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In from the Cold: Prospects for Conversion of the Defense Industrial Base

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At the end of the Cold War, the manufacturing operations involved in making military equipment and commercial goods are commonly believed to intersect hardly at all. Our analyses of 1991 survey data from a large sample of establishments in the machining-intensive durable goods sector show that there are few technical and competitive conditions separating the defense and commercial industrial spheres. Commercial-military integration of production is now the normal practice among the majority of defense contractors in this sector. Moreover, we find little difference between defense and commercial producers in the competitive conditions they face or in the diversity of their customers. However, defense contractors have an advantage over their strictly commercial counterparts because of their greater use of productivity-enhancing technologies.

During the Carter-Reagan buildup (1979 to 1987), the U.S. Department of Defense (DOD) became an increasingly important customer for domestic manufacturers, particularly in durable goods industries (*1*). By the end of 1993, however, reductions in orders for weapons already in production and the elimination of entire programs reduced DOD's real (inflation-adjusted) procurement budget by 58% from 1985 levels (*2*). In this transition to a post–Cold War economy, policy discussions about the competitiveness of U.S. manufacturing and the restructuring of the defense industrial base are intertwined.

At the peak of the recent defense buildup in 1987, defense purchases were responsible for nearly 12% of the total sales of durable goods manufactured in the United States (*3*). Much of the concern about the economic consequences of a continued drawdown from these high levels of defense spending stems from questions about the capabilities (and willingness) of defense contractors to successfully function in the commercial economy. The defense industrial base is widely believed to have become isolated and disconnected from the commercial manufacturing base. A host of studies and reports argue that defense contractors have little experience with commercial customers and are unfit for the rigors of competitive markets (*3*–*8*). As a consequence, conversion of defense manufacturing facilities to commercial uses is expected to be costly and have little chance for success. Moreover, some go so far as to warn against further reductions in defense spending on the assumption that if conversion is successful, defense-specific technical capabilities in the manufacturing supplier base will be irretrievably lost (*4*).

For the most part, previous research on defense manufacturing has been limited to case studies of a few leading companies and top-down analyses of government contracting practices, particularly as they affect corporate accounting and purchasing procedures. No analysis of a large sample of defense manufacturers has been conducted. The last systematic comparison of the practices of defense contractors and their counterparts operating strictly in commercial markets was conducted by Peck and Scherer 30 years ago (*9*). At the end of the Cold War, widely held suppositions about the singularity of defense production and its isolation from commercial practices have not been subject to rigorous empirical tests. With data from our 1991 survey of U.S. manufacturing plants from 21 durable goods industries, we demonstrate that structural and behavioral barriers thought to divide defense contracting from commercial manufacturing are actually quite rare. The defense industrial base is far-reaching and substantially "dual-use"; that is, meeting commercial customers' requirements and military specifications in the same facilities—indeed, using the same equipment and work force.

The Conventional Wisdom: Defense Manufacturing as an Isolated and Distorted System

Since President Eisenhower first employed the term in 1961, the "military-industrial complex" has conjured up an image of defense manufacturing as taking place in a specialized set of firms separated from the rest of the economy. Melman, one of the most widely cited critics of Pentagon spending during the 1970s, characterized the manufacturing of defense products as a "permanent war economy" where "whole industries and regions that specialize in military economy are placed in a parasitic economic relationship to the civilian economy" (*7*). Although there has been considerable academic debate over the question of whether defense expenditures have had a positive or negative impact on economic growth, there has been remarkably little discussion focused on the issue of how specialized and isolated defense manufacturing is from the rest of industry. At the end of the Cold War, even the most knowledgeable defense analysts assert that there is little overlap between defense and commercial manufacturing activities. Instead, much of the current concern focuses on procurement reform and the identification of those government contracting regulations or military technical requirements that are believed to be responsible for the divide that is assumed to separate the two industrial spheres. According to Alic *et al.*, for example, special technology requirements, unique products, and intrusive government oversight have led firms to "conduct military business in divisions that are managed separately from commercial operations, often with separate work forces, production and research facilities, accounting practices, engineering design philosophies, and corporate culture" (*3*). Although their explanations differ from those of Alic *et al.*, Markusen and Yudken also believe that there is an unbridgeable divide between commercial and military manufacturing, which they describe as "a wall of separation—a business culture on the military side that is ill-suited to engage in commercial production, and vice versa" (*6*).

The practice of isolating defense operations is not assumed to be limited to the large multidivisional corporations that are the recipients of major prime contract awards. Without reference to any empirical evidence, Markusen and Yudken claim that "subcontractors have become more, rather than less, specialized in military projects, as the 'wall of separation' reaches down into their ranks" (*6*). Similarly, former Deputy Assistant Secretary of Defense Gansler speculates that the high costs of weapons systems can be at least partly attributable to the dedication of lower tier suppliers to serving defense needs to the exclusion of commercial customers. At the end of the Cold War, he believes that "only a few

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suppliers remain in the lower tiers of the defense industry and they are highly specialized. The specialization of these firms in defense subcontracting means that DOD loses the economies of scale that could be realized in combining defense and non-defense production in the lower tiers of the industry" (5). In sum, most of the dollars spent by DOD on its weapons systems are commonly assumed to go to plants in which the entire organization—its technology, workers, and management systems—is dedicated exclusively to serving that military customer.

Government contracting practices are believed to be largely responsible for the differences separating the defense and commercial industrial spheres. Certainly, the contracting relationship between the government as "buyer" and defense contractors as "sellers" of weapon systems departs in significant ways from the conditions associated with a market system of exchange (9, 10). The stylized market system of exchange presumed to operate for commercial transactions is characterized by many buyers and sellers. Key features of this system simply do not apply to government purchases of military weapons manufactured by private companies. Rather than many buyers and sellers, there is only one buyer (the government) for military weapons. The buyer also has the political power to restrict the sale or use of products to other potential customers. A company that makes a new high-tech weapon for DOD cannot sell that weapon to another customer (such as another government) without DOD's permission. DOD even forbids commercial use or sale of some of the components of these systems.

For a substantial share of contracts for weapons systems, the government makes payments to defense contractors on the basis of costs rather than on competitively set market prices. The main reason for cost-based contracts is the uniqueness of the products that defense contractors make. Moreover, the government (as buyer) exercises considerable control over sellers' internal operations through its direct involvement in the development of new weapons systems and its auditing of suppliers' costs. These peculiarities of the defense contracting relation have led some analysts to conclude that there must be little potential for overlap between a production system that satisfies military needs and one designed for commercial transactions, causing companies to "spin away" their defense operations from their commercial activities (11). Instead of being organized to satisfy the diverse demands of many customers, defense contractors are believed to be "captive" suppliers to the government, oriented solely toward compliance with its regulations.

The burden of regulatory compliance is also thought to induce behavioral distortions. Special accounting rules and unique or esoteric technical requirements are blamed for a wall of separation dividing production for the military from commercial manufacturing. This division between commercial and defense activities is thought to extend from headquarters to the shop floor, serving to insulate a defense contractor's commercial activities from the rules affecting its defense operations. In the presumably rare instances when companies make commercial products alongside their military products, cost-based pricing rules are expected to provide perverse incentives with respect to subcontracting and investment decisions. As a result, defense contractors are thought to subcontract out less, employing more direct labor than do enterprises that make products only for commercial customers (9, 12). Moreover, because there is assumed to be little or no competitive pressure to reduce costs, defense contractors are also thought to underinvest in productivity-enhancing technologies (13).

Table 1. 1990 shipments from defense contractors in the MDG sector by type of contractor. Our calculation of the share of total defense shipments originating in the sector coming from subcontracts should be considered a low estimate, because the reports of prime contract shipments do not exclude the value of subcontracts let by the prime contractor.

Type of defense contractor	Share of all defense plants (%)	Share of defense subcontract shipments (%)	Share of total defense shipments (%)	Share of total commercial shipments (%)
Only prime contracts	9.63	0.0	0.84	9.94
Prime and subcontracts	26.23	46.0	77.04	51.26
Only subcontracts	64.14	54.0	22.12	38.80
Contribution of column total to commercial and military shipments from defense contractors (%)		14.80	36.09	63.91

Although there may be any number of other differences in the management styles and routines that distinguish companies with close ties to the Pentagon from other enterprises, our focus is on the underlying market structure and behaviors that are so frequently assumed to separate defense production from the commercial industrial world. Our study is the first to make systematic comparisons of commercial enterprises with defense contractors from the same set of industries and the same production processes for the period after the Carter-Reagan buildup. With data from our 1991 survey, we investigated four propositions concerning structural and behavioral characteristics thought to distinguish defense contractors:

1) Defense contractors tend to operate facilities that are largely dedicated to military contract work.

2) Compared with commercial enterprises, defense contractors and their managers and workers face less competition and are more highly dependent on a few customers (DOD and a few large prime contractors).

3) Defense contractors do less subcontracting of production operations than do commercial enterprises.

4) Defense contractors tend to invest far less than commercial enterprises in productivity-enhancing technologies that are relevant to nonmilitary production.

Data Description

Our analysis of the differences separating defense from commercial manufacturing is based on data collected in a 1991 survey of a randomly selected, size-stratified sample of manufacturing establishments. Eighty-four percent of the production managers we contacted completed the survey, yielding a final sample of 973 plants. The questionnaire focused on the competitive conditions, technology, and other practices affecting products manufactured at least partially through the machining process at the plant. The sample was selected from the sector we define as machining-intensive durable goods (MDG), which includes 21 industries at the three-digit level of the standard industrial classification (SIC) system of the Department of Commerce (14). Collectively, these industries account for virtually the entire capital goods sector (excluding computers) and certain consumer goods. The manufacture of high-tech military hardware in the form of aircraft, ordnance, navigational equipment, satellites, and missiles is concentrated in this sector. Overall, durable goods industries accounted for 82.5% of defense purchases of manufactured goods in 1990 and more than half (51.3%) of all defense purchases of durable goods in that year came from the MDG sector (15).

The Extent of Defense Manufacturing

DOD is the final customer (through prime contracts or subcontracts) for an enormous number of production facilities in the Unit-

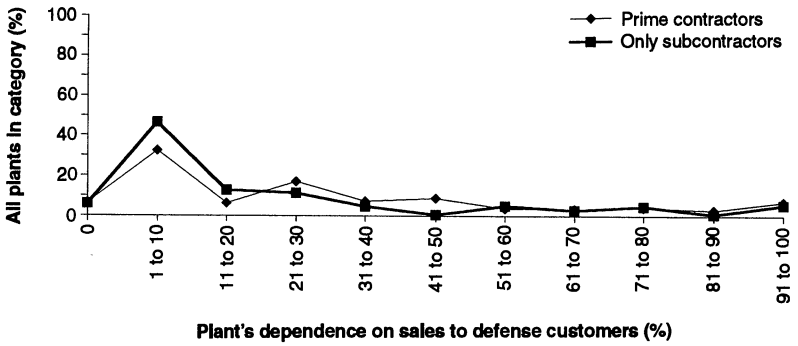

Fig. 1. Percentages of defense contractors by degree of dependency on sales to U.S. defense agencies or prime contractors. The degree of defense dependency is measured by the percent of the value of all shipments from an MDG establishment in 1990 that went to defense agencies or prime contractors to defense agencies. "Prime contractors" are plants that shipped at least some of that year's output directly to a federal defense agency. "Only subcontractors" are defense contractors that did not ship any output directly to a federal defense agency. For more than 75% of both types of defense contractors in this sector, shipments of products for the military account for less than 50% of the value of all shipments from the plant.

ed States. For the MDG sector alone, we found that 48.8% of all plants had defense contracts in 1991. We estimate that nearly 40,000 manufacturing plants in this sector throughout the United States were engaged in defense contracting at that time. This estimate of the extent of the defense industrial base in the MDG sector in 1991 corresponds closely to results obtained from the Bureau of the Census's 1988 survey of 10,000 manufacturing plants employing at least 20 workers (*16*). Using this government data source, we computed the percent of plants with defense contracts in 1988 for the same set of industries. Nearly half (49.7%) of all establishments with 20 or more employees in the MDG sector reported to the Census that they had defense prime contracts (selling directly to one of the federal defense agencies) or subcontracts to defense prime contractors. Despite declines in defense spending in real terms between 1988 and 1991, there is no statistical evidence of a decline in the share of the overall manufacturing base in the MDG sector serving DOD during this period.

In U.S. manufacturing, there is a vast, hidden defense industrial base consisting of a large number of subcontractors that have no direct dealings with the Pentagon. As Table 1 shows for the MDG sector, most of the plants (64.1%) with any defense-related sales in that year did not sell directly to DOD but rather served only as subcontractors or suppliers to defense prime contractors.

There is substantial pass-through of defense spending from major prime contractors to lower tier suppliers. Subcontracts alone accounted for 41% of all defense-related sales and shipments in the MDG sector during 1990. From one year to the next, the distinction between first (or prime) and lower (sub) tier contracting status will vary, because defense contractors often span tiers, making some products as a prime contract and others as a subcontract to another defense prime or subcontractor. Nevertheless, more than half (54%) of the value of shipments from subcontractors to prime contractors comes from lower tier suppliers; that is, those that had no prime contracts with a federal defense agency in 1990. Lower tier subcontractors contribute over one-fifth (22.12%) of all defense-related sales and nearly two-fifths (38.8%) of all sales from defense contractors to commercial customers in the MDG sector.

Our sample estimates of the extent of the pass-through from DOD prime contractors to subcontractors are well within the range of reports from government sources and from prime contractors about the extent of dependence on subcontracting. Using data on subcontracts to small enterprises that were provided by major prime contractors to the Pentagon, the U.S. Congressional Office of Technology Assessment estimates that 35 to 37% of all defense purchases in the 1980s went to enterprises that met one or another criterion as "small" (*17*). Of course, some subcontracts go to large companies as well. Our interviews with manufacturing managers at several major prime contractors (such as General Electric, Pratt & Whitney, Lockheed, and McDonnell Douglas) indicate that subcontracts account for 60 to 75% of major prime contractors' costs, depending on the product.

Only a few of the largest defense contractors are really very dependent on defense sales. Over the 5-year period ending in 1988, among the 100 largest defense prime contractors, the 67 that are publicly traded derived only 9% of their total sales from defense prime contracts, on average (*3*). Moreover, only 9 of those 67 firms had 50% or more of their sales coming from defense contracts during the peak years of the buildup. Yet, because some of these companies have set up a division for their defense business, indicating a formal separation between the reporting chains of command in their other product markets, previous studies have often assumed there to be little connection between the defense and commercial sides from the top to the bottom of the enterprise. However, in matrix organizational structures, the same work groups and organizational units may report to more than one product or market division and a functional department as well, such as manufacturing or engineering, that cuts across product market lines. Only establishment-level data can inform us about the extent to which activities undertaken to manufacture products for the military occur alongside those for commercial customers in the same organizational unit.

Drawing on our 1991 survey data for manufacturing establishments, we measured the extent to which defense procurement is dependent on a manufacturing base that is substantially isolated from commercial activities. Our indicator of the degree of defense segregation was the percent of total 1990 shipments from the plant that was sent directly to a federal defense agency (including any branch of the U.S. Armed Forces, the Defense Logistics Agency, depots of the services, and the Department of Energy) or to a prime contractor of one of those agencies.

Contrary to the conventional wisdom, we found that in 1990, the typical defense contractor was not especially dependent on the Pentagon. The median defense share in 1990 was only 15% for plants with any defense contracts in the MDG sector. The vast majority (80.4%) of establishments integrated commercial and military production in the same facility, selling more than half of their 1990 output to commercial customers. As Fig. 1 shows, only 21.4% of plants with prime contracts had more than 50% of their sales going to DOD in 1990. For the lower tier subcontractors, only 18.5% shipped more than 50% of their 1990 output to defense prime contractors. Moreover, as Fig. 2 shows, less than one-third (32.7%) of the total shipments of military goods from the MDG sector in 1990 came from plants that were highly dedicated to defense production (with more than 80% of their output going to a defense agency or a prime contractor).

The defense industrial base in the MDG sector includes both large and small companies. Multiplant companies have the option to place all of their defense orders in one facility and their commercial work in another. If multiplant corporations adopt such a segregation strategy, we should find a higher incidence of dedicated facilities among branch plants doing defense work than among single-plant enterprises. However, as shown in Fig. 3, there is no differ-

ence between these two types of companies in the proportions of facilities that are highly specialized in making defense products. We did several statistical tests (at $P = 0.05$) to examine the relation between the size of a plant or firm and defense dependence, as measured by the percent of total shipments from the plant in 1990 that went directly to a defense agency or a prime contractor. We found no significant correlation between size, as measured by sales or employment, and the degree of dependence on defense purchases. We considered both plant and parent company size in these calculations. Moreover, χ^2 tests fail to show any significant differences in the distribution of plants among plant or company employment size categories (1 to 49, 50 to 249, and ≥250) and the extent of the establishment's dependence on defense sales when grouped by categories, reflecting 10% intervals (that is, 0, 1 to 9%, 10 to 19%, 20 to 29%, and so on). We also tested the difference between group means, comparing the mean size of single-plant enterprises as a group to that of branch plants of multiunit companies. We found no statistical differences between the practices of large firms (represented by branch plants) and those of small firms (represented by single-plant enterprises) in the sample plants' dependence on defense purchases. For the plants of multiplant firms and single-plant enterprises alike, fewer than one in five of the plants that did defense work sold more than 50% of their output to DOD or a prime contractor.

Although the plants of large firms are not more defense dependent, on average, than those belonging to small firms, we did find that facilities dedicated to defense production were somewhat more common among those branch plants of larger companies that received prime contracts. As we show in Fig. 4, which looks only at branch plants of multiplant firms, defense plants that have any prime contracts are significantly more dependent on sales to DOD, on average, than are branch plants that only have subcontracting ties to DOD. For example, a larger fraction of prime contractors (22.3%) than of subcontractors (12.1%) depend on DOD (or other prime contractors) for 50% or more of their sales. These differences are statistically significant ($P = 0.05$) by several tests. Yet facilities that serve both commercial and military customers are still the norm for defense plants that are part of multiunit companies.

In short, at the level of the plant, we find considerable integration between the commercial and military industrial spheres in the MDG sector. Large multiplant firms that do defense prime contracting tend to be slightly more dependent on average than are subcontractors. But overall, we find that defense production in the MDG sector (whether directly for DOD or indirectly through subcontracts) usually takes place in facilities in which the majority of shipments go to commercial customers.

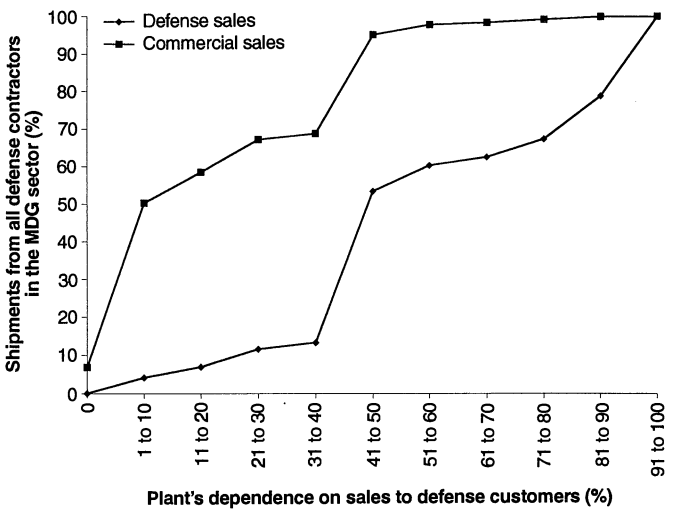

Fig. 2. Cumulative distributions of 1990 shipments by defense contractors to defense and commercial customers. The distribution labeled "Defense sales" shows the estimated cumulative percent of the total value of shipments to defense agencies or prime contractors to defense agencies from defense contractors, ordered by the degree of the plant's dependency on sales to defense customers. The distribution labeled "Commercial sales" displays the estimated cumulative percent of the total value of shipments to nondefense commercial customers from defense contractors. Plants that depend on defense contracts for more than 80% of their 1990 shipments contribute only 32.7% of the total defense shipments from the MDG sector.

Customer Diversity and Competitive Pressures

That defense contractors also serve some segment of the commercial market may not imply a broad capability to address a diverse set of customer demands. For example, defense contractors may conceivably be occupying specialized niches in commercial markets that are substantially different from those commonly filled by companies without the shelter of defense contracts. In this section, we address several questions about customers and competitive conditions in the MDG sector. First, we ask how many different customers defense contractors ordinarily serve and how that diversity of customers compares to that of plants operating in strictly commercial markets. Second, we investigate whether defense contractors are more dependent on sales to a small number of leading customers than are establishments with no defense contracts. Third, we consider whether defense contractors serve only a specialized niche in competitive environments that are more benign; that is, characterized by fewer rivals and less aggressive actions by competitors than those experienced by enterprises that are exclusively engaged in commercial transactions.

In our 1991 survey, we asked the plant managers to tell us how many different customers purchased products made by their plants in the previous year (1990). As Table 2 indicates, plants in this sector serve over

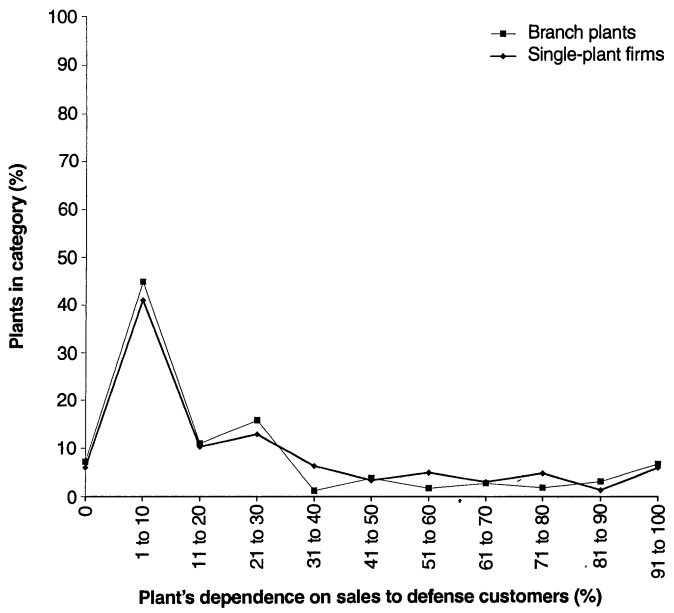

Fig. 3. Percentages of branch plants and single-plant firms with defense contracts by degree of dependency on sales to defense customers in 1990. Branch plants are establishments belonging to companies with multiple plant locations. Single-plant firms operate only one establishment. For both types of plants, there are no statistically significant differences between the distributions of the percentages of plants by degree of dependency on defense sales. Fewer than one in five plants in the MDG sector sell more than 50% of their output to federal defense agencies or defense prime contractors.

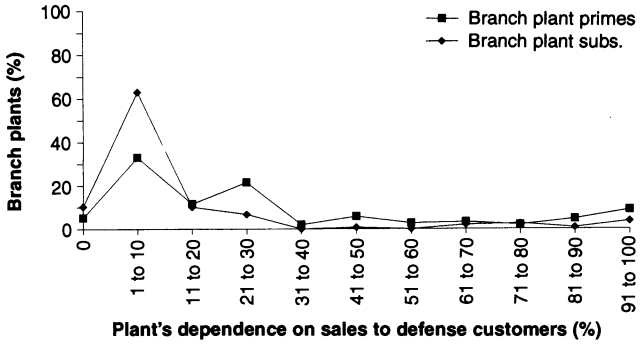

Fig. 4. Percentages of branch plants by contract status and degree of dependency on sales to defense customers in 1990. Branch plants are establishments belonging to companies with multiple plant locations. "Branch plant primes" shipped at least some of their output in 1990 directly to federal defense agencies. "Branch plant subs." did not ship any of their 1990 output directly to federal defense agencies. On average, branch plants with prime contracts are more dependent on defense sales than are branch plants that have only defense subcontracts. Among both groups of branch plants in the MDG sector, however, the majority depend on defense sales for less than 50% of their total output in 1990.

300 customers, on average, and there is no statistical difference in the number of customers reported by defense contractors as compared to enterprises serving strictly commercial markets. However, a substantial number of plants in both groups are niche producers, serving only a small number of customers. Fifty percent of defense contractors and their commercial counterparts have 30 or fewer customers. Moreover, establishments in the MDG sector depend on a small number of key customers, selling 60% of their total output, on average, to their largest three customers in 1990. The point is that on the whole, defense contractors have as diverse a customer base and are as dependent on a few key customers as nondefense establishments are.

Turning to the specific features of the product markets for machining output from these plants, we learn that custom-built products are the norm for this sector. The typical plant produces nearly half (46.9%) of its machining output in small lots of only one to nine items. Moreover, we find no evidence that defense contractors are more specialized in making highly customized machining products than are establishments making products solely for commercial customers. In fact, we find the opposite: Strictly commercial plants produce significantly more of their output in small lots (P = 0.0001); and compared with defense contractors (43.1%), a greater share of plants with no defense contracts (56.2%) specialize in customized products, making 50% or more of their total machining output in batch sizes of fewer than 10 items.

In assessing the competitive environment, we considered several indicators, including the number of competitors and the extent to which rivals are particularly aggressive in competing for the same customers in terms of price, quality, or service. On average, we find that defense contractors report having a significantly larger number of competitors than do enterprises that have no defense contracts (P = 0.0008). But, as is shown in Table 3, a substantial share of both types of plants operate mainly in markets with few competitors. Fifty percent of defense contractors report six or fewer competitors; the median for nondefense enterprises in this sector is five or fewer competitors. In the MDG sector, the competitive environment for half of the enterprises in strictly commercial product markets consists of only a few rivals rather than the many sellers assumed to prevail in commercial markets.

In sum, many of the features thought to be peculiar to the defense contracting relation also apply to a substantial share of the strictly commercial producers in this sector: a high dependence on a small number of customers, an evident willingness to custom-build products; and very few competitors.

In the 1991 survey, we asked about four different actions of competitors over the preceding 2 years. The most common competitive pressure came from price reductions offered by rivals to important customers. Nearly three-fifths (59.3%) of plant managers in the MDG sector reported that competitors had undercut their prices sometime during the previous 2 years. Offering new services or assistance to customers is another common way in which companies attempt to win business away from rivals in this sector. Less common are reports of predatory actions by rivals to discourage distributors or customers. And even though product quality has been touted in the business press as an important competitive pressure, few plant managers reported that their rivals were outcompeting them in quality.

Overall, we find no indication from these data that defense contractors are especially insulated or sheltered from competitive pressures experienced by companies operating in strictly commercial product markets. Indeed, in terms of two of the four indicators measuring the severity of competitive pressures, defense contractors experienced a significantly higher incidence of aggressive actions from competitors than did nondefense enterprises. Price undercutting behavior (P = 0.0001) and targeted attacks by competitors to undermine their ties to customers and distributors (P = 0.02) were more frequently experienced by defense contractors than by other manufacturers. Heightened rivalry among contractors for declining Pentagon orders may be part of the explanation for these differences, as might procurement reforms undertaken after the 1984 Competitiveness in Contracting Act that were designed to deliberately introduce greater price competition in defense contracting.

Table 2. Selected characteristics of customers and product markets of plants in the MDG sector. Group means are shown for defense contractors, for plants with solely commercial customers, and for the overall sample.

Customer and market characteristics	Plants with defense contracts	Plants with solely commercial customers	All plants
Number of customers for machining products in 1991			
Mean	281.7	346.2	314.5
Standard deviation	1476.5	8200.8	5944.3
Median	30	30	30
Number of plants			920
1990 sales revenue coming from the plant's top three customers			
Mean	60.7%	59.5%	60.1%
Standard deviation	25.4	28.5	26.8
Number of plants			889
Machining output in small lots (one to nine items)			
Mean*	40.0%	53.6%	46.9%
Standard deviation	36.7	39.2	38.6
Number of plants			959
Plants with 50% or more of machining ouput in small lots			
Mean (% = yes)*	43.1%	56.2%	49.7%
Number of plants			959

*P = 0.0001.

Subcontracting

All of the establishments surveyed in the MDG sector make products with precision machine-tool technologies. Although we do not have information on all types of subcontracting practices at these plants, our survey did ask about subcontracting of operations from the machining production process at the plant. Our maintained hypotheses were that cost-based pricing rules in defense contracting should contribute to hoarding of direct production labor, and that defense contractors should be less likely to engage in production subcontracting and to spend less on subcontracts when they did contract out, as compared with the strictly commercial enterprises.

Table 4 compares machining subcontracting practices in 1989–90 between defense contractors and plants with no contract ties to DOD. We find that, on average, defense contractors are actually significantly more likely than nondefense enterprises to rely on machining subcontractors (P = 0.0001). For this key production process, 66% of defense contractors subcontract out at least some part of that work to other firms, as compared with only 51% of plants that do no defense contracting.

Among those that do contract out, we find no statistical difference between defense contractors and their strictly commercial counterparts in the MDG sector in the amount of subcontracting they do, as indicated by the amount of purchases from machining subcontractors in 1990 as a share of the total value of shipments from the plant. Similarly, we find no difference between defense contractors and nondefense producers in this sector in the average number of subcontractors they employ.

With respect to the machining process, at least, we find no support for the presumption that defense contractors are reluctant to engage in subcontracting as compared with their strictly commercial counterparts. It is therefore unlikely that government accounting and pricing procedures deter defense contractors from subcontracting.

Table 3. Characteristics of competitive environments for machining products of plants in the MDG sector. Group means are shown for defense contractors, for plants with solely commercial customers, and for the overall sample.

Characteristics of competitive environment	Plants with defense contracts	Plants with solely commercial customers	All plants
No. of competitors for machining products			
Mean*	65.8	18.1	42.4
Standard deviation	267.5	96.5	203.9
Median	6	5	5
Number of plants			745
In 1989 or 1990, did your competitors ever:			
Undercut your price with an important customer?			
Mean (% = yes)**	68.0%	50.6%	59.3%
Number of plants			657
Introduce services or assistance you do not offer?			
Mean (% = yes)	37.5%	41.2%	39.3%
Number of plants			662
Try to limit your business by discouraging your customers or distributors?			
Mean (% = yes)***	30.3%	22.4%	26.4%
Number of plants			650
Introduce a similar product or service but with higher quality or performance?			
Mean (% = yes)	16.0%	12.5%	14.3%
Number of plants			656

*P in group means at 0.0008. **P in group proportions of 0.0001. ***P in group proportions at 0.02.

Table 4. Comparisons of machining subcontracting practices of defense contractors and plants with solely commercial customers.

Features of subcontracting	Plants with defense contracts	Plants with solely commercial customers	All plants
Do you usually contract out machining work to other firms?			
Mean (% = yes)*	66.1%	51.3%	58.5%
Number of plants			940
Total of 1990 sales revenue spent on machining subcontracts			
Mean	6.9%	5.9%	6.5%
Standard deviation	8.3	8.3	8.3
Number of plants with any spending on subcontracts			520
How many machining subcontractors did your plant use in 1990?			
Mean	7.5	7.2	7.4
Standard deviation	22.5	30.4	26.3
Number of plants with any subcontractors			618

*P in group proportions at 0.0001.

Technology Investment Practices

Hoarding of direct labor and the failure to make investments to improve productivity have long been identified as a possible source of high costs among defense contractors. Indeed, as early as 1976, a major Pentagon review of procurement practices concluded that defense contractors used only 42% as much capital equipment and facilities per dollar of sales as did durable goods manufacturers overall (*18*). In 1980, the House Armed Services Committee drew similar conclusions about the lack of investment in new manufacturing technologies by defense contractors (*19*).

During the 1980s, information technology applications in which computer software and microelectronic control devices are used to direct and monitor such ordinary production operations as machining, welding, testing, and inspecting were first introduced in the United States and elsewhere. These technologies have been heralded as providing cost, performance, and flexibility advantages for a wide range of uses (*20*). Cross-national comparisons of the adoption and use of certain applications, particularly for the machining process in the form of numerically controlled (NC) and computerized numerically controlled (CNC) machine tools

and flexible manufacturing systems (FMS), have come to be taken as indicators of the relative strengths of the manufacturing sectors of industrial economies (*21*).

Our survey results confirm a statistically significant difference ($P = 0.0001$) in the adoption rates of these types of advanced manufacturing technology related to defense contracting. But the differences we find, as shown in Fig. 5, are not what we would expect if defense contracting practices were a deterrent to investment in productivity-enhancing technologies. Sixty-six percent of plants with defense contracts have programmable machine tools (CNC, NC, or FMS), compared with 50% of plants that have no contract ties to DOD or any of its prime contractors. Moreover, defense contractors that adopt this technology employ a much higher fraction of programmable machines in their total machine tool stock than do establishments engaged in the same manufacturing process but having no defense contracts.

For each of the five common uses of computers in manufacturing shown in Fig. 5, defense contractors have higher rates of use. In addition to programmable machine tools, these applications include computer-aided design (CAD), computer-aided manufacturing process control systems (CAM—used to plan and monitor inventory, work-in-process, and materials flow), computer-aided materials planning, and the use of programmable automation in other production processes. For every one of these technologies, we find significantly higher adoption rates ($P = 0.0001$) among defense contractors than among plants serving exclusively commercial markets.

Although it is difficult to single out a particular cause for these differences, we believe that government policy initiatives and programs directed at the defense industrial base are at least partly responsible for the large technological gap we find between defense contractors and other U.S. manufacturing establishments in the MDG sector. From 1982 to 1992, the Industrial Modernization and Incentives Program of DOD provided technical assistance to contractors in assessing the applicability of advanced manufacturing technologies to defense contractors' operations. Through its manufacturing technologies (ManTech) program, DOD has also supported the development of advanced technologies and improvements in process technologies among defense suppliers. The Pentagon spent between $150 million and $200 million annually throughout the 1980s on these programs, which exceeded spending by all state governments on technical assistance programs aimed at manufacturing firms during the same period (*22*). Hundreds of defense contractors were directly assisted by these programs. DOD also sponsored annual conferences and workshops on manufacturing practices to highlight the lessons learned from the experiences of the early adopters of these advanced manufacturing technologies, providing an opportunity for representatives from the larger defense industrial community to become acquainted with the difficulties in implementing technical changes and the strategies employed by lead users to solve them. We believe that such forums promoted the dissemination of information about the implementation process that was not as readily available to manufacturing firms outside the defense contracting system. Our research also indicates that major prime contractors provided technical assistance and support to their suppliers that were less commonly available to companies with no contractual relation to DOD or its prime contractors.

Access to the technical assistance and supplier development activities of prime contractors and DOD can be construed as providing a competitive advantage to defense contractors that is not widely available in other supplier production chains. Research on supplier relations in the auto industry, for example, suggests that customer-supplier relations are not characterized by the type of information-sharing and technical assistance that we find to be so common among defense contractors (*23*). Other research also indicates that institutional mechanisms that foster information sharing and interorganizational learning can accelerate the diffusion of new technologies (*24*). Thus, the higher rates of adoption of advanced manufacturing technologies we find among defense contractors are at least partly attributable to the greater opportunities for interorganizational learning fostered by such government-sponsored activities.

Conclusions

Defense spending reaches a broad segment of manufacturing in the MDG sector, affecting nearly one-half of all establishments. Contrary to conventional wisdom, commercial-military integration is not only feasible but is largely the normal practice at the end of the Cold War. The vast majority of defense contractors in the MDG sector manufacture military products in the same plants with the same workers and equipment employed in producing items for commercial customers. In fact, commercial customers dominate the sales of most defense contractors in this sector. Moreover, defense plants, on average, face as much competitive pressure as do those that produce only for commercial markets. Also, defense contractors use more modern and flexible manufacturing technologies at a higher rate than their strictly commercial counterparts do.

We conclude that the legacy of the 1980s defense buildup has been the generation of an industrial complex poised to exploit certain quite common kinds of commercial markets—those involving customized durable goods—in a post–Cold War era of flexible manufacturing. In the MDG sector, DOD has provided a more supportive environment for long-term investments and the transfer of technology than occurs for firms engaged in strictly commercial customer-supplier relations. Moreover, we find little evidence to support the widely held contention that government contracting procedures have forced a divide in the organization of military and commercial production for the vast majority of contractors. The policy challenge will be to find new ways to promote such supportive interfirm exchanges outside the defense contracting network.

The integration of defense and commercial manufacturing activities may not be viewed as uniformly beneficial to society or

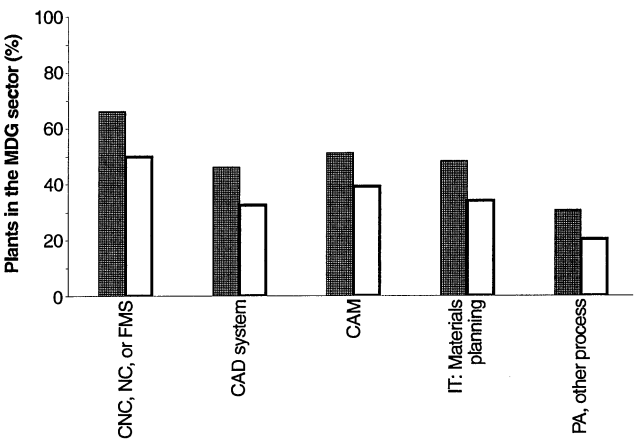

Fig. 5. Rates of adoption of selected advanced manufacturing technologies for plants with defense contracts (solid bars) and for plants with no defense contracts (open bars). The selected technologies are: programmable automated machine tools in the form of computer numerically controlled (CNC), numerically controlled (NC), or flexible manufacturing systems (FMS); computer-aided design (CAD) systems; computer-aided manufacturing process (CAM) control systems; computer-assisted materials planning systems; and programmable automation used in other production processes at the plant. In the MDG sector, for each of these technologies, plants with defense contracts have a significantly higher rate of adoption than do plants that operate strictly in commercial product markets (that is, they have no defense contracts).

even to the economy as a whole. For instance, the degree of integration we find at the end of the Cold War may reflect as much on the weaknesses of producers in commercial markets as on the capabilities of defense contractors or the influence of the Pentagon as an important buyer for this sector during the 1980s. We have focused here on the narrower questions involved in identifying the extent to which integrated dual-use capabilities exist among defense contractors and the degree of overlap between the competitive and technical environments of the defense and commercial industrial spheres.

Further research is needed to inform debates concerning the need for post–Cold War industrial technology policies. Policy discussions about the feasibility of the integration of military and commercial production and the barriers to defense conversion and diversification would benefit from more realistic assessments of the nature of the competitive environment that commercial enterprises face and the kinds of interdependencies among firms that are important to industry performance. Our study is the first to do so for a large cross-section of U.S. industry in a key sector. We think that other studies should be pursued, particularly in such processes as microelectronics and telecommunications. In our view, too much attention has been given to a few high-profile cases and too little attention to analyses of the broader industrial base. If our findings for the MDG sector hold true for manufacturing as a whole, we see few technical or organizational barriers to converting most defense plants to further serve commercial markets.

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15. These figures are based on the estimates of direct and indirect effects of defense spending in 1990 as reported in *Industrial Output Effects of Planned Defense Spending, 1990–1994* (Office of Policy Analysis, Economics and Statistics Administration, U.S. Department of Commerce, Washington, DC, February 1991).
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