with the objective of instilling a more "commercial" attitude in the market for military equipment. This shift in approach coincided with the appointment of Sir Peter Levene as head of the Ministry of Defence's Procurement Executive. The so-called "Levene reforms" increased the use of competitive tendering procedures in tandem with the imposition of more stringent contracts, which shifted responsibility for the risks associated with the development and production of defense equipment away from the Ministry of Defence to the defense contractors themselves. Cost-plus profit contracts were reduced in favor of incentive-based, target-cost, and fixed-price contracts specifying more stringent conditions and a shift towards commercial off-the-shelf procurement (James and Watts 1996).

In so doing, the Ministry of Defence changed the basis of its relationship with its suppliers, promoting more open competition instead of a system based on sustaining preferred suppliers. The

⁶ This report was published as part of the wider UK Foresight exercise that sought, through sectoral Panels comprised of representatives of government, industry and the scientific and engineering communities, to inform the Government's decisions and priorities in the area of science, engineering and technology. The fact that Defence and Aerospace had its own Panel is significant in itself, and says much about their importance in the UK National Innovation System. The inclusion of defense and aerospace as a specific area of attention made the UK Foresight exercise different from its German and Japanese counterparts (James and Gummett 1998).

result was a toughening of the competitive environment for defense firms, and a growing volume of criticism of the Ministry of Defence by industrialists for its alleged failure to realize the need for partnership and stability in the long-term development and maintenance of technological capabilities.

Whether such criticism was “special pleading” by an industry long used to a cosy relationship with a monopsonistic customer or reflected real problems within the defense innovation system is difficult to test empirically. However, it is clear that, in the perception of industry, the old relations of trust and cooperation between themselves and the Ministry of Defence had been replaced by a more straightforwardly commercial relationship. Criticisms have been raised that this emphasis on “value-for-money” paid little attention to concerns about its implications for UK defense industrial capabilities.

A series of official reports during the mid 1990s reflected industry concerns about the procurement system, raising two broad concerns. First, that the procurement system defined defense considerations and interpreted value-for-money too narrowly and failed to give sufficient weight to the wider technological and industrial implications of its procurement decisions. Thus, the Defence and Aerospace Foresight Report warned that the UK’s leadership in the trend towards more off-the-shelf purchases posed real threats to the medium to long-term capability of the UK defense technology base (Cabinet Office 1995). Similarly, the Ministry of Defence’s lack of formal responsibility to foster the strength of the defense industrial base or wealth creation, was noted by the 1995 joint report of the House of Commons Defence and Trade and Industry Select Committees (House of Commons 1995).

These reports also expressed concerns that foreign (for this, read American) firms had unfair advantages over UK firms in the UK procurement process. They argued that changes in government R&D funding meant that UK firms were expected to fund an increasing proportion of R&D expenditure, while their major competitors in France, Germany and the United States were benefitting from increasing government R&D funding. The size of the U.S. market meant that U.S. companies could benefit from the lower unit costs of longer production runs and benefit from government R&D support. The Foresight Report warned that this meant that equipment based on UK technologies would be replaced by equipment where UK companies would act as partners to U.S. companies, putting at risk the UK’s technological capability and its ability to participate in future collaborative projects or compete in the world market (Cabinet Office 1995).

In the context of these mounting concerns, the Ministry of Defence has, in recent years, signalled a shift towards a more explicit and public recognition of its role in the maintenance of national defense industrial capabilities. This changing attitude has been reflected in recent statements on procurement policy. Take, for example, the 1996 Statement on the Defence Estimates which comments:

We recognise the need to take defence industrial factors fully into account in our decision-making. . . . Where relevant, we consider the defence case for seeking to retain particular United Kingdom-based defence industrial capabilities. . . . (MoD 1996).

The publication in 1996 of an explicit statement of the Ministry of Defence's technology strategy and its priorities for defense research appears to have signalled a change of approach, not least an increased concern about critical technologies and the Ministry of Defence's role in influencing the character of the defense technology base. Publication of the Technology Strategy came after long-running calls in official reports for greater openness and the feeling that the Ministry of Defence lacked a coherent and well understood strategy to guide its procurement decisions that could help defense contractors in formulating their business and technology strategies.

Another potentially important shift has been signalled in the new Labour Government's 1998 Strategic Defence Review (MoD 1998). The Strategic Defence Review, a comprehensive review of UK defense policy, announced plans for significant changes to the procurement system and the introduction of what the Ministry of Defence has called "smart procurement." While details remain somewhat limited, it appears that the changes seek to address some of the recommendations of earlier official reports. The aim is to streamline and improve procurement processes, with increased emphasis on partnerships between Ministry of Defence and defense firms to more closely involve them in the definition of operational equipment and its development. In spirit, at least, it appears to signal a shift away from a strict interpretation of value-for-money towards a partnership-based approach to procurement. If this develops in practice, then it is likely to lead to a change in the relationship between the Procurement Executive and UK defense companies.

The Defense Research Establishments

Another important change in the context for innovation in the defense industry has been in the government's defense research establishments. The defense research establishments are an

important part of the UK National Innovation System. Approximately one-third of the government's defense R&D budget is spent in these research establishments, and the Defence Evaluation and Research Agency is the largest research organization in Europe, with more than 10,000 employees. These defense research establishments have experienced considerable changes during the 1990s both in their internal organization and their relationships with the Ministry of Defence and defense companies.

The Ministry of Defence's own research establishments comprise the Atomic Weapons Establishment (AWE) and the Defence Evaluation and Research Agency (DERA). AWE has responsibility for the design, development, and manufacture of the UK's independent nuclear deterrent. DERA supplies scientific and technical services to Ministry of Defence in the areas of strategic research, applied research, operational assessments and studies, project support, the formulation of operational requirements, and equipment testing services and quality assurance. It does this partly through its own laboratories and test facilities, and partly by placing contracts with industry and universities. It also provides scientific and technical services to other government departments and to other public and private sector customers where this supports the achievement of its main objectives.

Both organizations have experienced significant organizational changes. In 1993/94 management of the Atomic Weapons Establishment became the responsibility of a private contractor—Hunting-BRAE. DERA was established (in its earlier form as DRA) in 1991 as an Executive Agency of the MoD. This was part of a wider initiative to move civil service organizations into a more commercial relationship with government, while still leaving them under ministerial control. The aim was to improve performance by introducing a more commercial style of management, freed from traditional civil service constraints. In 1998 the government announced its intention to explore the possibility of some form of Public Private Partnership for parts of DERA, which would introduce private sector participation in the ownership of the organization and would mark an even more fundamental shift in its relationship with the Ministry of Defence (MoD 1998). These privatization plans have run into significant political difficulties, however. The proposals were heavily criticized in a report by the House of Commons Defence Select Committee. At the same time, the U.S. Department of Defense has expressed serious reservations about its implications for the long established relationships between UK and U.S. government defense research establishments.

The changes in DERA have altered its relationship with defense companies as well as with the Ministry of Defence. The defense research establishments and large UK defense companies have

traditionally had a close working relationship. DERA subcontracts work to industry and academic institutions worth between 30 percent and 50 percent of the organization's annual research funding and in 1996-97 such extramural research cost DERA £162 million (House of Commons 1998). This is DERA's principal mechanism for involving industry in defense research and an important mechanism for transferring the benefits of its work to the defense industry.

The move towards greater commercialization of DERA's activities has generated some tension in this relationship. A 1995 joint report by the House of Commons Defence and Trade and Industry Select Committees noted that companies had three broad concerns about DERA: whether enough of its research was contracted out to industry; whether it duplicated industry's own research; and the availability of DERA's research to companies (House of Commons 1995). Indeed, DERA's Chief Executive himself noted in 1996 that "There is deep unease at the working level in UK defense industry about DERA and its objectives" (DERA 1996, p. 7). Such concerns remain, and were the subject of comment in the House of Commons Defence Select Committee's 1998 report on DERA. The Report noted that a recent DERA survey had found that most industry representatives considered that the organization's pursuit of non-Ministry of Defence income had interfered with its relations with industry, and a fifth of the respondents considered that relations with DERA had been severely damaged by the introduction of competition between the Agency and the industry (House of Commons 1998). Clearly, any problems in the relationship between a key technological resource and companies has potentially important implications for the technological performance of the UK defense industry.

The National Innovation System And Defense Industry Competitiveness

A recurring theme in recent years has been that these changes in the National Innovation System, and company responses to those changes, are reducing the competitiveness of the UK defense industry. Official reports on the UK defense and aerospace sector have expressed concern about the future of the UK defense technology base and called for greater government support for the defense and aerospace sector. The 1993 House of Commons Trade and Industry Select Committee Report on the British Aerospace Industry, for instance, called for greater government support for the aerospace industry and warned that

There is no likelihood of a sudden decline of the UK aerospace industry in the short or medium terms. Instead, without the renewed government commitment we call for,

there is the possibility of a gradual loss of market share as its technologies are surpassed by competitors and ageing products fail to be replaced. The damage would be done before it became obvious, and would probably be irreversible . . . there could be relative or even absolute decline in the British aerospace industry which reflected not market forces but the fact that competitors received greater assistance from their governments (House of Commons 1993, paras. 130-31).

Similarly, the 1995 report of the Technology Foresight Defence and Aerospace Panel contains a strong warning about the UK's technological competitiveness. The Foresight Panel observed that the success of the defense and aerospace industry derived largely from the previous levels of investment by industry and government in research, development, and procurement in the 1970s and 1980s, and the Panel report identified

[T]he concern that the UK today is consuming its technological inheritance. Current UK success derives from past farsighted R&D programmes, particularly in government establishments and in industry, which have yielded world class technology. The UK must continue to make sufficient investment in key technologies and in technology demonstrators for continued success. This will require a national strategy and concerted investment in new technology (Cabinet Office 1995, pp. 18-9).

Many of these concerns have been framed in terms of the implications for the competitiveness of the UK defense industry in UK and export markets and as a partner in future collaborative projects. Thus, considerable emphasis has been placed on the importance of the UK sustaining and enhancing the key technological capabilities necessary to win a leading position in future collaborative programs, whether those are with U.S. or European partners. In this respect, above all others, the National Innovation System remains a key factor in the strategy and competitive performance of the defense industry.

However, a purely national perspective is no longer appropriate to the study of the UK defense industry. Indeed, it probably never has been in the modern age. The remainder of this chapter considers the role of the UK defense industry in transnational Sectoral and Technological Systems and how the interaction of National, Sectoral and Technological Systems influence the context for innovation in the UK defense industry.

Beyond The National Innovation System

Economic, technological, and policy developments mean that the institutions and relationships that contribute to the generation and application of technologies used in the UK defense indus-

try are increasingly transnational in character. In this respect, the UK is little different than many other countries (including the United States), as countries have become more interdependent in defense-related technologies (Edmonds et al. 1990).

While the UK defense industry has a broad range of defense industrial and technological capabilities, the UK accepted in the 1950s that self-sufficiency was beyond the resources of the country (Edmonds et al. 1990). Subsequent policies have encouraged weapons collaboration with European partners and close relationships with the United States in some technologies. At the same time, the UK has long imported some weapons systems, particularly from the United States. In this vein, the Defence and Aerospace Foresight Report noted that the UK could not lead across the whole spectrum of defense and aerospace, but needed to focus its strengths in the sub-sectors that are important for national security or where there is significant potential for wealth creation (Cabinet Office 1995).

A number of economic, technological and political factors are driving this trend towards growing interaction and interdependence:

First, the cost of developing weapons systems and the technologies that underpin them is escalating; few countries (with the exception perhaps of the United States) have military markets that are sufficiently large for the cost-effective design, development, and manufacture of such systems.

Second, technological change and complexity means that individual countries find it increasingly difficult to keep abreast with technological developments across the whole spectrum of military equipment.

Third, technologies are increasingly dual-use: advanced technologies of civil origin may be required in defense equipment, and scientific and technological knowledge is increasingly international, and the innovation process has an increasingly distributed character.

Finally, political factors are encouraging closer integration within Europe, both in research and technological development and (more controversially) in the fields of defense and security. The Western European Union/Western European Armaments Group is seeking to encourage increased European defense industrial cooperation and a European equipment market, and has responsibility for the EUCLID cooperative research and technology program. At the same time, OCCAR (Organisation de Coopération Conjointe en Matière d'Armement) is seeking to develop common procurement methods for Europe that will take both less account than in the past of *juste retour* and more account of managerial effectiveness, and also an institution that may ultimately be merged into a

European armaments agency. However, the significance of many of these actions is as much symbolic as anything else; there are formidable political barriers at the national government level to closer cooperation in the fields of defense and European security.

Similarly, various efforts by the European Union have been constrained by national political factors. The European Commission has expressed its opinion on matters related to the restructuring of the defense-related industries in two recent Communications (Commission of the European Communities 1996 and 1997). At the same time, while the Community's Framework Programme for Research and Technological Development is aimed at civil objectives, it can support the development of civilian applications of technologies of defense origin through technology transfer and R&D cooperation between civil and defense-related organizations. Defense-related organizations such as British Aerospace, Rolls-Royce, DASA, and DERA are active participants in Community programs, and the European Commission has estimated that between one-quarter and one-third of Framework Programme funding could be described as dual-use.

Defense As A Sectoral Innovation System⁷

It is increasingly appropriate to consider the UK defense industry as being part of a Sectoral System for the design, development, manufacture and sale of defense equipment.

Institutions of the Defense Sectoral Innovation System

Following Breschi and Malerba's (1997) conceptualization of Sectoral Systems, I consider the Defence Sectoral Innovation System to be comprised of those firms and other organizations that are active in the design, development, manufacture, and sale of defense equipment. Its distinctive-

⁷ In the remainder of this chapter, I follow the distinction drawn in parts of the innovation systems literature between Sectoral Systems (with their emphasis on that group of firms and other organizations active in developing and making a sector's products and utilizing its technologies) and Technological Systems (with their emphasis on dynamic knowledge and competence networks). In practice, the distinction is rather hard to draw in some circumstances. Empirically, the content of relationships is not always clear. Theoretically, the definitions overlap in some respects, not least because the specific technologies that are the focus of the Technological System perspective will also be utilized within the Sectoral System. However, bearing these caveats in mind, the distinction seems worth drawing, not least because it emphasizes that the innovation process involves much more than technology alone, and that knowledge/competence flows may be rather different from the flow of goods (in this case, defense equipment).

ness as a Sectoral System comes from its product—defense equipment—and its customers—the Ministries of Defence of national governments. The Sectoral System gains its coherence through the inter-relationships of firms through both competition and collaboration.

Note that I regard defense-related *firms* to be the main institutional components of the Sectoral System. These firms may be prime contractors, but may equally be suppliers of sub-systems and components. These firms may be defense specialized but (especially at the supplier level) they are also increasingly dual-use (James et al. 1998).

Competition as well as cooperation structures the Defence Sectoral Innovation System. Thus, competition among defense firms influences the context for innovation and the strategies of individual firms. Clearly, a central concern for UK companies is how they should respond to the growing dominance of U.S. defense companies. Of course, what has emerged from the restructuring process is a defense sector where a fragmented European industry faces a number of very large U.S. companies. Once post-merger integration is completed, these companies are likely to achieve competitive advantage from economies of scale and scope with regards to production and the development of technology. Notwithstanding the barriers to integration at the European level, the threat posed by the U.S. defense industry is increasingly driving European companies to seek to consolidate. At the same time, UK companies more than any others in Europe, have sought to collaborate with the U.S. giants by building on existing transatlantic relationships.

UK defense companies face competition not only in export markets but also in their domestic markets. There is competition, as I have already noted, in the procurement system for defense equipment in the UK and this drives the strategies of UK defense companies. Competition has forced them to reduce costs and also to seek collaborative relationships with companies who can provide access to off-the-shelf technologies, thus reducing development costs. In practice, that frequently means U.S. companies.

Cooperation In The Sectoral System

UK defense firms interact and cooperate with other firms within the Sectoral System through a variety of relationships. These include: collaborative consortia; cross-border ownership; joint ventures; and supply chain relationships. These types of relationship are not new—what is distinctive is the significant growth in these kinds of transnational relationships during the 1990s.

Bilateral and multilateral consortia to develop major weapons systems have been a common form of transnational relationship for a number of decades. European consortia have tended to arise out of intergovernmental agreement and have typically been based on the *juste retour* principle of work sharing among partners. In military aircraft, the UK and France cooperated from the 1960s to develop the Jaguar ground-attack aircraft; in the 1970s a UK-German-Italian consortium developed the Tornado; and Eurofighter is a consortium of companies from the UK, Germany, Italy and Spain. In naval systems, the Horizon next-generation frigate is being developed by a UK, French, and Italian consortium. At the same time, UK companies have close relationships with U.S. companies. British Aerospace has had a long standing cooperation agreement with McDonnell-Douglas (Boeing) and is teamed with Lockheed-Martin on the Joint Strike Fighter program.

European firms have encountered important barriers to transnational mergers and acquisitions. These barriers have included state ownership of some of Europe's largest companies, varying corporate legal frameworks, and significant differences in production costs between national defense industries and defense contractors. At the same time, defense continues to be viewed as a sector of strategic significance by national governments, who therefore actively scrutinize foreign interventions (Commission of the European Communities 1997; Gummert and Stein 1997; Lewis and Starr 1997).

Nevertheless, the situation is changing. The December 1997 joint statement by the governments of the UK, France, and Germany, which asked their national aerospace and defense industries to draw up plans for restructuring, suggested that national governments, having long lagged companies regarding these matters, had accepted the importance of such changes (Lewis 1997). The imminent formation of EADS, along with a revised corporate organization for Airbus Industries, is the outcome of this new found national will to achieve restructuring of the European aerospace industry.

UK companies already have some limited stakes in other European firms. British Aerospace recently took a one-third stake in SAAB as an expansion of an earlier marketing and production arrangement with the Swedish company. In 1997, Matra-British Aerospace Dynamics, a joint venture between France's Lagardere and British Aerospace, took a 30 percent stake in DASA's LFK missile subsidiary, and British Aerospace and DASA acquired the defense electronics assets of Siemens.

UK companies also have significant interests in the United States. GEC has acquired Tracor, the U.S. defense electronics company, to add to its existing U.S. defense electronics interests and has made approaches to Northrop-Grumman. Rolls-Royce acquired the Allison Engines Corp. in the

mid-1990s. Indeed, a recent industry survey estimated that UK-owned aerospace assets overseas (defense and civil) amounted to £2.3 billion, employing more than 25,000 people. This makes the UK aerospace industry one of the most globalized in the world (Society of British Aerospace Companies 1998b).

At the same time, it is worth noting that there is a small but significant degree of foreign ownership of UK defense companies. Issues related to the integrity of the defense industrial base have led the government to restrict the share of foreign ownership in major privatized defense contractors such as British Aerospace, Rolls-Royce and VSEL. Foreign firms have, however, been allowed to buy into the UK defense industry. Examples include Bombardier of Canada, which controls Shorts; Raytheon Systems; and, most controversially at the time, United Technologies, which took control of Westland Helicopters in 1986 (subsequently selling the business to the UK's GKN).

The considerable political constraints on cross-border ownership means that, in Europe at least, joint ventures have so far been the main mechanism for consolidation. Thus, Matra-British Aerospace Dynamics is a joint venture between France's Lagardere and British Aerospace. GEC has formed a joint venture (Matra Marconi Espace) with Matra over space interests, with Thomson of France over sonar (GEC Thomson Sonar), and with Italy's Finmeccanica. Many of these relationships between UK and European defense companies have been driven by concerns about work-sharing or economies of scale in production. However, it is also worth noting British Aerospace's technology demonstration program with Dassault as an example of a collaboration driven principally by technological motives and to emphasize that many relationships established for other motives develop an increasing technology component (for example, the British Aerospace-SAAB relationship).

UK firms also participate in the wider Sectoral System through supply chain relationships. Thus, Edmonds et al. (1990) have noted the extent of interdependence between countries through the supply of specialized systems and components. UK prime contractors rely heavily on U.S. suppliers of specialized sub-systems, although the extent of this dependence is hard to quantify. Certainly, the UK defense electronics industry is largely dependent upon overseas companies for components, and the Ministry of Defence places few restrictions on the use of foreign components and sub-systems in "British" defense equipment, preferring instead to devolve decisions to prime contractors with the key emphasis being on cost-competitiveness and not nationality of ownership (Taylor and Hayward 1989). Interestingly, the impression is that these supply chain relationships

are perhaps better developed than those *within* Europe, where there is surprisingly little evidence of a single market in defense-related components (James et al. 1998).

Technological Systems

The focus of this section will be on Technological Systems, those dynamic knowledge and competence networks involved in the generation, diffusion, and utilization of specific technologies. These technologies are used within the Defence Sectoral Innovation System in the design, development, and manufacture of defense equipment. Such Technological Systems may be comprised primarily of actors from the Sectoral System, but the emergence of dual-use technologies means that they are increasingly likely to be of civil origin.

The UK defense industry has long participated in transnational knowledge and competence networks. In part, this is a result of the recognition on the part of the UK government that certain classes of defense technologies were simply too costly to develop alone. More recently, it reflects the emergence of dual-use technologies that have their origins outside the Defence Sectoral Innovation System.

Defense-Related Technological Systems

The UK has long been part of international relationships for the development of specific defense technologies. In particular, the United States has played a key role. Thus, the UK's relationship with the United States on nuclear technology dates back to the 1950s, and the UK's "independent" nuclear deterrent, from Polaris to Trident, has been heavily dependent upon U.S. technological cooperation. Equally, the UK also has a long-standing technology transfer agreement on stealth technology stretching back over three decades, which is believed to include a classified demonstrator program conducted jointly by the UK Ministry of Defence and the U.S. Department of Defense (Cook 1998). The outcome of bilateral talks between the United States and UK on possible expansion of the UK's access to classified U.S. stealth technology is seen to be a key factor in the viability of the UK's plans for its Future Offensive Air System (Barrie and Hitchens 1998).

While the defense research establishments have played a central role in these Technological Systems, defense companies have also participated, both through collaboration with U.S. companies and by undertaking contract research for DERA, the U.S. Department of Defense, and other bodies. DERA is engaged in a range of international collaborative research and technology relationships.

Ministry of Defence policy sees international collaboration as attractive in reducing costs. The Ministry of Defence currently has collaborative research programs with 20 countries to which it commits 10 percent of its research resources, and effort is being directed to increasing this proportion. International collaboration is seen by the Ministry of Defence as a good way of promoting technology exchange, leveraging greater returns on investment, and providing wider benefits from exposure to multinational debate on defense research needs and key technologies as well as issues surrounding arms and export controls.

Among the bilateral and multilateral research programs in which the Ministry of Defence participates are the Anglo-French Defence Research Group, the Technical Cooperation Programme (with the United States, Australia, Canada and New Zealand), the NATO Defense Research Group, and the Western European Armaments Group's European Cooperation for the Long-term in Defence (EUCLID) program. In addition, the Ministry of Defence has also collaborated with the United States since 1985 on technologies related to Ballistic Missile Defense (DTI/OST 1996a; MoD 1996). In a recent initiative, the United States, the UK, France, and Germany have established committees to consider new ways of cooperating on international arms research, development, and procurement. The UK is heading a panel on sea systems and the United States a committee on space and command, control, communications, computers, and intelligence/surveillance. France chairs a committee on air systems, and Germany leads on land systems. The goal is to prioritize future military needs in each area and determine how best to cooperate in developing systems to meet those needs. If successful, the initiative may be expanded to include the participation of other NATO countries (*Jane's Defence Weekly* 1997). Reflecting the changes in the international environment, there are on-going discussions on defense technology with South Africa and a number of Eastern European states as well as a recently signed defense research and technology agreement with Sweden.

Dual-Use

Leadership in the development, design, and manufacturing of many key technologies with defense applications now resides not only with the government or the traditional defense industrial base, but also in commercial industry. With the emergence of these dual-use technologies and the decline in defense-related R&D expenditure, technology acquisition, especially at the sub-component level, is increasingly coming from the commercial sector. Defense companies have retained in-house design and production capabilities for the most sensitive and defense-specific components,

but they increasingly find themselves part of wider Technological Systems that extend beyond the defense sector. Thus, most semiconductors used in UK defense systems are sourced from commercial suppliers and many are imported, from the United States or South East Asia (Edmonds et al. 1998). The Foresight Defence and Aerospace Report noted that in technological terms the UK is lagging in areas, such as off-the-shelf electronic components, in which off-shore suppliers dominate the market (Cabinet Office 1995).

At the policy level, collaboration with the civil sector is seen as increasingly attractive by the Ministry of Defence, as it can encourage the use of dual-use technologies in defense applications. Interestingly, the Government's recent discussion (Green) paper on its proposed Defence Diversification Agency within DERA suggests that it will pay as much attention to the scope for the spin-in of technology from the civil sector as it will the spin-out of defense origin technologies to new civil applications.

Co-Evolution And The Shaping Of The UK Defense Industry

In this chapter I have sought so far to describe the UK defense industry in the context of three interlinked systems. Thinking about its place in the UK National Innovation System is no longer sufficient. Instead the strategy and competitive performance of the defense industry is increasingly shaped by its position at the intersection of distinct but overlapping National, Sectoral, and Technological Systems. These systems are part of a co-evolutionary process that shapes the context for innovation in the UK defense industry. A change in one system is likely to lead to changes in the others. The relationships are complex, but three examples serve to illustrate this co-evolutionary perspective.

Procurement Reform

The changes in the procurement system brought about by the Levene reforms provides a good example of co-evolution. In this case, change in the National Innovation System altered the competitive landscape of the Defence Sectoral Innovation System. UK defense companies, as we have seen, were forced to adapt their behavior to the new environment. They sought to reduce their production costs, increase dual-use technology acquisition, and develop collaborative bid strategies with foreign partner companies. At the same time, the emphasis on value-for-money and open competition presented new competitive opportunities for non-UK (principally U.S.) defense contractors.

The U.S. Competitive Challenge

A second example is provided by the competitive challenge from the U.S. defense industry. U.S. merger and acquisition activity has changed the terms of competition within the Defence Sectoral Innovation System. Not only has it driven changes within the Defence Sectoral Innovation System, but it has driven pressures for change in the UK National Innovation System. Thus, as I have noted, there have been growing calls for increases in defense-related R&D expenditure while the UK government has adapted its policy regarding transnational collaboration to embrace broader and deeper relationships with the United States and allies in Europe and elsewhere.

Dual-use Technologies

A final example is provided by the emergence of dual-use technologies. As we know, the rate of technological change in some Technological Systems dominated by civil users has meant that technological leadership in some fields has shifted from defense to civil-origin technologies. The consequence of these changes within Technological Systems has been to prompt changes in the National Innovation System as the Ministry of Defence and DERA have sought to spin-in technologies of civil origin. At the same time, companies within the Defence Sectoral Innovation System have sought to adapt their approach to technology acquisition.

Inevitably, these examples provide a rather crude “story” of what are complex issues. My objective has been to try to show that the UK defense industry is at the intersection of three distinct but overlapping systems. Each system influences the context for innovation in the defense industry and the strategy and competitive performance of defense companies. I believe that this perspective has some merit, although it requires further development.

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Ideas, Identity and the Limits of European Defense Technology Cooperation

Eugene Cobble

Among students of European integration there exists a pervasive, or rather a perverse, tendency to see Europe in realized terms. Too often, we become enamored with the rhetoric of manipulative national actors and self-promoting Europeanists who speak of a Europe that *is*, proclaiming the existence or sanctity of nearly everything European—a *European* technology base, a *European* aerospace industry—or of an effective and vibrant, collective *European* identity. Reality, of course, is not nearly so rosy. The states of the European Union (EU) are today closer toward a consensual political confederation and economic union than at any other time in their history, bound together under a dense web of organizations and initiatives that have brought greater harmonization, cooperation, and even incremental integration. Nonetheless, despite forty years of progressive reinterpretations of state sovereignty and of institutional innovation that have propelled the integration movement forward, “Europe” remains a potentiality—a whole that is less than the sum of its parts. There is no single defense industry, or technology policy, or for the moment, even a common currency; there are instead more than a dozen distinct state actors who admittedly too often acknowledge a European interest only when it is compatible with their national interests.

In the absence of radical change, the dynamic between existing state identities and a nascent European identity is hard to gauge. Numerous *Eurobarometer* polls and other surveys conducted over the last thirty years indicate that a discernible European identity now coexists along with fifteen separate national identities.¹ Although this collective identity is clearly the weakest facet within a hierarchy of local, regional, and state identities, its existence raises the question as to its ability to influence state policy. Thomas Risse argues that without substantive ideational transformations among state actors—the formation of a Deutschian community founded upon the convergence of interest, mutual sympathies, and a “we-feeling”—European integration will not proceed.² The

¹ For a focused review of popular attitudes concerning “European” solutions toward national security issues see Werner J. Feld, *The Future of European Security and Defence Policy* (Boulder, CO: Lynne Rienner, 1993), ch. 5, 11.

² Thomas Risse, “Identity Politics in the European Union: The Case of Economic and Monetary Union,” unpublished paper (March 1997), p. 6; Karl Deutsch, et al., *Political Community and the*

“collaborations of nations” that are the foundation of Europe will remain just that, and the necessary *integrations* of policies and markets that would mark the transition of the EU into a more state-like entity will not occur.

To mark the extent of a transnational European identity, therefore, is to denote the outer frontier of the union project. In an association of still sovereign states, however, analysis requires one to be sensitive to nuances of behavior that may betray a sensitivity to what Risse labels as “ideas of a collective Europeaness.”³ Here, one might expect a greater propensity for diffuse reciprocity, or in-group solidarity, or asymmetrical distributive outcomes, or just a simple willingness to aggressively pursue intra-regional cooperation in areas that have been traditionally dominated by the imperatives of state sovereignty. I contend that recent efforts to create a European system of innovation in both civil and defense technologies offer an excellent example of the limits of a collective European identity in shaping state behavior. Arguably none of the prominent examples of initiatives to promote multilateral cooperation in Europe such as BRITE or ESPRIT are themselves exemplars of “community spirit.”⁴ Nonetheless, differences in their organization and execution demonstrate the boundaries of European solidarity.

This chapter is a study of the failure of Western European states to institutionalize and multilateralize their cooperation in defense R&D within the European Cooperative Long-term Initiative in Defense (EUCLID) program, using a comparison between it and its nearest civilian counterpart: the European Research Coordination Agency (Eureka) initiative. Both are intergovernmental in nature; both stress the pursuit of national interest and oversight; both are organizationally minimalist, having been explicitly designed to produce as small a bureaucratic footprint as possible; and both focus upon enabling technologies, either at the precompetitive or intermediary stages of development. Yet here, the substantive similarities end. Eureka and EUCLID differ in terms of technological focus and outcome. The former is implicitly civilian; the latter is the only effort of its kind in the defense realm in Western Europe.

North Atlantic Area (Princeton: Princeton University Press, 1957), p. 36.

³ Risse, “Identity Politics,” p. 6.

⁴ BRITE: Basic Research in Industrial Technology for Europe; ESPRIT: European Strategic Programme for Research and Development in Information Technology

Eureka is a qualified success, promoting the europeanization of civilian R&D in Europe and the development of research contracts worth billions of ECU. Moreover, as Margaret Sharp notes, it has helped set the foundations for a regional technology base by creating “a complex network of horizontal and vertical collaborations [pulling] together the capabilities and resources of the Community across national boundaries and across old institutional divides.”⁵ EUCLID is, on the other hand, little more than a footnote—yet another failed or faltering effort among many to create a single European defense market. It suffers from the profound neglect of the same states who initiated it eight years ago to ease the national fragmentation of their collective defense effort. EUCLID has been under-funded and under-utilized in favor of national defense R&D programs and more limited interstate cooperative ventures.

That this discrepancy exists is a puzzle. After all, Europe enjoys the highest level of internationalized R&D of any region in the international system. Moreover, whereas this process has solidified with the emergence of the single European market in the early 1990s, it emerged first in the defense field nearly forty years ago in the late 1950s. At that time, the burdens of rapid technological change and spiraling development costs first began to compel European states to pool their resources and to share both the expense and risks of defense technological innovation.⁶ Today, Europeans face increasing pressures to embrace multinational defense procurement, as inter-generational enhancements have made some high technology weapons systems too costly for even medium-sized powers to develop unilaterally.

Further complicating the situation is the transformed relationship between the production of civilian and defense technologies, particularly the former’s new significance as an engine of technological development. In the 1950s, 1960s, and early 1970s, the civilian technology base benefitted from higher levels of military demand and military R&D financing of high technology. Today the reverse is true: the defense technology base is not only dwarfed by its civilian counterpart, it is dependent upon it as a source of innovation for materials, components, and complete systems in the form of dual-use goods. Consequently, the divisions between civilian and military technologies have blurred. The significance of this transformation in the European context cannot be overstated.

⁵ Margaret Sharp, “The Community and New Technologies,” in *The European Community and the Challenge of the Future*, ed. Juliet Lodge (New York: St. Martin’s, 1993), p. 219.

⁶ Interview, British Aerospace, Spring 1997.

Thirty-five years ago, multinational R&D collaboration in Western Europe was principally and explicitly defense-oriented; in fact, while cases of civilian pairings were exceptional, the military divisions of firms like British Aircraft Corporation, Dornier, and Aérospatiale cooperatively produced families of commercially and technologically successful weapons, albeit on a limited scale.⁷ Since that time, however, there has been a diversification of interstate technology cooperation privileging civilian production, one that has been partially guided by state and supranational actors. Yet as state governments and the institutions of the European Union recognize this transformation and seek to capitalize from it, defense production remains politically valued in a way that limits the potential for deepening interstate cooperation—even as upwards to 50 percent of the technologies produced through explicitly civilian collaborations have potential military applications.⁸

Europeans can and do collaborate to produce technologies with military value. Yet, they prefer the indirect and ad hoc creation of defense technologies through civilian channels to the coordination of a dedicated defense forum. I contend that EUCLID's failure is neither technological nor organizational, but is instead ideational. Europeans have been remarkably adept at recognizing their collective technological failings and then acting in concert to remedy them. In both civilian and military domains, they have created bi- and multilateral groupings to solve problems of common interest in areas ranging from integrated circuit design, to refining the land-based rearing of sea bass,⁹ to the development of helicopter gunships. The technologies under EUCLID's purview have been no more radical than these; indeed, EUCLID projects are not dissimilar to some conducted within the major civilian-oriented collaborative initiatives. Further, parallels between EUCLID and Eureka do not stop at technology. EUCLID's founders initiated the program with the successes of organized interstate civilian cooperation in mind. Consequently, they structured it as a coordinating organization along lines similar to that of the technologically and commercially successful Eureka program.

⁷ Interview, British Aerospace, Spring 1997.

⁸ European Parliament, *European Armaments Industry: Research, Technological Development and Conversion*, Final Report (STOA/GRIP/IA 1993), p. 49. For a discussion of changing state attitudes toward the civilian technology base, see Philip Gummert, "West European Defense Industrial Policy After the Cold War," in *Military R&D after the Cold War: Conversion and Technology Transfer in Eastern and Western Europe*, ed. Philip Gummert, Mikhail Boutoussov, Janos Farkas, and Arie Rip (Dordrecht: Kluwer Academic Publishers, 1996).

⁹ Eureka Project E!1376

I argue that EUCLID has failed to develop because of its symbolic character. The differences between it and ongoing efforts to institutionalize and Europeanize technology innovation in the civilian field were more visible than real. Nonetheless, in Europe as elsewhere, the links between the state and the provision of defense remains too strong to permit the smooth functioning of fixed transnational military R&D regime. The connection between state identity and armaments has imposed a fundamental barrier on the evolution of a “European” defense technology base through dedicated means, just as it has done in other areas of Western European procurement collaboration. In the following sections, I explore the nature of this relationship, and frame the larger discussion within International Relations Theory. I illustrate my argument with an empirical discussion detailing the evolution of technology cooperation in Western Europe since the early 1980s, paying particular attention the relative fortunes of the Eureka and EUCLID initiatives.

Theoretical Foundations

To understand European integration one must first understand and appreciate change: changing environmental pressures, changing state behavior, changing ideas of appropriateness, changing interests, and importantly, changing conceptions of state identity.¹⁰ Traditional analytical approaches within International Relations theory, namely neo-realism and neo-liberal institutionalism, do not emphasize interest, ideas, or identity—except, of course, to dismiss them as predetermined, as methodologically unapproachable, or as epiphenomenal. The study of European defense collaboration, however, requires that we consider all three, because in this area both conventional wisdom and governmental proclamations maintain that they are in flux, with an emerging regional identity, shifts in the value and extent of defense technological innovation, and finally a transformation in state interest that arises from these two developments. Any analysis of military R&D cooperation therefore requires a theoretical approach that deems identity and interests as mutable and as endogenous to observed behavior.¹¹

¹⁰ Ronald Jepperson, Alexander Wendt, and Peter Katzenstein, “Norms, Identity, and Culture in National Security,” in *The Culture of National Security: Norms and Identity in World Politics*, ed. Peter Katzenstein (New York: Columbia University Press, 1996), p. 51.

¹¹ Alexander Wendt, “Anarchy is What States Make of It: The Social Construction of Power Politics,” *International Organization* 46 (Spring 1992): 392.

This need is compounded by the special character of defense technology in the international system. Weapons are unlike any other commodity. They are uniquely defined by their lethality and, as the “distinguishing emblem of the modern nation,” by an almost organic tie to state identity.¹² Arms provide military protection, techno-industrial benefits, and status in a world system where “normative definitions of statehood” and of political efficacy are dependent upon the ability of states to produce, possess, and project military force.¹³ Consequently, if a supranational identity is indeed emergent and significant, multinational defense procurement is an ideal test of the value of new approaches in international relations. A new identity would need to be very potent to produce new definitions of state interests and new behaviors in an issue-area as historically bound to conventional visions of sovereignty and state identity as defense procurement.¹⁴ We cannot even assess this possibility, however, unless we are attuned to the roles that identity and the non-material aspects of armament play in determining how states behave towards defense technologies.

Constructivism, one the newer additions to International Relations theory is well suited to addressing armaments collaboration because it acknowledges both identity formation and shift.¹⁵ Like Realism and neo-liberal Institutionalism, modernist Constructivist logic, as pioneered by Wendt, Emmanuel Adler, Peter Katzenstein, and others, recognizes the primacy of state actors in the international system and the anarchic nature of that system. Unlike the mainstream theories, however, Constructivism offers a socially based view of the material resources that constitute social

¹² Cited in François Heisbourg, “Public Policy and the Creation of a European Arms Market,” in *The European Armaments Market and Procurement Cooperation*, ed. Pauline Creasey and Simon May (New York: St. Martin’s, 1988), p. 86; Mark O’Connell, “Putting Weapons in Perspective,” *Armed Forces and Society* 9 (Spring 1983): 450; Mark Suchmann and Dana Eyre, “Military Procurement as Rational Myth: Notes on the Sociological Perspective on Weapons Proliferation,” *Sociological Forum* 7 (March 1992): 151.

¹³ Dana Eyre and Mark C. Suchmann, “Status, Norms, and the Proliferation of Conventional Weapons: An Institutional Theory Approach,” in *The Culture of National Security: Norms and Identity in World Politics*, ed. Peter Katzenstein (New York: Columbia University Press, 1996), p. 92.

¹⁴ Holly Wyatt-Walter, *The European Community and the Security Dilemma, 1979-1992* (New York: St. Martin’s, 1997), p. 253.

¹⁵ Nevertheless, it has rarely been applied to security issues. See David Segal, Mady Segal, and Dana Eyre, “The Social Construction of Peacekeeping in America,” *Sociological Forum* 7 (March 1992): 125.

structures.¹⁶ A Constructivist analysis of interstate collaboration, for example, would note that state identity (e.g., sovereign, capitalist, advanced, French, etc.) determines the potential for either cooperation or competition, based upon initial conceptions of the self and other.

Arms production is driven by material and ideational incentives that establish the potential for interstate collaboration. The military significance of defense technology is perhaps the most easily understood of these ideals, and it is thus the most readily overemphasized. After all, weapons are the ultimate tools of statecraft: replacing diplomacy with purposive violence when the former fails. These systems allow states to control their own populations, resist outside incursions, and apply controlled force in the advancement of foreign policy. Armaments procurement provides the tools needed to preserve a state's political autonomy and to protect its territorial integrity. The politics of weapons production is therefore intertwined with the very existence of the state itself.

The relationship between defense technology and the state, however, extends far beyond the provision of military power. Arms industries sit at the nexus between security and economics—between power and plenty.¹⁷ The potential material benefits from a domestic defense industrial base (DIB) and defense technology base (DTB) are enormous, not only for a country's force posture but for its economic well-being as well. An indigenous production capacity offers secure, dependable access to the means of defense without reliance on foreign sources of supply that may either deny the availability of war goods or perhaps use a dependence relationship as a source of political leverage. Defense industries also provide economic side-benefits: jobs for the civilian labor market through direct employment and potential technological spin-off to the civilian sector. Policy-makers in the West and elsewhere regarded military technological innovation as an engine for growth that could pull an entire national economy with it, particularly in high-return, "sun-rise" sectors based on emerging technologies.¹⁸

¹⁶ Alexander Wendt, "Constructing International Politics," *International Security* 20 (Summer 1995): 73.

¹⁷ Ethan B. Kapstein, "International Collaboration in Armaments Production: A Second-Best Solution," *Political Science Quarterly* 106, no. 4 (1991-92): 658.

¹⁸ For an example of this phenomenon in the French case, see Edward Kolodziej, *Making and Marketing Arms* (Princeton: Princeton University Press, 1987), p. 138. See also Michael Borrus and John Zysman, "Industrial Competitiveness and American National Security," in *The Highest Stakes: The Economic Foundations of the Next Security System*, ed. Wayne Sandholtz, Michael Borrus, John

While economic and security incentives certainly may explain much of state behavior here and elsewhere, they cannot provide a complete picture. States do not procure arms simply to defend their territories or protect their labor markets. Weapons also have socio-cultural value. As Dana Eyre and Mark Suchmann note:

... technology is never just technology ... every machine has a socially constructed meaning and a socially oriented objective and that the incidence and significance of technological developments can never be fully understood or predicted outside their social context.¹⁹

Armaments are positional goods: they convey status and prestige in an international system, in which a country's "membership in modernity" is defined by the sophistication of its force posture.²⁰ Some symbols, however, are more potent than others. Within the armaments field, status adheres not just upon the possession of weapons, but also upon the ability to design and to locally produce them—and furthermore, not just any weapons, but sophisticated, high-technology goods. As states face normative incentives to modernize their economies, a high-tech weapons capacity denotes both a great nation and a great national economy capable of considerable technological innovation. These weapons are consequently "loaded with meaning," symbolizing sovereignty, technological advancement, strength, and political efficacy. In the early 20th century, the battleship epitomized how technology of this type could become tightly embedded in a state's self-perception, and, as important, how that state wished to be regarded by others. Michael Howard writes:

The Battleship was indeed a symbol of national pride and power of a unique kind; one even more appropriate to the industrial age than armies. It embodied at once the technological achievement of that nation as a whole, its world-wide reach and, with its huge guns, immense destructive power. It was a status symbol of universal validity, one which no nation conscious of its destiny could afford to do without.²¹

Zysman, Ken Conca, Jay Stowsky, Steven Vogel, and Steve Weber (New York: Oxford University Press, 1992), pp. 29-31.

¹⁹ Eyre and Suchmann, "Status, Norms," p. 86.

²⁰ Alexander Wendt and Michael Barnett, "Dependent State Formation and Third World Militarization," *Review of International Studies* 19 (1993): 337.

²¹ Michael Howard, "War and the Nation-State," *Daedalus* 108 (1979): 104.

Today, other technologies fill this role: the air-superiority fighter, the *chobham*-armored main battle tank, and the ballistic missile submarine among others. The social value of these technologies is tightly intertwined with their material attributes. In many cases, however, symbolism can outweigh any objective criterion. For example, defense-seeking states require both artillery shells and ground-attack jets if they are to maximize their military potency. Both can be important tools of statecraft, but when judged solely from the historical record, artillery is a far more effective means of either killing or disrupting enemy forces. Nonetheless, because ground-attack planes are carriers of national prestige due to their status as symbols of techno-economic sophistication, this technology receives undue attention in decision-making fora.

Consequently, the social incentives of weapons production can, and sometimes clearly do, outweigh the material incentives of procuring those items. These possibly divergent motivations can have a significant impact upon the conduct of multinational defense collaboration between different classes of defense commodities. In Western Europe, multinational procurement has evolved over the last four decades. From a limited and ad hoc beginning, it now involves increasingly complex interactions producing many kinds of military hardware, including sizable inventories of high-tech, high value-added weapons.

What is rarely recognized, however, is that this ideational component of defense procurement can shape cooperation for enabling technologies and dual-use goods as well. Armaments are more than the end-user items that one finds on a parade ground or airplane pylon. They are the sum of production processes and sub-assemblies, some of which may not have an explicitly military focus. For example, the same techniques and machine tooling used to manufacture a howitzer barrel can also be used to produce a naval propeller shaft or the axle of a railroad car. The development of rotary forges may seem, at first glance, a poor symbol of state sovereignty. Yet, when they are produced within a distinctly defense context, any objective banality disappears and the technologies become contested by states, who strongly resist sharing them with their allies. This phenomenon is most clearly seen with a comparison of civilian and defense collaborative schemes in which similarities in technology have nonetheless led to wildly disparate outcomes. The EUCLID and Eureka programs demonstrate how the interplay between identity and defense can produce such an effect.

EUREKA

Eureka predated EUCLID by nearly five years, having been initiated in 1985 as a French-led response to the perceived techno-industrial challenge posed by the United States' Strategic Defense Initiative. Specifically, it reflected a growing awareness among European elites that national technology assets could be best protected and expanded in an increasingly competitive global environment through interstate collaboration. In the early 1980s, the European Commission had initiated a series of moderately successful cooperative programs, most notably ESPRIT, which promoted regional collaboration in information and telecommunications technologies at the pre-competitive level. Eureka's founders sought to capitalize upon this development as well as to reassert state inputs into the collaborative process. European governments hoped to promote and guide industrial cooperation while concurrently preempting the europeanization of technology policy through the supranational influence of the European Community.²²

The initial French proposal, while vague in detail and requiring no formal treaty, nonetheless envisioned a "top-down" framework in which intergovernmental committees determined R&D policy and state governments provided substantial program funding.²³ The only notable difference between the original Eureka plan and EUCLID was the former's implicitly civilian orientation, even though its initial technological emphasis was very similar to that pursued under the Strategic Defense Initiative, and later under EUCLID: remote sensing, optoelectronics, high-speed computing, materials, lasers, and communications systems among others. As Eureka coalesced during 1985 and 1986, the involvement of additional state actors and the largest information technology firms in Western Europe pushed the program away from its initial, state-driven conception and toward a framework that was at the time unique in the region. Industry insisted that "Eureka should be product and market-oriented."²⁴ Germany and Britain, along with other states in consultation, refused any

²² Wayne Sandholtz, *High-Tech Europe: The Politics of International Cooperation* (Berkeley: University of California Press, 1992), p. 295.

²³ David Dickson, "EUREKA! Cooperative Research & Development Program in Europe," *Technology Review* 91 (August 1988), available from <http://web.lexis-nexis.com/universe>; accessed 16 December 1998.

²⁴ "Declaration of Common Intent" by GEC, Siemens, Philips and Thomson. Quoted in John Peterson, "Technology Policy in Europe: Explaining the Framework Programme and Eureka in Theory and Practice," *Journal of Common Market Studies* 29, no. 3 (March 1991): 278.

mandatory state funding requirements. Moreover, they rejected the creation of a centralized decision-making secretariat in favor of *ad-hoc* industrial control complemented by minimal state and intergovernmental oversight.

Eureka's Declaration of Principles, signed in late autumn 1985 by representatives of seventeen West European states, codified all of these demands. Eureka officially became a "near-market" initiative intent upon collaborative technology development and commodification. In practice, however, it represented more of a "technological potluck" in both emphasis and technical content. The Eureka label has been attached to collaborative projects as far afield as biotechnology and infrastructure development, and to schemes at nearly every stage of development from the pre-competitive level onwards.²⁵ The initiative's civilian orientation was retained; both to set it apart as a distinct alternative to SDI, and to win the support of European neutrals and the publics of a number of allied states, namely Germany.²⁶

Eureka's brilliance lay not its technological portfolio, however, but rather in the way that it promoted cooperative development. The Declaration stressed that commercial interests should prevail over political imperatives whenever possible in shaping collaboration and defining program priorities. To this end, the framework established a "bottom-up" program in which firms chose objectives of collaboration and the means to achieve it. Indeed, although the initiative was intergovernmental in structure, its operation was explicitly industry-led. There was no governing organization or common funding. Eureka states invested national firms with the responsibilities of defining projects and arranging industrial partnerships. To attain Eureka status, all that was required was for two or more firms from at least two Eureka member states to declare an intention to collaborate upon a project of their choosing.²⁷ This information would be then transmitted to the respective national governments involved, and if approved, would permit the possible allocation of state matching funds, which served as a cooperation subsidy. Manufacturers not only proposed tentative ventures for Eureka status and support, they also reserved the right to either invite or reject other firms as

²⁵ Sandholtz, *High-Tech Europe*, p. 283.

²⁶ Dickson, "EUREKA!"

²⁷ Henry Durand, "Building Up a Common European Science and Technology Policy," *Technology in Society* 13 (1991): 374.

potential partners in cross-border consortia.²⁸ Furthermore, questions of intellectual property remained under the purview of the collaborating parties. Industry alone determined the nature and extent of technology transfer between participants. Finally, as firms independently established partnerships on commercial and technical competence criteria, and in the absence of guaranteed public funding, states did not insist upon *le juste retour* (fair return), leaving the issue of appropriate national industrial representation within projects to be settled amongst participant firms.²⁹

This is not to say, of course, that the state played no role in Eureka's conduct other than that of a passive financier. Eureka possessed a permanent secretariat from the outset, but it was limited to six clerical staff and a bi-annually rotating group of seven civil servants selected from the member states. The secretariat's role was limited to the collection and dissemination of information pertaining to proposed collaborations. A Council of Ministers convening annually held ultimate authority. Although this group was composed of national research and industry ministers, with rotating state chairs providing de facto political leadership, the Council's powers were limited to the formal approval of Eureka projects. No proposed scheme has ever been rejected by the Council.

Real administrative competence lay at the national level. Each member state possessed a national Eureka office, often attached to either its economics or science ministries. These organizations assessed proposed projects and distributed public funding to those national firms and research institutes that initiated multinational consortia and thus qualified for Eureka status. The program offices represented the primary interface between the state and Eureka. Through them, governments could select specific, national R&D objectives deemed politically or industrially important. They

²⁸ John Peterson, *High Technology and the Competition State: An Analysis of the Eureka Initiative* (London: Routledge, 1993), p. 32.

²⁹ *Juste retour* has been a feature of most European industrial collaborations in defense, and also in civilian industry before the emergence of widespread industry-initiated interstate partnerships in the mid-1980s. The practice of *juste retour* allowed state governments to predetermine the level of involvement of their national firms within any interstate collaborative project; and moreover, to do based solely upon the level of financial support that the state or its leading firm contributed to the collaboration. For example, in the Anglo-German-Italian *Tornado* fighter-bomber project, the participating states held a 42.5/42.5/15 percent respective cost-share/work-share. This meant that Britain provided 42.5 percent of the total R&D costs and, in return, was permitted to produce 42.5 percent of the value of the airframe, engine, and avionics packages. The UK also received 42.5 percent of the total production run of planes. See Peterson, *High Technology*, p. 72.

could then strategically apply state subsidies to indigenous companies as an incentive for them to forge transnational relationships in other European countries to better achieve the desired ends.³⁰

These mechanisms provided both states and firms with a mutually beneficial cooperative environment. The former could use public funds to coax select firms to establish cross-border partnerships for advanced technology research, and thus help vitalize their national industrial and technology bases; moreover, they enjoyed the participation of other national governments who could potentially provide support to these same projects, thus spreading the financial burden and ensuring a minimum of national expenditure by any given country.³¹ The firms, on the other hand, enjoyed limited state subsidies on collaborative projects that in some instances might not have otherwise occurred. Eureka offered both sides exactly what they wanted from interstate R&D cooperation and without any pronounced faults in organization or implementation that might taint its appeal. Indeed, the record shows that both government and firms throughout the Eureka community were quite quick to exploit the tool that they had created for themselves. The framework quickly became the most successful program of its type in Western Europe. By 1996, Eureka had grown to 1250 approved projects across all technology domains with a total investment of over 18 *billion* ECU.³² Between 1986 and 1992, 505 separate projects worth more than 8 billion ECU had been sanctioned by Eureka officials. Of these, 107 were authorized during the first year at a value of 3.2 billion ECU.³³

While the statistics of Eureka's success were unmatched by any another regional collaborative R&D initiative, and in fact, remain unparalleled, one must not forget that these impressive figures were made possible by the Eureka framework's singular ability to harness diverse national interests and integrate them into a diffuse sense of European solidarity. John Peterson argues that the

³⁰ State financial support for Eureka projects varied according to state interest in promoting a given technology or industrial sector. Among Eureka member countries, this support ranged from 30 percent to 50 percent of the funding supplied by national industrial contributions, and averaged approximately 30 percent for the Eureka community as a whole. Durand, "Building," p. 375.

³¹ Peterson, *High Technology*, p. 101.

³² FBIS Report. FBIS-EST-96-013. 4 July 1996. "EUREKA 1996: Positive Results for France and Belgian Presidency," *AFP Sciences*, 4 July 1996, p. 1.

³³ Peterson, *High Technology*, p. 33.

program's variable geometry of state-state and state-industry contacts allows national governments to pursue their particular policy agendas for technology innovation through subsidies and indirect guidance, but nonetheless to act such that national policies converge within a European framework.³⁴ Through Eureka, states could attain their parochial objectives by encouraging private actors to effectively "Europeanize" their behavior by instituting the inter-state, industrial relationships within the community that are a prerequisite for eventual economic union. Thus, European decision makers could enjoy the best of both worlds: pursue the national self-interest, while also acting in concordance of the loftier ideals of European integration, and in such a way that brought these ideals closer to fruition. Even Margaret Thatcher, while certainly no advocate of European union, argued in June 1986 that "Eureka is a key element in *Europe's* industrial strategy . . . Through Eureka, *European* firms can help us identify the steps to open markets which will most help them."³⁵

Proclamations such as this that have surrounded the Eureka program since its initiation must be embraced cautiously. Eureka did not emerge from some radical shift in state perceptions and attitudes. It both reflected and promoted state interests, albeit enlightened interests, that acknowledged the legitimacy of transnational modes of technology innovation, were shaped by the interests of others pursuant to some commonly valued goal, and significantly, were made compatible with the grander aspirations and processes of community-building and of regional integration. Eureka demonstrated the permissive potential of a nascent European identity—the "idea of collective Europeaness"—to redefine state interests toward a communal good. While such an identity was not strong enough to overwrite national prerogatives and, in this case, facilitate the creation of a unified system of innovation, it at least supported the harmonization of those interests.

EUCLID

While Eureka might show the promise of a European identity, when viewed comparatively, it also demonstrated the fundamental weakness of that identity and its limited applicability to other areas of European activity—even those that overlap with Eureka's mandate. By the end of the 1980s, Eureka's success was undeniable, with nearly 300 approved collaborative projects totaling nearly

³⁴ Ibid., 201.

³⁵ Cited in Peterson, *High Technology*, p. 70. Emphasis added.

6.5 billion ECU by January 1, 1990.³⁶ With a record like this, Eureka became a model to be emulated, and Europeans were keen to do so elsewhere in hopes of attaining the same level of performance. The troubled regional defense industry was quickly seen as the ideal area to apply the lessons learned in the civilian arena. Here was an entire industrial sector with considerable existing collaborative activity, but under pressure due to falling defense budgets and a legacy of interstate cooperation that rewarded inefficiency and hindered any meaningful rationalization of the regional defense industrial base.

In order to understand better the EUCLID project, one must first appreciate the environment in which it was crafted. Since the founding of the European alliance system defined by NATO and the Western European Union in the late 1940s and early 1950s, armaments collaboration has been a core objective of the collective military effort. In fact, multinational procurement had become well established in some high-cost areas such as aerospace and defense electronics. Systems such as *Roland*, *Jaguar*, *Tornado*, and *Gazelle* all reflect the considerable energy invested into procurement cooperation, to say nothing of the billions of marks, francs, pounds, and lira. This collaboration, however, was not the same as integration. Europeans have been very keen to retain maximal influence over their defense industrial bases and to receive maximum material and security returns from them. Moreover, as Rae Angus asserts, they structured their cooperative endeavors so as to move “the shortest possible distance from autarky.”³⁷ This was cooperation that served the economic and military pretenses for collaboration while preserving sovereignty and rigid national control over the procurement process. Indeed much of traditional European armaments collaboration occurred through processes best characterized by petty nationalism, industrial bickering, and the waste that these factors produce in bulk—a situation that did more to hinder integration than to promote it.

Defense cooperative schemes since the 1960s—and continuing into the present day—exhibited four principal *disintegrative* traits. First, collaboration was de-marketized. Defense Ministries regarded the outright purchase of foreign arms to be, at best, a “measure of last resort” undertaken

³⁶ Durand, “Building,” p. 375.

³⁷ Rae Angus, “The Tornado Project,” in *International Arms Procurement: New Directions*, ed. Martin Edmonds (New York: Pergamon Press, 1981), p. 166.

under the most extreme economic or political constraints.³⁸ Only the smaller allies, with their restricted defense industries and tiny defense budgets, had to rely upon the direct purchase of competitively-priced foreign defense technologies. The medium-sized and large states, with home industries to protect and money to spend, insisted on maximum domestic production, even when they ostensibly bought weapons from abroad. Through offset compensation and licensed production, states either distorted defense trade or evaded it by selecting national firms to produce up to 100 percent of the contract value within a given program. This took the form of either the domestic production of subsystems, with local firms functioning as subcontractors to foreign primes under offset packages, or the complete assembly under licensed production.

The choice for national production did not reflect any cost or competence criteria but instead represented the political desire to channel technology transfers and work orders to specific actors within national defense industries. This principle was also prevalent in the multinational *ab initio* collaboration based on arms co-development that occurred principally among the larger, and more self-contained, defense producers such as France and the UK. Here, procurement cooperation would begin through inter-governmental agreements to control rising defense technology costs by pooling national resources to attain common equipment goals. States again adhered to the principle of “no money across borders.” Countries would share the total costs of development and/or production, but all national funds would go exclusively to national research centers and firms, even as this guaranteed dis-economies through higher transportation costs, and duplicated administrative and assembly nodes.

Second, the division of responsibilities underlying co-development/co-production projects reflected the practice of *le juste retour*, or fair return. States demanded an immediate and exact workshare equal in value to their contribution to a given project’s development cost. These figures were meticulously measured and were often changed to reflect currency fluctuations or revised national military requirements. In some cases, states calculated cost-share/work-share to the hundredth decimal point in order to extract some techno-industrial benefit from every last cent of expenditure.

The third feature of traditional European armaments collaboration has been its deliberately uninstitutionalized and *ad hoc* nature. European governments denied international organizations any

³⁸ James Moray Stewart, “The European Defense—Principles and Policies,” *NATO’s Sixteen Nations* (December 1989/January 1990), p. 21.

real control over the conduct of their collaborative projects, and continue to do so. The European Community, for example, has been flatly denied competence, while dedicated procurement-harmonizing groups, such as NATO's Council of National Armaments Directors or the Independent European Programme Group (IEPG), could only rubber-stamp projects after states had already established cooperation guidelines. This type of limited collaboration permitted states to micro-manage procurement collaboration. Moreover, it allowed them to maximize potential gains to their defense base through access to technology and to production skills without the meddling of a long-standing, potentially efficiency-seeking institutional arrangement—organizations that, as Walker and Gummett note, might

. . . [compel] governments to submit to a form of arbitration which diminishes their individual command over industrial assets most tightly embedded in notions of sovereignty—a tall order in the best of times.³⁹

Collaboration thus assumed an *a la carte* character as states engaged in strategic alliances on particular projects and then dissolved those partnerships once the desired technologies had been obtained. Throughout the 1960s, 1970s and 1980s there were a host of joint venture programs, such as *Tornado* or *Jaguar*, in which states united behind a co-development scheme and then parted company after final production.⁴⁰ This behavior ensured that European decision-makers, as well as the actual producing firms, did not enjoy a learning-curve in cooperation and thus could not easily improve their collaborative strategies across programs.⁴¹

³⁹ William Walker and Philip Gummett, "Nationalism, Internationalism and the Future of the European Defence Market," Chaillot Paper of the Institute for Strategic Studies (Western European Union, 1993): 4.

⁴⁰ One must note that the experience of cooperation is not forgotten after project completion. Accumulated trust and knowledge of former partners has prompted states and their firms to renew contacts for future programs. PANAVIA Tornado exemplifies this phenomenon given its "evolution" into Eurofighter EFA. Nonetheless, the terms of cooperation have changed from project-to-project as states renegotiate their partnerships.

⁴¹ A good example of this phenomenon is the relationship between the Tornado Eurofighter projects. Among the same three states and three national aerospace industrial champions, lessons learned in the earlier Tornado project were not applied to Eurofighter. This led to considerable waste of time and resources until the participating firms established greater contact between their Tornado and Eurofighter divisions several years into the Eurofighter R&D phase. Interview, 19 February 1997.

The fourth and final feature of traditional European armaments cooperation was its pervasive tendency away from multilateralism. Although the West Europeans fielded twelve national militaries for the collective defense, the bulk of their procurement collaboration has been limited to dyadic or triadic groupings. Even cooperation in defense-related research has followed this general pattern, with over 70 percent of such collaborations occurring bilaterally among France, Germany or the United Kingdom.⁴² These limited partnerships have guaranteed that administrative costs of cooperation have been kept to a minimum and thereby assured that the desired cost-savings of collaborative procurement vis-à-vis solely national production could be attained. Although “minilateral” cooperation facilitated the development of collaboration by making the process financially viable, it has not served to bring defense producers together on a regional level.

EUCLID reflected the recognition that defense collaboration in Western Europe could be done better, at least within the area of research and development. The Eureka model, or more precisely its methodology, and its theoretical applicability to this area seemingly offered a ready-made solution. France was the first to argue that such a conversion take place, and to stress the point, assigned its Eureka national program coordinator, Yves Sillard, in 1989 to the French delegation of the Independent European Programme Group (IEPG) to promote Eureka’s extension into the defense field.⁴³ By the summer of that year, IEPG national armaments directors had agreed that pushing collaboration as far upstream as possible into the initial stages of development would significantly enhance armaments cooperation.⁴⁴ They hoped that such an initiative would offset the national fragmentation of R&D assets within Europe by promoting cross-border linkages between armaments producers. These relationships, coordinated under the soon-named EUCLID program, would pool research funds, thus minimizing defense R&D duplication among states, as well as providing a larger potential funding base per project than might be available within a purely national effort.

Eurico del Melo, the Portuguese minister of defense in 1990, noted that EUCLID’s principal aims were to increase Europe’s developmental capacity in critical technology areas and to create the

⁴² Assembly of the Western European Union, “WEAG: The Course to be Followed,” Document 1483, 6 November 1995, fn. 88.

⁴³ Peterson, *High Technology*, p. 53.

⁴⁴ Assembly of the Western European Union, “European Cooperation on the Procurement of Defense Equipment—Lessons Drawn From the Symposium,” Document 1587, 4 November 1997, para 28.

foundation for what later observers labeled a “defense research Europe”—the cornerstone of what was to be a European community of technology.⁴⁵ To this end, the initiative was structured around eleven, later fifteen, Common European Priority Areas (CEPA) of technologies deemed strategic to the Allied defense effort and to the continued competitiveness of the regional defense industrial base (Table 1).

Table 1
List of CEPA Technologies

CEPA 1	Advanced Radar Technology
CEPA 2	Microelectronics
CEPA 3	Materials and Advanced Structural Technologies
CEPA 4	Modular Electronics
CEPA 5	Electric Gun [§]
CEPA 6	Information Processing/Artificial Intelligence
CEPA 7	Stealth [§]
CEPA 8	Optoelectronics
CEPA 9	Satellite Surveillance
CEPA 10	Underwater Detection and Associated Technology
CEPA 11	Human Factors – Simulator Technologies
CEPA 12	Aerothermodynamics
CEPA 13	Biological and Chemical Defense Technology
CEPA 14	Energetic Materials
CEPA 15	Missile Control and Guidance Technology

[§] Inactive

Source: Carol Reed, “Sharing Out the Cost of R&T,” *Jane’s Defense Weekly* 10 June, 1995, p. 50

Each CEPA had a steering committee composed of academic, industrial, and state defense representatives from IEPG countries, who selected specific research and technology projects (RTP) to be pursued within each domain. These projects typically sought to support the enabling technologies that would facilitate the later development of future equipment deemed necessary by the steering committees. In fact, it was hoped that the development of precursors, such as high speed analog-digital converters, “ruggedized” microelectronics assemblies, combinatorial algorithms, solid-state

⁴⁵ David Fouquet, “IEPG Hopes to Copy Success of Eureka Research Project,” *Jane’s Defense Weekly*, July 8, 1989, p. 12.

lasers, and computer workstation design, would provide the foundation for collaborative weapons production between two more member states at some future date.⁴⁶

For each RTP, the state pledging the largest amount of financial support received lead nation status and assumed responsibility for attracting additional state participants, performing program management, and selecting an international industrial consortium to conduct the given research contract. Although the EUCLID framework officially encouraged state participants to consider techno-industrial competencies and the competitive awarding of research contracts, in practice neither goal was assured because they were left to the discretion of the member states. Countries—beginning with the choice of lead nation—literally bought admittance into advanced technology research. Participant states could subsequently select their respective national firms to comprise the consortia that actually performed the research. Even those countries lacking basic technological capacities within certain fields, namely the developing defense industry countries (DDI), could join as equal partners by way of their financial contribution to a given RTP.

Such behavior did very little to promote research efficiency, and as we shall soon see, it was a contributing factor to the EUCLID framework's eventual failure. Nonetheless, its structure offered the prospect of more diverse national participation within the regional defense technology base, as firms throughout the IEPG community began tentative steps toward cooperative development in technology fields once dominated by the major arms producers located in the larger defense markets. EUCLID multilateralized European defense R&D collaboration to an extent hereto unmatched. Some research projects had as many as eight national participants, with an average of four per RTP in the defense electronics fields.⁴⁷

EUCLID's success was largely limited to symbols such as this. By mid-1996, 57 RTPs had been approved by EUCLID member states with a total contract value of nearly 250 million ECU.⁴⁸ While this figure may seem impressive, it fell far short of the founders' stated ambitions. It was

⁴⁶ Mark Stenhouse, "The Future of Collaborative Production and Procurement," *International Defense Review* 26 (January 1, 1993): 19.

⁴⁷ Assembly of the Western European Union, "The Euclid Programme and Cooperation Between European Defense Electronics Industries," Document 1524, 14 May 1996, Appendix II.

⁴⁸ Of these, eight had been completed, 24 were under contract, 11 were in preparation, and 14 had reached the implementation stage.

hoped initially that EUCLID would eventually consume 30 percent of total IEPG R&D spending each year, valued at approximately 500 million ECU.⁴⁹ By Spring 1997, however, EUCLID projects had averaged roughly a tenth of this figure per annum.⁵⁰ Throughout its first seven years, the initiative consistently failed to live up to expectations. In fact, it had encountered significant problems from the outset. EUCLID's objective was to bring greater coordination to Western Europe's collective defense, but the very states that launched the initiative and claimed to support its mandate remained wedded to existing modes of collaborative behavior. More significantly, they continued to privilege the national production of defense technology to such an extent both within and without the EUCLID framework that they effectively stifled the framework.

Consider, for example, the overwhelming state control over EUCLID's execution. Strict intergovernmentalism colored nearly all of the program's conduct. A committee of national defense ministerial representatives meeting semi-annually within the IEPG possessed primary program oversight authority. All decisions, ranging from the nomination of EUCLID projects to the organization of the industrial consortia assigned to work on them, required consensus among the participating states.⁵¹ Even though national financial contributions determined lead nation and subcontractor status under *juste retour* rules, these relationships still required the explicit approval of all member governments. While industry was invited to offer suggestions and was obliged to provide 50 percent of project funding, ultimate control remained firmly vested in state actors.

The desire for maximal state control over the innovation process actually extended beyond guidance and had far more immediate consequences. First, state involvement at nearly every stage of decision-making significantly slowed the speed of cooperation. With upwards to thirteen states on each CEPA selection committee and the need to appeal to each national government for project approval and funding contributions, the time required for a project to move from initial examination

⁴⁹ FBIS Report, FBIS-EST-97-002, 6 December 1996; Christel Tardif, "EUCLID Corrects the Errors of its Youth," *Air & Cosmos/Aviation International*, 6 December 1996, p. 24.

⁵⁰ FBIS Report, FBIS-WEU-97-120, 8 May 1997; S. Brosselin, "European Military Research in Trouble," *Paris Electronic International Hebdo*, 8 May 1997, p. 16.

⁵¹ Claude Serfati, "Reorientation of French Companies," in *Restructuring of Arms Production in Western Europe*, ed. Michael Brzoska and Peter Lock. (New York: Oxford University Press, 1992), p. 103.

to implementation could exceed 14 months.⁵² During this period, firms often lost interest, as the proposed research ceased to be topical and the potential returns from cooperation no longer warranted the required financial contribution.

Second, and far more critical from the defense industry's perspective, was the issue of intellectual property rights. While industry performed the research, the draft memorandum of understanding (MoU) that founded EUCLID gave the participant states full and free access to the technologies that it produced. These countries were then entitled to use the information as they desired, either to apply it immediately in a production program, to withhold it, or possibly even to transfer it to other manufacturers not involved in the original innovation process.⁵³ Not surprisingly, industry rejected this arrangement and held the initiative in limbo until the final MoU was revised, in September 1990, to give manufacturers shared control over their own R&D discoveries. This issue has yet to be adequately resolved to the satisfaction of all members of the European defense industrial community. In any case, the fear that states may transfer technology to third parties and thus possibly undermine the commercial interests of producing firms played a significant role in impeding EUCLID's initial development. By the Fall of 1992 only 37 RTPs had been approved and only seven contracts signed.⁵⁴

The defense industry's reluctance to participate in EUCLID was paradoxically matched and strengthened by the detached behavior of the member states themselves. Even as state governments shaped the initiative to maximize their presence in the collaborative process, they nonetheless remained uncomfortable with it as a vehicle for cooperation. In 1990 EUCLID signatories pledged to provide a total of 120 million ECU through national contributions to selected RTPs. These promises quickly proved hollow, however, as annual state funding failed to exceed half that level. According to a European Defense Industries Group report, governments were declining to allocate moneys even to those projects for which they had declared an interest.⁵⁵ Moreover, when they contributed funds,

⁵² Assembly of the Western European Union, "The Euclid Programme," para 20.

⁵³ "Defense Research Programme is Hit by Dispute Over Intellectual Property Rights," *Reuter Textline Engineer*, August 9, 1990.

⁵⁴ Walker and Gummett, "Nationalism," p. 52.

⁵⁵ Assembly of the Western European Union, "The Euclid Programme," para 21.

the amounts were meager when compared to the support for national research programs. EUCLID projects in 1994 received only 1 percent of the French and United Kingdom defense research spending, 2 percent of German R&D expenditures and between 5 to 50 percent of that of the other member states.⁵⁶

A report produced by the Western European Union noted that in some technology sectors, collaboration within EUCLID was at best marginal. For example, the modular avionics CEPA was an active component of EUCLID from its inception. Yet during its first half-decade, the member states approved only one, two-year research project in this area, while concurrently devoting tens of millions of ECU to R&D collaboration in existing minilateral procurement projects involving similar technologies, most notably *Eurofighter* and *Tiger*.⁵⁷ States consistently kept the bulk of their collaborative activities outside the EUCLID framework, and by the mid-1990s the initiative had become saddled with an undisclosed, but reportedly significant, number of inactive RTPs as both governments and industry either refused to pursue new contracts or withdrew from existing ones.⁵⁸ Chief Inspector De Beauchene, member of France's D el egation G en eral pour l'Armement and former EUCLID coordinator, argued that this

. . . collapse was foreseeable partly because the small countries dragged EUCLID down and partly because the two or three nations committing themselves to binational or multinational cooperation programs among themselves never helped put EUCLID across. The program was actually complementary to the mechanisms concerned with major cooperation programs, but never replaced them.⁵⁹

In 1994, the EUCLID governments declared their intention to correct this situation and revitalize the institution. They created a permanent secretariat in the form of the 7-person Research Cell. This was appended to the secretariat of the IEPG, now renamed the Western European Armaments

⁵⁶ Germany, France, and the United Kingdom are the dominant defense markets in Western Europe, providing upwards to three-quarters of all military expenditures within the EU. Thus higher levels of relative support by the smaller states actually denote marginal amounts of absolute funding. Assembly of the Western European Union, "The European Armaments Agency—Reply to the Thirty-ninth Annual Report of the Council," Document 1419, 19 May 1994, para 69.

⁵⁷ Assembly of the Western European Union, "The European Armaments Cooperation After Maastricht," Document 1419, 23 October 1992, para 68.

⁵⁸ Assembly of the Western European Union, "The Euclid Programme," para 21.

⁵⁹ Brosselin, "European Military Research in Trouble," p. 16.

Group. The Cell sought to coordinate the CEPA steering committees and to assume management over new and existing research and technology projects. Moreover, by early 1996, member states pledged to grant The Cell the responsibility of assigning research contracts—a move that EUCLID officials hoped would speed up the process and thus motivate greater industrial participation in the program. In fact, overcoming industry's reluctance to participate was a major component of EUCLID's renovation. The states no longer demanded that industry provide at least 50 percent of research financing, and under the EUROFINDER procedure overseen by the Research Cell, firms could now offer unsolicited bids on approved EUCLID contracts.⁶⁰

It is unclear as whether these institutional innovations produced the desired effect. The most recent available data, however, suggest that they did very little move the program forward. Decision-making procedures improved, with the waiting times between preparation to implementation of RTP contracts falling to approximately nine months. Further, by May 1997, the number of approved of RTPs had increased by 14 new projects since spring 1996, to a total of 71. Nonetheless, the total contract value remained unchanged at 250 million ECU, and the average value of EUCLID projects actually declined from 5 million ECUs to 4 million ECUs per RTP contract.⁶¹ Moreover, state contributions to EUCLID projects continued to stagnate at a level between 50 million and 60 million ECU per annum—a figure that is less than 3 percent of all yearly IEPG-Europe defense research spending and perhaps a third of total resources devoted to collaborative R&D projects not included in weapons platform development.⁶²

Philippe Girard, chairman of the European Defense Industries Group, argued in 1996 that after nearly seven years, EUCLID's objectives remained largely "hypothetical."⁶³ While some work had been accomplished, arguably benefitting the participating states and firms, the initiative never achieved a critical breakthrough that would denote sincere interest on the part of both states and industry to use it as an effective forum for collaborative defense research. Firms remained reluctant

⁶⁰ Tardif, "EUCLID Corrects Errors of its Youth," p. 24.

⁶¹ Assembly of the Western European Union, "The Euclid Programme," Appendix I; fn. 4.

⁶² Carol Reed, "Sharing Out the Cost of R&T," *Jane's Defense Weekly* 10 June 1995, p. 49; Brosselin, "European Military Research in Trouble," p. 16.

⁶³ Tardif, "EUCLID Corrects Errors of its Youth," p. 24.

to invest substantial funding at any level to projects not wholly embraced by their own governments and, moreover, accompanied by foreign industrial partners who might possibly be present only by government diktat and unable to provide any substantive contribution to the innovation process. The member states, on the other hand, although eventually accepting some limits on program oversight, continued to insist on patent ownership rights while treating the initiative with an almost benign neglect.

Defense economist Andrew James at the University of Manchester contends that EUCLID never had a chance to develop; indeed, was never given the chance. It has been a relative non-entity, largely undiscussed in European defense analysis circles and barely remembered elsewhere now at the end of the decade.⁶⁴ This is unsurprising in an environment in which 50 percent of all multinational cooperative R&D occurs bilaterally between just two states, France and Germany, and well outside any multilateral framework. EUCLID never represented a viable alternative to the status quo. Its founding states crafted a program that offered them exactly what they wanted—access to cooperatively funded, advanced defense research—but they engineered it in such a way as to ensure that they received little that they desired; indeed, not only did the initiative alienate those who would develop the technology, EUCLID states did not move with any force to either exploit its potential or to correct its glaring faults.

EUCLID represents an example of what one German official has identified as the pervasive European habit of placing symbolism over substantive action in matters of collaborative defense.⁶⁵ It was a showpiece institution intent upon europeanizing defense technological innovation but put forward in an environment in which the desire for such a transformation was weak. Its failure, however, was more remarkable than it might seem at first glance. As we have seen, EUCLID was not the only attempt to create the foundations for a regional technology base in Western Europe during the 1980s, but it was the least successful. EUCLID research projects rarely focused upon the extraordinary; exotic technologies, such as Stealth or hypervelocity weapons, though officially under the EUCLID mandate, were not explored at all. In fact, most RTPs dealt with technologies that were not

⁶⁴ Workshop on The Place of the Defense Industry in National Systems of Innovation, Cornell University. 17-19 October 1998.

⁶⁵ FBIS Report, FBIS-WEU-98-020, 20 January 1998; Michael Peter and Friedrich Thelen, “The Last Screw,” *Duesseldorf Wirtschaftswoche* 11 December 1997, p. 22.

inherently defense oriented in function. For example, the first research project conducted under EUCLID's Optoelectronics CEPA involved study of light-weight thermal imaging sensors. This particular technology is as easily adapted for use in the firing control systems in tanks and aircraft as it is to less lethal applications such as terrain mapping, firefighting, and commercial security devices. When pursued within the EUCLID framework, however, collaboration was distorted and endangered by states intent upon securing maximum return from its production.

Conclusion

EUCLID has often been referred to as the "Military Eureka."⁶⁶ Like Eureka, its structure was intergovernmental, projects pursued within its framework received a combination of public and private funding, and much of the technology research was dual-use. Most important, its founders explicitly praised the Eureka model as a template for action that they would apply to the defense field. Yet after more than ten years, and a handful of research projects, EUCLID governments have failed to fully embrace the methodology that they had praised and from which—in the civilian area—they had prospered. EUCLID not only failed to approximate Eureka's performance, it also did not seriously affect existing state defense research practices. Whereas Eureka projects such as Eurimas, FAMOS, Prometheus, and COSINE have become important parts of the European techno-industrial scene, EUCLID's RTPs were nearly unrecognizable—much like EUCLID itself, in fact.

The question remains why many of the same states that enjoyed Eureka's achievements were both unwilling and unable to translate this success into the defense domain. This difference in fortunes between the two frameworks is best understood in the context of the symbolic relationship between defense technology and the state. In many instances, the technologies explored by the two programs differed by designation only.⁶⁷ Eureka's EUROFAR project offers an excellent case-in-point.⁶⁸ EUROFAR is a six-firm scheme to research tilt-rotor aircraft design with the stated intent of satisfying potential demand in civilian air transportation. This particular technology, however,

⁶⁶ Fouquet, "IEPG," p. 12.

⁶⁷ The example of EUCLID's thermal imaging research and technology project is particularly salient here. The Eureka project database lists 5 projects that are either underway or have been completed that are devoted to infrared sensing applications. See <http://Eureka.belspo.be>.

⁶⁸ Dickson, "EUREKA!"

has immediate military applications, as it can provide capable combat transport and assault platforms—a fact that has not gone unnoticed by the United States Marine Corps, which has actually weaponized the technology.

Work such as this, when produced under Eureka, is expressly “civilianized” by both government officials and industrial representatives; potential defense uses are rarely discussed for fear of unsettling certain state elites or national publics, even when some of the participant firms may be defense-oriented companies or corporate divisions. Significantly, however, the conduct of Eureka does not change during these instances. States continue to allow their firms to conduct interstate cooperation within a depoliticized environment and according to commercial and technological criteria that served their parochial economic interests.⁶⁹ Under the EUCLID umbrella, on the other hand, the rules are completely different. State involvement is strict, “top-down,” and ultimately self-defeating; and moreover, states behave in this manner for technologies and processes that are far more banal than innovative airframe designs. Computer workstation design (CEPA 6, RTP 1) or “training system concepts” (CEPA 11, RTP 1) will not in themselves, carry 40 fully armed soldiers or deliver a payload of iron bombs. Yet when pursued in a purely defense framework, these assume subjective values that make them as potent and as desirable to state decision-makers as any complete weapons system.

The symbolic character of defense technology cannot be overemphasized, as the link between its possession and the exercise of state sovereignty is extremely strong. States are socialized to covet this technology unlike any other. It not only provides a means for self-protection in a violent international system, it also becomes a component of state identity: the embodiment of national grandeur and autonomy. The evolution of European union invites us to assess the degree that these ancient ideals are changing in the face of new collective understandings of self and interest. EUCLID was a symbol of European solidarity in defense—but one that did not exemplify a seamless convergence of national interest or the subtle effects of a collective regional identity. It instead highlights the extraordinary calculus that state decision-making elites will engage in whenever they are faced with the acquisition of defense technology, one of the last barriers to the deepening of European integration.

⁶⁹ Peterson, “Technology Policy in Europe,” p. 279.

Europeans can collaborate in the development of advanced technology, and do so quite effectively—albeit not necessarily for the most European of motives. Eureka, after all, is a mechanism by which states strive to accomplish national goals, e. g., protecting home industries and technological competencies, through poly-national means. It contains no formal device for promoting intra-regional competition or opening national markets;⁷⁰ and it could never, in the words of Pierre-Henri Laurent, “fuse all national high-tech businesses into one intertwined transstate giant.”⁷¹ Nonetheless, the fact remains that Europeans under the Eureka banner cooperate with considerable zeal, and these collaborations have pushed forward the internal market. States freely indulge in cross-border industrial linkages and mutual dependencies that both reflect and create what one might recognize as the foundation of a common European identity. EUCLID, on the other hand, forcefully demonstrates that, despite the ideational transformations that may have occurred in Western Europe over the last forty years, an act of definition as “defense” can determine the perimeters of European cooperative behavior, because that designation evokes traditional conceptions of national identity and interest that are inimical to the establishment of any effective collaborative regime.

⁷⁰ Guy de Jonquieres, “European High Technology; Fresh Impetus for Collaboration,” *Financial Times*, 30 June 1986, SURVEY, p. 1 [newspaper on-line]; available from <http://web.lexis-nexis.com/universe>; Internet; accessed 16 December 1998.

⁷¹ Pierre-Henri Laurent, “Eureka, or the Technological Renaissance of Europe,” *Washington Quarterly* 10 (Winter 1987) [journal on-line]; available from <http://web.lexis-nexis.com/universe>; Internet; accessed 16 December 1998.

III. THE PLACE OF THE DEFENSE INDUSTRY IN TRANSITION AND INDUSTRIALIZING ECONOMIES

The Russian National System of Innovation

Judith Sedaitis

Few national systems of innovation have experienced so dramatic a change in fortunes in so compressed a period of time as the systems of post-socialist countries generally and of Russia in particular. Support for science and technology was historically a top priority for the Soviet regime and its satellite states. Innovation became especially important over the tense Cold War years, when spending on R&D grew seven-fold, from 2.4 billion rubles in 1958 to over 15 billion in 1973, and resulted in one of the largest and most militarily-oriented concentration of scientific researchers and personnel in the world (Berliner 1976, 172). The Russia Federation inherited the lion's share of the former Soviet system of innovation. With the demise of the USSR, support for this huge sector disappeared virtually overnight. Funding for R&D went from roughly 12 percent of the state budget to barely 2 percent. Demand for innovation generally dried up as domestic production plummeted. Scientific personnel began to leave the field in droves with 13-17 percent of research personnel leaving the sector yearly since 1992 (Kuznetsov 1994). It is estimated that most Russian scientific institutes today are roughly half the size they were before economic reform.

How to characterize the current Russian system and level of innovative activity is a topic of great debate. While some Russian researchers find that roughly 50 percent of industrial firms currently engage in some form of innovation (Gaponenko 1995), others suggest the figure is no more than 6 percent. The discrepancy in large part stems from how "innovation" is measured and, to a lesser extent, where it is located. In line with the logic of fast privatization that prevailed in Russia, high expectations were placed on the restructuring of the old, large industrial enterprises and scientific institutes that made up the former national system of innovation. Western advisors and the IMF argued that it was more efficacious to make existing enterprises efficient, as they already held the country's resources, than to shift those resources to new organizations and firms. As such, there is little systematic attention or data on the innovative activity among new and small firms. Regardless

of which path restructuring takes, it is clear that to survive, former Russian innovators need to learn how to shift their strengths and findings in military research to civilian production and new product development.

Two processes capture the myriad of new institutional arrangements for restructuring Russian science and technology: the integration of research units with production, and the opposite process, a fragmentation of enterprises and institutes into smaller, quasi-separate private firms. After a brief overview of the organization and collapse of the former Soviet innovation system, this chapter marshals theoretical and empirical evidence on both processes of fragmentation and integration. Survey data collected from 100 research firms and their spin-off new firms are used to test which strategy, if any, is more conducive to supporting innovation and the transfer of technology. Finally, the findings of this research will be reviewed to suggest that, in contrast to official Russian policy and much Western advice (Schneider 1994; Schweitzer 1996), the nascent sector of private R&D firms stands poised to become an important new driver of national innovation. In particular, their combination of access to state technologies without the “responsibilities of largeness,” helps the new and parasitical firms transfer technology and innovation away from their former military focus to commercial applications.

Organization of Soviet R&D

Although the Soviet era R&D budget historically supported both higher education and basic research, the lion’s share of research funding (80-60 percent) was channeled into the industrial ministries, where most innovation and research was conducted for military ends (Holloway 1984). Three basic types of Soviet organizations constituted the innovation system: scientific institutes, design bureaus, and in-house industrial research units. Scientific institutes were the main source of new ideas for products and processes in the Soviet Union. Those scientific institutes that engaged in largely applied research did so by working on generally narrow (by Western standards) specific technical issues under the auspices of the industrial ministry of their specialization.

Large institutes incorporated the whole development chain and included on-site laboratories, design offices, testing facilities, and small plants for prototype production, but in general, however, these facilities were separated from each other, and often by great distances, so that former partners now reside in different countries. Small institutes were primarily research and teaching institutions. In the 1960s, there were approximately 1700 scientific institutes (Bergson and Levine 1983). As

Table 1 indicates, in response to the precipitous crisis their formal numbers grew steadily, from 1762 in 1990 to 2200 in 1994! This ostensible growth was one of fragmentation. Unable to pay their workers, institutes have allowed them to set up their own institutes in order to increase the trickling flow of state subsidies.

Table 1
Russian R&D Organizations (1991 - 1994)

R&D Organizations	1990	1991	1992	1993	1994	Change 1991-94
Scientific Institutes	1762	1831	2077	2150	2240	+27.1
Engineering-design bureaus	937	930	865	709	589	-37.1
Engineering- construction bureaus	593	559	495	395	353	-40.1
Experimental factories	28	15	29	17	20	-28.6
In-house	449	400	340	299	302	-32.7

Source: The Russian Ministry of Science and Technology, 1995.

Design bureaus were differentiated as those that designed structures or designed new products and processes. The latter began their work after receiving the initial research and development phase from scientific institutes. Design bureaus specified the ideas in the form of working drawings and other technical documents that were then sent either to an experimental factory for prototype testing or directly to the end-user production facility. In the early 1970s there were approximately 4000 design bureaus. As Table 1 indicates, the number of design bureaus dropped sharply between 1991-1994. Construction design bureaus in particular were hit hard by the transition, and their numbers fell by about 41 percent. It is unclear, however, to what extent the decrease in number of design bureaus is the result of mergers with production facilities.

Finally, Soviet research was also carried out in the small in-house research division of Soviet enterprises. These were always the smallest, most incrementally-oriented organizational sector of the R&D establishment and numbered approximately 449 in 1990. Following the experience of Eastern Europe, these in-house units have the greatest prospects for the future in sectors that experience growth. Gokhberg and Kuznetsova (1998) argue that most innovation is currently driven by these

in-house R&D units in the Russian mining and chemical sectors, specifically. They are currently among the most competitive and hence most able to invest in R&D. However, others find that only about 6 percent of all in-house R&D units introduced any new product or process over the early transition years (Gaponenko 1995). Their number fell by about 33 percent to 302 units in 1994 and continued to fall through the 1990s.

Adjustment to Market Reform: The Option of Organizational Integration

Neoclassical economic models are of little help to struggling Russian R&D organizations, since economics traditionally couldn't even conceive of the problem. Technology commercialization isn't problematized because the traditional view predicts that appropriation of innovation will naturally follow market demand (Coombs et al. 1987). However, the real and often high cost of shifting innovation systems away from state dependence is now clearly evidenced by the struggle of state research centers in both the United States and Russia. Both state-owned systems are challenged to find commercial significance for their military research (Alic 1997; Alic et al. 1992; Branscomb 1993). The difference for the Russian system is the obvious lack of any countervailing private sector innovation to help ease the process. In order to meet the demands of liberalization, some analysts suggest that Russian research centers have attempted to create the same organizational integration of research and production facilities they credit for driving successful, efficient R&D appropriation in the U.S. private sector (Schneider 1994).

Prior to World War II, most of the important innovations in the United States came from integrated, in-house R&D units of private sector firms (Mowery 1992). As integral parts of a larger firm, in-house innovation units have the slack resources that make it easier for them to bear the high risk of R&D, while their integration as part of a production center lowers the coordinating costs between research and product development (Williamson 1981; Florida and Kenney 1990). In addition to providing economies of scale and command over resources, integration across the production value chain has been shown to facilitate flexible and iterative communication. Communication between upstream innovators and their downstream implementers is key to a more finely-tuned commercialization process, as important insights by the producers or other end-users, such as marketing specialists, can more easily feedback to original designers (von Hippel 1978; Florida and Kenney 1990; Alic 1997) Finally, integration also encourages the helpful cross-pollination of different specialists and facilitates creative synergies.

In Russia, these advantages point to the greater efficiency and control of integrating the formerly stand-alone R&D sites with production facilities through share-holding (Schneider 1994). Thus, organizational integration should help former R&D facilities retain the better part of their resources and staff, while making it more efficient to adapt their capabilities to manufacturers' needs and new product development.

Consolidation of former defense enterprises along the same production chain is clearly supported by certain groups of Russian policy-makers as well. The efficiencies of vertical integration were a large part of the rationale given by the Ministry of Defense for its official program supporting the creation of so-called "financial-investment groups." Beginning in 1993, the financial-industrial group (FIG) form was promoted by Deputy Defense Minister Kokoshin as the best Russian approximation of the successful industrial groups in Southeast Asia, such as the *kereitsu* in Japan or the *chaebol* in South Korea (FBIS-SOV June 11, 1993; FBIS-SOV July 27, 1993). However, subsequent legislation aimed at defining and regulating official FIGs disallowed cross-shareholding and limited block shareholding to no more than 10 percent ownership. These stipulations thwarted any strong investment or governance role for banks, which had been a key motivating factor behind their initial popularity. As a result, only 5 FIGs were officially registered by September 1995, including one in the defense sector. Unofficially, however, the tendency to consolidate ties among former defense enterprises or to form new groups has continued, especially in the aviation sector.¹

Two of the largest of these conglomerations include the Yakovlev Design Bureau. It teamed up with two separate aviation companies to create a group of cross shareholders that together cover the whole stream of aircraft production (Sanchez-Andres 1995). Another world-renowned design lab, the Krunachev KB, designer of the Energia rocket systems, became the lynchpin of the new Energia Association, an effort to join several design, diagnostic, and manufacturing firms in Moscow and in other cities across European Russia. Although both groups claim that the majority of their output is now civilian, the state has retained a controlling block of shares in these and other industrial conglomerations of former defense enterprises (Drugov 1995).

The second factor of continued or increased role of the state in Russia's future science base involves the importance of state funds in support of the difficult re-tooling and conversion process.

¹ For the purposes of this research, consolidated enterprises are defined as those in which dominate ownership is held by outside, domestic organizations (excluding state agencies).

After serious neglecting the research sector in the initial throes of market reform, the Russian government began planning to increase subsidies for technology transfer to commercial usage. In April 1995, a special decree on state support for the development of science announced that future civilian R&D investment would be increased to at least 3 percent of the federal budget in 1996 (FBIS-SOV April 28, 1995, p. 24). Similarly, the new conversion fund decree earmarked 7.3 trillion for the new 1995-97 conversion program, up from the 1.4 trillion promised in 1994-95 (FBIS-SOV September 20, 1995, p. 38; FBIS-SOV January 22, 1996, p. 49). The new conversion program is centered on facilitating import substitution, similar to current Chinese policy and to earlier Israeli policies. The plan also includes support for civilian output worth 41.1 trillion 1995 rubles with the goal of absorbing thousands of former defense sector specialists.

Certainly state funding can ease the difficulty of market transition, and the option of integration may be appropriate for some industries, such as the competitive aviation sector in Russia. However, the program of further state control and integration generally faces several structural obstacles and political criticisms. Close Western observers suggest that integration in Russia may be less a new attempt to rationalize and de-militarize Russian R&D than the preservation of the former military industrial complex (Blank 1995). Consolidation may support a hawkish political agenda of increasing Russian military presence in the region or even reintegrating the new nations of the CIS into a singular military production structure (Blank 1995). In addition, the legacy of the centralized command structure of Soviet R&D makes this model both difficult and inappropriate.

Most Russian enterprises are specialized, stand-alone facilities whose rationale depended on administrative links and a political system that are now defunct. In the Soviet Union, research institutes and design bureaus were often physically separated by vast distances from their production sites (Berliner 1983). In addition, the culture of secrecy surrounding their work meant that units in the same development chain were administratively organized into separate ministries and their researchers put into competitive relationships with one another. These security concerns seriously precluded the possibilities of collegial exchange among specialists and limited critical feedback from downstream the production flow (Evangelista 1988).

As a result, the level of Soviet technological innovation was generally poor. In addition to the limits of their segregated organization, R&D units suffered the same irrational constraints of the administrative command system that stymied risk-taking and personal initiative across the Soviet economy. Instead of supporting innovation, therefore, the Soviet R&D system evolved into one less

geared towards creating innovations itself than at finding and adapting innovations made elsewhere, including and especially military technologies (Holloway 1983). As such, the R&D units bear little resemblance to the Japanese industrial groups or U.S. research consortia that the Ministry of Defense purports to emulate. Without major internal revisions, the simple integration of former research units could risk preserving traditional Soviet management practices and dependence on state subsidies that will hardly foster economic competitiveness (Kuznetsov 1994).

A Counter-Option: Satellite Firms and Organizational Fragmentation

Clearly, the structure and experience of Russia's R&D sector stands in stark contrast to the history of U.S. research and development, particularly in the private sector. Instead of swimming against the tide of institutional history, therefore, an alternative to integration for Russian research institutes would be to streamline further. Rather than imitate the Japanese *keiretsu* or other foreign system, Russian R&D managers could capitalize on their unique legacy of stand-alone research and design units to pursue new flexible networks of small, specialized research. In this way, the emerging national innovation system in Russia would take the shape many see as the harbinger for future global competitiveness.

Small organizations have overtaken large firms as the biggest source of innovation over the last 40 years and now challenge traditional notions of the benefits of economies of scale (Piore and Sabel 1984; Best 1990). Particularly in sectors of rapid technical innovation such as semiconductors, software, and biotechnology, the flexibility and networking skills of small firms give them a head start in commercializing new technologies (Powell et al. 1994; Mowery 1992). If future global competitiveness continues to favor flexible alliances between small and specialized, stand-alone R&D firms, Russia's new satellite sector will provide a structural advantage rooted in the peculiar disadvantages that plagued Soviet innovators in the past.

In response to their loss of mission and funds, many R&D institutes in Russia began the process of fragmentation by first adopting a holding company form in their privatization process. This form varied across institutes but in essence was a hybrid model of ownership combining public and private status. The technology "core" of an organization generally remained state-owned through granting the supervising state agency the majority of shares. In this way, the institute could claim all the benefits of its former state-owned status, such as energy subsidies. At the same time, small new satellite companies were encouraged in order to provide lab personnel the freedom to experi-

ment with new product development at low cost. A new, shell entity within the institute was designated as the “holding company,” which was also the repository of the shares of the new private satellite firms.² The extent of shares owned and control exercised by the state lab varied depending on the nature of the technology involved. Unlike the spin-off process in U.S. labs, however, the Russian state lab gets back a portion of the profits from successful transfer attempts and is more inclined to encourage rather than constrain access to the potentially most practical technologies. Ideally, the state-owned core retains control over sensitive research and gives scientists an environment dedicated to the pursuit of scientific knowledge, unpressured by demands for practicality. At the same time, those same employees who are seeking opportunities to apply their research are able to do so without draining the lab of talent or putting themselves at great financial risk. Organizational decoupling allows for control where it is necessary and market forces where it is not. As a result, the spinning off of new satellite firms is sweeping across Russia (Sabel and Prokop 1996; Schweitzer 1996).

A hallmark of Soviet collectivity was the wealth of tacit knowledge built up over the many years that Russian research teams typically stayed together. Spin-offs could ostensibly help converting enterprises hold on to their talented staff by providing them a safe haven for releasing their creative and commercial capabilities (Sabel and Prokop 1996). They offered the scientific entrepreneur access to the often sophisticated tools and infrastructure of the enterprise for a fraction of the overhead costs. At the same time, satellites were not encumbered with the range of social and state obligations, such as providing social welfare and guaranteed employment for their workforce. They were more free to engage in the high risk activities of adapting innovations to new products and to make the maximum use of the slack and extensive resources at extant, parent institutes. In this way, satellites could access the positive attributes of the old-style Soviet R&D firms, while sloughing off the rest.

Despite the potential of satellite firms as the genesis of a new Russian technology base, the fragmentation of formerly large military science institutes is not without its potentially negative

² Before privatization, a “spin-off” is a new firm whose capital stock and premises are controlled by a parent firm. After privatization, spin-off refers to those firms whose simple majority share belongs to a “founding” organization. In Russian legal terms, a spin-off is a “dependent” firm when the parent company owns at least 20 percent of its stock and is a “daughter” firm when the parent company owns at least 50 percent.

consequences as well. Russian policy-makers feared that satellite firms would exacerbate the hemorrhaging of large institutions who were losing their top scientific personnel or that they would give foreign companies the opportunity to “cherry pick” the best of what a parent state institute had developed without full compensation. The phenomena became so wide-spread and worrisome that the formal creation of daughter companies at R&D organizations was legally forbidden in 1994 without the approval of the relevant ministry (Kayukov and Silliman 1997). Satellites might also increase the risk of lapsed security and easy access to dangerous nuclear or chemical materials that are housed in these institutes (Marten-Zisk 1994). Or their commercial fervor could help facilitate the sale of Russian arms and technology to unfriendly, rogue states (Shlykov 1995; Sapir 1997; von Hippel 1995; Cheung 1993).

The Technology Satellite Research Project

Are satellites any more or less effective a mechanism for facilitating the process of technology commercialization than integration or direct state aid? Or do satellites simply focus on commercial success and draw brain power away from the transfer of technology problem? How do those parent firms that created satellite compare with those that didn't? We have undertaken research in Russia to address these questions.

The data were gathered in the spring of 1995 and consist of 100 Moscow area defense organizations with varying degrees of R&D capacity. The sample was randomly drawn from the membership list of the League of Defense Enterprises, which is a political lobbying group that includes enterprises under Roskomoboronprom, as well as secondary suppliers. Respondents were visited in person by our Russian colleagues, who administered an hour long in-depth interview instrument. Our sample consisted of 41 satellite firms and 59 former large military R&D establishments, which were fairly evenly distributed among the different organizational types in the Soviet R&D institutional chain: 13 science institutes, 5 design bureaus, 17 scientific production enterprises and 14 factories (limited to technology-intensive production). Ownership status was also varied; while the 41 satellites were new firms, 31 percent of the sample were still state-owned, and 28 were privatized. The number of personnel employed ranged widely, from fewer than 50 workers to about 12,400. Since this range is large, the enterprise size as measured in terms of personnel was used as a control variable in the model.

The goal of this research was essentially to consider both the causes leading up to satellite creation and the ramifications of integration versus fragmentation. In particular, the effect of having created daughters was used to explain the exodus of staff from the parent company, the parent's income stream, and the parent's attempts to transfer technologies to new product development. The first of these variables was measured as the difference between the number of people employed in 1995 and the number of people that used to work at the same enterprise in 1990. Income was measured as the firm's yearly sales turn-over in millions of rubles for 1994. Finally, the success of technology transfer was operationalized as a weighted index based on the response to twelve concrete mechanisms gleaned from the literature and compiled by Gibson and Rogers (1994, 354). These mechanisms ranged from passive methods, such as publishing scientific articles, to more active and interactive methods, such as arranging special site visits for showcasing technologies to potential users and investors.

Fragmentation was construed as the process of creating satellite firms. This concept was operationalized as an indicator variable that singled out companies that had created at least one daughter firm. Conversely, integration was measured as an indicator variable that separated companies that had reliable ties to suppliers from those that did not.

Two extraneous elements must be controlled for in the regression analysis. One is the role of the state, which is crucial in the early transition phase. Links to the state were conceptualized as both financial and political. Financial links were measured as the percentage of a company's working capital coming directly from state funds. Political links were identified with the strength of ties to state administrators and operationalized as an index measuring enterprises' lobbying activities with respect to the executive branch of the federal government. The second important control variable was the size of the firm. In addition, another control variable that measured the firm's retention of scientific employees was included in the regression analysis. The size of the enterprise was measured as the natural log of current staff size excluding temporary employees. The retention of scientific staff was calculated as the change in the relative proportion of scientific staff to total staff between May 1994 and January 1991.

First, however, the antecedents to satellite creation were considered. These include the proportion of scientific output of a firm (i.e., drawings, prototypes, computer code, analytic/diagnostic services) to total output and the ratio of consumer products to total output. Ownership and profitability were also important considerations of whether a firm would be likely to fragment and allow

satellite firms, in particular the ownership structures over intellectual property. Where a parent has clarified intellectual property rights or feels secure in their control, the creation of satellites raises fewer risks to that control and should be more likely. Finally, as noted above, the size of the firm was controlled for by using a natural log of the original size of the firm in 1990 as one of the independent variables.

Findings

Which types of Russian R&D firms were the most likely to create satellites? Interestingly, our preliminary research points to a link between firms that self-reported themselves as profitable as one of the strongest predictors. Those that were profitable in 1994 appeared more likely to also be those firms that created daughter satellite companies, even when controlling for the important variable of original firm size. The two other variables that were significant in the logistic regression were the importance of intellectual property rights holdings by the parent firm and the proportion of scientific products in the output of the firm (see Table 2). As expected, those that felt secure in their control as the originators of innovation were also those more likely to allow for fragmentation. Similarly, satellite creation was also associated with those parents with a greater proportion of scientific production. The results of the regression, taking the number of the satellite companies created as the dependent variable, are very similar. The effects of profitability are somewhat weaker, as the relevant coefficient is significant only at the 10 percent level. But the security of intellectual property rights and the proportion of scientific goods in total output remain highly significant for the process of satellite firm creation.

Our preliminary findings on the consequences of creating satellites is consistent with those tracing the antecedents leading to satellite creation. Overall, the creation of daughter firms at former Soviet R&D enterprises appears more important than integration. Table 3 indicates the effect of these relationships on staff exodus and firm income streams, and on the firm's attempts to actively engage in technology transfer. In terms of staff exodus, daughter satellite firms lost the most. Parents of satellites also showed a positive relationship to staff exodus, but it was only significant at the 10 percent level. Interestingly, this model indicates that those firms that had lost the larger percentage of their technical staff were more likely to retain their other, non-technical staff. This finding coincides with other anecdotal data on the difficulty facing the large state institutes, whose best and

brightest have left for more lucrative settings, leaving their institutes burdened with the non-creative staff to support.

Table 2
Characteristics Associated with the Creation of Satellite Companies

Independent Variables:	Creating at least One Satellite Firm (logistic) n=57	Number of Satellite Firms Created (neg. binomial) n=57
Intellectual property controls	.74*** (.28)	.73*** (.20)
Proportion scientific products	.023** (.011)	.026*** (.010)
Proportion consumer products	.008 (.017)	.017* (.012)
Log of original size	.62** (.27)	.78*** (.26)
State-owned	1.17* (.80)	1.00* (.62)
Profit	1.78** (1.01)	1.00* (.72)

* significant at the 10 percent level, one-tailed test
 ** significant at the 5 percent level, one-tailed test
 *** significant at the 1 percent level, one-tailed test

Satellite creation showed a positive relationship to firm income. Just as firms reporting profits were more likely to create satellites, they also showed more positive income streams. The satellites themselves did not, however. Interestingly, the politicized firms with strong ties to state offices showed a significantly negative relationship to income.

Finally, in terms of technology transfer, both integration and fragmentation evidenced strong links to active technology commercialization attempts. Being the parents of satellite firms was helpful, but so were strong ties to supplier firms as well as state financial subsidies. Most interestingly, those strongly linked to active technology transfer were the small, new satellite firms themselves.

Table 3
Regression of key organization variable to staff exodus, firm profitability,
and fostering technology adaptation

	Staff exodus (n=67)	Firm income (n=67)	Technology transfer attempts (n=85)
Integration	2.78 (15.4)	-8.2 (.9.5)	2.38** (1.3)
Fragmentation	17.8* (16.9)	22.2** (10.7)	2.4** (1.4)
Satellite	110.4*** (17.2)	-.01 (.15)	3.16*** (1.4)
State subsidies	.25 (.26)	.19 (.16)	.04** (.02)
State ties	5.52 (12.5)	-13.6** (.8.0)	-.25 (1.10)
Natural log of total staff	7.8*** (4.0)	-.004 (.004)	.05** (.03)
Change in percent of technical personnel	-1.4*** (.44)	-.04 (.04)	.83** (.33)
Adjusted R-squared	0.5	0.03	0.22

* significant at the 10 percent level, one-tailed test

** significant at the 5 percent level, one-tailed test

*** significant at the 1 percent level, one-tailed test

Discussion

Given the size of this sample and the difficulty of gathering objective data in the FSU, the findings on satellite creation can be only suggestive at best. Nonetheless, they point in the opposite direction from both the American organization of effective industrial R&D and the image of satellite firms in the popular Russian press. Contrary to the fears of Russian policymakers (Kayukov and Silliman 1997), satellites seem not to drain away manpower and profits at the expense of adjustment by extant parent organizations. Instead, those firms that created satellites show more income than extant firms that did not and more income than the satellites themselves. This may reflect one feature of satellite creation criticized by Russian economists, that they allow parents greater flexibility in behavior, but also for record-keeping and tax evasion, which is especially important to rule-bound, state-owned enterprises. In turn, the satellites themselves appear the most focused on the project of channeling older technologies in new, market-oriented directions and, as such, have higher staff turnovers and lower income streams. The Russian case of technology adaptation stands in stark

contrast to the Western experience, where concerns about the personal enrichment of private-sector firms using public research have constrained the support for entrepreneurial activity at U.S. federal labs.

At the same time, the organizational approach does not so much oppose the market model as it seeks to explain the dynamics that drive it. As such, the fragmentation process of creating new, satellite firms is not mutually exclusive of state support, but rather indicates how the firms used the important breathing room that federal funding made possible. State subsidies while firms attempted conversion were helpful to this process. Similarly, the rational integration of firms within their own supply chains also gained support in the research, and those firms with stronger ties to other, downstream producers were also those more actively seeking to transfer their technologies. While the new satellites themselves may be the harbinger of Russia's future technology sector, therefore, this future is still distant.

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The Defense Sector as a Window into China's National System of Innovation

Corinna-Barbara Francis

Introduction

China's approach to market reform has allowed and encouraged individual public institutions and government agencies to engage directly in business.¹ Governmental offices and departments, educational, cultural, religious, scientific, and other types of public institutions actively engage in the market economy by operating their own profit-making companies and enterprises,² and they form joint ventures with other agencies. In other cases entire agencies or institutes are transformed into semi-independent corporations. While China's private sector still remains relatively small, the sector of "quasi-public" firms affiliated with government agencies and institutions has been dominant in China's market. This approach to market transition raises a host of questions. What precisely is the nature of this government entrepreneurship? How does it work? What is its impact on the workings of the market, on the functioning of government, and on the integrity of public institutions?

China's military-defense institutions, like most other governmental and public agencies, have been actively engaged in commercial activities since the initiation of market reforms in the late 1970s. This chapter explores the key features of military entrepreneurship in China, using the military to illustrate key features of China's evolving national system of innovation and emerging market system. China's military (despite having distinct qualities) reflects key aspects of China's evolving national system of innovation. First, it reflects the degree to which entrepreneurship has penetrated to the core of the state. China's military's vast business empire reflects the fact that virtually no

¹ Marc Blecher, "Development State, Entrepreneurial State: The Political Economy of Socialist Reform in Xinju Municipality and Guanghan County," in Gordon White, ed., *The Chinese State in the Era of Economic Reform: The Road to Crisis* (London: Macmillan, 1991); Jane Duckett, "The Emergence of the Entrepreneurial State in Contemporary China," *The Pacific Review* 9, no 2 (1996): 180-98; Milton Mueller and Zixiang Tan, *China in the Information Age: Telecommunications and the Dilemmas of Reform* (Washington, DC: Praeger Publishers, 1997).

² Corinna-Barbara Francis, "Bargained Property Rights in China's Transition to a Market Economy: The Case of the High-Technology Sector," in Andrew Walder and Jean Oi, eds., *Property Rights and Economic Reform in China* (Stanford: Stanford University Press, 1999).

niche within the public sector has been immune to the pressure to “jump into the sea,” i.e., to engage in commerce. Second, military entrepreneurship illustrates the fragmented structure of ownership and management within this quasi-public sector associated with government entrepreneurship. Far from being firmly controlled by “the state” as a whole, or even by large macro-institutions and regional entities within the state such as the military, control over enterprises is decentralized to myriad low-level units. We cannot even say that the top command within “the military” exercises firm control over its sprawling business empire. Rather, control is fragmented among myriad sub-units of the military.

Third, military entrepreneurship illustrates both the negative and positive features characteristic of China’s approach to market transition. The last section of this chapter examines the impact that military entrepreneurship has had on China’s economy—its contribution to the relatively more efficient use of resources, increased revenue, and other positive impacts on China’s market transition and economic modernization on the one hand, and the rise of corruption, the anti-market forces, and the erosion of the integrity and sanctity of the military as an institution on the other hand.

The concept of a national system of innovation is used here in the broadest sense to refer to the distinct characteristics of the process of research and development, production, and diffusion of economic goods (including but not restricted to technology) as it operates within a nation-state.³ This concept has been criticized on a number of grounds, including the choice of the nation-state as the critical unit of analysis, which is said to overstate the distinction of national institutions and to downplay the impact of global networks and the global impact on national economic processes.⁴ However, the concept is useful in the Chinese context, due in part to the relative isolation of the Chinese economy from the global economy for many decades prior to the post-Mao economic reforms and to the continued impact of China’s distinct institutions on economic processes.

³ Richard Nelson, ed., *National Innovation Systems* (New York: Oxford University Press, 1993); Charles Edquist, ed., *Systems of Innovation: Technologies, Institutions and Organizations* (Washington, DC: Pinter Press, 1997).

⁴ Slavo Radosevic, “Defining Systems of Innovation: A Methodological Discussion,” *Technology in Society*, 1998: 75-86.

The Origins and Development of Military Entrepreneurship

The rise and growth of military entrepreneurship in the post-Mao period mirrors broader trends in government entrepreneurship in China during this period. The first stirrings of such activity began in the late 1970s. But it was from the mid-1980s that the number of military-affiliated companies grew at an astounding pace. According to one estimate the number of military-affiliated companies doubled from 10,000 to 20,000 between 1985 and 1988.⁵ The types of military businesses also reflect broader economic trends. For instance, the explosion of service companies in the post-Mao period includes a large number of military-affiliated companies. The number of service companies run by the military reportedly increased a hundredfold from fifty to five thousand firms between 1978 and 1992.⁶ The pattern of growth in military business is also indicative of broader economic trends. For instance, military businesses experienced rapid growth in the post-1992 period, as part of the overall national response to Deng Xiaoping's renewed push for economic liberalization after his "Southern trip."⁷ China's military business empire also illustrates the high level of diversification that is typical of business empires operated by most public institutions in China. It has companies in a broad range of economic sectors, including transportation and shipping, pharmaceutical production, vehicle production, electronics, satellites, telecommunications, vehicle production, trade, real estate, and services, to name only a few.

The factors contributing to the rise of military entrepreneurship in China mirror those influencing other institutions. First and foremost, the military, like other institutions has been motivated by budget cuts. China's post-Mao economic reforms entailed serious budget cuts that affected local governments, public agencies, and all variety of public institutions, including the military. Notwithstanding the government's stated commitment to the long-term modernization of the military,

⁵ According to one estimate the number doubled from 10,000 in 1985 to 20,000 several years later. Cheung, "The Chinese Army's New Marching Orders," in *Mixed Motives: Uncertain Outcomes: Defense Conversion in China*, ed. Jörn Brömmelhörster and John Frankenstein (Boulder: Lynne Rienner, 1997), p. 183.

⁶ Ibid.

⁷ In 1992 Deng Xiaoping took a well-publicized trip to China's southern region, visiting the Shenzhen economic zone, among other places. This trip was used to signal his intention to revive economic reforms following the slow-down after the 1989 Tiananmen Square incident, and it sparked a rapid nation-wide resurgence of market activities in China.

as suggested by the military's inclusion in the "Four Modernizations," the military-defense budget declined steadily as a portion of the state budget during the 1980s, dropping from 16 percent in 1980 to a low of 7.52 percent in 1993.⁸ Despite small nominal annual increases the military budget experienced a steady decline in real economic terms due to inflation.⁹ This financial pressure has forced the military, as it has other institutions like universities, research institutes, cultural organizations, etc., to find its own financial solutions and to generate more of its own revenue.

Second, the military illustrates how government policies have directly encouraged public organizations to engage in commercial activities. Specifically, the policy of military conversion that was promoted in the late 1970s and early 1980s was similar to policies that the government promoted in other sectors.¹⁰ It had similar goals—to push institutions in a profit-oriented direction and to enhance the use of specialized technology and resources (in this case military technology) for broader use in the civilian and commercial arenas. As officially stated, military conversion was to "reform and convert the past unified military product system into an integrated military-civilian national defense scientific research and military-industrial production system."¹¹ This reflects policies applied to science and technology (S&T) sectors, which have sought to enhance the utility of technology and scientific resources for commercial production.¹² Finally, military entrepreneurship

⁸ Paul H.B. Goodwin, "Estimating China's Military Expenditure," in *Chinese Economic Reform: The Impact of Security*, ed. Gerald Segal and Richard H. Yang (New York: Routledge, 1996). By contrast, the total portion of the state budget allocated to culture/health/education/S&T increased slightly over the same period. In real economic terms, according to Chinese government reports, the military budget declined at a rate of 5.8 percent in the 1980s.

⁹ The government's new international security policy in the 1980s, which stressed the peaceful nature of China's international environment, resulted in sharp drops in production orders for military enterprises, thus putting added financial burden on the military.

¹⁰ For further discussion of these factors in the high-technology sector see Francis, "Bargained Property Rights in China's Transition to a Market Economy."

¹¹ Commission on Science, Technology and Industry for National Defense (COSTIND), Science and Technology Intelligence Agency, ed., *Shijie junshi gongye gailian* [Survey of World Military Industry] (Beijing: National Defense Industry Publishing House, 1990), p. 107. Also quoted in Mel Gurtov, "From Swords to Market Shares," *China Quarterly*, No. 134 (June 1993): 213-241.

¹² For an overview of reform policies in the S&T sector see Shulin Gu, *A Review of Reform Policy for the S&T System in China: From Paid Transactions for Technology to Organizational Restructuring* (United Nations, Institute for New Technologies, Maastricht, The Netherlands, UNU/

also reflects the simple role of greed—given the opportunity, organizations and individuals have acted to enrich themselves, a motivation going far beyond simple institutional survival.

Military Conversion

The policy of military conversion promoted by the Chinese state in the late 1970s and early 1980s has been part of a broad economic strategy of shifting public resources to more efficient and productive uses in order to serve economic growth and modernization.¹³ In the Chinese context defense conversion has entailed not only the transfer of military technology to civilian use, but as importantly the commercialization of defense production under the continued supervision of the military. Policies encouraging the shift of military production to commercial markets are reflected in other sectors—educational, cultural, and scientific—in which public institutions have been pushed to be financially more self-sufficient. These policies have aimed at relieving the state's budget burden and have been key to China's overall modernization strategy. The greater financial self-sufficiency of public institutions is expected to contribute to their eventual modernization. The revenue generated by the military's commercial activities is expected to contribute to military modernization.¹⁴

The clear distinction between civilian and military products makes it easier to assess the degree of commercialization within the military, as opposed to civilian industries. One can assume that production of civilian goods or provision of services by the military has been largely driven by profit motivation.¹⁵ Conversion has been most complete in particular areas within the military, such as high technology, satellite technology, computer and electronics, microelectronics, nuclear energy,

INTECH Working Paper No. 16, January 1995) and Gu, *Spin-off Enterprises in China: Channeling the Components of R&D Institutions into Innovative Businesses* (United Nations, UNU/INTECH Working Paper No. 16, Maastricht, The Netherlands, December, 1994).

¹³ Jörn Brömmelhörster and John Frankenstein, eds., *Mixed Motives: Uncertain Outcomes: Defense Conversion in China* (Boulder: Lynne Rienner, 1997).

¹⁴ This policy had the additional goals of absorbing excess personnel and production capacity, providing job opportunities for public sector employees, and putting to greater use the resources often hoarded by public institutions.

¹⁵ In order to more completely assess the shift to for-profit production one would also have to add production of arms and military equipment for sale.

aerospace, lasers, and more.¹⁶ However, it has affected all sectors to a degree. At the beginning of China's economic reforms in the late 1970s around 8 percent of military output was in civilian goods. By the mid-1990s these figures were nearly reversed; it is estimated that civilian production accounted for around 80 percent of total military output.¹⁷ According to a *People's Daily* article, in 1994 77.4 percent of gross output value of the military-defense complex was in civilian products.¹⁸ In 1993 only about 10 percent of China's defense production capacity was being used for defense production.¹⁹ The figure varies between military industrial sectors. The electronics industry experienced one of the most rapid conversions, with civilian production reaching 97 percent in 1992.²⁰ The Ordnance Ministry stated that in 1994 90 percent of its production was civilian products.²¹

The Fragmented Structure of China's Military-Defense Complex

The structure of China's military business empire replicates the institutional fragmentation of the military-defense complex. Far from being centrally controlled by the "the military," or even its core macro-institutional components, control over military businesses is dispersed among myriad organizational components. The Chinese military business empire is a sprawling network of enterprises and companies controlled by various units and organizations divided by institutions of affli-

¹⁶ Mel Gurtov and Byong-Moo Hwang, *China's Security: The New Roles of the Military* (Boulder: Lynne Rienner, 1998), p. 155.

¹⁷ According to the 1995 OECD Report on Chinese defense conversion, about 80 percent of the Chinese military-industrial complex had been involved in conversion by 1995. Reported in John Frankenstein and Bates Gill, "Current and Future Challenges Facing Chinese Defence Industries," *China Quarterly*, no. 146 (June 1996), p. 419, fn. 60.

¹⁸ "Conversion of Military Technology to Civilian Use Discussed," *FBIS*, 25 March 1994, p. 35. Also cited in John Frankenstein, "China's Defense Industry Conversion: A Strategic Overview," in *Mixed Motives*, ed. Brömmelhörster and Frankenstein, p. 3.

¹⁹ "Making a modern industry," *Jane's Defense Weekly*, 19 February 1994, p. 28. Also quoted in Frankenstein and Gill, "Current and Future Challenges," p. 396.

²⁰ Frankenstein, "China's Defense Conversion," p. 3. Cited in China Electronics Industry Trading Delegation catalog, 1993 Hong Kong Conference on International Cooperation to Promote Conversion from Military to Civilian Industry, Hong Kong, 7-11 July 1993, p. 1.

²¹ "Arms Maker Produces More Civilian Goods," *FBIS-CHI*, 9 June 1994, p. 36. Cited in Frankenstein, "China's Defense Conversion," p. 3.

ation, hierarchical level, and region. It thus mirrors the fragmented structure typical of China's governing institutions.²²

At the highest level China's military-defense business empire is divided between the People's Liberation Army—the name given to China's combined army, navy, and air force—and its defense industries, such as the Ministry of Nuclear Industry and the Ministry of Ordnance, which have overall responsibility for the research, development, and production of military equipment and technology.²³ This institutional separation has been in place since the 1950s when captured Guomindang defense factories were placed under the control of newly established defense ministries rather than under the PLA.²⁴ The two components of the military-defense complex are now supervised through separate channels. The Central Military Commission (CMC), which has both a party and a government component, has been the highest military authority. It oversees the PLA through three, co-equal, departments—the General Staff Department (GSD), the General Political Department (GPD), and the General Logistics Department (GLD). The State Council supervises the defense industries through a variety of organizations, including the State Planning Commission, the now disbanded State Economic Commission, and the Ministry of Finance, which also have responsibilities for non-defense related production.²⁵

²² Kenneth Lieberthal and Michel Oksenberg, *Policy Making In China: Leaders, Structures, and Processes* (Princeton: Princeton University Press, 1988).

²³ Between 1978 and 1987 the 6 defense ministries were as follows: 1) The Ministry of Nuclear Industry; 2) the Ministry of Astronautics Industry, including space rocketry satellites, telecommunications, and microelectronics; 3) the Ministry of Aeronautics Industry, including aviation, metallurgy, computer-controlled machinery, and electronics; 4) the Ministry of Ordnance, including munitions, guns, cannons, tanks, and optics; 5) the Ministry of Electronics Industry, including consumer and military electronics and microelectronics; and 6) the China State Shipbuilding Corporation, including civilian and military ocean-going ships, submarines, oil-rigs, etc. For further discussion see Paul Humes Folta, *From Swords to Plowshares? Defense Industry in the PRC* (Boulder: Westview Press, 1992). The term military defense industry is somewhat misleading, as these ministries have always also produced some civilian goods, although prior to the reforms their output was primarily military goods.

²⁴ As a consequence, since that time there has been a separation between the ultimate end-users of military technology and its producers.

²⁵ Folta, *From Swords to Plowshares*.

The defense industrial bureaucracy has gone through important restructuring over the years. In the early 1960s China's industries were under eight machine-building ministries (which were numbered for secrecy), six of which were involved in armaments production.²⁶ A major reform towards the goal of military conversion was implemented in 1982, when the defense industries were placed under civilian control—i.e., under the sole supervision of the State Council. In 1988 the various defense industries were restructured and reduced to three—the Ministry of Energy Resources (MER), the Ministry of Machine Building and Electronics Industry (MMBEI), and the Ministry of Aerospace Industry (MAS).

A third major component of China's military-defense complex is the set of organizations whose primary task has been to coordinate between the PLA and the defense industries and to coordinate military R&D and production among the defense industries. The Commission on Science, Technology, and Industry for National Defense (COSTIND) was established in 1982 through the merging of the National Defense Science and Technology Commission (NDSTC) and the National Defense Industry Organization (NDIO), a move aimed to overcome the longstanding conflict between the military research and development sector and production sector and to better coordinate these tasks and organizations.²⁷ COSTIND was put in charge of supervising China's military conversion and given supervisory authority over the commercial ventures of the defense industries.

The Chinese Military-Defense Business Complex

PLA Business

The first major component of the military-defense business empire consists of the businesses affiliated with the PLA. In principle, the Production and Management Department (PMD) under the General Logistics Department has overall responsibility for management of PLA-affiliated enterprises. However, in practice component units of the PLA, down to unit-level group armies may oper-

²⁶ In the early 1960s, coordination of weapons production was vested with the National Defense Industry Office (NDIO). The National Defense Science and Technology Commission (NDSTC) was responsible for military R&D, funding, training, and weapons testing. The NDIO and the NDSTC were supervised by both the CMC and the State Council.

²⁷ For further discussion see Benjamin Ostrov, *Conquering Resources: The Growth and Decline of the PLA's Science and Technology Commission for National Defense* (Armonk, NY: M.E. Sharpe, 1991).

ate their own commercial ventures and exercise the key managerial control over these companies. In some cases companies themselves operate with little effective supervision. PLA enterprises can be divided into three categories: enterprises managed at the highest level of the PLA; enterprises operated by regional and provincial-level military units; and enterprises managed by unit-level PLA entities.

In the first category we can differentiate enterprises operated by the general departments of the PLA (the GSD, GLD, and GPD), the three armed services departments (the army, air force, and navy), and other top-level components of the PLA such as the People's Armed Police (PAP). In this group the enterprises affiliated with the PLA's general departments have tended to be the largest and most profitable. The General Staff Department of the PLA operates two of the largest military-affiliated corporations—the Poly Group Corporation and the China Huitong Corporation. Poly was first established as the foreign weapons trading arm of the GSD's Equipment Department in 1983 [although it has assumed a civilian identity as a unit of China International Trust and Investment Corporation (CITIC)]. In 1992 it was converted into a nominally independent enterprise group. The General Political Department also operates some large corporations including the Kaili Corporation (Carrie Corporation) and China Tiancheng Corporation. Kaili illustrates the diversification of military-affiliated corporations. It began as a trading company, later becoming active in real estate development and audiovisual products. It is also said to run an iron-ore mining company in Australia and a bank in Cook Islands, has a range of businesses in Hong Kong, and is involved in international weapons sales.²⁸

The General Logistics Department, the third general department in the PLA, also operates some large corporations. One of the largest is the China Xinxing Corporation, which was founded in 1984 and now has more than 100 enterprises and a range of subsidiaries in a variety of industries.²⁹ Xinxing was initially established to promote the commercial sale of products that GLD factories had earlier produced for the army. It then gradually diversified and subsequently became the

²⁸ Cheung, "The Chinese Army's New Marching Orders," p. 186-87.

²⁹ According to one estimate, the Xinxing Corporation has around 140,000 workers. Cheung, "The Chinese Army's New Marching Orders," p. 187.

GLD's core company engaged in weapons sales.³⁰ Another GLD business group, the 999 Enterprises Group, was formed in early 1992 in order to bring together under unified management all the GLD companies operating in the Shenzhen Special Economic Zone. According to one report, within its first 10 months of operation the 999 Group generated 157 million yuan in profits in industrial sectors as diverse as pharmaceuticals, import-export, electronics, real estate, clothing, food, stock and securities, and more. By the mid 1990s this group had 34 enterprises and fixed assets of 1.6 billion yuan.³¹ In 1993 the foreign trade of the Group was reported to be worth nearly \$12 million, involving trade with Russia, Sudan, Singapore, Hong Kong, Egypt, and Qatar.³²

China's armed services departments—its army, navy, and air force—also operate their own commercial ventures. The air force has been estimated to have around 430 enterprises and mines, 160 air bases, nearly 400 farms, and to run its own commercial airline (United Airlines). By 1992 this airline had established 39 domestic routes.³³ The air force has eight airport construction teams that undertake commercial contracts to build civilian and military airports. China's navy uses its shipping fleet to engage in commercial ventures. According to one account, units of the South China Fleet are involved in more than 460 construction companies in the special economic zones in southern China.³⁴ The China Songhai Industrial and Commercial Corporation is the navy's main business conglomerate. China's Second Artillery, the PLA's main infantry force, has not been left behind in the rush towards commercialization. Its Shanhai Enterprise Group runs a range of commercial ventures, that have established a particularly strong position in the pharmaceutical industry.³⁵

³⁰ Xinxing is primarily involved in the sale of logistics equipment. For further discussion see Ellis Joffe, "The PLA and the Economy: The Effects of Involvement," in *Chinese Economic Reform*, ed. Segal and Yang.

³¹ *Zhongguo Xinwen She*, 29 November 1992; *FBIS*, 9 December 1992, p. 33. Cited in Joffe, "The PLA and the Economy," p. 21.

³² *Jiefangjun bao* [Liberal Army Daily], 10 June 1993; *FBIS*, 21 September 1993, p. 43. Cited in Joffe, "The PLA and the Economy," p. 22.

³³ *Jiefangjun Bao*, 4 October 1993; *FBIS*, 14 October 1993, p. 20. Cited in Joffe, "The PLA and the Economy," p. 21.

³⁴ Beijing, *Xinhua* [Domestic Service], 9 April 1993; *FBIS*, 20 April 1993, p. 22. Cited in Joffe, "The PLA and the Economy," p. 21.

³⁵ Cheung, "The Chinese Army's New Marching Orders," p. 188.

The military's business holdings are further divided according to regional military commands. China's military regions and provincial military districts operate their own enterprises and business interests. The Shandong Dongyue Corporation oversees the 600 army-owned enterprises in the Jinan Military Region. The Sichuan Military District set up the Sichuan Bashu Enterprise Group in 1992 to oversee its businesses.³⁶ Differences in profitability between military business groups are influenced by a range of factors, including their geographical location, resources, technology, infrastructure, etc. Many of the most successful military-affiliated corporations are in the southern Guangdong area. Some of the special economic zones (SEZ) in the south were established and are operated by regional military units, including the Shantou SEZ, which is operated by the Guangzhou military region. Military enterprises that operate in more remote areas, such as in the Third Front, are at a much greater disadvantage. The Southwest Great Wall Economic Development General Corporation, which oversees the enterprises in the Chengdu military region, covering remote areas in Tibet, Sichuan, and Yunnan, faces considerable disadvantages compared to those in the Guangdong area.³⁷

The decentralization of the military's business structure extends to the lowest level of the military hierarchy, with group armies and individual departments within higher level commands and regional armies also operating their own business ventures. The businesses operated by these lower level units tend to be smaller and less profitable than those operated by higher level units. In-land military groups in general have fewer commercial opportunities than coastal groups. The Luyan Enterprise Group, operated by a group army in Shaanxi province, is more typical of an in-land type group, consisting of only ten enterprises, mostly factories and mines.³⁸ There are, however, exceptions. The 42nd Group Army that is based in Huizhou, Guangdong province, operates the Changcheng (Great Wall) Huihua Industrial Corporation, one of the largest and most successful business

³⁶ Ibid., p. 190.

³⁷ The Third Front refers to the military-industrial complex set up Mao in the 1960s as a means of spreading China's industrial capability over diverse geographical areas. These enterprises are geographically isolated and cut off from resources and adequate infrastructure. They have a difficult time retaining skilled personnel and suffer from old technology, outdated equipment, and over-staffing.

³⁸ *Jiefangjun Bao*, 10 January 1992, p. 1. Cited in Cheung, "The Chinese Army's New Marching Orders," p. 190.

conglomerates in southern China. Changcheng has over 90 enterprises that operate throughout the southern coastal area, including in special economic zones such as Shenzhen and Shantou.³⁹

The range of industries in China's military-defense complex is evident from the above discussion. A look at aggregate figures confirms the important position of military-affiliated businesses in a wide range of economic sectors. Military-defense production accounts for about 20 percent of China's annual passenger car production. There are nearly seventy automobile plants owned by the military, with a total annual capacity of 50,000 vehicles and 500 million yuan worth of vehicle parts.⁴⁰ The PLA alone operates around 400 pharmaceutical factories, which were estimated in the early 1990s to account for around 10 percent of China's annual output in this sector.⁴¹ The PLA continues to operate the farms and enterprises that traditionally were intended to make it more self-sufficient in food, supplies, and spare parts. In 1993 the PLA's military farms earned it extra revenue of around 700 million yuan.

Defense Industries Business

The business complex operated by China's defense industries is a second major component of China's military-defense business complex. In some ways the defense industries have been better positioned than the PLA to launch commercial ventures. Military-defense R&D has always been concentrated in the defense industries and they have been responsible for production of advanced and technical equipment. Furthermore, the defense industries have always had a greater concentration of scientists, engineers, technicians, and other skilled personnel than civilian industries, and than the PLA, as well.⁴² The institutional separation between the end-users of military equipment and technology and its producers has meant that the PLA has not required the same level of technically skilled personnel. The original purpose of PLA factories was to support everyday needs of the

³⁹ *Jiefangjun Bao*, 1 December 1988, 26 January 1992. Cited in Joffe, "The PLA and the Economy," p. 22.

⁴⁰ *Zhongguo Jingying Bao*, 28 October 1994, p. 7. Cited in Cheung, "The Chinese Army's New Marching Orders," p. 190.

⁴¹ *Zhongguo Junzhuannmin Bao*, 8 January 1991, p. 1. Cited in Cheung, "The Chinese Army's New Marching Orders," p. 192.

⁴² Gurtov and Hwang, *China's Security*, p. 155.

armed forces—not to produce high-technology equipment or engage in military R&D. PLA factories have therefore had a history of producing low-technology goods, which support the army directly, including quartermaster goods, textiles, food production, etc.

Most of the defense industries have rapidly redirected their production towards the commercial market. The aerospace industry is a good example of this. The Ministry of Space Industry, converted from the old 7th Ministry of Machine Building in 1982, has been quite successful in utilizing its technology to shift into civilian/commercial production. In 1980 civilian products accounted for 16 percent of this industry's output value, but this increased to 75 percent by 1988.⁴³ The industry operates 16 plane-manufacturing companies and has contracts with numerous foreign companies, many in Southeast Asia, to manufacture aircraft parts. By 1990 the industry had a total workforce of 800,000, and its sales abroad were U.S. \$294 million. It operates three export-promoting corporations to handle its sales abroad. Despite its advantages, it still took this industry time to become commercially successful. Its greatest foreign currency earnings come from its sale of tactical ballistic missiles to the Middle East.⁴⁴ And the industry has faced considerable difficulties, such as numerous disastrous satellite launches in the mid-1990s.

A second major defense industry that illustrates the defense industries' rapid and relatively successful shift to civilian and commercial production is the nuclear industry. This industry employs about 300,000 workers in 200 enterprises. Like other defense industries it has been restructured a number of times.⁴⁵ Production of nuclear power at two nuclear power plants for the civilian market

⁴³ SPC (State Planning Commission) and COSTIND, eds., *Zhongguo guofang gongye junminjiehe shizhounian zhuanji*, Special Edition on the 10th Anniversary of Military Conversion in China's Defense Industries (Beijing: Ordnance Industry Publishing House, 1990), p. 13. Cited in Gurtov and Hwang, *China's Security*, p. 155.

⁴⁴ John Lewis and Hua Di, "China's Ballistic Missile Programs: Technologies, Strategies, Goals," *International Security* 17, no. 2 (Fall 1992), p. 34.

⁴⁵ Originally the nuclear industry was part of the secret cluster of numbered machine-building industries responsible for the atomic bomb construction. In 1982 it was converted into the Ministry of Nuclear Industry, which reflects the new importance placed on civilian nuclear power. Then in 1988 it was transformed into the China Nuclear Energy Industry Corporation and placed under the supervision of the Ministry of Energy Resources. Finally, in 1993 it was converted into the China National Nuclear Corporation (CNNC). See John Lewis and Litai Xue, *China Builds the Bomb* (Stanford: Stanford University Press, 1988), pp. 54-59. See also Gurtov and Hwang, *China's Security*, p. 156.

has been a key source of this industry's profits.⁴⁶ Its other commercial products include nuclear technology and radioisotope products, fire alarms, rare-earth products, nonferrous and precious metal products, metallurgical-chemical products, and machine instruments. Between 1989 and 1996 the proportion of the industry's civilian production increased from 42 to 80 percent of its output value, and in 1996 it reported annual growth of 20 percent.⁴⁷ With the proportion of nuclear power in China's total electricity output increasing steadily, this industry can probably count on steady growth for some time.⁴⁸ There is a large potential international market for China's nuclear industry, including the building of nuclear power plants, not to mention the sale of weapons-making capability that has been such a concern to the United States.

COSTIND Businesses

A third component of the military-defense business empire are the commercial ventures directly affiliated with the institution that coordinates between the PLA and the defense industries—COSTIND. This illustrates how even the organizations responsible for regulatory activities have also “jumped into the sea.” While COSTIND is responsible for supervising and regulating the commercial activities of the defense industries and for coordinating overall military R&D and production, it has simultaneously set up its own business companies.⁴⁹ Its larger business entities include the Xinshidai Corporation, which is engaged in marketing and publications among other things; the Xiaofeng Technology and Equipment Corporation, which is involved in computers and other high-technology ventures; and the Yuanwang Group. It has up to a hundred other companies in addition.⁵⁰

⁴⁶ According to one report the production of civilian nuclear power was responsible for a fourfold increase in the industry's profits from 1984 to 1986. Gurtov and Hwang, *China's Security*, p. 156.

⁴⁷ Gurtov and Hwang, *China's Security*, p. 156.

⁴⁸ In 1995 nuclear power accounted for 1.2 percent of China's electricity output, but the percentage is expected to rise to 6 by 2020. “Nuclear Power Plays Important Electricity Role,” *China Daily*, January 6, 1996. Cited in Gurtov and Hwang, “The New Military Economy,” p. 156.

⁴⁹ One indication of the important status of this organization is the fact that its head is typically a member of the Central Military Commission.

⁵⁰ Frankenstein and Gill, “Current and Future Challenges,” p. 400-01.

According to official Chinese statistics, the defense sector's share in the total production of various goods include automobiles, 9 percent; motorcycles, 60 percent; and container trucks, 26 percent.⁵¹ Upwards of 90 percent of the production in the electronics industry is estimated to be done by defense-affiliated enterprises. Among the eight big automobile manufacturing entities in China, three belong to the defense industrial system.⁵²

Earnings

There is considerable variation in earnings among the various components of the military-defense sector. Many military enterprises run in the red. According to a common estimate, one half to two-thirds of the PLA's industrial factories run a deficit. Military industrial enterprises have had the worst record, and the industrial enterprises of the Third Front are among the worst performers. It would appear that larger enterprises have performed better than smaller ones owing to advantages in terms of bank loans, access to capital and technology through domestic and foreign sources, governmental preferential treatment, employment of skilled personnel, etc. Three of the PLA's corporations—the Poly Group, Shenzhen's 999 Group, and the Xinxing corporation—are said to account for about one third of the PLA's total business earnings.⁵³

Declared profits from PLA businesses have been around 10-15 percent of the official defense budget. In 1992 PLA businesses declared 5 billion yuan in profits, out of a total defense budget of 37 billion yuan.⁵⁴ Western estimates of military profits have tended to much higher, between U.S. \$5 to U.S. \$20 billion.⁵⁵ However, only rough estimates of the earnings of military-affiliated businesses can be made. Official figures almost certainly under-report profits, for several reasons. First,

⁵¹ Feng-cheng Fu and Chi-Keung Li, "An Economic Analysis," in *Mixed Motives*, ed. Brömmel-hörster and Frankenstein, p. 48.

⁵² Beijing Jeep, Chongqing Changan, and Guizhou Aviation. See Fu and Li, "An Economic Analysis," p. 48.

⁵³ Cheung, "The Chinese Army's New Marching Orders," p. 194.

⁵⁴ Loc. cit.

⁵⁵ Richard A. Bitzinger, "China's Defense Budget," *International Defense Review* (February 1995): 36. Some have put the figure between U.S.\$1-2 billion. See Cheung, "The Chinese Army's New Marching Orders," p. 196.

there are a considerable number of PLA businesses that are illegal or whose legality is borderline, as discussed further below. The PLA is heavily involved in the booming prostitution business, contraband, manufacturing of pirated CDs and other products, smuggling of foreign products into China, and more. These illegal activities could account for large-scale under-reporting of its profits by the PLA.⁵⁶ Second, like most business entities, the PLA is interested in minimizing the taxes its subsidiaries have to pay, and may not therefore push for thorough accounting and auditing of its enterprises. The underdeveloped financial system further contributes to the state's difficulty of effectively regulating China's burgeoning businesses. Finally, top military commanders have had their own difficulty in monitoring the commercial activities of their own subordinate entities. A self-audit conducted in 1993 by the auditor general of the PLA discovered billions of yuan in unauthorized spending by military units.⁵⁷ Reportedly, a review of more than 130 receipts, bills, and invoices brought to light 3.25 billion yuan in economic benefit to the PLA. One can guess that only a portion of the hidden economic activities was discovered by the PLA auditors. This means that at least billions of yuan are going unreported to the PLA by its subordinate units annually.

Military Entrepreneurship and Business Forms

The military-defense sector illustrates the variety of business forms that government entrepreneurship has taken in China. Several can be identified. First, the establishment of new profit-seeking firms and the transformation of existing enterprises into profit-seeking firms, which operate under the supervision of a parent governmental agency. Second, the transformation of entire public institutions and government agencies into (at least) nominally independent, profit-seeking entities. Third, the establishment of business conglomerates jointly owned by a plurality of government agencies and public institutions. These may be formed through the spinning-off and merger of portions of various government agencies, or through the establishment of a joint-venture by a number of government agencies which each own a portion of the shares.

⁵⁶ The military is perfectly positioned to engage in such activity because of its traditional operational autonomy and the difficulty which any state police force would have in effectively supervising its activity.

⁵⁷ Beijing, *Xinhua* [Domestic Service], 18 August 1993; *FBIS* 20 August 1993, p. 21.

In the first category, a common source of new, profit-oriented enterprises in the military has been restructured Third Front enterprises, which are often relocated from in-land to coastal areas. Third Front industry enterprises are typically located in remote areas with difficult access to energy sources, infrastructure, capital, human resources, etc. One solution adopted has been to restructure and relocate resources from these in-land enterprises to the coastal areas, or to establish entirely new enterprises on the coast with the military's resources. This type of enterprise is referred to as a "window" for the third-line military sector, as it offers a connection to an area in which capital, resources, infrastructure, personnel, etc. are more available. This has been a restructuring strategy adopted by in-land provinces such as Shaanxi and Sichuan that have a high concentration of Third Front enterprises.⁵⁸

The military also illustrates the second type of business form, which has resulted in what one commentator refers to as "ministerial-cum corporations."⁵⁹ The aim of this transformation has been to turn ministries, or portions of them, into semi-private business corporations responsible for their profits and losses.⁶⁰ While nominally independent, these new corporations still operate under the supervision of a military superior, either COSTIND or a ministry. For instance, the former Ministry of Aerospace was broken up into the China Aerospace Corporation (CASC) and the Aviation Industries of China (AVIC), both of which are supposed to operate as independent business entities under the guidance of COSTIND. The old Ministry of Ordnance was converted into the China North Industries Group (NORINCO), now one of China's largest arms trading companies. These "ministry-cum corporations" typically remain large and highly diversified, with a large number of subsidiaries. AVIC includes more than 200 trading companies and enterprises, employs more than 500,000

⁵⁸ For example, this became a key strategy in Shaanxi province. National level officials met in 1986 and decided that because more than 50 percent of the country's third-line enterprises were located in remote areas, that they would advocate the restructuring and relocation of some of these enterprises to the coastal areas. In many cases, entirely new, non-military managers were appointed to these new enterprises. Gurtov and Hwang, *China's Security*, p. 155.

⁵⁹ Frankenstein, "China's Defense Industry Conversion."

⁶⁰ China State Council Information Office, "China: Arms Control and Disarmament," *Beijing Review*, no. 48, p. 16.

workers, and has more than 30 affiliated research institutes and six universities and colleges.⁶¹ The subsidiary enterprises of these corporations can themselves be quite large.

Through the 1980s the structure of the military-defense business empire fairly closely mirrored the military's bureaucratic structure. However, new commercial organizations have proliferated that cut across the old structure, giving rise to new business forms. For instance, military conglomerates have been established that operate across a number of regional territories. The Nanfang Industrial and Trading Corporation, which reported exports of \$117 million in 1993, operates across 5 provinces.⁶² Like other public agencies, the military has also become a partial owner in a variety of joint ventures with domestic and foreign entities.

Property Rights: Profits and Control

Who really owns these military-affiliated companies? They differ from the traditional state-owned enterprise, but neither are they privately owned. This question is central to China's distinct market system. One way to assess this is to look at the distribution of profits and managerial control.

In principle the profits from military-defense affiliated enterprises are divided between the enterprise and a number of superior units—i.e., between the enterprise, an immediate supervising unit, and sometimes an even higher level authority. Written guidelines state how this distribution should be made, although these are often very crude. A good example is the *Complete Practical Guide to Chinese Military Finance*, which outlines how profits in a variety of enterprises should be divided. According to this guide, commercial guest houses and hotels operated by units within the PLA are expected to turn over 20 percent of after-tax profits to the PLA's GLD, while the distribution of the remainder can be decided by the various units involved. Troop services centers are supposed to turn over 30 percent of their profits to the GLD, with the distribution of the remaining 70 percent also controlled independently by the units in charge. The distribution of profits from other companies is decided by the units in charge. These guidelines also specify the distribution of profits for the large corporations directly managed by top level commands. For instance, the China Xinxing Corporation is expected to hand over 70 percent of its annual profits to its supervising unit—the GLD—while it is allowed to retain the remaining 30 percent. A separate set of guidelines

⁶¹ Frankenstein and Gill, "Current and Future Challenges," p. 399.

⁶² Cheung, "The Chinese Army's New Marching Orders," p. 189.

exist for the People's Armed Police, although they are quite similar to those operating in the other divisions of the PLA. Enterprises directly under the PAP headquarters are supposed to turn over 70 percent of their profits to the PAP logistics department. Enterprises operating under provincial level PAP corps or colleges are expected to hand over 20 percent of profits to PAP headquarters, and 30 percent to the corps or college, and may retain the remaining 50 percent.⁶³ The specific formula and allocation of profit may vary from branch to branch within the military, and from enterprise to enterprise, but a basic system exists in which profits are divided three ways among the enterprise itself, its immediate supervising unit, and the higher level unit. Despite guidelines such as these, the evidence suggests that in practice the distribution of profits of commercial ventures is subject to negotiation by the parties involved and is affected by the degree of leverage that each exercises, a pattern that is also evident in other public sectors.⁶⁴

The Impact of Military Entrepreneurship

Positive Consequences

The entrepreneurial activities of the Chinese military illustrate both the strengths and weaknesses of state entrepreneurship more generally. The positive aspects include greater economic dynamism, enhanced competitiveness, the generation of extra-budgetary revenue, more efficient utilization of resources, including technology and human resources, and other contributions to China's market transition. The military's commercial activities have generated extra-budgetary revenue needed to cover military budgets that were declining throughout the 1980s. The military has raised roughly one fifth of its total revenues from its businesses. These funds have been critical for maintaining the institution—paying for soldiers' salaries, living necessities, training, as well as paying

⁶³ *Zhongguo junshi caiwu shiyong daquan* [Complete Practical Guide to Chinese Military Finance] (Beijing: Jiefangjun chubanshe, 1993), pp. 32-33. See also Arthur S. Ding, "China's Defense Finance: Content, Process and Administration," *China Quarterly*, no. 146 (June 1996): 428-42.

⁶⁴ For the role of bargaining in the distribution of profits from high-technology companies operated by universities, research institutes, and other educational institutions see Francis, "Bargained Property Rights: China's High Technology Spin-off Firms."

for the purchase of modern weapons. Comparisons between the conditions of the Chinese and the Russian military help to put this positive function in perspective.⁶⁵

Military entrepreneurship has contributed to China's economic reforms by encouraging greater and more efficient use of military resources, including technology, capital, plant facilities, human resources, etc. Military conversion, for example, has also ameliorated the problem of overcapacity by encouraging the shift of underutilized plant facilities, resources, technology, etc. to civilian and commercial uses. China's military business activities also demonstrate how governmental entrepreneurship may contribute to the level of competition in the economy in the shift away from a centrally-planned economy. The fragmented structure of control and property rights within the military's business empire contributes to the level of competition. The enterprises supervised by diverse organizations within the military's institutional framework must compete with each other. Competition may even exist *within* a single institutional group. While the air force operates its own airline, a trading company set up by the air force also set up an airline, which could potentially come into competition with the one operated by the air force itself!⁶⁶

Military entrepreneurship illustrates how the generation of revenue from commercial activities can create a feed-back mechanism which in turn promotes modernization of that sector. The transfer of technology and resources from public sectors (including the military, education, etc.) to civilian/commercial uses has generated revenue that is then used to modernize those sectors. Military conversion has been used to modernize military technology, to pay for additional military R&D, to purchase foreign technology and weapons, and more. For instance, the revenue generated by the military's nuclear industry's conversion to production of civilian nuclear power has helped to fund an active research program in nuclear fusion and large reactors.⁶⁷

⁶⁵ See Jörn Brömmelhörster, "Semantic Differences: Comparing Defense Conversion in China and Russia," in *Mixed Motives*, ed. Brömmelhörster and Frankenstein.

⁶⁶ *The China Business Review* (Sept.-Oct. 1989), p. 30. Cited in "The PLA and the Economy," p. 21.

⁶⁷ Xinhua (Beijing) domestic broadcast, January 10, 1996, in *FBIS-CHI* 96-016, January 24, 1996, pp. 23-24. Cited in Gurtov and Hwang, *China's Security*, p. 156.

Negative Consequences

The Chinese military also illustrates negative or ambiguous aspects of China's approach to economic reform. First, the direct engagement by public institutions in commercial activities can create a conflict over their fundamental identity and integrity. They must simultaneously seek to maximize their profits and respond to political directives from the state. This type of conflict was reported by managers of China North Industries Corporation (NORINCO) plants, whose commercial plans reportedly clashed with the State Council's effort to impose certain military production targets.⁶⁸ While it is difficult to assess the extent to which this may threaten national security, evidence of the tension is clear. At a practical level, this tension is evident in the simple question of supplies. As an organization committed to national security, military institutions would be expected to maintain adequate supplies on hand in the event of a security conflict. On the other hand, in the role of profit-seekers they would not want to maintain excess inventory. Military entrepreneurship could also affect the attitude of the military towards the outbreak of war if the military had business holdings with the countries involved. Given that the military was involved in more than 300 joint ventures with foreign companies in 1995, including some from countries with which China has potential national security issues, such as Taiwan and Japan, the chance of that should be seen as considerable.

Commercial activities can damage the military's institutional professionalism and integrity in other ways. It can create tension between treating its soldiers as a labor force versus treating them as a professional force. Soldiers are hired as laborers in many of the military's factories. This creates a tension in the military's interest in paying them low wages and benefits in order to maximize profits, and its interest in maintaining their professional status. Using soldiers as workers risks the morale of the troops, many of whom may find themselves working in low-skilled, low paying positions that have little to do with the role of the soldier. It also conflicts with the goal of professionalizing the military that has been advocated by the state during the reform period.

There is evidence that the focus on profits has damaged professional standards within the military. According to some Chinese press reports, military units sometimes cut short military train-

⁶⁸ Frankenstein and Gill, "Current and Future Challenges," p. 399.

ing with the excuse that they lack the funds to carry them out.⁶⁹ In response to this problem in 1993 the government imposed a resolution that prohibited military enterprises from hiring active service military personnel in their enterprises. Military entrepreneurship appears to have contributed to the decline of ethical standards within the ranks. Promotions, awards, sought-after transfers, recruitment of new party members, etc. are reported to be increasingly contingent on bribing the officers in charge. To get the necessary funds to bribe his officers for a desired promotion one soldier in Beijing was reported to have become a thief.⁷⁰

Commercialism appears to have weakened the institutional coherence of the military through an erosion of financial control. Commercial activities have exacerbated the decentralization of control over revenue and expenditures. Finance departments within the military were weak to begin with, lacking control over a number of important expenditures, including equipment (which accounts for one third of the military's published expenditures), scientific research, and capital construction.⁷¹ The reform process has further weakened their authority. Extra-budgetary revenue generated through the military's commercial activities are typically not turned over to finance departments.⁷² Finance departments have not been given managerial authority over profits from production operations or other forms of extra-budgetary revenue. As a consequence, the increased revenue from these sources has further decentralized financial management within the military.

Anti-market Forces

The military's commercial activities illustrates the anti-market potential of government entrepreneurship. The military's monopoly over certain resources can inhibit competition in certain

⁶⁹ *Jiefangjun Bao*, 16 March, 1990. Cited in Cheung, "The Chinese Army's New Marching Orders," p. 197.

⁷⁰ Li Xusheng, Li Quanmo and Tao Ke, "Xin shiqi gongfu de meili" ["The charm of being a public servant in the new era"], *Jiefangjun bao* [Liberation Army Daily], 14 December 1992. Cited in David Goodman, "Corruption in the PLA," in *Chinese Economic Reform*, ed. Segal and Yang, p. 44.

⁷¹ Ding, "China's Defense Finance," p. 439.

⁷² Arthur Ding argues that the fact that finance departments are part of the military's logistics system is an additional disincentive against military-defense units turning their earnings over to them, since they are perceived as having their own distinct interests to protect. See Ding, "China's Defense Finance," p. 440.

sectors, even as there is overheated competition in other sectors. For instance, in some localities the military exercises a near monopoly over commercial transportation and shipping because of its large fleet of vehicles, aircraft, and ships, and its vast transportation network of railways, harbors, airports, and roads that are often for its exclusive use. This is evident in the coal industry, where in many remote areas the military exercises a monopoly over transportation, in addition to owning numerous coal mines.⁷³ While this may be good for the military's business, it is deleterious for the market system.

Military commercialism illustrates the persistence of soft-budget constraints towards government-affiliated enterprises. From one-half to two-thirds of military enterprises are estimated to be operating in the red.⁷⁴ The military, like other state sectors, has resources to keep failing enterprises going, and they are under political pressure to do so in order to minimize unemployment and maintain social order. Commercial activities, ironically, may to an important extent facilitate the subsidizing of failing enterprises. Continued soft-budget constraints may undercut the role of competition in weeding out poorly performing enterprises. Furthermore, military enterprises have access to a wide range of subsidized goods and commodities and some of them enjoy special tax and customs breaks, as well as privileges in importing and exporting.⁷⁵

These factors can lead to irrational market fragmentation, with an excess number of firms competing in a limited market. When a new product or industry is "hot," the military, like other government agencies, rushes to enter this sector, creating a glut. However, the relatively soft budget constraints characteristic of government-operated companies weakens the role of the market mechanism in weeding out less efficient companies. The result is that a glut of companies in a particular industry does not always get weeded down through market competition. This occurred in the real estate industry, electronics, home appliances (refrigerators, televisions), etc. The result is often a failure to consolidate and restructure in the style of Western markets. Rather, the Chinese military

⁷³ Min Chen, "Market Competition and the Management Systems of PLA Companies," in *Mixed Motives*, ed. Brömmelhörster and Frankenstein, p. 212.

⁷⁴ Cheung, "The Chinese Army's New Marching Orders," p. 194.

⁷⁵ *Ibid.*, p. 188.

mirrors the continuing tendency for government agencies to subsidize their loss-making enterprises from their profitable ones.⁷⁶

Corruption

The military's commercial activities illustrates the potential corruption associated with governmental entrepreneurship. Because of its status and its role in national security the military has probably been one of the worst perpetrators of corruption in China. It has been close to immune from inspections and investigation. For example, the simple fact that the cargo being hauled in its military transport vehicles does not get inspected the same way as cargo in civilian commercial transport vehicles opens up a whole arena of potential corruption. Furthermore, military corruption cases have been treated as classified. For the most part the military has regulated corruption within its ranks, and as of January 1, 1993 cases of corruption within the military were put under the sole jurisdiction of military tribunals and subject to military secrecy.⁷⁷ Economic pressures are also a source of corruption within the military. Declining living standards of PLA soldiers have made the military an unattractive career—activities that generate extra revenue to counterbalance this trend have thus become an institutional necessity.

Corruption within the military reflects the various forms of corruption flourishing in China, including bribery, smuggling, fraud, and illicit use of public resources, personnel, and equipment for personal or collective gain. Military agencies, like other state agencies, accept kickbacks and commissions in exchange for contracts, sell state-subsidized goods in the private market at below-market prices, and engage in other forms of bribery. Embezzlement, the outright theft and sale of state property, and the illegal or illicit use of public resources are particularly severe in the military because of its vast resources. Within a three month period between February and April 1991 a political instructor of a unit of the PLA Navy was reported to have stolen more than four tons of fuel

⁷⁶ Richard J. Latham, "A Business Perspective," in *Mixed Motives*, ed. Brömmelhörster and Frankenstein.

⁷⁷ "Junshi fayuan shenli jingji jiufen anjian de ruogan wenti" ["Several questions on handling cases of economic disputes by military tribunals"] in *Jiefangjun bao* [Liberation Army Daily], 4 January 1993; and Geng Renwen, "Junnei jingji shenpan yin zhunxun weihu junshi liyi yuanshe" ["The trial of economic cases in the army should follow the principle of protecting military interests"] in *Jiefangjun bao* [Liberation Army Daily], 31 May 1993. Cited in Goodman, "Corruption in the PLA," p. 39.

from a military oil terminal, which he sold for 4,400 yuan.⁷⁸ The PLA's Liberation Daily reported that the theft of weapons and military equipment had become a common practice among soldiers.⁷⁹ The extent and types of corruption are evident in the regulations aimed at prohibiting these activities. The "ten nos" issued in 1989 sought to prohibit the PLA from activities such as setting up businesses without permission; buying goods illegally, fixing prices, and profiteering; producing and selling fake goods; using military equipment or vehicles to engage in smuggling, speculation, etc.; leasing or selling of military equipment, vehicles, bank accounts, blank invoices; using officers and men on active duty to run enterprises and to engage in trade; and exploiting the positions of military men for business purposes.⁸⁰

Smuggling has become a specialty of the military because of its access to transportation vehicles such as helicopters, ships, and gunboats, and its ability to transport goods with little risk of inspection. PRC Customs anti-smuggling teams need special approval from Beijing in order to investigate a military unit.⁸¹ One of the best known smuggling cases was the Hainan province case of 1985, in which the Hainan local government used its special status to buy foreign luxury cars that were then resold to buyers on the mainland. Both the PLA Navy South China Sea Fleet and the army cooperated with the local government to smuggle the cars into China using their helicopters and gunboats. In another big case, 38 gun-boats, torpedo boats, escort vehicles, and submarine chasers that were being used in smuggling were captured in Guangdong in 1992. In this case the military defended itself by claiming that these vehicles had already been retired and that the military was thus not involved.⁸² Because military personnel and units enjoy special privileges, there has been an

⁷⁸ Zheng Jingjie, "Zhiquan shengliao tan moushi de jieti" ["Power becomes a tool for him to seek personal gain"] in *Jiefangjun bao* [Liberation Army Daily], 14 December 1993. Cited in Goodman, "Corruption in the PLA," p. 44.

⁷⁹ Gao Laifu and Liu Xiangiang, "Jiaqiang dui junren weifa fanzui shehui youyin de fangfan" ["Strengthen guard against temptation for soldiers to commit crimes"] in *Jiefangjun bao* [Liberation Army Daily], 17 May 1993. Cited in Goodman, "Corruption in the PLA," p. 44.

⁸⁰ *Hong Kong Zhongguo Tongxun She*, 25 April 1989; *FBIS*, 2 May 1989, p. 116. Also cited in Joffe, "The PLA and the Economy," p. 23.

⁸¹ Goodman, "Corruption in the PLA," p. 46.

⁸² Yan Changjiang, *Guangdong Da Lieban* [The disintegration of Guangdong] (Jinan University Press, 1993), p. 242. Cited in Goodman, "Corruption in the PLA," p. 46.

explosion of fraudulent use of military official seals, registration plates, and military registration forms that enable non-military individuals and organizations to pass themselves off as belonging to the military.

Conclusion

The Chinese military's entrepreneurship reflects key features of China's evolving national system of innovation—the emergence of state entities and public institutions as dominant market actors, the fragmentation of ownership within this quasi-public sector, increased economic dynamism coupled with heightened corruption, and more. On the positive side, military entrepreneurship has contributed, along with other forms of public entrepreneurship, to the overall dynamism of China's market economy. It has helped to shift public resources to more efficient and profit-oriented enterprises. It has enhanced the use of military technology for civilian production. And the revenue from military businesses has been critical to sustaining the military institutionally, helping to pay for the purchase of advanced weapons as well as subsidizing institutional maintenance expenditures. On the other hand, military entrepreneurship illustrates the potential pitfalls of public entrepreneurship. It has helped to extend the practice of soft-budget constraints to new, nominally market-oriented firms. It has allowed the emergence of sectoral and regional monopolies and has in certain ways undercut the role of competition in weeding out inefficient enterprises. Finally, the military's commercial activities show how public entrepreneurship can erode the integrity and cohesion of public institutions and potentially undermine their professionalism.

The Changing Role of the Defense Industry in Israel's Industrial and Technological Development

Dov Dvir and Asher Tishler*

Introduction

Since the end of the cold war, national defense budgets have shrunk drastically while production capacity has not changed much. Consequently, export markets have become more competitive, and national defense industries, which until several years ago were the dominant suppliers in their home markets, are no longer fully protected from competing imports. Moreover, despite the increased competition and the use of cheaper off-the-shelf commercial components instead of specially designed military ones, the prices of new weapons and defense systems seem to be rising inexorably. Economic necessity is beginning to wear away the defense industry's segregation, forcing companies and governments to cooperate as well as to compete across borders. The outcome of this consolidation has been the emergence of a small group of defense giants in the United States and Europe. Size, it seems, is a crucial factor in the defense industry (*Economist* 1997).

Though the Israeli defense industry, like defense industries elsewhere, suffers from excess capacity and, hence, inefficient operation, myopic government policies and lack of long-run planning, have prevented it from following the world-wide trend of consolidation and mergers across borders. Clearly, this isolationism cannot be sustained much longer. The Israeli defense firms, some of which are world leaders in various defense products, must change, or risk default.

In this chapter we describe the Israeli defense industry, emphasizing its role in Israel's industrial development. In particular, we show how the effect of the defense industry on the economy depends primarily on the following factors: (1) the defense needs of the country; (2) the overall economic situation of the country and the size of its defense industry relative to the civilian industry; and (3) the stage of technological development of the country.

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Our analysis shows that judging the defense industry on economic performance alone is misleading, since it does not account for the threat from enemies and disregards the defense vision of the nation, thus ignoring Israel's need to conduct defense research and development (R&D) for its own exclusive use.

The limited available data suggest that the Israeli defense industry was instrumental in transforming the country's civilian industry into a successful high-tech sector. The entrepreneurial spirit, the problem-solving approach, and the system-oriented approach, which are characteristic of most of the successful high-tech firms in Israel (Kaplan 1998), originated in Israel's military and the defense industry. Moreover, the defense sector is still a very important source of new technological know-how and experienced human resources for the civilian high-tech industry.

The Israeli Defense Industry—Its Origins and Development over Time

The Israeli defense industry can be traced back to the early 1920s, when the first attempts were made to produce weapons and ammunition to defend the small Jewish community in the land against Arab attacks. In 1933, when Palestine was still under British rule, TAAS, the first industrial defense enterprise, was established. It manufactured rifles, mortars, hand-grenades, and ammunition in small underground workshops.

In the 1950s, after the War of Independence, the defense industry developed primarily by establishing new organizations, most of them government owned. An R&D division was established in 1952 within the Ministry of Defense (MOD). This division was reorganized in 1958 as a separate entity, Rafael (the Armament Development Authority), which over the years turned into the country's central defense development organization. Bedek, established in 1953 for the purpose of maintaining and refurbishing aircraft, later developed into the Israel Aircraft Industry (IAI). Several refurbishing and maintenance centers were also established within the army for the purpose of maintaining armored and support vehicles. At a later stage, these centers began to specialize in the reconstruction and improvement of tanks and armored vehicles.

Some privately-owned defense firms were also founded during the 1950s. Soltam, which specialized in manufacturing mortars and cannons, was established as a joint venture of Koor and a Finnish consortium, which provided technology and know-how. Tadiran, currently the largest military communication equipment manufacturer in Israel, was formed by the merger of two small privately-owned factories making dry cells and light bulbs.

By the mid-1960s, the defense industry workforce had grown to about 15,000 from some 5000 during the 1950s. The rapid growth of the Israeli economy that followed the 1967 Six Day War prepared the ground for the subsequent continuous growth of the defense industry over the next two decades. The number of employees in the defense industry tripled between 1967 and 1975, and increased by a further 50 percent between 1975 and 1985. The rapid growth of the 1967-1975 period was due mainly to the rapid growth in internal demand (especially after the 1973 Yom Kippur War). The growth in 1976-1985, by contrast, was based mainly on a tenfold increase in defense exports during this period (Lifshitz 1999; Tishler and Rotem 1995).

The slow-down in the growth of the defense industry, which started in the mid-1980s, turned into a severe crisis at the beginning of the 1990s, following the termination of the cold war and the signing of peace treaties between Israel and several of its Arab neighbors.

The path of technological development along which the Israeli defense industry has progressed is similar to that of other developing countries. At the beginning, before the establishment of the state of Israel and until the mid-1950s, the young defense industry concentrated primarily on the production of light arms and ammunition and the reconstruction of surplus equipment. The second period, after the 1956 Sinai Campaign, was characterized by production under license, especially from French firms. A notable example is the production of the Fuga Magister, a light jet training aircraft, which was produced under license from a French aircraft manufacturer. In the third phase, the industry started to modify and improve weapon systems produced under license or purchased from other countries. During this phase, for example, the Fuga Magister aircraft was converted into a fighter plane by adding guns and rocket launchers. The expertise gained during these improvement programs was used later on to produce new platforms such as the "Eagle," an Israeli version of the Mirage 5. A new era opened in the late 1960s and early 1970s when the local industry was called on to develop entirely new weapon systems. Since then, the Israeli defense industry has developed a fighter plane (the "Lavi"), unmanned airborne vehicles (UAVs), main battle tanks such as the Merkava, missile boats, various types of air-to-air, air-to-ground and ground-to-ground missiles, and even communication and intelligence spacecraft.

Currently, Israel's defense industry consists of about 150 firms. The ten largest firms account for 78 percent of the defense industry workers, 82 percent of its total sales, and 87 percent of its total

exports.¹ More than 75 percent of the sales of the defense industry are exported. Defense products and systems account for 32 percent of Israeli industrial exports.

Israeli defense firms can be divided into three groups. The first group includes the three large government defense organizations, IAI, TAAS and Rafael, which mainly develop and produce defense systems. The second group consists of privately-owned large and medium size firms. Three of the firms in this group—ELOP, Elbit Systems and Elisra—concentrate almost entirely on defense products. The other firms in this group, ECI and Tadiran, produce mainly civilian products (communication equipment), but have defense systems divisions. The third group consists of relatively small privately-owned firms, each producing a narrow line of defense products. For example, BVR develops computerized aircraft simulators, Astronautics manufactures command and control systems, International Technologies produces laser designators, and Rokar develops navigation equipment (MOS 1996/7). Beside the three groups mentioned above there are several large refurbishment and maintenance centers that are part of the army's Division of Technology and Logistics. These centers maintain armored vehicles, aircraft, communication equipment and other support devices used by the military forces. One large refurbishment center is devoted to the Merkava battle tank.

The largest defense firms not only rate among the largest industrial firms in Israel; they are also included among the 100 largest defense firms in the world. Only eight out of the 100 largest defense firms in the world are from developing countries, and five of them are Israeli firms.

The defense industry in Israel incorporates a vast array of technology, from computers and electronics to electro-optics, aeronautics, mechanical design and metal works, chemical engineering, software engineering, and many other areas. Table 1 provides information on the total sales, the number of employees and the areas of expertise of Israel's six largest defense industry firms. The areas of expertise of the smaller defense firms are similar to those of the larger firms. However, some of these smaller firms specialize in specific areas. For example:

Ordan: heavy metal casting, including tank armor;

Soltam: mortars and cannon barrels;

Beit Shemesh Engines: refurbishment and fabrication (under license) of jet engines;

Elisra (a subsidiary of Tadiran): naval, airborne and ground EW systems;

¹ See Lifshitz 1999, for a detailed description and analysis of Israeli defense firms by size, ownership and expenditure on R&D.

Magal: security systems;

BVR and Rada: airborne interrogation systems.

Table 1
Largest Defense Firms in Israel, 1995

Name	Sales (million \$)	Number of Employees	Area of expertise (defense products only)
Israel Aircraft Industry (IAI)	1394	13260	Fighter and support aircraft, manufacturing, UAVs, aircraft refurbishment, space craft, ground-to-air and ground-to-ground missiles, communication equipment, radar, EW equipment, navigation equipment, surveillance systems, command, control and communications systems
Tadiran	1049	8130	Communication equipment, electro-optic surveillance systems, command, control and communication systems, EW systems
Elbit	968	5430	EW equipment; surveillance systems; command, control and communication systems; UAVs; guidance systems; tank command and control systems
TAAS (IMI)	405	5100	Guns and cannons, ammunition, ground-to-ground and anti-tank missiles, heavy metal alloys, robotics systems
Rafael	400	4350	Air-to-air, ground-to-air and anti-tank missiles; rocket engines; communication equipment; EW equipment; surveillance systems; command, control and communications systems; simulators; antennas; reactive tank armor
El-Op	129	1150	Electro-optic guidance and surveillance systems, command and control systems, laser designators.

The Israeli government is heavily involved in the defense industry, being the owner of some of the main defense organizations and, at the same time, acting as the industry's main customer (through the military). The government also controls defense export via a special division in the MOD called "Sibat," which is in charge of authorizing export of classified products.

By virtue of their size, the management and workers unions of government-owned defense firms have accumulated considerable “political” power, which is sometimes used to promote “private” interests. Nevertheless, there is a consensus on the importance of the local defense industrial capability and wide public support for its needs.

The relations between the military and the defense firms are very close. The small size of Israel and its economy, the common background of military service of almost all citizens, and the small number of engineering schools have created the basis for open communication between the military professional staff and the industry. Over the years, these close relations have enabled the shortening of development time, the cutting of development costs, and the development of some unique weapon systems suitable to the conditions in the Middle East and to the special needs of the IDF.

For the last ten years, in addition to its excess capacity problems, intense competition in the worldwide market for defense products, and the chronic shortage of experienced and skilled manpower in electronics and computers, the Israeli defense industry has been suffering from several other specific problems. First, the Israeli defense firms are small in comparison to the large American and European defense firms (*Economist* 1997; Lifshitz 1999). Currently, large firms have considerable advantages in developing and marketing the platforms, large systems, and expensive components that are also produced by Israeli firms. Second, Israel’s target markets are geographically far away. Third, several Israeli firms with similar technologies are competing fiercely among themselves for the same international markets. Fourth, Israeli labor unions in the government defense firms are very influential. They intervene in the daily operations and managerial decisions of their firms, thus preventing the necessary adjustments to the ever-changing, shrinking, and more competitive world market for defense products.

In the following sections we analyze the economic and structural issues related to the above-mentioned problems, laying the basis to the changes that, it is to be hoped, will result in better use of the potential of the Israeli defense industry and improve its performance and competitiveness.

Military Technology and the Civilian Technology Base

There are no official statistical data on the activities of the defense industry in Israel. Indeed, the term “defense industries” is not well defined. There are lists of Israeli and non-Israeli firms that engage in R&D for the defense sector in Israel and abroad (MOS 1996/7; AEI 1998; Greenwald

1992). However, except for the large government-controlled defense organizations such as Rafael, IAI, and TAAS, data on the production and sales of the defense-related products and services of most of the firms on these lists are unavailable. Moreover, many Israeli firms develop, produce, and sell the same final goods, services, semi-finished goods, and materials to both the civilian and the defense sectors (for example, silicon wafers, voice recognition systems, satellite equipment, laser devices, etc). Thus, it is not a simple matter to classify these products as civilian or defense, particularly when sales data are not classified according to customers (see Lifshitz 1999, for a literature review on this issue). For the purpose of this work, firms are included in the defense industry if they produce platforms, finished products and/or systems for the IDF or other armies. Thus, firms that produce components for defense and civilian use are not considered here.²

The effect of the defense industry on an economy depends primarily on the following factors: (1) the defense needs of the country; (2) the overall economic situation and the size of the defense industry relative to the civilian industry; and (3) the stage of technological development of the country.

The Defense Needs of the Country

Countries that face a serious security threat place a higher value on defense relative to other goods than countries in less dire security situations. The defense sector is instrumental to Israel, which lives under a constant threat to its survival. Israel's defense vision calls for the use of state-of-the-art technologies in order to gain a clear edge over its potential enemies. Being a small country with little flexibility in the use of land as a buffer zone, a limited capacity to take large numbers of military or civilian casualties, and economic and social constraints, a quick end to any major war is essential. This means that Israel has to continuously develop and maintain weapons and systems that are not anticipated by its enemies. This approach, which Israel believes is the only way to ensure a sufficiently high probability of a swift and crushing defeat of its enemies in a full-scale war, calls for a very developed defense industry and viable local military R&D programs.

² See the somewhat different definition proposed by Kenneth Flamm in his chapter in this publication.

A somewhat similar, though less extreme, approach is adopted by countries that feel they need to maintain a well-developed army in order to intervene when their allies are threatened (the United States and, possibly, France, Britain, and Russia).

The Overall Economic Situation and the Size of the Country's Defense Industry Relative to its Civilian Industry

The local purchases of Israel's Ministry of Defense were 8 percent (5 percent) of GDP in 1985 (1990). Thus, the defense sector constitutes a sizeable proportion of the country's industry,³ and may have macroeconomic repercussions on the economy as a whole. Clearly, the government's policy toward the defense industry depends on its defense expenditures. Generally, the local demand for defense products depends on the country's perception of the threat from its enemies in both the short and the long run, though the economic conditions of the country serve as a constraint on this demand. Since the defense sector normally plans for the long run, we expect that the activities of the defense firms will be somewhat counter-cyclical; that is, government purchases of locally produced defense products will have some, but not necessarily a strong, correlation with the country's long-run economic performance (GDP or government expenditure). Hence, we expect that the defense industry will be perceived as a larger burden on the country during slow-downs or recessions (as was the situation in Israel during 1996-8). On the other hand, expanding demand for locally produced defense products can be very helpful during the process of getting out of a recession (as was the situation in Israel during 1967-1968).

The Stage of Technological Development of the Country

The technological development of Israel's industry during the 1960s and the 1970s was led mainly by the defense firms. These firms were required to supply the IDF with the modern and sophisticated weapons and systems it was no longer able to purchase abroad because of the French and American embargo. For Israel, which does not have any natural resources but is endowed with a relatively highly-educated population, this push in the direction of self-sufficiency based on highly developed technologies proved to be the right one (Tishler and Rotem 1995). However, as Israel is probably the exception rather than the rule, and as the country's civilian industry becomes more

³ See Lifshitz (1999) for comparison to other countries.

developed (as has been the case since the mid-eighties), the defense firms may lose their role as technology leaders, except in a number of very specific defense-related applications.

The Effect of the Israeli Defense Industry on the Civilian Industry

As the statistical data on the activities of the defense industry in Israel are all anecdotal, it is difficult to estimate the effect of the defense industry on the economy as a whole and on Israel's civilian industry in particular. It is, however, generally agreed that the defense Industry was a leader in R&D during the 1960s and 1970s, when entrepreneurs began converting the high level, defense-related R&D base into profitable high-tech industries (MOS 1996/7; Teubal 1993). These efforts were aided by industrial R&D grants from the Ministry of Trade and Industry and others and brought about a rapid proliferation of high technology into civilian firms, mostly in electronics, aviation, electro-optics, and computers. This created a strong, technology-oriented economic base, and boosted Israel's industrial high-tech exports. Many of the applications developed in the civilian industry during that period were derived from defense R&D in the areas of sensors, optics, information gathering technologies, etc. Note, however, that the sharp expansion of R&D within the defense industry, particularly during 1973-1987, may have crowded out direct civilian R&D (Teubal 1993).

Almost all the technology transfer from the defense to the civilian sector may be attributed to individuals. Commercialization of defense technologies by defense firms has usually been a failure (Dvir, Hauptman et al. 1998; Hougi et al. 1998). Engineers, scientists, managers, and officers moving from the defense industries or the military to the civilian sector have applied the knowledge and training they acquired in the defense sector to civilian projects. Moreover, as already noted, the intricate and close relations between the defense and civilian sectors in Israel may be attributed to the common denominator of military service, often followed by long service in the reserves. This is a formative element in the overall education and attitudes of most of Israel's citizenry.

The system-oriented approach, which is one of the characteristics of Israel's high-tech industry, is a legacy of its military and defense industry origin (MOS 1996/7). The high quality of project management and the entrepreneurial approach to problem solving can also be traced to the defense industry (Tishler et al. 1996; Dvir, Lipovetsky et al. 1998; Lipovetsky et al. 1997). Civilian R&D in image enhancement, video and audio compression applications, high speed image analysis, and optical inspection systems are all examples of defense program spinoffs. Specific examples of technology transfer from the defense industry to commercial use are listed in Table 2.

Table 2
Technology Transfer from Defense Industries to Commercial Use

Firm	Technology transferred	Commercial use
EVS	Computerized pattern recognition	Defect identification in fabrics
Frutronics	Computerized pattern recognition	Defect identification in fruit
Comverse Communications	Voice recognition and logging	Voice logging systems
NICE Systems	Voice recognition and logging	Computer Telephony Integration (CTI)
Geotech	Frequency hopping communication	Cellular telephony
DSP	Speech recognition	Speech compression for telephony
Tadiran systems	Electro-optic Surveillance	Wide area protection
Motorola Israel	Satellite positioning technology	Vehicle positioning
Ituran	Direction finding and positioning	Vehicle positioning
Madacom	Frequency hopping communication	Wireless wide area paging
ISORAD	Nuclear radiation	Metal detectors for air fields

Many of the high-tech firms in Israel are headed or owned by entrepreneurs who started their career as officers or professionals in the defense sector in Israel. Table 3 lists several examples. In addition, most of the military engineers, computer software personnel, and other professionals from the intelligence, air force, and communications core are employed in the civilian industry after they retire from the military, mostly by high-tech firms. Their defense sector background, particularly their entrepreneurial approach and experience in project management, is highly valued.

Finally, Israel's overall expenditure on defense R&D in 1997 has been estimated at more than US\$800 million, which is about 0.9 percent of GDP (for comparison, civilian R&D was about 2.3 percent of GDP and outlays for education amounted to 9 percent of GDP). A substantial portion of the defense R&D is spent within universities and civilian research institutes (some of these outlays are for maintaining "knowledge centers"), thus contributing directly to both the defense and the civilian sectors.⁴

⁴ See Teubal (1993) on the role of Israeli universities in defense and overall R&D in Israel.

Table 3
Firms Managed or Initiated by Personnel Previously Employed
in the Defense Industry or Military Organizations

Firm	Area of expertise
Gilat Communication	Very Small Aperture Satellite Terminals (VSAT)
NICE Systems	Computer Telephony Integration (CTI)
Check-Point	Fire-walls for Internet communications
Orckit	High speed modems
BVR	Simulators, virtual studios
Technomatics	CAD/CAM SW for the automobile industry
ESC	Laser surgery equipment
Medis-EL	Cancer diagnosis equipment
Cubital	Fast prototyping machines
Magic Computers	General Data Base SW
Teldor Computers	SW development
RAD Computers	Data communication equipment
Lannet	Data communication equipment
DSP	Speech processing devices
Nexusus	Two-way paging systems
Optrotech	Printed board inspection systems
Tadiran	Communication and telephone equipment
Telrad	Telephone switching systems
Elbit	Defense and medical instrumentation and communication systems

The Structure of Israel's Defense Industry: Theoretical Considerations

Economic principles suggest that a fully competitive market is almost always the desired structure. Public goods, natural monopolies, and externalities are the exceptions to this rule. Generally, government should regulate monopolistic markets. Moreover, if a monopolistic market can be made more (or fully) competitive, the government should act to transform it by legislation and other means into a competitive one.⁵ These principles suggest that the defense industry should be made fully competitive, unless it can be shown that some of its products (services) are public goods, their market calls for the existence of a natural monopoly, or their production exhibits externalities.⁶

⁵ See, for example, Levi-Faur (1998) on the liberalization of the Israeli telecommunication industry.

⁶ See, however, Williamson (1998) on the limitations of current economic theory and practice in the analysis of the performance of existing institutions.

It seems that the markets for new platforms or very large integrated systems (such as an advanced fighter plane, battleship, integrated anti-aircraft radar system, or ballistic missiles) are best organized as a natural monopoly. This argument is justified on the grounds that the fixed cost of production of such platforms or systems (which includes the relevant R&D, the set up of the production line, etc) is very high relative to the (also high) marginal cost of production (see Flamm, this publication, on the case of fighter aircraft). The quantity demanded of these products is relatively low for two reasons. First, their maintenance and operating costs are high. Second, their purchase price is high because their marginal production cost is high and the producers are, generally, monopolies that charge a price that is higher than the marginal production cost (see, however, *Economist* 1998b). Flamm shows that “an industry that designs and produces only small numbers of advanced aircraft is going to yield a product that is virtually unaffordable, and at a substantial disadvantage when exported.” Consequently, it seems reasonable that in the future only large international or American firms will have the vast amounts of capital need to develop and produce these expensive platforms and very large integrated systems (see Flamm, James, Lovering, Markusen, Reppy, Serfati, all this volume; Lifshitz 1999; *Economist* 1997, 1998b). Since the cancellation of the Lavi (the Israeli fighter plane) project in 1987, Israel has realized that it should not attempt to develop and produce such platforms or very large integrated systems alone (Lifshitz 1999; Teubal 1993).

Two questions remain: (1) what should be developed and produced by Israeli defense firms, and (2) how should the defense sector in Israel be organized?

The answers to these questions depend, among other factors, on the threats facing the country, and the resulting Israeli defense vision. It is important to note that the process of adjusting the Israeli defense industry to its desired structure (one that is consistent with the answers to the two questions posed here) depends on the industry’s current structure.

The “defense vision” is a set of rules according to which the country plans its long-run defense policy and actions. It can be derived by maximizing the country’s long-run security, subject to various constraints. The constraining factors are: the long-run economic resources that are expected to be available to the country, the political situation in the region and elsewhere, the quality and quantity of its human resources during the relevant time horizon, the evolution of the country’s social fabric over time, the available and expected technology, and other variables that may influence the security of the country. For obvious reasons, the official Israeli defense vision is not

available to the public. However, its principles can be inferred from the studies of Ben Israel (1998), Halperin (1988), Lifshitz (1995, 1999), and the Peled Committee (1999). Briefly, these principles are based on the following assumptions:

- C Israel cannot afford a long war or many casualties. That is, it should defeat its enemies swiftly and fully in an all-out war.
- C Israel's economic resources are relatively small (Israel's GDP in 1998, about US\$100 million, is somewhat larger than the GDP of its four immediate neighbors combined. It is, however, much smaller than the GDP of all the countries in the Middle East that are, potentially, Israel's opponents).
- C The real prices of new platforms and modern defense systems increase at an annual rate that is much higher than the long-run average rate of growth of the Israeli economy (Lifshitz 1999).

These three assumptions and the state of development of the military forces of Israel's potential enemies imply the following three conclusions.

- C In the long run Israel will not be able to sustain a sufficiently large arsenal of modern platforms (fighter planes, tanks, guns, armored vehicles, ships, etc.) to enable a swift and full defeat of its potential enemies, who are equipped with similar platforms.
- C Israel's advantage in the long run is in its technological know-how and the quality of its human resources. Modern technologies in the hands of motivated, educated, enterprising, and well-trained soldiers can be transformed into "power multipliers." Therefore, Israel must base its main weapon systems on state-of-the-art technologies and ensure that some of these weapons and systems are unknown to its potential enemies (Ben Israel 1998; Lifshitz 1999). Moreover, it is instrumental for Israel to excel in Information Warfare (see Ben Israel 1998; U.S. Army 1997, Toffler and Toffler 1995). Provided the know-how and skilled human resources are available, this may well be the least costly policy to execute and the most effective in both full-scale and low-intensity war. Combining the element of surprise with high-tech is probably sufficient, even with a relatively small army, for Israel to inflict a swift and full defeat on its enemies.
- C Due to the highly destructive nature of the weapon systems that are available to its potential enemies, its small size, and its economic inability to sustain a large regular army, Israel has to detect and predict any forthcoming war or major attack in an accurate and timely manner

(unlike the experience of the Yom Kippur war in 1973). Hence, the continuous development of modern and highly sophisticated intelligence system—an area in which the Israeli defense industry is very active—is required. To avoid surprises, at least some of these systems should be unknown to Israel's potential enemies; they must therefore be developed and produced solely for the IDF.

The necessity to develop and maintain weapon systems that are unknown to its potential enemies (to be denoted Israeli Specific Weapon Systems, ISWS) plays a key role in the design and operation of Israel's defense industry. Clearly, because of the need for absolute secrecy in the development and production of ISWS, competitive markets for these types of products cannot exist. Obviously, the R&D cost of these products and possibly but not necessarily their production and maintenance must be borne and controlled by the government. Private Israeli firms could produce ISWS, but, since these products cannot be sold elsewhere, the government has to shoulder most of the risk and cost of their production (part of the risk may be borne by firms bidding for their production).

The Role of R&D in the Defense Industry: Theoretical Considerations

Defense and civilian technologies that are based on R&D activities are generally non-rival; that is, their use by one firm or country does not limit their use by another. The availability of these technologies in the world market will bring about strong spillovers, and will enhance R&D in similar technologies in other countries (Romer 1990). Hence, R&D exhibits some of the characteristics of public goods (Romer 1990, 1994; Hall 1996; Leahy and Neary 1997; Goolsbee 1998). Conventional wisdom holds that these public good characteristics make private R&D spending lower than the social optimum (Romer 1990; Goolsbee 1998). No wonder, then, that in most of the developed countries government involvement in R&D is substantial (Goolsbee 1998). Most recent macroeconomic models, particularly those in the area of endogenous growth theory, single out R&D (combined with human capital) as the most important factor for sustained economic growth (Romer 1990, 1994; Grossman and Helpman 1994; Pack 1994; Evans, Honkapohja, and Romer 1998; Segerstrom 1998).

Public policy toward defense R&D should depend on the role of the defense industry. First and foremost, a country's defense industry should serve its defense needs, which, in turn, depend on its enemies and the threats to its existence. Public policy toward defense R&D should be similar to policy for civilian R&D in countries without enemies or threats. Countries that view themselves as needing a well-developed army may choose to produce "country-specific" weapon systems in

addition to those that can be purchased in the world market. In this case, public policy toward defense R&D should depend, among other things, on whether, and to what degree, these “country specific” weapon systems are shared with other countries (through exports and/or joint ventures). Hence, it is helpful to classify defense R&D into three main categories, depending on how much spillover of knowledge (technology) is allowed: (i) R&D that is country specific, (ii) R&D aimed at developing technologies that will be shared with a small number of allies, and (iii) R&D aimed at developing technologies that will be available to almost all interested buyers (via exports or joint ventures).

In the extreme case of R&D for country-specific technologies when no R&D spillover is allowed, all of the defense R&D risk and cost should be borne by the government, and defense R&D expenditure on these technologies should be determined almost exclusively by the country’s defense needs and resources (summarized in the country’s defense vision). At the other extreme, category (iii), the optimal public policy toward R&D—the type and amount of subsidies the government should allocate to defense R&D and the level of government regulation of the monopolistic competition in this market—should be determined according to economic models such as those in Romer (1990), Leahy and Neary (1997) and Segerstrom (1998). R&D in category (ii) is a hybrid of the other two categories, and should therefore be determined on a case by case basis. The R&D of the Arrow (anti-ballistic missile) project, for example, is a joint venture between Israel and the United States. Its technology will not be available, for sometime at least, to other countries. Hence, it should be viewed as category (ii) R&D. The Eurofighter, which is being developed as a joint venture by several European countries, will be available for sale to many but probably not all countries in the world. The Eurofighter R&D can be thought of as a category (iii) R&D, but with relatively smaller than average spillover.

Following the analysis in Section 4 and bearing in mind that Israel lives under a constant threat to its survival, we suggest analyzing the country’s R&D according to the three categories described above. Israel’s R&D for ISWS is country-specific, category (i), and should be wholly financed by the Israeli government. R&D for categories (ii) and (iii) should be determined according to economic models similar to those in Romer (1990), Leahy and Neary (1997), and others.

The Structure of Israel's Defense Industry: Practical Considerations

Our analysis shows that Israel should maintain viable R&D capabilities in order to continuously develop and upgrade ISWS that are unavailable elsewhere. Three additional issues should be further discussed at this stage.

1. Should the Israeli industry alone produce and maintain ISWS in addition to performing the necessary R&D? Or should production, upgrades, and maintenance be left to qualified bidders?

2. Other than in the R&D process, are there externalities in the production, upgrading, and maintenance of defense products that justify government intervention in this market?

3. What are the implications of the structure of the international market for defense goods and services on the desired structure of the Israeli defense sector?

The answer to the first question is simple enough. The United States, Britain, and other western countries have been successful in contracting with private firms to perform production, upgrading, maintenance, and even some R&D of top-secret weapon systems. Israel, too, has been successful in awarding top-secret production, upgrading, and R&D contracts to private Israeli firms); controlling these types of processes may not be an easy task, but it is certainly more efficient than preserving current excessive production capabilities.⁷

The answer to the second question is more difficult. First, Israel has had much difficulty in recovering from the trauma of the June 1967 French embargo, a time when France was practically Israel's only supplier of major weapon systems (Lifshitz 1999; Melman and Raviv 1994). Moreover, for the last twenty years Israel has been subjected to an American embargo on various technologies, high-tech components, and systems, which is eased whenever Israel proves it has an alternative (Lifshitz 1999; Ben Israel 1998). Nevertheless, the high level of dependence on American platforms and technology gives the United States much latitude in determining Israel's edge in defense capabilities over its potential enemies, in accordance with its own rather than Israel's objectives in the Middle East. In particular, the United States does not necessarily support a swift and full defeat of Israel's enemies in a full-scale war (Melman and Raviv 1994; Louscher et al. 1998). By maintaining local capacity to produce major weapon systems Israel thus assures its non-dependence on American supplies. At the same time, the world market has recently become very competitive in almost all

⁷ For a survey and analysis of the existing, feasible, and desired interactions among the government, the Department of Defense, and defense suppliers in the United States, see Lichtenberg (1988), Kovacic and Smallwood (1994), and Rogerson (1990, 1994).

traditional modern weapon systems, and their purchase is normally a simple procedure (Tishler and Rotem 1995; *Economist* 1997; Flamm, this publication). Moreover, it is likely that a viable private Israeli defense industry, in the form of at least two major private firms, will continue to operate successfully in Israel and abroad, serving as a shock absorber when required. Thus, we conclude that the Israeli government should gradually transfer the ownership of all government defense organizations, other than those specializing in R&D or production of sensitive warfare materials, to the private sector.

The third issue—the globalization of the world market for defense, as well as civilian, platforms and complex integrated systems (*Economist* 1997, 1998a, 1998b; Lifshitz 1999)—poses a severe constraint on the Israeli defense sector. The recent wave of mergers and buy-outs in the world defense industry has decreased the number of producers of specific high-tech products, transforming their R&D and production into monopolistic markets. Besides the power that monopolistic producers exert on their customers, the added pressure of governments supporting their own defense industry is also becoming apparent. The emergence of large U.S. firms and European conglomerates is evidence of these political and economic pressures (Melman and Raviv 1994; *Economist* 1997, 1998a, 1998b; Louscher et al. 1998). The complications of marketing in an environment that is governed by large monopolies and governments suggest that in the future only large organizations will be able to compete in the markets for expensive modern defense products, particularly integrated systems. Smaller firms, however, will be able to survive, and even prosper, in the components market or very specialized products.

The wave of mergers and consolidation of defense firms in the United States began with the rapid acquisition of second tier contractors by Loral, which emphasized financial rather than engineering priorities, and was accelerated by the Pentagon's policies (and financial incentives) following Perry's "last supper" in 1993 (Markusen, this publication). The American consolidation triggered a flurry of similar though initially unsuccessful efforts in Europe, whose defense firms perceived themselves as too small to compete against American giants such as Lockheed-Martin, Boeing-McDonnell Douglas, Raytheon and others.⁸ It is interesting to note that these mergers and

⁸ James (this volume); for another view see Louscher et al. (1998).

joint ventures may not be justifiable by economic theory.⁹ They also contradict conventional political wisdom insofar as they lead to the proliferation of high-tech weapon systems to marginal customers in problem regions where sales are likely to feed existing tensions and local disputes perceived as harmful to the West (Flamm, this volume). Nevertheless, the consolidation efforts in Europe and the cross-Atlantic mergers and joint ventures between American and European defense firms are continuing and will, most likely, be successful in the near future.

If Israel chooses to ignore the negative and unfortunate consolidation trend and reject mergers and/or joint ventures of Israeli defense firms with foreign defense firms, opting unilaterally to continue to support a few, relatively small, local defense firms, it will find itself increasingly isolated. This isolation may have further adverse effects on Israel if the so-called “Inner Circle” approach is adopted by the United States (Flamm, this volume). If successful in jointly producing platforms and high-tech weapon systems and jointly controlling their diffusion around the globe, the “Inner Circle” of a handful of producers, such as the United States, France, Britain, and Germany, will be able to prevent the proliferation of high-tech weapon systems in “problem regions and countries.” This may, however, be detrimental to Israel’s security if it leaves Israel outside of the main circle.

A Desirable Structure of the Israeli Defense Industry

The structure of the Israeli defense sector should be based on optimal theoretical considerations, the current and future structure of defense industries in the world, the Israeli defense vision, and on the sector’s current structure and characteristics. Due to the small size of the Israeli economy and army, and the excess production capacity for defense products, Israeli defense firms are being forced to export a large share of their production. Indeed, the Israeli defense sector exports about 75 percent of its production (Ben Israel 1998; Halperin 1988; Lifshitz 1995, 1999; and Tishler and Rotem 1995). The theoretical considerations that we present here call for extensive government-operated national laboratories that will provide the necessary R&D for ISWS as well as for basic research (Peled Committee 1999). Clearly, these laboratories should exploit the capabilities of academic and other research organizations in Israel and abroad. In our opinion, the Israeli defense R&D

⁹ See Leahy and Neary (1997) on the negative welfare effects of lax competition, and Kovacic and Smallwood (1994) on the incentives and positive aspects in forming these mergers.

effort should be considerably larger than it is at present (including the R&D that takes place within the IDF). Moving from the current inefficient defense industry structure to a more efficient and mostly private one should free substantial resources for investment in R&D.¹⁰

The government-controlled defense organizations, other than those in R&D, should be merged into two privately-owned firms.¹¹ One firm, for example, could be based on the electronic, aerospace, and missiles divisions of Rafael, IAI, and TAAS. A second firm could include the remainder of TAAS, the IDF's maintenance and refurbishment bodies, the unit producing the Israeli tank (the Merkava), and several other smaller units of the IAI and Rafael. The strength of the labor unions of these organizations should be taken into account during the consolidation and privatization process (Lifshitz 1999; Peled Committee 1999), and the workers should be consulted and possibly offered partial ownership in the newly formed firms. However, the process itself must be carried out quickly and be based on a massive reduction in the number of workers and restructuring of wages. The financial structure of the newly formed firms should be changed (particularly, their own capital should be expanded) to allow them to operate independently in the local and international markets. Clearly, the two firms should be, unconditionally, private. Once the restructuring and privatization processes have been completed, the two firms should be free to form international alliances. The Israeli government should let the newly formed firms and the already existing private defense firms decide whether, with whom, and how to merge or form joint ventures.¹²

The Israeli government should encourage mergers of private Israeli defense firms with other Israeli or foreign firms. It can do this by suitably adjusting the structure and size of its tenders for future production to the local market and the contracts that the national laboratories sign to test and later produce newly developed products.¹³

Finally, forming national R&D laboratories is not enough. Israel should develop an R&D policy that also supports the private Israeli defense firms (Romer 1990; Leahy and Neary 1997; and

¹⁰ For a possible priority list of areas of R&D see Ben Israel (1998) and Peled Committee (1999).

¹¹ For the size and other details of the major defense firms in the international markets, see Lifshitz (1999), Flamm (this volume), James (this volume) and the *Economist* (1997).

¹² For analysis and justification of joint ventures between Israeli and foreign defense firms see Teubal (1993).

¹³ For similar incentives to American firms see the *Economist* (1997).

Goolsbee 1998). As Goolsbee (1998) notes, most of the expenditure on R&D consists of salary payments for R&D workers, and the supply of this scientific and engineering talent is quite inelastic (Hall 1996; Grossman and Helpman 1994; and Flamm, this volume). Goolsbee shows that U.S. government increases in R&D spending through subsidies or direct provision brought about significant increases in the wages of engineers and scientists in areas that directly benefitted from these increases, particularly aeronautical, mechanical, metallurgical, and electrical engineers, as well as physicists. Federal R&D spending (85-95 percent of which goes to defense, space, and energy) has no significant effect on the salaries of mining, civil, industrial, and chemical engineers, or scientists in agriculture, biology, and geology). At the same time, U.S. government spending on R&D has had an insignificant effect on the quantity of inventive activity (measured by hours of work of workers in R&D). Goolsbee also shows that, through the wage increases, the U.S. government spending on R&D directly crowds out private spending on R&D (similar crowding out effects were observed in Israel at the peak of its defense investment on the Lavi project during 1982-87).

Thus, Israel's public policy should determine the level of spending on defense R&D, as well as monitor and properly use incentive schemes to ensure the desired allocation of R&D spending to wage increases and to increasing the quantity of inventive activities.

Summary

In this chapter we have described the Israeli defense industry, emphasizing its role in Israel's industrial and technological development. In particular, we show how the effect of the defense industry on the economy depends, among other things, on the following important factors: (1) the defense needs of the country; (2) the overall economic situation of the country and the size of the defense industry relative to the country's civilian industry; and (3) the stage of technological development of the country.

The limited available data suggest that the Israeli defense industry was instrumental in transforming Israel's civilian industry into a successful high-tech industry. Moreover, the defense sector is still a very important source of new technological know-how and experienced human resources for the civilian high-tech industry. Other major conclusions of the paper are as follows:

- C Israel must base its main weapon systems on state-of-the-art technologies, and ensure that some of these systems are unknown to its enemies. Moreover, Israel has to excel in informa-

tion warfare, which may be the least costly to execute and the most effective in both full-scale and low-intensity conflicts.

- C The Israeli defense industry must continue to develop modern and highly sophisticated intelligence systems. To avoid surprises, at least some of these systems should be unknown to Israel's potential enemies; hence, they must be developed and produced solely for the IDF.
- C Israel alone should not attempt to develop and produce by itself platforms or very large integrated systems that can be purchased elsewhere. Adhering to this policy may also be helpful in avoiding excessive crowding out of civilian R&D by defense R&D (see Teubal 1993 for a similar argument).

The analysis that we present here calls for extensive, government-operated, national laboratories to provide most of the necessary defense R&D. This conclusion is not new—see Ben Israel (1998) for a possible priority list of areas of R&D, and Peled Committee (1999). Clearly, these laboratories should exploit the capabilities of academic and other research organizations in Israel and abroad. Additionally, in our opinion, Israel's defense R&D should be considerably expanded.

- C The government-controlled defense organizations, other than those engaging in R&D, should be merged into *two* private firms at most. The consolidation process must be carried out quickly and be based on a massive reduction in the number of workers and restructuring of wages. The two firms should be unconditionally private. Once the restructuring and privatization processes are completed, the two firms should be free to form international alliances. The Israeli government should also encourage joint ventures and mergers of private Israeli defense firms with other Israeli or foreign firms.
- C Almost all of the technology transfer from the defense to the civilian sector may be attributed to individuals (engineers, scientists, managers and officers) moving from the defense industries or the military to the civilian sector. The experience that these individuals gain during their military service, often followed by a long service in the army reserves, is an important factor in their overall education and attitudes.
- C Finally, Israel's welfare and security depend on its defense forces which, in turn, depend on state-of-the-art technologies and defense R&D. Though only anecdotal statistical data are available on the Israeli defense industry, it is possible to analyze its past and present structures and plan and suggest better ones, relying on economic theory, the experience of other nations and Israel's defense vision. The non-availability of data is crucial, however, in

understanding the processes in which the defense and civilian industries interact. Specifically, it is important to better understand the channels of technology transfer between the two sectors and the effect of the Israeli draft system on defense and civilian R&D. We plan to investigate these processes in future research.

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Economic Restructuring, National Strategies, and the Defense Industry in Newly Industrializing States

Etel Solingen*

The Impact of Economic Reform on the Defense Industry

This chapter addresses the impact of economic reform on military-industrial complexes in the industrializing world. No simple formula can estimate the precise impact of internationalization across industrial sectors, let alone the resulting *political* effects of that impact. We are still—paraphrasing Clausewitz—under the “fog of internationalization.” Indeed, the rapidly changing scene regarding both markets and democracy suggests that the “fog” extends to our understanding not just of economic but also of political reform as they affect responses to internationalization. Nonetheless, I would like to begin by sketching a more general argument that hopefully can shed light on the fortunes of the military-industrial complex in a broader political context.¹

Internationalization involves not merely an orientation to the global economy but also to an array of nested regimes, institutions, and values. Political entrepreneurs rely on material and ideal, real and imputed, aspects of internationalization to broker coalitions across constituencies. From myriad political constellations two ideal-typical coalitions can be identified: internationalist and backlash. The elusive implications of internationalization—sometimes evident both to entrepreneurs and constituents—can produce a third, hybrid category. Internationalist and backlash coalitions are expected to differ in their preferences over domestic and international resource extraction and allocation, in their time-horizons, and in their orientations toward regional and international behavior. Accordingly, each endorses a grand strategy with synergistic effects across the domestic, regional, and global arenas.

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¹ For an extended formulation of this argument, see Solingen 1998.

Internationalist Coalitions

The grand strategy of internationalist coalitions amalgamates economic liberalization at home, cooperation and stability in the region, and the maintenance of secure access to global markets, capital, investments, and technology. The economic programs of these coalitions give primacy to macroeconomic stability and to the discipline induced by international competition. Macroeconomic stability reduces uncertainty, encourages savings, and enhances the rate of investment (including foreign). Why are these coalitions cooperative with their neighbors? Conflict-prone postures need to be backed up with the internal mobilization of resources for potential military conflict. Such mobilization often contributes to many of the ailments afflicting these countries' domestic political economy (from the standpoint of internationalist coalitions): the expansion of state power, the maintenance of unproductive and inflation-inducing military investments, the protection of state-owned enterprises under a mantle of "national security" considerations, and the perpetuation of rent-seeking patterns. In principle, therefore, internationalist coalitions resist this syndrome, in an attempt to avoid inflated military budgets that increase governmental and payments deficits, raise the cost of capital, curtail savings and productive investment, deplete foreign exchange coffers, induce overvalued exchange rates, currency instability and unpredictability, and distort the humanpower base. The increasing high-technology content of modern weapons multiplies these effects, rendering the trade-offs imposed by military investments more evident than ever before. In sum, in light of the high opportunity costs of military expenditures, internationalist coalitions are often less predisposed to extract and mobilize societal resources for external conflict, because such extraction threatens important macroeconomic and macropolitical objectives they endorse.

This is not to say that internationalist coalitions do not invest in weapons at all, but that when they do so, two conditions are likely to hold:

(a) Their levels of military expenditures do not fundamentally endanger their internationalist strategy or shatter the fiscal discipline essential to their political-economic agenda. This approach to military expenditures is underpinned by a primary concern with sustained economic growth, and is thus compatible with both the *capital formation model* and the *export-led growth model* of the impact of military expenditures on economic performance, as discussed by Chan (1992). The *capital formation model* stresses private investment as the key determinant of economic growth. The *export-led growth model* argues that military expenditures tend to deprive the most dynamic sectors—those involved in exports—of important resources and skills. The consequent decline in international com-

petitiveness thus leads to a weaker currency, structural unemployment, chronic trade deficits, and a less attractive environment for international investments—all outcomes that are anathema to internationalist coalitions. Where military expenditures are kept at a level that averts such outcomes, hard political choices between guns and butter can be deferred, as was the case in some East Asian states until the 1997 crisis.

(b) The second condition likely to hold is that military investments by internationalist coalitions are incurred as an insurance policy, particularly against backlash adversaries in the region or against generalized uncertainty (of the kind unleashed, for instance, by the end of the Cold War). Broader foreign policy patterns reflect this defensive posture as well. The essential ingredient of an internationalist grand strategy is economic access, not military prowess. Yet, politically successful internationalist coalitions are able to persuade their domestic and foreign audiences alike that they can provide defense, growth, and welfare at the same time, as the 1996 re-election of Taiwan's President Lee Teng-hui suggests.

These two conditions are key to understanding the role of military expenditures in states ruled by internationalist coalitions, a point frequently muted (and most often missed) by aggregate accounts of military investments.

Backlash Coalitions

The grand strategy of backlash coalitions seeks to preserve statist and ancillary military-industrial complexes, to uphold a regional context of insecurity and competition, and to resist international regimes that threaten those objectives. First, these coalitions have an inherent affinity with import-substituting models of industrialization and classical populist programs involving a strong, active government controlling prices, overvaluing the currency to raise wages and profits in non-traded-goods sectors, protecting state enterprises and the military-industrial complex, allocating credit at low interest rates, and dispensing rents to protected private industry. Arms-importing and arms-producing military establishments are often adversely affected by adjustment programs, as is the military as an institution frequently addicted to heavy budgetary transfers. We are all familiar with the proliferation of military and security agencies—with overlapping jurisdictions—competing for budgets throughout the industrializing world. External threats are used to legitimize their existence, yet domestic repression and the ruling coalition's survival are their most common mission, as in Iraq and Syria. Military-industrial complexes are also beneficiaries of indirect rents, via

state subsidies of important inputs, including raw materials and energy, as in the Russian Republic. Such complexes (and rents) are often justified on the basis of their positive impact, or spinoffs, on the development of a modern economic infrastructure. Under backlash coalitions, the military has thus captured a lion share of rationed foreign exchange.

A second factor accounting for the strong association between backlash coalitions and the military-industrial complex is that the resolution of regional conflicts has a detrimental impact on the military-industrial complex. The waning of external conflict weakens the military institutionally (through its contraction in size and mission) and personally (top and middle echelons undergo radical trimming in material advantages and prerogatives).

A third factor is the threat that an internationalist grand strategy posits for the military-industrial complex, in the form of emerging global security regimes that restrict the rationale for military-industrial complexes and undermine notions of territorial sovereignty that are central to the military as an institution. An internationalist grand strategy, by definition, implies an acceptance of certain strings—political and strategic—that constrain the military and its industrial complex.

In sum, generally speaking, internationalist coalitions may invest in military capabilities but prevent such investments from overwhelming domestic reform, regional stability, or global access. Backlash coalitions, instead, create and maintain a *Wehrwirtschaft* (war economy) that functions as their core political pivot.

International Institutions

More open, liberal, international economic structures and regimes have undermined the viability of military-industrial complexes and military establishments. Structural adjustment efforts often threaten these complexes, as does the very demand for greater budgetary accountability and transparency in intergovernmental relations. Whatever disagreements on guns-versus-butter tradeoffs there may be in the scholarly community, it is rather clear to the relevant political actors that economic stagnation exacerbates such tradeoffs. The tradeoff is most salient for developing countries facing severe financial constraints (onions versus weapons in India). International investors understand such tradeoffs well, and the World Bank has begun addressing, more directly than ever, the size and transparency of military budgets. The fact that the interlocutors of these international institutions are mostly Central Banks and finance ministries and not military agencies, is a double-edged sword. On the one hand it can undermine the domestic legitimacy of such agencies, accused

of taking their cues from foreign institutions. On the other hand it can be used to shift the blame for downsizing “national” symbols—such as the military sector—to external actors, while highlighting the positive economic, social, and political outcomes of that process.

Preliminary Findings

I have examined this general argument quantitatively (Solingen 2000) through an historical analysis of four industrializing regions (the Middle East, East Asia, Latin America, and South Asia), with many states and many coalitions within them. This study surveyed a sizeable part of the industrializing world longitudinally, allowing a dynamic assessment of older forms as well as more current responses to internationalization. This led to a wide domain of cases and to a deeper historical probe than would be possible if I had concentrated on the post-1990 era alone. After all, the conceptual framework has roots in earlier periods, even if it has gained sharper definition at the end of the twentieth century.

This overview of coalitional behavior regarding economic openness, military investments, and regional and international security regimes suggests that there is more in common within coalitional categories than across them. Thus, entrepreneurs coalescing an internationalist coalition are more prone to deepen their country’s trade openness, expand exports, attract foreign investments, tame profligate military-industrial complexes, eschew weapons of mass destruction, defer to international economic and security regimes, and strive for regional cooperative orders that reinforce those objectives. Although pristine and coherent grand strategies are hard to find, the links between a commitment to an internationalized economic strategy and regional cooperation and stability are evident. The links are even thick with respect to nuclear policies, where the avoidance of a nuclear competition is expected to have positive externalities at home (downsizing a major backlash constituency), regionally, and internationally. This link transcends differences in the depth of security dilemmas across regions, and is found from South Korea to Egypt to Latin America’s Southern Cone.

Examples of internationalists’ performance in military investments include South Korea, where external and internal conditions weighed in favor of an expansive military complex. Yet, despite such circumstances Park—a military ruler—subdued supporters of a large statist military-industrial complex that threatened his grand strategy (Amsden 1989). South Korea’s GDP grew by 10 percent (1965-1989 average), whereas military expenditures as a percentage of GDP remained

largely constant, declining to 3.6 percent by the early 1990s.² Even during the period of consolidation of its export-led strategy (1962-72), South Korean expenditures for economic development were higher than for defense.³ The defense burden absorbed on average 4 percent of the GDP before 1975, although U.S. direct military assistance was extensive between 1953 and 1973. Beginning in the early 1970s U.S. military grants declined drastically (ceasing completely in 1978), raising South Korea's average military expenditures to near 6 percent of GDP initially, decreasing to 5 percent by 1985 and 3.6 percent by the 1990s. Taiwan's military expenditures/GDP was 8 percent (on average for 1961-1987), declining by the 1970s as internationalization took root (Chan 1992). Averages for internationalizing Southeast Asia by 1990-1991 were 2.8 percent.

Backlash entrepreneurs were found to restrict and reduce trade openness and reliance on exports, curb foreign investment, build expansive military-industrial complexes, spearhead weapons of mass destruction programs, challenge international security and economic regimes, and exacerbate civic, religious, and ethnic nationalist differentiation within their region through an emphasis on territoriality, sovereignty, and self-reliance. Even when states attempted to avoid what might be self-defeating wars and arms races, the risks and externalities of these policies pushed toward them. Backlash entrepreneurs have used chemical weapons and have spearheaded an overwhelming majority of the wars fought since World War Two, in many cases prodding reluctant superpower benefactors: for example, North and South Korea in the 1950s or Egypt in the 1960s and 1970s. At the same time, the Cold War era provided a more supportive global structure for the objectives pursued by backlash coalitions, from economic protection to militarization and regional conflict. This structure may also explain the relative scarcity and weakness of internationalist coalitions and entrepreneurs during that era (relative to backlash cases) and their diluted grand strategies.

The record of backlash coalitions regarding military expenditures contrasts dramatically with that of internationalists. The high incidence of backlash coalitions in the Middle East helps account for particularly high regional averages (nearly 19 percent of GDP in the 1970s-1980s), over three

² Data on military expenditures are from Stockholm International Peace Research Institute (SIPRI) (1975-1996), International Institute for Strategic Studies (IISS) (1995-96, 266-67), and World Bank (1998, 279).

³ On how military investments came to compete with economic developmental objectives by the 1970s, with the onset of nearly full employment of human and fiscal resources, see Wolf (1981, 82). See also Byung Chul Koh (1984, 210-11), Moon and Hyun (1992), and Ball (1988, 54).

times higher than the industrializing world's average.⁴ Iraq's military spending reached over 50 percent of GDP (1973-1985), ten times the global mean. Military expenditures/GDP under Nasser and Sadat's backlash period (1970-1973) reached 24 percent, and Syria's mean under Hafez al-Asad was 16 percent (1973-1985), declining with incipient liberalization to less than 10 percent after 1988.⁵

Hybrid instances were common, and, as expected, straddled the grand strategies of their purer types, intermittently striving for economic openness, the contraction of the military complex, and cooperative regional and international policies, albeit less forcefully or coherently. As this last point suggests, notwithstanding coalitional commonalities, the relative domestic strength of a coalition and the degree to which entrepreneurs must logroll across disparate sectors create significant differences even within coalitional categories, compelling different entrepreneurs to package their grand strategy differently, maintaining some aspects while discarding others. For instance, in Israel Netanyahu's hybrid coalition slid towards more backlash constituencies after 1996, reversing the decline in military spending under the internationalists, and this despite the most favorable regional conditions ever. Netanyahu proclaimed a strategic decision to increase military spending and "strengthen security" as the first budgetary priority.

In Argentina, President Raúl Alfonsín's hybrid coalition contracted military budgets to some extent between 1984 and 1989 but retained the air force's Condor II program in 1985, maintained relatively high levels of military expenditures as a percentage of GDP (over 3 percent), and sustained Argentina's opposition to the NPT and its right to peaceful nuclear explosions, as well as its refusal to ratify the regional Tlatelolco treaty (Franko 1994, 37-74). By contrast, President Carlos S. Menem's internationalist revolution drove military expenditures to all-time lows, both relative to past military expenditures (1 percent of GDP in 1992) and relative to health and education (51 percent), the lowest in three decades. The military's total size shrank by 60 percent from the 1970s in absolute terms, and by 70 percent relative to population. Employment in military industries declined by 80 percent, the officer corps was dramatically reduced, compulsory military conscription ended (1996), and a pillar of the military-industrial complex (DGFM)—the largest drain on the

⁴ The average ratio of military expenditures over GDP for developing countries in the 1970s and 1980s was between 4 and 6 percent (West 1992, 25, 31).

⁵ SIPRI warns its figures for regimes such as Iran tend to *underestimate* military expenditures.

federal budget—was privatized.⁶ Part of Menem's strategy for neutralizing the Argentine military's *domestic* presence was to engage them in UN peacekeeping activities, an endeavor that only enhanced Argentina's new internationalist credentials.

Military investments were high overall during the Cold War, particularly in regions more directly affected by it. Hence, one might argue that the dice are somewhat loaded against finding effective differences across coalitional variants. Furthermore, a number of internationalist coalitions—notably in East Asia—were particularly engulfed by Cold War threats and their regional corollaries. Nonetheless, the evidence does reveal clear contrasts across coalitional variants. While investing in military capabilities internationalist coalitions have largely prevented them from overwhelming domestic reform, regional stability, or global access. By contrast, backlash coalitions reflect the hypothesized penchant for extensive military expenditures as a percentage of GDP. Not every backlash coalition exhibits such high levels, although they do reflect military investments that are higher than their internationalist counterparts in the same country. Hybrid regimes facing powerful backlash constituencies at home and in the region exhibited, as expected, higher levels of military expenditures as a percentage of GDP and an essential inability to contract them.

Conclusions

Important sectors within the military have opposed internationalization in many cases, including Argentina, Brazil, Uruguay, Egypt, and Thailand, at least initially (and witness current winds in Venezuela and Ecuador as of 2000). By contrast, in Chile and South Korea, the leading political entrepreneurs (generals in both cases) coalesced their respective armed forces behind a strategy of integration into the global economy. In Algeria and Turkey, the military transformed itself from custodian of the post-independence statist-nationalist (or backlash) project to the main line of defense against recent backlash and confessional onslaughts on economic liberalization. It is important to recognize that the interests of military factions can differ and that highly fragmented armed forces have led to factions supporting competing coalitional arrangements. Under such conditions, political entrepreneurs within or outside the armed forces have sometimes been able to impose a leading grand strategy over military factions (Presidents Park and Menem are examples).

⁶ DGFM's cumulative deficit was estimated at over \$700 million and its assets at \$5.6 billion in 1990 (Manzetti 1993, 197).

Which faction will prevail is never easy to predict *ex ante*. As economist Díaz Alejandro (1983, 45) concluded prophetically in his study of international economic openness, “the nature and laws of motion of the collection of men in uniform are the darkest black boxes in Latin American social science, but one may conclude that the attitude of the armed forces toward economic openness has been neither unambiguous nor steady.”

The findings reported here suggest that, on the whole, military institutions seem more likely to join backlash—rather than internationalist—coalitions, thus turning dependencia-style arguments about a basic alliance between global capitalism and local military establishments on their head. Dependency theory has traditionally thrown the military into the “globalizing” camp, as the chief political executor of “external” designs, brutally whipping production for the global economy. The historical affinity between inward-looking statism and military regimes challenges this assumption. Integration into the global economy does not require military-industrial complexes, while inward-looking statist-nationalism has more often than not overlapped with the expansion of such complexes. The domestic allies of global capitalism can be the military’s most powerful political adversaries. In broad terms, the fact that the explosion of economic liberalization (and the rise of its political bearers) has been associated with a dramatic collapse in budgetary allocations to the military—and in the latter’s political leverage—deals a rather serious blow to dependency-deterministic theories of military institutions and their associated industrial complexes in the industrializing world.

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