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Defense Spending and the Geography of High-Tech Industries

ANN R. MARKUSEN

Many industrial policy experts argue that the future viability of the U.S. economy lies with its high-technology sectors. High-tech industries are generally heralded, at least in the popular press, as clean, innovative, entrepreneurial, and generating new technologies to improve human welfare. Such "sunrise" industries, to borrow a phrase from Lester Thurow (1980), are often contrasted with the dirty, sluggish, bureaucratic, and conservative performance of management in the more mature, or "sunset" industrial sectors like steel.

Do these industries have a spatial counterpart—new innovative regions whose fortunes are on the rise? Several regional economists and geographers have argued that they do. In their view, certain Sunbelt subregions appear to possess sufficient entrepreneurship and dynamism to warrant labeling them "seedbeds" of innovation, a function once ascribed to older, mature metropolitan centers (Norton and Rees, 1979; Weinstein and Firestine, 1978; Hall, 1982). Some see this shift of the innovative center of gravity as chiefly accidental—the residence of particularly creative entrepreneurs (Hall, 1982). Others argue that the oligopolistic dominance of certain mature sectors in regional factor markets has repelled innovators from the Snowbelt and driven newer industries to sprout at new or greenfield sites (Chinitz, 1960; Checkland, 1975; Markusen, 1985). Empirical studies to date, relying largely upon survey and anecdotal evidence, underscore the prominence of regional skilled labor and amenities in attracting high-tech industries (Rees and Stafford, 1983; Joint Economic Committee, 1982; Hall and Markusen, 1984).

This paper accepts the hypothesis that the seedbed function is shifting, but argues that the origins of this change are closely tied to a factor rarely addressed—the location decisions determining the siting of defense manufacturing facilities.[1] It poses a set of hypotheses about the location of defense-related industry and labor. The major theoretical notions developed are that land, military installations, and skilled labor are the most important locational determinants of military-related production. How-

ever, since labor is highly mobile, an indigenous or preexisting local labor force has been less important than the ability of firms to attract and assemble a labor force in a new location, which in turn is sensitive to certain amenities in the area.

The hypothesized outcome of this locational calculus is that major defense-related sectors, the majority of the "high-tech," have formed the core of new centers of urban growth. These lie on the periphery of older metropolitan areas, and increasingly, around detached, medium sized cities, drawn by inexpensive land, nearby military facilities, and amenities which permit them to recruit and assemble a specialized labor force from other regions. While labor costs are not generally important to these "cost-plus" contractors, unionization rates are, so that locations of new defense facilities in the postwar period fall disproportionately outside the core Manufacturing Belt where labor is highly organized. The newer, defense-dependent communities have generally benefited from rapid rates of growth, often at the expense of other regions, although the growth is often of a relatively nondiversified nature, vulnerable to defense spending cutbacks.

The outcomes occur because defense based high-tech industries have quite distinct corporate structures and strategies which result in spatial imperatives quite different from traditional market and resource oriented commercial sectors. In this sense, they resemble military activities in previous epochs in their dramatic reshaping of human settlements. The first part of this chapter explores this continuity. In the second part, the nature of military related production is examined and a number of hypotheses about twentieth century defense-related high-tech locational priorities are proposed.

Empirical research on the relationship of military spending to regional and urban growth has been extensive. In the third portion of this paper, I briefly review this literature. I conclude that it has underestimated the role of "defense pull" in regional restructuring, particularly because its success in generating high-tech complexes has not been carefully studied.

In the fourth portion of this chapter, I report preliminary research results from a county level study of 4-digit high-tech manufacturing industries in the United States (Glasmeier, Hall, and Markusen, 1983c). It illustrates that military spending plays a very important role in the spatial patterning of high-tech activity. Military-related high-tech sectors are identified, computed to account for almost half of all high-tech employment, and shown to be more spatially concentrated than other high-tech sectors. Highly high-tech dependent areas are mainly to be found outside of the Manufacturing Belt. High-tech sectors seem to have favored both "younger" Standard Metropolitan Statistical Areas (SMSAs) and medium sized cities in disparate parts of the Sunbelt.

THE HISTORICAL ROLE OF THE MILITARY IN HUMAN SETTLEMENTS

Military concerns have played a critical role in the settlement patterns of all complex societies. Until the capitalist epoch, warmaking was an essentially labor intensive operation, dependent upon horses and boats for mobility and metalworking for weapons. Medieval towns were originally fortified gathering places for more dispersed agricultural populations; crafts activities and interregional commerce sprouted around these old city walls. The design and manufacture of weapons became an early agglomerative activity in these towns, stimulating urbanization.[2] Shipbuilding, another sector whose product became increasingly central to the prosecution of war, was also an important force in stimulating urbanization; in the United States, this was particularly true in the early colonial seaboard cities like Boston, Newport, and New York. Arsenals and armories were centrally located in these cities, convenient to the civilian population who formed the bulk of military manpower in times of crisis.

In the nineteenth century, the warmaking activity appears to have increasingly dispersed population in counterpoint to its earlier role in concentrating population. Military bases, previously more or less temporary camps or forts located with respect to the current military campaigns, became more permanent and more detached from urban centers. Training and weapons' repositories were increasingly removed to these nonurban sites, as military manpower became more professionalized and the tools of war more sophisticated. Movement of bases to the interior and westward in the United States was related both to the vulnerability of coastal sites, to the growing sophistication of warships in imperialistic rivalries, and to the eradication of native Americans in the great frontier land grab. The Civil War front provoked the hasty construction of numerous bases on either side of the Mason-Dixon line.

Until late in the nineteenth century, the production of war material remained largely an urban function. Arms production was generally carried out directly by the state, as private manufacturers were preoccupied with the expansion of commercial shipbuilding, textiles, engineering, and iron and steel production (Kaldor, 1981, pp. 29–31). These plants were generally in or around large urban centers. Nonarms supplies became increasingly urban in character. The Civil War in the United States played a central role in the rapid erosion of certain small town crafts like shoemaking and of home production of such items as clothing. As these items became mass produced, they stimulated the growth of manufacturing complexes in cities like Boston, New York, and Chicago.[3]

But beginning with the final two decades of the nineteenth century, the production of war goods began to disperse just as military bases had before it. In large part, this was an outgrowth of a fundamental change in

the nature of the relationship between the state and the private sector in arms production. The large entities formed as a part of the enormous corporate era became increasingly interested in military markets. In Britain, for instance, periodic depressions in commercial markets and growing competition from German and American corporations forced steelmakers, shipbuilders, and engineering firms to turn to the state for business. In the 1880s, British military equipment procurement began to shift from government arsenals and dockyards toward operations of these private firms, institutionalizing the practice of the military contract.[4] These developments, at least in the British case documented by Kaldor (1981), led to the creation of the modern warship, a total transportation/weaponry system whose construction was undertaken by vertically integrated (through merger) corporations. These "capital ships" were often built at new sites where the entire array of activities—blast furnaces, foundries, machine shops, chemical laboratories, gun works, and shipbuilding—all agglomerated as a new, specialized armaments center. An example is Elswick, in England, whose historic product encompasses both the naval warship and the army tank. Elswick employed 13,000 workers in 1895, 20,000 in World War I, and only 2,000 today, and its history is parallel to the rise and fall of the Vickers corporation as a major military producer (Kaldor, 1981, pp. 49–53).

A cursory reading of the historical literature in the United States suggests that large military-related production facilities such as shipyards, aircraft plants, and ammunition factories were also increasingly located at greenfield sites, outside major existing industrial complexes from the early twentieth century onward. In aircraft production, for instance, an early lead by New York was badly eroded by the growing eminence of California in the airframe segment by the 1930s. The California plants were heavily dependent upon military markets. Aircraft manufacture was much more regionally concentrated by 1940 than all manufacturing employment, with 32 percent of all workers in the leading state of California. Furthermore, inside these regions, aircraft employees worked at sites peripheral to existing urban areas. By 1939, only 7 percent of aircraft workers were employed in cities of more than 500,000, while 62 percent were in communities with less than 25,000, mainly on the periphery of cities like Los Angeles. By contrast, 23 percent of all industrial workers were in the biggest cities and only 40 percent in the smallest. The contrast with industries like autos and machine tools is even greater; these sectors had 33 percent and 43 percent of their workforce in big cities.[5]

The notion that innovations bunch up at certain points in the long wave cycle has recently been extended to suggest that new spatial configurations accompany each era (Hall, 1984). The third Kondratieff revolution, beginning in the 1890s and running through the mid-1930s, was based on

electric machinery, autos, and chemicals. This ensemble had its militarized component in the tank and armored vehicle, which reinforced heavy urban concentrations in industries like autos and machine tools just mentioned (Malecki, 1983, p. 92). The new ensemble which began to emerge in the 1930s was based on aircraft, electronics, communications equipment, and scientific instruments. Military imperatives may have been chiefly responsible for determining the character of this round of innovation and the resulting spatial restructuring. It has been argued that the military buildup has been the industrial policy of the United States since World War II, the equivalent of Japan's Ministry of International Trade and Industry, and a clear contributor to uneven regional development (Stein, 1983; Markusen, 1984).

Confirmation of the evolution of military-related locational patterns awaits a fuller historical inquiry. However, it is worth pondering why military-oriented industries have tended increasingly to shun the older Manufacturing Belt SMSAs for relatively virgin manufacturing sites. What are the locational determinants of production in these sectors? How do the structures and conducts of each affect the location decision? And finally, for the purposes of understanding the current geography of high-tech, why might these industries be high-tech by their very nature.

THE LOCATIONAL TENDENCIES OF THE DEFENSE INDUSTRY

The private sector activities which are heavily military-oriented operate in markets which differ markedly from sectors competing in commercial markets. The sectors which fall into this category include military construction, aircraft, ammunition, ordnance, tanks, shipbuilding, missiles, communications equipment, electronics, explosives, scientific instruments, industrial trucks, and nonferrous metals.[6] The following conceptual discussion of locational tendencies in these sectors is designed to fit the period from about 1920 to the present, although clearly locational priorities have changed over those years.

First of all, the nature of demand is almost entirely different from other manufacturing sectors. Military goods are sold mainly to single buyers, the federal government, who is thus a monopsonist. But unlike private sector monopsonists, this customer does not use its market power to depress the price of the product (and therefore the profits of sellers) in the market transaction. Numerous authors have stressed the importance of performance and time as dominant selection criteria for the Department of Defense; demand is price inelastic and may be zero during wartime. Cost insensitivity has been institutionalized into the cost-plus contract, where overruns in excess of 100 percent are common in larger weapons

and equipment procurement programs (Baldwin, 1967, pp. 80–89; Gansler, 1980, pp. 82–92; Melman, 1984, pp. 27–39).

On the supply side, these industries are highly oligopolistic. A small number of corporations do the bulk of Defense Department business (Adams, 1981, pp. 33–41). The top 100 companies account for 70 percent of total business, the top 25 for 50 percent, and the top 5 for 20 percent (Gansler, 1980, pp. 36–45). Concentration ratios at the sectoral level are high and have been increasing over time (Baldwin, 1967, pp. 62–73). At the level of individual products, firms generally compete with only one or two others for the initial contract for a new system and after that, exercise a virtual monopoly. Subcontracting is considerably more competitive, but in this arena too, concentration has been growing rapidly, in part because the larger prime contractors have increasingly chosen to produce "in-house" than to buy from others. Often subcontractors have survived by occupying market niches and becoming monopolists of certain highly specific parts (Gansler, 1980, pp. 128–44).

The nature of the military product and its production process is also quite distinct from commercial manufacturing. The units of output of assembled weapons, equipment, and transport systems are often (and increasingly) few in number and highly sophisticated. The product embodies constant innovation, requiring large numbers of scientific and technical personnel engaged in design, prototype building, and testing. Skilled labor for assembly (e.g., machinists) is also a large cost component. In contrast, materials account for a relatively small proportion of total costs. Often immense in size (e.g., submarines, military transport planes, missiles), these products tend to be produced in very large-scale facilities. Batch, rather than assembly line, production predominates, so that defense-oriented plants are more like huge craft shops than standardized mass production factories.

We can hypothesize from this brief sketch that the array of locational pulls exerted on manufacturing sectors generally are ordered very differently in the case of military-oriented industries. The traditional dichotomy of resource and market orientations, so important in an earlier era and especially in industries like steel,[7] are both relatively unimportant in this case. Materials costs form a low portion of total costs and those used tend to be high value relative to the cost of transportation. Markets are ephemeral. In one sense, the Department of Defense in Washington is the market, but since military products are not used there, the physical orientation to the customer's headquarters is not important. Some assembled products, like ships, submarines, and aircraft, literally transport themselves to market. Most other military products are stockpiled and stored for some future mobilization, but the location of these receptacles may be dispersed, secret, and variable (e.g., the case of missiles). Since

most military material and equipment is indeed meant to be mobile, the physical link to markets is probably not very important.

Two other input factors do rank high on the list of locational features: land and labor. Land is important because the immense size of some plants requires extensive space for construction. Furthermore, the innovative nature of many products requires significant on-site experimentation and testing, so that additional space must be available for this purpose. In the case of large, mobile products like fighters, bombers, and transport planes, this space need is extraordinary. In the case of highly sensitive or potentially lethal products, space for experimentation requires extensive, unpopulated land area. A second reason why land may be an important determinant of the location decision is the desire on the part of initiators to ensure low cost housing for their workforce and perhaps to profit as well from further land development around the new site. Both of these factors may favor areas with large tracts of undeveloped land amenable to both industrial and residential use.

Labor is also an extremely important locational requirement. As we have seen, labor costs are a large portion of total costs, and scientific and skilled labor is an important determinant of competitive edge. Yet for a number of reasons, labor may be more mobile than other factors in the special case of military-oriented sectors. Since cost competition is not a major aspect of market conduct, and since a standard rate of return may be charged on all legitimate costs, it may be feasible for military contractors to routinely recruit labor from other regions and to assemble a labor force at a relatively new location, paying the relocation costs. Especially in the case of engineers and scientists, this appears to be common practice. In war time, skilled blue collar labor may be similarly recruited.

Recruiting and building a new local labor supply may have certain advantages for military-based industries. It is a good way to avoid unions, although not for the conventional reason of keeping wage costs down. Union work stoppages, work rules, and efforts to improve working conditions may hamper the ability of a company to complete a contract on time. The desire to create a new workforce far from older industrial centers may also be an unconscious expression of the conflict between military and civilian, corporate attitudes toward manpower. Collective bargaining, responsiveness to financial incentives, and labor mobility are aspects of capitalist labor relations inimical to the military mode, which has a completely internal labor market with advancement based on merit and an emphasis on loyalty to the organization above any individual interest (Fallows, 1981, pp. 107–14). The frequent movement of management between the Defense Department, the armed services (retired personnel), and military-oriented firms may result in the transfer of these values into the location decisions of the latter. This cultural factor may also explain why military-oriented industries may be willing to dominate a

local labor market in a medium-sized or even small town remote from a larger metropolitan area.

Intersectoral connections form a final important location factor for defense-oriented plants. One can hypothesize that there is a spatial dimension to the so called military-industrial complex. These agglomerations may be of two types. First, defense-oriented production may locate in close proximity to existing military bases for several reasons. For one, the experimental nature of the product may require collaboration between base personnel and producers—test pilots for example. Second, military bases may provide a regular stream of trained, specialized workers mustered out after short (2 to 3 years) or medium term (20 year) service. Since these discharged soldiers generally are not paid to return to their home towns (though they are paid for their trips to bases to begin with), significant numbers of them may choose to remain nearby. Third, military bases may often provide free infrastructure to firms producing nearby. The most extreme case is the closing of a military base by the Department of Defense, and the conversion of the facility for private business use.

Government facilities of other types may also serve as magnets for military production. The location of government R & D labor is significantly more skewed toward the South and West than is private corporate R & D (Malecki, 1981). Much of this R & D is military-oriented, and it would be reasonable to assume that commercial applications of this research and development activity might be sited nearby.

The second set of intersectoral connections consists of the force exerted by certain pioneer sectors on their suppliers. Decisions to locate large military production systems outside major existing industrial complexes over the period may have stimulated sequential shifts by related sectors to those sites. This would occur not only because of a market orientation on the part of the latter, but because the creation of a new, skilled labor force could act as an input magnet for them as well. An example of such a sequence might be the initial decision by airframe manufacturers to locate outside the old Manufacturing Belt, followed by shifts of machining, steel, and other metals, electronics, communications, and missiles in and around the same complexes.

It is important to note that the federal government has often played a direct role in the location of productive capacity in these sectors. Many defense-oriented manufacturing activities take place in government built and owned facilities. Wartime imperatives explain a fair amount of this investment, but some plants have been built in peacetime as well. While many government built plants have been sold to private firms, others remain government owned but contractor operated (GOCOs). Yet others continue to be operated as well as owned by the government itself. The location decisions of the federal government, both in siting bases and productive manufacturing capacity, are often affected by strategic consid-

erations not raised in this discussion. An example might be the opening up of the Pacific front in the Second World War, with its dramatic impact on Pacific coast military staging and manufacturing. However, many of the considerations suggested to affect private firms location decisions may also operate within the Department of Defense.

In summary, I have hypothesized that land and existing military bases are perhaps the chief locational factors explaining the long term orientation of American defense-oriented manufacturing. These factors have attracted military systems plants to Sunbelt locations and to a lesser extent, to peripheral sites within the Manufacturing Belt. In turn, a manufacturing labor force has been drawn and anchored around these sectors, and a number of supplier industries, some old and some new, have attached themselves to these centers.

The spatial outcome can be hypothesized as follows. The few, large scale manufacturing plants increasingly associated with military procurement have led to new, spatially concentrated industrial complexes. These complexes are disproportionately located outside the older manufacturing cities, because of the attraction of large parcels of undeveloped land, the proximity of existing military bases, and the presence of an ununionized workforce. They have created, in the process, new peripheral communities which house disproportionate numbers of skilled workers and are marked by relatively conservative and promilitary attitudes. These communities may be adjacent to older metropolitan centers, but have few interconnections with them, essentially forming their own labor market and cultural ties. Or, they may be in relatively nonurban or out-of-state locations, where one type of activity dominates the local economic structure.

THE HIGH-TECH NATURE OF MILITARY-ORIENTED MANUFACTURING

The phrase "high-tech," as an adjective and even a noun applied to individual industries, has been used quite loosely by academics, the popular press, and policymakers alike. It generally connotes one or more of three features: an extensive degree of technical sophistication embodied in a product, a rapid rate of employment growth associated with an innovative product, and a large research and development effort associated with production.[8] However, not all sectors producing a sophisticated product or engaged in extensive R & D are growing rapidly, and vice versa. A compromise and empirical definition, encompassing both the product sophistication and research-intensive features, classifies as "high-tech" those industries which have a higher than average proportion of their workforce in scientific and technical occupations (engineers,

engineering technicians, computer scientists, life scientists, mathematicians).

For the reasons noted above in the discussion of military product and industry structure, we would expect military equipment, weapons, and transport to be highly "high-tech" in nature. Cold war rivalries have resulted in the institutionalization of innovation in weaponry and delivery systems. The goal of military R & D is to make the product of the opposition ineffective, and the interaction of international competition of this sort, particularly between the Soviet Union and the United States, has been to create a dynamic wherein existing products are rapidly rendered obsolete. Product innovation, then, rather than process innovation, dominates industrial research and development activities in these sectors, creating what Malecki (1983, p. 91) calls technology push in place of demand pull as the growth trajectory. These sectors are thus more or less permanently locked into the initial stages of their product cycles, except that should an entire system be displaced by another (battleships by submarines and aircraft), their demise is sudden and final.

Because of this constant product innovation and because the products themselves are highly sophisticated, large numbers of scientists and technicians are employed by these military suppliers. Engineers alone accounted for relatively larger percentages of the workforce in aircraft (11 percent), communications equipment (15 percent), guided missiles (31 percent), and ordnance (5 percent) than in manufacturing as a whole (3 percent) (DeGrasse, 1983, p. 33). Three major military-oriented categories—aircraft and missiles, electrical equipment and communications, and machinery—accounted for one in three R & D scientists and engineers in a 1967 NSF study (Dumas, 1982, pp. 12–13). Defense-generated employment was skewed in 1970 toward the professional and technical categories in comparison with all U.S. employment (Dempsey and Schmude, 1971). Several studies have attempted to estimate the percentages of scientific and engineering jobs attributable to direct and indirect impacts of defense spending. One found that defense spending accounted for 48 percent of aeronautical engineers, 23 percent of physicists, 21 percent of electrical engineers, 19 percent of all mathematicians, and 16 percent of industrial engineers in 1970.[9] Another found that 59 percent of all aeronautical engineers, 38 percent of physicists, 22 percent of electrical engineers, 20 percent of technical engineers, 20 percent of mechanical engineers, and 20 percent of metallurgical engineers were employed either as civilians directly by the Defense Department or by defense-related industries (Rutzick, 1970, Table 2). Given the heavy reliance of military producers on this type of scientific personnel, it is logical to anticipate that these sectors are apt to figure prominently among high-tech industries, however defined.

THE GEOGRAPHY OF DEFENSE SPENDING

The role of defense spending in regional growth has been a central concern of regional scientists in the postwar period. Especially in the 1960s, many of the most talented regional economists and geographers turned their sights upon the relationship between military buildup or disarmament and differential rates of regional development, employing methods such as input-output and econometric analysis. Since the end of the Vietnam War, this preoccupation has largely disappeared, despite the politically potent claims by groups like the Congress's Northeast-Midwest Institute that defense spending has been underwriting the growth of the Sunbelt at the expense of the Northeast.

A number of oft cited publications have argued dramatically that the disproportionate distribution of defense spending in the Sunbelt is undermining the economic viability of the Northeast (see Mazza and Wilkinson, 1980; Anderson, 1982; Anderson, 1983). Studies of this type have several methodological problems. The Marion Anderson study calculates net employment losses given the jobs that would be created in other sectors, inappropriately using multipliers generated by an earlier longitudinal study of the relationship between defense and nondefense proportions of the budget (Russett, 1970). The Mazza/Wilkinson and Anderson studies argue that regions get back less in defense outlays than they pay in taxes; yet this presumes that certain types of taxes, on dividends and interest, for instance, represent contributions by regional residents, and that all taxes and expenditures "ought" to be proportional to population. The entire "regional fairness of federal outlays" literature is plagued by lack of explicit presumption about what appropriate regional distributions might indeed be (Markusen and Fastrup, 1977).

Because of these interpretative problems, descriptive data on the actual locational patterns of defense outlays are preferable to per capita allocations net of taxes. Studies of postwar trends in defense spending confirm that disproportionate shares of outlays go to the South and West. Especially remarkable has been the regional shift of prime contract awards away from the Northeastern and North Central states (which, in 1951, received the highest aggregate and per capita amount of such awards and the largest proportion of the national total) toward the Southern and Western states (which by 1976 received the highest amount and the highest proportion). In addition, the largest number and greatest proportion of installations continued to be located in the Southern and Western regions up through the mid-1970s (McBreen, 1977). Bolton (1966) found similar patterns in an earlier period. The northeastern quadrant of the country suffered disproportionate defense facilities closings and a large net shift of military personnel toward the Sunbelt (Mazza and Wilkinson, 1980).

Critics of conclusions drawn from such data note that they generally include only direct employment and prime contracts and do not trace the interregional flows of expenditure which arise from indirect and induced effects of military spending. Several studies have tracked the spatial array of subcontracting by prime contract recipients (Karaska, 1967; Riefler and Downing, 1968; Rees, 1981, 1982). All found that subcontracting tended to reinforce the primacy of the major prime contract regions, specifically the Pacific coast and northeast/midwest regions. Subcontracting, on the basis of these studies, does not appear to have dispersed the impact of the military budget.

Rees's (1981) recent study is particularly interesting because he tries to marshall the subcontracting evidence in a way that refutes the claims of the Northeast/Midwest Institute. He shows that the "periphery," defined as the arc of census regions from West North Central through South Atlantic, receives less through subcontracting than do the Pacific and Manufacturing Belt regions. He also documents the manner in which prime defense contracts let in the South and West are subcontracted to firms in the Northeast and Midwest. Others have shown that the reverse is true as well. Karaska (1967, p. 118) found that California was the leading nonlocal subcontractor for Philadelphia's defense-space industry. A major problem with all of the subcontracting data, as with the prime contract awards, is that in many cases they are identified spatially with the location of the recipient firms, rather than individual plants actually performing the work. This tends to bias the findings in the direction of major metropolitan areas in certain large industrial states; actual production and employment may be located in more dispersed, nonmetropolitan sites.

An analysis of contracts and subcontracting does not complete the spatial tracking of defense spending. Indirect effects of subcontractor spending are not included, nor are the induced effects of expenditures by recipients of defense-generated incomes. Two studies have relied upon input-output models to chart the total regional effects of cuts in defense spending (Leontief, Morgan, Polenske, Simpson, and Tower, 1965; Bezdek, 1975). Unfortunately, both use compensated changes in defense spending, so that the regional differences reported are partly a function of the distribution of alternative programs as well as defense cutbacks. Both found that the West and South would be relatively worse off under these alternative nonmilitary expenditure patterns, especially California and Texas, while the Manufacturing Belt would fare better. Another study used the Harris model to allocate national interindustry effects of defense spending cuts upon states and found that expected unemployment levels would vary widely, with the greatest adversity experienced by states heavily dependent upon military expenditures and lacking diversified civilian economies (Cumberland, 1973).

Most of these efforts to trace indirect and induced effects address regional and state levels, so that it is difficult to get a sense of the degree of defense dependency of individual urban economies. A few studies have been done of the interindustry effects within individual metropolitan areas. One study of the Los Angeles area in the 1960s found that a modest 7.7 percent of employment tied directly to defense—space actually accounted for 43.5 percent of all Los Angeles-Long Beach SMSA employment when indirect and induced effects were computed. The same study estimated that the defense market amounted to 8 percent of direct employment in California in 1960, but in total, was responsible for 2.6 million workers or more than 40 percent of statewide employment (Tiebout, 1966, pp. 127–31). A study of defense dependency ratios for individual SMSAs and counties found that the ratio was as high as 45 percent and most areas with high ratios were found to be relatively small in terms of work force (Riefler and Downing, 1968).

Most of these studies employ cross sectional methods of analysis, tracking spending differentials and their immediate growth consequences. Despite all of this empirical work, we know very little about the actual regional *development* consequences of defense spending, especially over time. An exception is the ambitious study undertaken by Roger Bolton in the 1960s (Bolton, 1966). Bolton found that defense purchases accounted for 34, 23, 23, and 22 percent respectively of current personal income in the Pacific, Mountain, South Atlantic, and New England states, while the other regions had shares below 20 percent and as low as 12 percent in the case of the East North Central region. Bolton also found that over the period 1952–62, defense demand could account for 27 percent of personal income growth in the Mountain region and 21 percent in the Pacific region, but that it contributed a negative 3 percent to personal income growth in the Middle Atlantic states and a large, negative 21 percent to that in the East North Central.[10]

While this finding applies only to the mid-1970s, a number of studies of individual industries and regions also underscore the importance of this relationship between defense spending and high-tech growth. See, for example, Saxenian's (1983) study of electronics in Silicon Valley, Zlatkovich's (1978) study of Wichita Falls, Levy (1972) on San Diego, Clayton (1962) and Tiebout (1966) on Los Angeles, Tansik and Billings (1971) on Arizona, Bowen (1971) on Alaska, Mulhern (1981) and Glickman (1977) on Philadelphia, Siegel (1983) on Huntsville, Kahley (1982) and the *New York Times* (1963) on the Southeast, Johnson (1978) and Osterbind (1967) on Florida, and Browne and Gavian (1981) and *New England Business* (1981) on New England. As a body, these studies suggest that defense spending has been a powerful force in the changing composition of the American economy, especially in promoting high-tech innovation, and has been a central factor in the growth of economies such

as central Utah; the Los Angeles area; Huntsville, Alabama; and Melbourne, Florida; and more recently, in the revival of New England. For a fuller account of several of these, see Markusen and Bloch (1984).

The empirical evidence is thus compatible with an interpretation which suggests that the new defense-related industries of aerospace and electronics formed an ensemble of dynamic growth sectors which sparked the growth of the South and West. However, they have major shortcomings for the purposes of testing hypotheses about the impact on human settlements. First, they have been forced to use data on a firm, rather than a plant basis, which may overstate the role of SMSAs like Los Angeles, where many of the firms are based. Second, they tend to focus on the distribution of dollar flows and facility location rather than on distribution of associated employment. Third, and perhaps most problematic, analysis has been restricted for the most part to a state and regional level, rather than inquiring into substate concentrations. Each of these problems has been addressed in our recent study of the location of high-tech industries (Glasmeier, Hall, and Markusen, 1983a, 1983b, 1983c).

REGIONAL DEVELOPMENT IMPLICATIONS

These hypothesized locational priorities of defense-related firms suggest a number of corollary hypotheses about the role of military spending in regional restructuring and development. First, military spending may have created a number of relatively new, empirically identifiable "defense-industrial" complexes around the United States. Second, these complexes have sprouted up on virgin territory, either surrounding an older metropolitan area like Boston or Los Angeles, or in areas with relatively little previous manufacturing activity. They may have been strong contributors to the postwar suburbanization of manufacturing and to the more recent phenomenon of nonmetropolitan industrial growth.

Third, these industrial complexes may have played a lead role in the shift of manufacturing activity in general toward the Sunbelt, or more accurately, toward a defense perimeter that includes Seattle and New England, but skirts the traditional Great Lakes/Ohio Valley Manufacturing Belt. Fourth, this skewed pattern of military-related production may help to explain the remarkable relocation of the postwar U.S. population, with New York losing four percent of its population in the 1970s while several intermountain western states grew in excess of 50 percent. New England, which lost its shoe and textile manufacturing sectors in the 1950s, has already restructured, pushing wages down below national averages and improving its business climate (Harrison, 1984). The manufacturing heartland, spanning the Great Lakes and Ohio River Valley, and the Middle Atlantic States, has lost out because of its relatively youthful industrial structure, geared to serving mass consumer markets,[11] its highly

oligopolized business structure, and its heavily unionized, often militant, workforce (Markusen, 1985; Federal Reserve Bank of Chicago, 1967).

The regional economies which host these new defense-industrial complexes may display unique development features, suggesting another set of hypotheses. First, they may have higher proportions of nonindigenous labor, with labor continually being recruited from other regions. Second, they may demonstrate high rates of defense-dependency, relying heavily upon these sectors as their economic base. As a result, they may experience employment growth and immigration rates closely associated with swings in defense spending. Third, and a corollary to the last feature, they may exhibit diversification rates below those expected of industrial areas of similar size; that is, some of the features which make these regional sites attractive to military-related sectors discourage other types of industrial activity. Fourth, they may create social structures much more homogeneous than the average large industrial region—occupationally, racially, and ethnically.

THE GEOGRAPHY OF DEFENSE-BASED HIGH-TECH INDUSTRIES: SOME EVIDENCE

Determining how important military spending is (and has been) in the growth and location of high-tech industries is not a simple task. First, some definition of high-tech industries which can be operationalized must be chosen. Second, an estimate of the importance of military spending as a source of demand for each high-tech sector must be found. Third, evidence on the growth rates and geographical incidence of these defense-dependent sectors must be assembled. In this section, I present empirical evidence drawn from our larger study on the location of high-tech industries and from Bureau of Industrial Economics work on military market shares of industrial output. These results are favorable to the hypotheses presented above, but almost certainly understate the role of military spending, for several reasons.

A number of researchers have recently argued that regional patterns of employment and plant location are best studied at the level of highly disaggregated industrial sectors (Markusen, 1984; Bluestone and Harrison, 1982; Massey and Meagan, 1982). We have chosen to work at a 4-digit level in our study of high-tech industries because we believed at the outset that sectors grouped together in higher orders (e.g., 3-digit Standard Industrial Classification [SIC] sectors) are highly diverse in product, growth performance, and geographical location. We defined high-tech industries as those with disproportionately large shares of scientific and technical occupations (Glasmeier, Markusen, and Hall, 1983a). This exercise produced a set of 100 4-digit manufacturing SIC sectors.[12]

The importance of defense spending as a contemporary source of

demand for these sectors can be gauged from recent Bureau of Industrial Economics (BIE) research results. Using updated and adjusted coefficients from the 1972 national Input-Output model, the BIE estimated the direct and indirect (but not induced) shares of industrial output accounted for by Department of Defense outlays. They concluded that "major effects are confined to a relatively small group of industries"—some 58 (mainly 4-digit) sectors (Henry, 1983). With the exception of several mining, construction, and transportation sectors, these were concentrated within manufacturing.[13] A comparison with our high-tech manufacturing sectors indicates that 36 of our 100 sectors are among those with major defense spending impacts. A list of these high-tech sectors is shown in table 5.1, along with their recent employment levels, defense market shares, and expected defense-related output growth rates.

With the two data sets, it is fairly easy to demonstrate two propositions: that heavily defense-dependent manufacturing sectors are dominated by those in the high-tech category, and that a substantial portion of high-tech industries are important military suppliers. First, while defense-impacted sectors are not exclusively high-tech, the top twenty of BIE's defense-dependent manufacturing sectors (defined by defense share of output) include only two sectors not classified as high-tech in our study—shipbuilding and repair and miscellaneous nonferrous foundries.

Second, while the 36 sectors in table 5.1 encompassed less than half of our set of high-tech manufacturing sectors, they accounted for 47 percent of all high-tech manufacturing employment in 1977, or approximately 2.25 million jobs. By 1984, they will undoubtedly account for an even higher percentage, given the recent military buildup. The extraordinary impact of the Reagan buildup is shown by the defense output growth rates predicted for each by the BIE, shown in the final column of table 5.1. The majority will see their defense output grew by more than 50 percent in the five year period. As a result, the defense share of output will rise significantly for many of these high-tech sectors. The biggest share shifts will occur in ammunition, missiles, aircraft, explosives, engineering instruments, electronic tubes, computers, and radio and TV equipment. By 1987, these high-tech sectors will be significantly more defense-dependent than they were in either 1979 or 1982.[14]

The military market shares calculated with the BIE method are almost certainly significantly understated for several reasons. They use only the Department of Defense outlays in estimating military demand. However, other agencies within the federal government also spend significant amounts on military-related activities. The Department of Energy, by its own accounting procedures, devotes over half of its budget to the research, development, testing, and production of nuclear warheads, nuclear materials, and nuclear waste disposal (Hartung, 1984). Spending by the National Aeronautics and Space Administration is estimated by the

TABLE 5.1

DEFENSE-RELATED HIGH-TECH INDUSTRIES

SIC#	Industry Name	Employment 1977	Defense Output Share 1982 (percent)	Defense Output Share 1987 (percent)	Defense Output Growth 1982-1987 (percent)
2812	Alkalies and Chlorine	11,831	5.6	7.1	53.3
2813	Industrial Gases	7,332			
2816	Inorganic Pigments	12,003			
2819	Inorganic Chem. Misc.	78,192			
2865	Cyclic Crudes, Dyes	35,499			
2866	Organic Chem Misc.	11,242			
2892	Explosives	11,546	34.3	41.2	58.7
3482	Small Arms Ammunition	12,199	25.0	39.9	129.5
3483	Ammunition, Ex Small Arms	20,589	90.0	93.2	55.6
3484	Small Arms	17,495	13.8	6.5	-43.3
3489	Ordnance	19,042	79.7	81.2	35.3
3541	Machine Tools, Cutting	59,432	6.2	7.5	54.4
3542	Machine Tools, Forming	23,154	4.8	6.3	70.0
3544	Special Dyes, Jogs, Molds	106,175	6.0	7.5	45.4
3545	Machine Tool Accessories	54,177			
3562	Ball, Roller Bearings	50,286	5.8	6.8	45.4
3573	Electronic Computing Equip.	192,510	7.1	12.7	141.0
3624	Carbon, Graphite Products	12,086	7.7	9.3	51.4
3622	Radio, TV Communications	333,006	58.0	62.5	54.2
3671	Cathode Ray Tubes	36,808	7.3	11.5	105.3
3674	Semiconductors	114,011	12.5	12.5	51.4
3675	Electronic Capacitors	28,647	17.0	19.8	49.3
3676	Resistors, Electronic	24,918			
3677	Resistors, Electric	22,424			
3678	Connectors	26,020			
3679	Electronic Components	125,998			
3721	Aircraft	222,805	40.4	46.1	58.7
3724	Aircraft Engines	106,322	53.5	56.1	32.9
3764	Missile, Space Engines	17,011			
3728	Aircraft Parts	101,900	41.2	44.2	34.9
3769	Missile, Spacecraft Parts	10,189			
3761	Missiles, Space Vehicles	93,933	67.5	79.4	64.4
3795	Tanks, Tank Parts	12,122	93.8	95.0	47.2
3811	Engineering Instruments	42,178	27.7	33.6	59.9
3825	Instruments Measuring Elec.	66,622	8.4	9.8	49.7
3832	Optical Instruments	29,883	28.0	30.7	38.0

SOURCES: Census of Manufactures, 1977, as tabulated in Glasmeier, Hall, and Markusen, (1983b, Table 1, p. 5) and Henry (1983, Table 3, p. XLVII). The BIE estimates reported by Henry are sometimes aggregated into 3-digit SICs, thus the shared percentages in the latter three columns.

General Accounting Office and antinuclear groups to consist of significant shares of strictly military-related activities, in excess of 25 percent (Shutt, 1984). Also excluded are expenditures for paramilitary forces such as the U.S. National Guard, which is supported by individual states with some help from the federal government, and the Coast Guard, funded by the Treasury in peacetime (Kennedy, 1983, pp. 50–51). Smaller omissions are the direct and indirect effects of spending by the Selective Service, by the Federal Emergency Management Agency for civil defense activities, and by the General Services Administration for the stockpiling of strategic materials (Shutt, 1984).

But perhaps the greater source of downward bias in defense market shares comes from the absence of military exports to foreign governments in the calculations. These are of considerable magnitude and have increased dramatically in the past decade. Weaponry produced in the U.S. accounts for about 45 percent of total world arms transfers, compared with 20 percent in 1970 (Boston Study Group, 1982, p. 258). In 1975, the federal government procured for itself only $17 billion worth of military equipment, compared with $12 billion it bought from the U.S. defense industry for foreign governments. Currently, 840,000 U.S. jobs are generated by foreign military sales, and eight of the top 25 contractors have over 25 percent of their total defense business in foreign sales (Gansler, 1980, pp. 208–209). The aerospace industry on its own has been responsible for the largest U.S. trade surpluses of manufactured goods of any single industry in the postwar period (Boretsky, 1975, p. 81). These sales are escalating under the Reagan policy of permitting first generation technology to be marketed abroad and of encouraging high-tech firms to innovate for the specific military situations of third world countries. From $10 billion in 1974, foreign arms sales rose to $21 billion by 1982 and to an expected $31 billion in 1983 (Klare, 1983, p. 90).

How highly concentrated spatially are these military-dependent high-tech industries? Is there evidence that large scale plants and continual innovation result in highly concentrated employment in these sectors? Our data on county level employment patterns at the 4-digit level permitted us to answer these questions by constructing entropy measures for each industry.[15] Table 5.2 shows the relative ranking on the entropy index in 1977 for all high-tech manufacturing sectors in which military demand accounted for more than 25 percent of output. It also gives the total number of counties ($N_1$3,140) in which production occurred at all in 1977. The rankings of the heavily military-dependent sectors show that they are among the most concentrated among all high-tech sectors ($N_1$100). Most highly concentrated are tanks, missiles and spacecraft, missile engines, missile equipment, and small arms ammunition—these five sectors account for half of all industries in the first decile. Seven of the fourteen sectors fall within the first quartile and ten within the first one-third. The

only three sectors that are more highly dispersed than the median are radio and TV communications, optical instruments, and engineering instruments. These figures do suggest that the spatial incidence of military-related high-tech industries is more concentrated than that of other high-tech industries.

Are concentrations of military-related high-tech industries associated with diversification, or do they tend to produce highly dependent local economies? Preliminary evidence on this issue can be drawn from a cursory look at the most heavily high-tech dependent SMSAs in our study (table 5.3). High-tech dependency ratios are computed as the total high-tech employment in all 100 SICs as a percent of the area labor force. These ten SMSAs (out of a total of 266) are almost wholly located on the periphery of the Manufacturing Belt or deep in the Sunbelt. The first four are heavily dependent upon military demand (ordnance, missiles, aircraft, electronics/communications, respectively). Recent research by Glasmeier (1984) suggests that a substantial number of small and medium sized SMSAs are dominated by just one 4-digit SIC, often military-related.

TABLE 5.2

MILITARY-ORIENTED HIGH-TECH: ENTROPY RANK AND COUNTY INCIDENCE, 1977

Sector	Defense Share 1982 (percent)	Entropy Rank	County Incidence 1977
Tanks and Tank Parts	94	2	19
Ammunition, Large Arms	89	26	68
Ordnance	80	14	66
Missiles and Spacecraft	68	6	21
Radio and TV Communications	58	84	456
Aircraft Engines	54	27	117
Missile Engines	54	7	19
Aircraft Parts	41	36	210
Missile Parts	41	1	31
Aircraft	40	17	101
Explosive	34	30	78
Optical Instruments	28	56	198
Engineering Instruments	28	76	259
Ammunition, Small Arms	25	5	52

Thus, some extraordinary cases do exist in which dependency of the local labor market on military-oriented high-tech sectors has not to date brought with it industrial or even service diversification. Furthermore, not all of these are relatively small metropolitan areas. The fact that the San Jose SMSA ranks fourth out of 266 metropolitan areas suggests that even large agglomerations of high-tech may not lead to diversification.

Are the centers of recent job growth in high-tech industries primarily metropolitan areas in the older Manufacturing Belt, newer central city SMSAs in the Sunbelt, adjacent SMSAs on the periphery of older agglomerations, or smaller metropolitan areas? Table 5.3 shows the top ten metropolitan areas in terms of overall high-tech job growth in the mid-1970s.[16] Of the top ten, only Boston is an older central city SMSA in the Manufacturing Belt. Three others are newer peripheral areas adjacent to older central city SMSAs—San Jose, Anaheim, and Worcester—though only the latter is in the Frostbelt. Youthful Sunbelt central city SMSAs like Houston, San Diego, Dallas, and Phoenix posted large high-tech job

TABLE 5.3

TOP TEN METROPOLITAN AREAS: JOB GROWTH AND HIGH-TECH RATIOS, 1972-1977

SMSA	High-Tech Ratio,* 1977 (percent)	SMSA	High-Tech Job Growth 1972-1977
Rockford, IL	19.6	San Jose, CA	31,909
Melbourne-Titusville, FL	18.0	Anaheim, CA	30,612
Wichita, KS	17.7	Houston, TX	18,932
San Jose, CA	17.4	San Diego, CA	16,782
Binghamton, NY	15.2	Boston, MA	15,173
Lake Charles, LA	14.7	Dallas, TX	12,067
Cedar Rapids, IA	14.6	Worcester, MA	9,893
Bloomington, IN	12.9	Oklahoma City, OK	8,363
Johnson City, TN-WV	12.8	Lakeland, FL	8,132
Longview, TX	12.7	Phoenix, AZ	7,796
Median	4.4	Median Gain	248

*The proportion of the areawide labor force accounted for by high tech industry jobs.

SOURCE: Glasmeier, Hall, and Markusen (1983c) Tables 3, 6.

gains in this period. Two smaller, detached Sunbelt SMSAs—Lakeland, Florida and Oklahoma City—make a rather surprising showing in these ranks of absolute job gainers. In terms of *relative* high-tech growth (metropolitan percent gains in jobs), the ten top ranking SMSAs were located outside the traditional Manufacturing Belt and were relatively small—less than 3,000 high-tech jobs at the outset (Glasmeier, Hall, and Markusen, 1983c, table 5).

This last table encompasses all high-tech jobs, including those in sectors not particularly military-dependent. Thus, it is not possible to determine exactly to what extent military spending is responsible for the extraordinary growth posted by these places, although sectors with significant military demand account for almost half of all high-tech jobs. However, collaborating evidence on the importance of defense spending to the growth of high-tech jobs can be had directly from the results of regression analysis performed on our data base. Using some 19 characteristics of SMSAs, capturing sets of labor market, business climate, amenities, cultural, and transportation/communication features, we found that defense spending (on a per capita basis) was consistently a significant determinant of high-tech geography. Defense spending per capita was the single most important variable explaining high-tech dependence—it accounted for one-third of total variation across the set of 266 metropolitan areas.[17] Defense spending was also important and significant in explaining variation in high-tech job growth rates across metropolitan areas from 1972 to 1977. Since this was a period of retrenchment in defense spending (although the distribution of prevailing levels of defense spending may still have been shifting toward the Sunbelt), this finding may reflect the longer lags in underlying defense spending patterns throughout the postwar period.

DIRECTIONS FOR FURTHER RESEARCH

The evidence just cited offers modest support for the hypotheses about military-related high-tech locational priorities and their impacts on regional development. The disaggregation to the 4-digit industrial level and to the county and SMSA spatial levels permits a more detailed look at the actual array of high-tech employment than is popularly envisioned in the Silicon Valley stereotype. Yet this rich data base, available at this point only for the years 1971 and 1977, is inadequate for probing the hypothesis that military procurement has engendered high-tech complexes that have formed the basis of new types of human settlements. More work needs to be done on the spatial interrelationships among sectors to test whether military-related high-tech is clustered and in what types of locations. Even more importantly, a longitudinal study should be done that dates back to the 1930s, to determine the sequential associations among mili-

tary bases, personnel, military-oriented manufacturing facilities and industrial spin-offs, as a test of both the locational hypotheses offered here and the population and income generating impacts of these complexes over time.

NOTES

1. For instance, in the Rees and Stafford review of the contribution of regional growth and industrial location theory towards understanding the development of high-technology complexes (chapter 2), there is no mention of defense spending. Several authors have recently addressed the close relationship between defense spending and high-technology industries; see Stein (1983) and Malecki (1983).

2. Wise (1949) describes the agglomeration of gun making in Birmingham, England, in the eighteenth century. As these weapons were sold both nationally and internationally, gun manufacture became a type of export base activity contributing to the growth of that city.

3. For brief locational histories of the apparel and shoemaking industries and their role in urbanization and regional shifts in the U.S., see Markusen (1985, Chapter 10).

4. Kaldor, *The Baroque Arsenal* (1981, pp. 31–33) cites the case of a shipbuilder who ran for Parliament with the express interest of dispersing admiralty contracts from the royal dockyards to commercial firms. Kaldor also documents the governmental rationale for this shift: the stimulation of competition among inventors and manufacturers, and the creation of a reservoir of suppliers for rapid response in wartime.

5. This data on the aircraft industry is drawn from Cunningham (1951, pp. 58–65).

6. See the section of this chapter entitled "The Geography of Defense Spending" for contemporary evidence on the defense share of each of these sectors.

7. See, for example, Perloff, Dunn, Lampard, and Muth (1960) on the steel industry, see the debate addressed in Karlson (1983) and Markusen (1985, Chapter 8).

8. Glasmeier, Hall, and Markusen (1983a) discuss these connotations and the difficulties of operationalizing each of them.

9. Dempsey and Schmude (1971, p. 14). The narrow definition of defense spending used in these studies means that these are probably underestimates; this issue is addressed in the section of this chapter entitled "The Geography of Defense Spending."

10. Bolton's work required painstaking efforts to construct regional income and defense spending data.

11. A large portion of wartime production of material has been located in the Midwest. But after World War II, for instance, auto and farm machinery makers rapidly dismantled tank plants or converted them back to conventional products.

12. We confined ourselves to manufacturing sectors because highly disaggregated spatial data, at the county level, was available only from the Census of Manufactures and not for other industry censuses. A total of 29 three-digit SICs were designated "high-tech" using recent Occupation Employment Survey data. Since sufficiently disaggregated occupational data was available only at this three-

digit level, we had to classify all 100 four-digit SICs within them as "high-tech." Yet we chose to present the results for all of them rather than reverting to using three-digit SICs, since the use of the latter would not eliminate this problem.

13. This emphasis on manufacturing bears out the interindustry results of an earlier study in which 66 percent of all private employment attributable to Department of Defense spending (direct and indirect jobs but not induced jobs) fell into the manufacturing sectors (Oliver, 1971, Table 4).

14. In the case of industries like electronics and computers, this reverses a postwar trend in which commercial applications have grown faster than military ones (Saxenian, 1980).

15. Data on county-by-county plant locations for four-digit manufacturing sectors was available to us for recent Census of Manufactures years. Since it is arrayed by employment interval, we were able to estimate county level employment by using national means for each interval for each four-digit SIC (see Glasmeier, Hall, and Markusen, 1983b). The computation of the entropy index is described in Glasmeier, Markusen, and Hall (1983c).

16. Because this period was actually one of declining real defense spending, these places may owe their growth to the lagged effect of defense spending spurts in the past rather than to increases in direct military-related employment during this period.

17. Percent Latino and percent Black were the two variables ranking second and third in importance, suggesting that these military-oriented high-tech enclaves have high proportions of whites in their local populations (Glasmeier, Hall, and Markusen, 1983c, pp. 41–42).

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