Technology

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BYPASSING AMERICA'S OUTLANDS:

RURAL AMERICA AND HIGH TECHNOLOGY

By

Amy Glasmeier

Graduate Program in Community and Regional Planning

The University of Texas at Austin

June 1988

Final Report to the Rural Economic Policy Program, Aspen Institute, the Ford Foundation

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Abstract

Rural areas gained high tech jobs and plants over most of the period studied. This growth is, however, intimately tied to the historic economic base of rural communities, including primarily mature production manufacturing. Mature high tech industries, like their traditional counterparts, are relatively slow-growing and subject to future changes in a world-wide market system. Rural gains in high tech industry are also related to overall trends of industrial decentralization. These larger trends have recently abated and thus the future of high tech growth in rural areas is in question.

Rural communities making the most significant gains in high tech jobs are those adjacent to metropolitan areas. Those with the largest absolute numbers of high tech jobs are located near metropolitan areas in the Northeast and Midwest. In contrast, those experiencing the largest job gains over the study period are near cities in the South and West--another sign that rural high tech is tied to larger shifts of population and jobs among America's regions.

States are active in recruitment and retention of high tech jobs and yet emphasis is rarely given to the unique problems of rural economies. Unless policy can be redirected toward enhancing existing industry competitiveness, it is doubtful rural communities will share in economic benefits of future high tech growth.

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PART I

Section I
INTRODUCTION

Rural High Tech: Problems and Prospects

The great majority of research on high tech industries in the United States has focused on metropolitan areas and, specifically, on a few wildly successful places--Silicon Valley in California and Route 128 in Massachusetts, for example (Saxenian 1985). Yet, with few exceptions, there has been almost no research on high tech industries in rural areas (See Barkley, 1987, for a recent exception). Inadequate research on rural high tech development is not simply due to an insignificant number of high tech jobs in rural areas. Rather, the lack can be partially attributed to the early relative prosperity of rural areas compared with cities in the 1970s, and to the fact that high tech is largely a metropolitan phenomenon.

Over the last fifteen years, public debate and policy efforts have been directed toward understanding the reasons for and stemming the tide of job loss in cities and states in the Manufacturing Belt. Major efforts have also been directed toward identifying key ingredients of Sunbelt growth and reasons for the apparent loss of innovative capacity in traditional centers of manufacturing (Perry and Watkins 1977; Bluestone and Harrison 1982. At some point, debate shifted to the national level, and concerns about the nation's lost industrial competitiveness. Problems of rural areas simply fell away from policy discussions. Rural areas were considered relatively well-off or at least stable and, therefore, less in need of specifically targeted place- or sector-based policies (Lonsdale and Seyler 1979).

But times have changed drastically since the 1970s. At that time, rural areas were thought to have reversed their long-term trend of population and economic decline. Recent research by Garnick (1985) suggests, however, that the economic balloon of the 1970s that briefly lifted rural America out of its previous state of decline has indeed burst. The Rural Coalition, a Washington rural advocacy group, reports that, today, 91 percent of the nation's counties showing unemployment levels double the national average are rural (Businessweek, June 21, 1986).

Garnick also shows that income growth in rural areas has once again begun to lag behind growth in urban areas. Even more troubling for the near future, many core non-metropolitan manufacturing industries of rural America--such as textiles, food processing, agriculture and mining--are in advanced states of restructuring, and they are not likely to add significant numbers of new jobs in the future. Thus, there is a critical need to explore alternative sources of economic development for rural areas, including high technology industries.

In the past, rural America's economic fortunes were intimately tied to the exploitation of raw resources, especially agriculture and mining, and the decentralization of manufacturing production to rural areas from cities. According to some experts, both resource development and mature manufacturing are now much less significant sources for future growth in rural areas (Bloomquist 1987).

Problems facing rural areas are not unlike those faced by older industrial cities. There, long-established sources of employment are drying up and, in some cases have simply disappeared. The response to the consequent large-scale job loss has included efforts to develop new industry--particularly those considered "high tech" (Markusen 1988). Such programs emphasize industrial recruitment, research into new technologies, small business financing and development of research consortia (Plosila 1987). To date, there have been limited efforts to evaluate the success of such programs. Despite the gap in assessment of these efforts, funding high tech industry continues to constitute a major aspect of local and state development policy.

Given the emphasis placed on high tech industry, it is important to ask whether high tech development is indeed an option available for rural counties in the United States. Do high tech industries operate like traditional manufacturing which decentralized into rural communities over the last twenty years? Are there other special characteristics of high tech industries that do locate in rural areas making them amenable to further growth? Or, are high tech industries in rural areas simply more modern versions of mature manufacturing industries with all their inherent limitations? This study attempts to answer these questions by examining the spatial location, industrial composition, growth experience and environmental factors associated with high tech industries in rural counties of the U.S.

To set the tone for the following report, we now provide a brief review of high tech success stories in rural counties which provide both a measure of hope for the development of certain types of rural high tech industry and indicate the limitations to such development in rural areas.

High Tech Success Stories

And what of the rural communities outside of metropolitan areas which have successfully attracted high tech industries? Answers to this question are hinted at in our study's results--i.e., the rural communities best able to compete for high tech industries are those adjacent to metropolitan areas which have a well-educated labor force, universities, and a lack of unions. A more precise answer to this question requires that we look beyond impersonal numbers to instances where high tech jobs and plants have successfully developed in rural communities. Thus, this section presents highlights from case study interviews with high tech firms located in rural communities outside of, but adjacent to, metropolitan areas.

State of the Art, Inc.

State College Pennsylvania, home of the Nitany Lions and Pennsylvania State University, is the economic focal point of Centre County, a rural county in Pennsylvania. While the county experienced rapid growth over the 1970-80 period, it is still quite rural and provides the first case study which we review.

Because State College is a university town, there are a number of qualities which make the community particularly appropriate for high tech development. The level of social and cultural amenities is high, the population well-educated, and the University has a number of programs which lend themselves to discovering technologies that are adaptable to commercial use. The University has helped create the context for new firm creation and, with limited success, a few high tech firms. Completely separate from the University's influence, however, is one firm which is, by any measure, an unqualified high tech success story. The following discussion briefly recounts the history of State of the Art, Inc., a medium-sized high tech company which produces capacitors for the electronics industry.

State of the Art, Inc. was established by Don Hamer, a former employee of Erie-Murata, a large capacitor producer in Erie, Pennsylvania. In 1980, he decided to leave the company and, for personal reasons, moved to State College. For five years, he was a salesman and technical consultant for companies he'd worked with at Murata. At the end of five years, he identified a market niche unfilled by the big capacitor producers, in variable size-batch production capacitors, and he set up production in State College.

State of the Art, Inc. (SAI) started out quite modestly with less than twenty employees. Don understood the market for capacitors and chose to compete in both the commodity-end, as well as the higher-value-added end, of military products. Over the course of four years, the company flourished and grew into the second largest capacitor producer (on a volume basis) in the U.S. When interviewed in 1986, SAI had 100 employees, employed sophisticated production equipment, and used largely local high school graduates and individuals with less than a full college degree as production staff. The manager of design, for example, was a former social science student at Penn State who for various reasons chose not to finish his degree and instead pursued a career in design engineering for SAI.

SAI has grown steadily and solidly since the company was formed. Even during a period of downturn in the industry, SAI avoided layoffs because production had been carefully built-up in such a way that, as the company grew, it wisely invested in new technology. Throughout the development of the company, decisions were made to automate and upgrade workers' skills rather than maintain a labor-intensive production posture, the least costly direction to pursue in the short-run.

To the extent that geography matters, the success of the company really came down to being near a community where education was highly-valued such that local elementary and high schools provided a solid education. Thus, even non-college- bound students were prepared for success in industry.

The locational isolation was not a problem for SAI because the product's markets were national and international in dimension, individual units of the product were small, varied, and lightweight, and they could easily be shipped by overnight delivery to customers. Customer satisfaction and a competitive edge revolved around providing quantities, ranging from 100 to 100,000, of the final product. Thus, the company's success rested, not with a extraordinarily technological product per se, (though certainly the product produced for use in satellites was well-made and of the highest quality) but on the ability to supply a wide variety of customer demands which large firms would have overlooked.

An important factor in SAI's success, given its isolated location, is the role of distributors and manufacturers' representatives. SAI has no internal sales force and uses instead sales representatives and distributors to market the product. These individuals and organizations vastly extend the reach of SAI, making a rural location possible and also profitable.

By being flexible on the marketside, SAI was able to gain new customers on an ongoing basis. But perhaps the overriding factor in the company's success is the enlightened owner who continued to innovate, recognized that the cheapest way, labor-intensivity, is not always the best way, and chose instead to continually upgrade his work force and production equipment as the company pursued increased market share.

Gore and Associates

Goretex, the preferred material for all sorts of outdoor gear, is a material created by a scientist and former employee of the Dupont Chemical Company in Maryland. Mr. Gore developed the product in his basement and then opened his own business in the late 1950s. The chemical qualities of Goretex go far beyond simply outdoor equipment. The material is used in a wide variety of products ranging from medical products to materials used in space flights.

Gore and Associates rapidly grew from a small basement-based company to a multi-million dollar corporation. By 1985, the company began considering selection of a production location to serve the Western U.S., and looked particularly at Texas, a large market for the company's products.

In 1986, Gore and Associates selected a site for production outside Austin, Texas, in the rural county of Bastrop. There, the company employs around 100 people with a modest variety of skills, and the plant makes cable harnesses for the electronics industry.

The selection of the Bastrop site provides additional insights about competitive qualities of rural communities adjacent to metropolitan areas. The site was picked because of its bucolic qualities, availability of qualified labor (including engineers expected to come from the nearby university), cheap land, and access to a metropolitan area. After lengthy discussions, the company decided to locate in Texas. In part, the Bastrop site was picked because, at the time, Austin was one of several hot-spots for high tech development in Texas.

Again, as with SAI, the product, its production process and its market, mattered heavily in the firm's success in locating in a rural county. Gore and Associates major western market was Dallas. The product was relatively light and somewhat customized to the final user's needs. Inputs were received through intra-corporate purchases and hence local inputs were not necessary. Perhaps most importantly, the product design was stable--so a large cluster of engineers was unnecessary for the operation to run successfully. Thus, markets could be easily served from Bastrop, inputs did not have to be found locally, and labor of a variety of skills and qualities was readily available. Also, like SAI, aside from corporate accounts serviced directly from headquarters, Gore and Associates use the services of manufacturing representatives and distributors to sell their products.

Rural skills, for the most part, matched the firm's requirements; more important than skills, however, the workers had a positive work ethic and responded well to the Gore corporation's incentive system. Proximity to Austin provided access to a labor pool qualified for general engineering tasks, while management was brought in from corporate headquarters.

Summary

SAI and Goretex exhibit a number or similarities which made them ideal candidates for high tech development in rural areas. First, both products are not constrained by particular locational factors, so both companies enjoyed greater freedom in site selection. In other words, no single factor, such as markets or inputs, forced either company to select a particular location. Second, in both cases, the product was specialized and possessed long-distance markets. Third, the two companies each had unique corporate cultures where investments in people were an important aspect of the business. Fourth, and clearly important, the firms operated in rural areas successfully because of the network of distributors and manufacturing representatives through which they sold their products. Distributors and representatives absorb much of the risk associated with sales, reduce personnel costs to small firms, and provide enormous amounts of market information, all of which help make the firms more successful. Finally, neither firm chose a low-cost, third-world alternative but chose instead to locate in the U.S. and to invest in America's rural workers.

Product type, markets, management, and distribution networks are all important determinants of rural high tech success. Neither rural community selected was, however, far removed from a larger metropolitan area. Thus, while these case studies provide some hope for the success of high tech industry in rural locations, they also point up some obvious limitations for widespread high tech development in rural areas.

Unique Characteristics of High Tech

As these case studies illustrate, a realistic assessment of high tech development in rural areas requires recognizing that these industries differ on a number of important counts from manufacturing industries traditionally attracted to rural communities. First, and perhaps foremost, these industries employ high levels of scientific and technical personnel (Glasmeier 1986b). This has been a critical explanatory variable in high tech's predominantly metropolitan locational tendency.

Second, while American firms enjoyed an early monopoly in many high tech industries, they are highly international now and thus competition for market shares is serious. Firms have instituted and continue to adopt a variety of production strategies to remain competitive.

Linked to these strategies, during the early development of key industries, firms shifted the most labor-intensive aspects of production to low-cost, third-world locations where quantity but, more importantly, quality low-cost labor could be found. In part, this shift was determined by high tech production processes that for the most part defied automation until only recently and, thus, remained labor-intensive (Gordon and Kimball 1987). Rapid product changes also discourage investments in labor-saving capital equipment. Companies choose instead to invest in new-product development while relying on low-wage labor for assembly. This has meant that many jobs traditionally equated with a process of "industrial filtering" (Erickson 1978)[1] have consequently never been done in the United States.

Another distinguishing characteristic of high tech industries is their long-standing links with the U.S. Defense Department (DOD). DOD was a critical market early in the life of many high tech industries, such as semiconductors and communications equipment. Even today, these high tech industries still sell large portions of their total output to the military. Military requirements differ from those of commercial markets and impact on the locational behavior of many of these industries. Some authors contend this has slowed industrial filtering and reduced the number of jobs which might have reached rural areas (Markusen 1985).

For rural America, perhaps the most important characteristic regulating industrial location of these industries is the availability of skilled labor--always a limiting factor in the case of rural economic development. Any analysis of high tech development in rural communities, then, must focus on how labor requirements regulate locational behavior.

Limits to High Tech: The Low-Wage, High-Skill Contradiction

This dependence on several unique types of labor also means that firms producing high tech products face both choices and constraints in selecting production locations. The focus on low-wage labor as a locational factor therefore needs qualification.

On the surface, high tech industry's low-wage production employment would seem a perfect job source for rural communities. But this ignores another facet of the spatial division of labor, and its relationship to high tech: the quality of the labor force. While high tech companies might prefer to use low-skilled and thus low-wage labor, the production process is necessarily complex even for the most labor-intensive operations (Glasmeier 1987a). As a consequence, high tech firms are constrained to use well-educated, but low-paid labor to perform relatively routine tasks. Companies have historically shifted production to the Newly Industrializing Countries (NICs) not only for cheaper labor but, more importantly, because this labor was well-trained compared with America's low-wage workers. For example, a worker in Singapore, Taiwan, or South Korea can perform calculus upon graduation from high school, a capability far more advanced than those of American students with similar levels of education.[2]

The continually changing occupational structure within high tech industries and the falling proportions of low-wage and low-skilled labor used in high tech production also limit development in rural communities. Just 10 years ago, 40 percent of the semiconductor industry's occupations were skilled labor. Today over 60 percent of the industry's occupational profile consists of skilled labor (Monthly Labor Review, April 1988). Thus, the absolute number of unskilled jobs within this industry is rapidly declining. This suggests that potential employment in less-skilled occupations is also rapidly declining and, hence, the number of jobs which might decentralize to rural areas is further limited.

If technical industries increasingly upgrade their skill requirements, what then are rural communities long-term prospects for receiving high tech jobs? In the absence of jobs in the more technical industries, are there other high tech industries which may provide employment in rural areas? Are particular characteristics of rural areas more attractive than others for the development of high tech industries? How is current policy likely to affect the location of high tech and, more importantly, prospects for rural communities to benefit from high tech growth? With these questions in mind, the following section describes our research and outlines the structure of the resulting report.

Research Methodology and Results

Design of This Study

Using a highly detailed data base of manufacturing plants and estimates of employment, we examine the location of high tech employment in 1972, and again in 1982, to capture changes over a period of particularly rapid high tech growth (See Appendix A for description of data sources used in this study). Careful attention is paid to those places where high tech growth in rural areas appeared to be strongest. To assess the appropriateness of targeted high tech development policies in rural areas, we look in detail at the types of high tech industries commonly found in rural areas and determine which industries experienced significant job growth over the ten-year period.

Emphasis is placed on strategic sets of industries, including those in the computer-electronics-computer complex and in defense-dependent sectors. We then assess the extent that high tech growth has followed national shifts in population and manufacturing employment over the ten-year period. That is, given that the population was shifting southward and westward, along with manufacturing, were high tech jobs also exhibiting similar spatial patterns of change? And, were high tech job growth rates in line with, or in excess of, these overall population changes? Such findings could indicate possibilities for high tech-led development in rural areas.

A unique facet of this study is our attempt to assess just where high tech industries are located and why. Given that the overwhelming majority of all high tech jobs in rural areas are in counties immediately adjacent to metropolitan areas, we develop a number of tests which identify metropolitan characteristics important in explaining both the absolute number, and absolute change in number, of high tech jobs in rural-adjacent counties.

Complementing the empirical analysis of high tech growth prospects for rural areas, we also assess the extent that existing high tech economic development policies apply to the peculiar case of rural development. A survey of state high tech programs provides important insights into existing policies to encourage the growth of these industries.

Structure of the Report

The report begins by reviewing the basics. Section II of Part I discusses the problems of defining "high tech" industries. After commenting on definitional problems, we present a commonly used working definition. From there, we review the growth experiences of high tech industries and highlight the variable growth of many such industries over the ten-year period.

Subsequent sections of Part II blend industry analysis with place analysis, to examine high tech industries across the urban-rural continuum of counties in the U.S. This analysis sets the stage for studying the spatial location of high tech industries within rural counties of the four large census regions--the Northeast, Midwest, South and West. Comparisons are made between high tech growth and other regional aggregates, such as population size and manufacturing employment.

The sixth, seventh and eighth sections of Part II further descend the geographic hierarchy and study the role of high tech industries in rural counties of individual states. At this level, spatial concentration patterns of high tech employment in rural areas become readily apparent. We then shift the focus to analyze high tech job growth in those rural counties located near or adjacent to metropolitan counties. Here, it is evident that both the older periods of industrial decentralization from America's industrial heartland to her hinterlands, as well as the more recent shifts in industrial location toward the Sunbelt, help to explain current rural high tech location.

Part III analyzes factors associated with non-metropolitan high tech plans and employment and changes in them over the 1972-82 period.

A review of current state high tech development policy presented in Part IV finds no emphasis on rural economic development. The discussion clearly shows that government efforts are not designed or intended to redress the special problems of rural areas. In fact, most policy assures inhibition of rural high tech development, given an emphasis on existing concentrations of industries and pre-existing research facilities. This is clearly an area where more thought is needed to improve the competitive prospects of rural America for additional rounds of high tech industrialization.

We conclude with a discussion of policy implications of this study.

Section II
DEFINITIONS AND THEORIES:
WHAT IS HIGH TECH?

A Working Definition

Before examining the incidence of high tech industries in rural America, it is necessary to define the term "high tech" as used in this study. Our working definition of high tech is based on the human capital component of the labor process (Vinson and Harrington 1983; Glasmeier et. al. 1983; Richie et. al. 1983; Malecki 1984). In other words, for the purposes of this study, high tech industries are those which employ large numbers of engineers and scientists. Using occupational statistics for all manufacturing industries, high tech industries are defined as those with greater than the national average of engineers, engineering technicians, computer scientists, mathematicians, and life scientists, including chemists and geologists.

On the basis of this definition, 28 industry groups are identified as producing high tech products. These industries are further disaggregated to include their constituent parts. Table 2.1 lists the detailed industries examined. This section first examines problems associated with defining high tech industries, and then discusses the measurement of high tech industries employed. We then review the theoretical framework used to study high tech in this report.

Early attempts at defining "high tech" resorted to such imprecise measures as industry employment growth, before-tax R&D spending, and numbers of patents per product (see Glasmeier 1983 for a review of other definitions). Using these measures, there was general agreement that industries such as computers and microelectronics were high tech, but still some question about whether industries such as chemicals and portions of machinery should be considered "high tech." It was commonly accepted that computers and semiconductor production are based on the application of scientific principles in the development of new products. They also necessarily employ large numbers of scientific personnel in production. It has simply been taken for granted that the chemical and machinery industries were similarly dependent on scientific skill. However, the real issue is that the first set of industries is <u>new</u>, while the others are of an older vintage. And yet, the unifying quality making both sets "high tech" industry is the application of science and engineering principles in product development.

Problems of defining high tech really come down to measurement and data availability.[3] We would like to identify high tech industries on the basis of product qualities, and then be able to make distinctions among products being produced at different locations. Even more critical, if the key qualitative attribute of high tech is "innovativeness," then we would prefer to identify products and processes at a very early stage in their development. By the time a product receives an SIC code from the Office of Management and Budget, however, it has already been in existence at least five years. Thus the attributed "new" no longer applies. Unfortunately, data are simply not available to contend with these problems with any level of precision. Consequently, researchers use a definition as rigorous as possible, yet amenable to policy analysis.

Most lists of high tech industries are based on the Standard Industrial Classification (SIC) system. SIC codes are the numerical classification system developed by the federal government to group industries at increasingly finer levels of disaggregation. The classification scheme goes from the general, represented by one-digit industries, to the very specific five- and seven-digit level product classifications. Using an SIC code-based classification system, a definition of high tech includes parts of industry groups such as chemicals, electrical machinery, transportation equipment, communications equipment, and engineering and scientific instruments. This study, too, analyzes high tech industries on the basis of three- and four-digit standard industrial classification codes. Both levels provide detailed information on industry and product group behavior.

Table 2.1

High-Technology Manufacturing Industries

SIC	Product Line
2812	Alkalies and chlorine
2813	Industrial gases
2816	Inorganic pigments
2819	Industrial inorganic chemicals n.e.c.
2821	Plastic materials, synthetic resins, and non-vulcanizable elastomers
2822	Synthetic rubber
2823	Cellulosic man-made fibers
2824	Synthetic organic fibers
2831	Biological products
2833	Medicinal chemicals and botanical products
2834	Pharmaceutical preparations
2841	Soap and other detergents
2842	Specialty cleaning, polishing and sanitation preparations
2843	Surface active agents, finishing agents, sulfonated oils and assistants
2844	Perfume, cosmetics and other toilet preparations
2851	Paints, varnishes, lacquers, enamels and allied products
2861	Gum and wood chemicals
2865	Coal, tar, crudes and synthetic intermediates, dyes and organic pigments
2869	Industrial organic chemicals n.e.c.
2873	Nitrogenous fibers
2875	Fertilizers, mixing only
2879	Pesticides and agricultural chemicals n.e.c.
2891	Adhesives and sealants
2892	Explosives
2893	Printing ink
2895	Carbon black
2899	Chemicals and chemical preparation
2911	Petroleum refining
3031	Reclaimed rubber
3511	Steam, gas, hydraulic turbines
3519	Internal combustion engines
3531	Construction machinery and equipment
3532	Mining machinery
3533	Oil machinery
3534	Elevators and moving stairways
3535	Conveyors and conveying equipment
3536	Hoists, industrial cranes
3537	Industrial trucks, tactors, trailers, stackers

Table 2.1 (continued)

3541	Machine tools, metal conducting types
3542	Machine tools, metal forming types
3544	Special dies and tools, die sets, jigs and fixtures, and industrial molds
3545	Cutting tools, machine tool accesories, and machinists' precision measuring devices
3546	Power-driven handtools
3547	Rolling mill machinery and equipment
3549	Metalworking machinery n.e.c.
3561	Pumps and pumping equipment
3562	Ball and roller bearings
3563	Air and gas compressors
3564	Blowers, exhaust and ventilation fans
3565	Industrial patterns
3566	Speed changers, industrial high-speed gears
3567	Industrial process furnace and ovens
3568	Mechanical power transmission equipment
3569	General industrial machinery
3573	Electronic computing equipment
3574	Calculating and accounting machines
3576	Scales and balances
3579	Office machines
3612	Power, distribution and specialty transformers
3613	Switchgear and switchboard apparatus
3621	Motors and generators
3622	Industrial controls
3623	Welding apparatus
3624	Carbon and graphite products
3629	Electronic industrial apparatus
3651	Radio and TV receivers
3652	Phonograph records and tapes
3661	Telephone and telegraph apparatus[1]
3662	Radio-TV transmitting[1,2]
3671	Electron tubes
3674	Semi-conductors[1]
3675	Electronic capacitors[1]
3676	Resistors for electronic apparatus[1]
3677	Elecronic coils, transformers[1]
3678	Connnectors for electronics
3679	Electronic components, n.e.c.[1]
3721	Aircraft[1,2]
3724	Aircraft engines and engine parts[1,2]

Table 2.1 (continued)

3728	Aircraft parts and equipment, n.e.c. [1,2]
3743	Railroad equipment
3761	Guided missiles and space vehicles [1,2]
3764	Guided missiles and space propulsion units [1,2]
3769	Guided missiles and space parts and eqipment, n.e.c. [1,2]
3795	Tanks and tank components
3811	Engineering, lab, science research instruments
3822	Automatic controls for regulating residential and commercial environments
3823	Industrial instruments for measuring, display, and control of process variables; and related products
3824	Totalizing fluid meters and counting devices
3825	Instruments for measuring and testing of electricity and electrical signals
3829	Measuring and controlling devices
3832	Optical instruments and lenses
3841	Surgical and medical instruments
3842	Orthopedic and surgical supplies
3843	Dental equipment
3861	Photographic equipment

1 = Innovative high technology manufacturing industries
2 = Defense related high technology manufacturing industries

Industries examined in this study are confined to the broad category of manufacturing. Other researchers have included certain key high tech services, such as software production, in similar studies of high tech industry. While this study would have been significantly enhanced through examination of such service industries, it is important to note that high tech services are highly spatially correlated with high tech manufacturing. Thus, while their exclusion is unfortunate, we would not expect their spatial incidence to differ significantly from that of high tech manufacturing.

Models of High Tech Location

There is no single model of high tech industry development or location to guide this research. Instead, there are a number of partial theories which help explain industry behavior in the current period. Two important ones, the product cycle model and the spatial division of labor, structure this inquiry. The product cycle model of industrial development, and the process of industrial filtering, are cited frequently by scholars (Erickson 1978; Rees 1978; Norton and Rees 1979; Markusen, 1985) to explain growth in rural manufacturing and in particular high tech location over the early post war period.

The Product Cycle Model

As industries mature and markets stabilize, companies set up manufacturing plants where labor costs are low. More formally, as products reach maturity and markets reach saturation, producers undertake cost-cutting measures to maintain market share. One choice often pursued is selecting production configurations to minimize costs of variable inputs--most particularly, labor costs.

One way to achieve low-cost production is to shift manufacturing to locations with an ample supply of low-wage labor. Rural communities are considered prime candidates for the mature phases of manufacturing. The low cost of land, coupled with relatively docile and certainly lower-cost labor relative to metropolitan areas, are singled out as qualities drawing manufacturing to rural areas in the 1960s and the 1970s (Haren and Holling 1979).

But, in the peculiar case of high tech, we are not primarily dealing with mature products and industries, and hence some of the explanatory power of the product cycle model is lost. While most scholars would agree to its general usefulness, the product cycle model does not tell us enough about youthful industries and how they behave locationally. Thus, a number of refinements are in order which relate specifically to unique characteristics of the more youthful high tech industries. To carry out these refinements, the model of industrial development based on the unique labor-skill requirements of high tech industries is important.

The Spatial Division of Labor

The spatial division of labor has evolved as firms sought locations with profitable supplies of appropriate labor (Clark 1981; Glasmeier 1986). Historically, location decisions of single-unit firms were constrained by factors such as transportation costs, access to markets, and labor. Rigid, mechanically-integrated methods of production also restricted manufacturing location (Storper 1982). In recent years, firms locational choices increased dramatically--through changes in corporate organization from single to multi-establishment firms (Cohen 1977; Hymer 1979); telecommunications advances allowing real-time communication among far-flung production operations; decreases in shipping time and costs among different production units and markets; and, by the application of microelectronics to manufacturing processes, making production capacities more flexible, and hence, more divisible (Storper and Walker 1983).

As production becomes more complex, corporations are constrained by labor requirements to shift production to locations where high- and low-skilled workers are found (Glasmeier 1986). This brings to center stage the notion of a spatial division of labor. While certain types of skills are found distributed ubiquitously throughout a country, others--particularly technical skills--are highly spatially concentrated. If companies are to compete successfully in high tech markets, increasingly they must find production locations where both technical and non-technical, but also high quality and generally well-educated labor can be found (Massey 1984).

As part of this study of high tech industries in rural areas, we combine insights from the two models. As the report unfolds, it will become apparent that earlier periods of decentralization were probably motivated by product cycle concerns. In more recent times, however, characteristics of high tech industries themselves have intervened and structured anew the locational possibilities and selections of high tech industries. The spatial division of labor thesis is central to explaining rural high tech of a more recent vintage.

PART II

Section III
JOBS, JOBS, JOBS:
THE GROWTH OF HIGH TECH INDUSTRIES

The decade of the 1970s were golden years for high tech industry growth. Basic industries upon which America's post war manufacturing might was built--steel, chemicals, and autos--were drastically contracting in terms of both jobs and productive capacity. In their place, like a Phoenix rising from the ashes of America's industrial past, high tech industries were emerging as the new symbol of the nation's continuing industrial prowess.

One need only to look at the problems of America's industrial cities and their ties to specific industries to comprehend why high tech industries garnered such attention. As General Motors and the Ford Motor Company struggled to maintain market shares in the face of fierce competition from Japanese auto makers, companies like IBM and National Semiconductor met seemingly unlimited markets and had trouble keeping up with demand for their products. While cities like Detroit literally collapsed under the weight of their dependence on autos, places like San Jose, California, and Boston, Massachusetts, could hardly contain their burgeoning populations and the job growth associated with high tech industry.

On the basis of popular press accounts, one is often left with the impression that high tech industries are therefore unmitigated job generators. The broad list of high tech industries analyzed in this study, however, contains many highly variable growth experiences. Analysis of the growth in employment in these industries over the ten-year period, 1972-1982, indicates there are large numbers of high tech industries which actually lost jobs. For example, many chemicals industries lost jobs at an annual rate of almost three percent though there were a few spectacular cases of dramatic job growth, e.g., semiconductors which doubled their employment base in just ten years. Their rise to prominence no doubt occurred because, in comparison with overall manufacturing, these few high tech industries did experience dramatic growth in new jobs over the 1972-1982 period.

While total manufacturing jobs declined by almost 500,000 jobs between 1972 and 1982, high tech manufacturing grew by 1.22 million (Table 3.1). The rate at which these industries grew also contributed to their elevated status. High tech industries growth rates exceeded national job growth by 27.9 to 21 percent between 1972 and 1982. As the ten years passed, these industries were also becoming more important to the overall national manufacturing base, and finally, accounted for 29 percent of all manufacturing jobs in 1982, up from 24 percent in 1977.

Few Industries Make Impressive Gains

Examination of individual four-digit industries indicates, however, that high tech industries experienced very erratic growth rates. Of the 94 high tech industries studied, eight grew at more than 100 percent over the ten-year period, while six other industries increased employment by 80 percent. While these growth rates are truly impressive, this

Table 3.1

Growth in High Tech Establishments and Employment 1972-1982

	Establishments	Employment
1972	44,147	4,379,777
1977	52,101	4,760,507
1982	56,131	5,601,503
Difference 1972-1982	11,984	1,221,726

Percentage Change, High Tech Employment and Plants 1972-1977, 1977-1982, 1972-1982

	Establishments	Employment
1972-1977	18.0	8.7
1977-1982	7.7	17.7
1972-1982	27.1	27.9

Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

pattern characterizes a distinct minority of all industries studied. Between 1972 and 1982, 32 of the high tech industries studied lost jobs and 57 grew at a rate less than the national average (21 percent) for all non-agricultural employment. For example, within the broad industry group, Chemicals (SIC 28), 12 of 28 industries lost employment over the 1972-1982 period. Similarly, within the broad category of Machinery, SIC 35 (including computers), 10 out of 29 industries also experienced negative changes in employment. In all, 30 of the 94 industries defined as high tech actually lost jobs over the 1972-1982 period (See Appendix B for table of industry growth rates 1972-1982).

Sub-Groups: The Electronics-Computer Complex and Military Dependent Sectors

High Tech Networks: The Electronics-Computer Complex

As part of this report, we also examine two restricted groups of industries. The first consists of the electronics-computer complex. Industries in this group are those truly dynamic ones regularly referenced in the business press--including computers, semiconductors, communications equipment, and electronics components. These four industries alone added almost half of all new high tech jobs created (580,000) in high tech industries over the ten-year period (Table 3.2). We include a separate analysis of these industries because of their dynamic history and their continuing importance in reshaping regional development in the U.S.

Rapid growth of these industries in the recent period is attributed to a number of factors. Among these, commercial application of products is perhaps the most important factor; semiconductors are the most obvious case. Semiconductors consist of two types of products--discrete devices which perform only one function; and integrated circuits which can perform multiple functions. Increases in industry output since the 1960s are due to developments in integrated circuitry. In the 1950s, integrated circuits contained fewer than 10 discrete devices. By the late 1960s, chip capacity increased one-hundred fold. Since then, chip capacity has doubled every two years. Sheer volume of chips available helps boost demand, but a far more important factor is the delivery of chips at constantly decreasing prices per unit of computing power. With every new generation of chips, prices fell as firms got better at production. Thus, succeeding generations of chips were not just more powerful, but they were also cheaper. A "bit" of memory (one piece of stored information) fell from .01 cent to 1/1000 of .01 cent from 1973 to 1986.

Prior to the late 1960s, the majority of semiconductor output was sold to the Defense Department. Demand was small but stable, and prices for products were high. With the advent of the microprocessor and its commercial application in other industries, demand increased almost exponentially.

Over the period studied, products such as semiconductors and computers gained wide acceptance in American and in world-wide markets. These industries are highly interconnected and the growth of one almost always influences growth in other related industries. The interconnectedness of the CEC industries also explains, in part, their rapid expansion. For example, expansion of the computer and communications industries

Table 3.2

Top Four High Tech Industry Job Generators 1972-1982

	Employment 1972	Employment 1982	Percentage Change 1972-1982
Computers 3573	144,661	348,821	141
Communications Equipment 3662	317,556	491,821	60
Semiconductors 3674	97,389	184,019	89
Misc. Electronic Components 3679	98,340	226,362	130

Absolute difference: 593,077

Percent of total high tech job gains 1972-1982: 49%

Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

was made possible by advances in semiconductor design. Smaller and more powerful chips allow computers to shrink in size while expanding in power. In turn, computers facilitate increasing yields in semiconductor production. By allowing chip producers to automate production, computers thus increase yield and decrease per/unit production costs.

As costs fell due to the interconnected nature of the semiconductor and computer industries, more industries made use of the new devices. And, as the use of computers and semiconductors penetrated other non-electronic industries--such as autos, scientific instruments and machinery--demand for these products also increased. In all cases, further changes required heightened levels of electronic components.

Thus, expansion in the four industries had a snowball effect. Increasing demand for one sector's output produced positive and reinforcing levels of demand for other high tech products. As demand for these products increased, scale economies allowed production to reach levels of standardization and mass production. Products of these four high-growth industries entered an expansion phase accompanied by spatial decentralization of employment and plants over the 1972-82 period.

The Defense Connection: Military-Dependent Sectors

The second subgroup of industries are those selling a major portion of their output to the Defense Department. This market has been critical in the initial development of a number of high tech industries. Another major factor in high tech industry growth is the role played by the U.S. Department of Defense in supporting selected R&D. Support for R&D spending translates into new products and protected markets for specific high tech products. A national model of inter-industry input/output relationships clearly identifies the importance of high tech products in Military applications. Markusen (1984, 1985) identifies those high tech sectors with greater than 20% of output sold to the Defense Department (see Henry 1983, for method used to identify these sectors). These industries include aircraft, aircraft engines, missiles, space vehicles, space vehicle parts and equipment, and scientific and professional instruments (SICs 3721, 3724, 3728, 3761, 3795, 3811, and 3832).[4]

Six of the seven defense-dependent sectors gained jobs over the ten-year period. And yet, with the exception of the space vehicles and scientific instruments industries, growth rates for these sectors were only slightly above the national level for all high tech industries.

Over the post war period, the Defense Department has continued to function in a dual capacity as sponsor of high tech research and product development and as provider of a critical and protected market for high tech products. The role of the Defense Department in the growth of high tech industries is clearly influenced by political forces operating at a national level. During de-escalation of the Viet Nam war, for example, several defense-dependent high tech industries lost jobs (Table 3.3).

Data used in this study show both a period of slow defense-sector growth from 1972-77, and a period of considerable defense spending build-up during the Reagan years, 1980-82. We examine these industries separately because their location is at least somewhat amenable to national policies and because they have occasionally been targets

Table 3.3

Employment Growth in Defense Dependent Sectors 1972, 1977, 1982

Industry	1972	1977	1982	% change 72-77	% change 77-82
Aircraft 3721	231,919	220,800	264,295	-3.9	18.6
Aircraft Engines 3724	99,563	106,200	134,530	11.1	26.7
Aircraft Parts and Equipment 3728	102,414	101,934	137,201	-.5	34.6
Space Vehicles 3761	118,309	93,929	112,417	-20.6	19.7
Missiles 3795	5,319	12,120	16,753	127.0	38.0
Scientific Instruments 3811	36,482	42,197	47,448	15.7	12.4
Optical Instruments and Lens 3832	19,637	29,906	53,348	24.0	78.4

Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

of federal efforts to relocate defense production from previous concentrations in the Northeast. As part of this analysis we will look at just how successful such decentralization has actually been over the 1972-1982 period.

Section IV
WHERE ARE HIGH TECH JOBS?

High Tech Jobs, Distribution Across the Urban-Rural Continuum[5]

Like general manufacturing, high tech industries are predominantly metropolitan. Because of their relative youthfulness, high tech industries concentrate in cities where needed infrastructure, skilled labor, and markets can be found (Glasmeier 1987). Their dependence on technical labor makes them even more concentrated in metropolitan areas than other mature manufacturing industries. For example, the two key centers of American high tech, Boston, Massachusetts, and Santa Clara, California, are premier concentrations of technical talent. So dense is the pool of skills in these two regions that companies from all over the world, such as Seimens of Germany and NEC of Japan, actively recruit specially trained workers there.

Although high tech industries are largely a metropolitan phenomenon, still, there is evidence of some employment decentralization to rural areas over the ten-year period. Hewlett-Packard, a California computer and scientific instruments company, operates production plants in Roseville, and Rohnert Park, California, both rural communities. Japanese firms have followed suit and located plants in similar communities of California and Oregon. The AMP Corporation of Harrisburg, Pennsylvania, makes a policy of locating plants in small towns in Pennsylvania and, more recently, in small cities of the South. Even Nebraska benefited from high tech growth as the Dale Corporation, the nation's largest capacitor producer, located plants in small towns in that state. To begin to understand the locational tendencies of high tech industries in metro and non-metro counties, we examine the results of a modified shift-share analysis--showing the shift component of expected and actual growth of high tech employment in urban and rural counties (Table 4.1).

The analysis considers both total high tech employment as well as sectors in the computer-electronics and communications equipment complex and defense dependent sectors. The calculation essentially compares the actual number of jobs created in each urban-rural category with the number of jobs which would have been created if the industries in rural areas had grown at the same rate as those in the nation (See Appendix C for description of Rural-Urban continuum).

According to this analysis, metropolitan counties with over one million people lost almost 420,000 jobs. This loss was in part due to slow growth in defense sectors. This was somewhat offset by higher-than-average growth experiences in the CEC sectors. All other metropolitan counties, however, posted significant gains over those expected, with one exception--employment in the CEC sectors was lower in counties on the fringe of large metropolitan counties than expected, given the base of employment.

Table 4.1

Modified Shift-Share Analysis of High Tech Employment Growth Across the Urban-Rural Continuum 1972-1982

Urban-Rural Continuum	Absolute Employment 1972	Expected Employment R	Actual Employment N	Difference R-N
0[1]				
HT Emp[2]	1,604,524	449,267	33,199	-416,068
DDS[2]	316,341	82,248	2,114	-80,134
CEC[2]	266,703	240,032	280,032	40,000
1				
HT Emp	782,067	218,978	336,271	117,292
DDS	100,584	26,152	40,983	14,831
CEC	164,332	147,898	132,024	-15,874
2				
HT Emp	1,013,041	283,651	293,938	10,287
DDS	138,598	36,035	53,366	17,330
CEC	142,022	127,819	110,998	-16,821
3				
HT Emp	357,790	100,181	110,353	10,172
DDS	16,133	4,194	41,131	36,936
CEC	41,692	37,523	46,188	8,665
4				
HT Emp	223,133	62,477	24,852	-37,625
DDS	22,699	5,902	6,346	444
CEC	23,966	21,569	3,567	-18,002
5				
HT Emp	98,647	27,621	20,552	-7,069
DDS	629	163	2,614	2,450
CEC	6,729	6,056	2,330	-3,726

Table 4.1 (Continued)

Modified Shift-Share Analysis of High Tech Employment Growth Across the Urban-Rural Continuum 1972-1982

Urban-Rural Continuum	Absolute Employment 1972	Expected Employment R	Actual Employment N	Difference R-N
6				
HT Emp	144,620	40,494	46,514	6,020
DDS	11,194	2,910	3,241	331
CEC	6,551	5,895	5,939	43
7				
HT Emp	130,351	36,498	49,390	12,892
DDS	3,204	833	5,761	4,928
CEC	4,061	3,655	8,206	4,551
8				
HT Emp	11,979	3,354	4,072	717
DDS	160	42	481	439
CEC	636	572	3,387	2,814
9				
HT Emp	11,995	3,359	4,953	1,594
DDS	96	25	398	373
CEC	437	393	379	-314

[1] See Appendix B description of urban-rural continuum

[2] HT Emp = High Tech Employment
DDS = Defense Dependent Sectors
CEC = Computer Electronics Communications Complex

Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

In contrast, rural counties experienced high tech job growth below the national average. Over the ten-year period, 1972-1982, rural high tech jobs grew at only 24 percent. Had all rural counties grown at the national rate, then 23,111 additional jobs would have been created.

Low rates of growth occurred in the largest rural counties, including those both adjacent and non-adjacent to metropolitan counties. These counties also performed below average in the CEC sectors. Smaller and more distant rural counties posted impressive gains in both the total and in the subsets of high tech industries. This growth was unfortunately not large enough to counteract losses in the bigger counties. Thus, job gains in smaller counties, while significant, must be viewed in light of the small initial base which tends to overemphasize modest absolute changes. For example, in 1972, a small rural county in Texas might have had 7 jobs in high tech industries. By 1982, this figure could have increased by 14 jobs. Change in this instance would be 200 percent, yet a total of only 14 jobs would be created.

What Kind of Jobs and Plants Locate in Rural Counties?

That rural counties have had some success in attracting high tech industry plants and employment raises questions about the composition of this industrialization and its relationship to traditional rural manufacturing industries.

Given rural communities' tendency to attract mature, and often slow-growing industries, we would expect a similar pattern to prevail in relation to high tech industries. Indeed, for the most part this is the case. A major finding of this study is that high tech industries concentrated in rural counties are a small subset of the 94 industries studied.

Tables 4.2 and 4.3 list high tech industries which have 20 percent or more of the industry's total employment and plants in rural counties. A number of observations can be made about these industries. First, and perhaps foremost, industries with large concentrations of employment and plants in rural counties are either slow-growing or experienced negative growth rates over the 1972-1982 period. In the case of plants, only nine of 25 industries with 20 percent or more of the nation's total plants in rural areas had growth rates at or above the national level for total high tech plant growth. As for employment, out of 36 industries with 20 percent or more total employment in rural counties, only seven had growth rates at or above the national average for all high tech industries.

A second observation relates to the type of industries with either plant or employment concentrations in rural areas. Approximately half of the 25 industries with plant concentrations in rural areas, and a third of those with employment concentrations, are in the chemicals industry. Many of these are tied to other traditional rural industries. For example, organic chemicals are tied to agriculture as inputs to farming. Others, such as gum and wood chemicals (SIC 2861), are found in proximity to natural resources--in this case timber, used in the production of wood products such as plywood. Still others, such as synthetic organic fibers (SIC 282), are inputs to textiles, a traditional rural industry. Finally, an industry such as explosives (SIC 2892) seems drawn, if for no other reason than public safety, to places with sparse populations.

Table 4.2

Industries with > 20% of Total National High Tech Plants in Rural Counties 1982

	> 20%	21-25%	26-30%	31-40%	41-50%
INDUSTRIES	+ 3533	+2819	* 2812	* 2824	- 2861
	* 3612	+3519	- 2823	+2874	+2873
	+ 3677	* 3621	+ 2879	* 2892	- 2875
	- 3721	* 3624	+ 2911		- 2895
	* 3743	* 3675	* 3531		+3532
	* 3769		* 3562		

Growth Experience Over 1972-1982:

+ = above-average industry growth rate

* = growth positive, but below-average growth rate

- = negative growth rate

Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

Table 4.3

Industries with Significant Concentrations of High Tech Employment in Rural Counties 1982

INDUSTRIES	> 20%	21-25%	26-30%	31-40%	41-50%
	-3536	* 2899	-2812	+2819	-2824
	+3842	- 3531	-2874	- 2823	-2861
	-3031	+ 3534	+2879	- 2873	-2892
	* 3631	* 3537	* 3546	- 2875	-2895
		- 3542	* 3568	* 3532	* 3675
		- 3574		- 3562	
		- 3651		3563	
		+ 3822		- 3612	
				3621	
				* 3675	
				- 3676	
				- 3677	
				+ 3824	

Growth Experience Over 1972-1982:

+ = above-average industry growth rate

* = growth positive, but below-average growth rate

- = negative growth rate

= insignificant change

Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

High tech industries in the machinery sector (SIC 35) are also linked with the economic base of rural communities. For example, industries such as construction and farm and mining equipment are heavily represented in rural counties. Other industries in the machinery sector are quite common and produce goods such as ball and roller bearings, a product widely used in industry. With the single exception of aircraft production, SIC 3721, industries with high proportions of total employment and plants in rural counties are either tied to the rural economic base of agriculture and resource extraction, or they are common inputs of a variety of industrial sectors, such as machine tools and dies.

These two tables clearly indicate that the high tech industries which have large shares of their employment or plants located in rural areas are the more mature, least technical and, in many cases, the more vulnerable industries within the group. The crucial link between rural high tech industries and other traditionally rural manufacturing industries is a key finding of this study.

Thus, a major explanatory factor in rural high tech industry location is the presence of these traditional sectors as a necessary foundation for growth in these areas. This means that growth in high tech industries in rural areas is significantly affected by growth in traditional rural industries and neither independent of, nor a replacement for, these traditional industries. For example, synthetic fibers are an integral part of the textile industry. It is widely known that developments in synthetic fibers actually pulled the textile industry toward higher uses of new technologies making the industry more competitive worldwide. It is possible to conclude that efforts to stimulate growth in the electronics and computer sectors are likely to have little impact on rural economic development unless they are tied to concurrent efforts to increase development and growth of traditional rural sectors.

Counter examples abound of problems arising when high tech industries which have no such attachment to the local or state economy locate in rural communities. In the early 1980s, rural counties in Idaho successfully attracted a couple of semiconductor plants. These facilities are "cathedrals in the desert." They have generally induced no other firms to locate near them, nor have they become more integrated into the state's overall economy. When semiconductor markets became saturated in 1983-1984, these isolated plants experienced major job losses.

The problem of unstable industries is not new to rural communities but, in the peculiar case of high tech industries, the highly international nature of their products and the intense foreign competition in many product markets, speed up the rate of product obsolescence. Given that rural communities attract mainly the more mature aspects of high tech production, they can only count on greater instability in their economic base if they become dependent upon high tech industries.

The Select Few: Job Generators in Rural Areas

Table 4.4 lists industries which added more than 500 jobs in rural counties over the ten-year period. The range of these industries is quite broad and includes everything from computers and electronic components to photographic equipment. Rural counties gained substantial new jobs in both the more traditional rural high tech industries, such

Table 4.4

Industries that Gained >500 Jobs in Rural Counties 1972-1982

	Rural Continuum Categories					
	4	5	6	7	8	9
INDUSTRIES	-2812	2819	2821	2819	3573	2819
	2834	2834	-2824	-2823		
	2869	2869	2873	2834		
	2879	-3531	2891	2869		
	3519	3533	2911	2911		
	3533	3535	3519	3532		
	3569	3546	-3531	3544		
	3621	3561	3537	3545		
	3661	3573	3544	3561		
	3675	-3612	-3562	-3562		
	3679	3674	3563	3564		
	3728	3679	-3612	3568		
	3823	3824	3613	3573		
	3825	3842	3662	-3576		
	3841		3678	3613		
	3842		3679	3621		
			3724	3622		
			3728	3661		
			-3822	3662		
			3825	3679		
			3829	3724		
			3842	3728		
				3841		
				3843		
				3861		

- = negative growth rate over the 1972-1982 period

Bureau of the Census, 1986, <u>Census of Manufactures, Plant Location Tape</u> (1972, 1977, 1982).

as chemicals (SIC 28), as well as in more traditionally urban industries, such as aircraft (SIC 37), and semiconductor production (SIC 36).

It is interesting to note that the smaller rural counties, those with an urban populations of less than 20,000 persons, experienced the greatest diversity in high tech job gains. Having said this, the two types of rural counties, adjacent and non-adjacent, had a mix of high tech industries--consisting almost equally of industries that lost jobs nationally while gaining them in rural areas, as well industries showing substantial job gains above the national rate. For very small rural communities, regardless of proximity to metropolitan areas, only one of the 94 industries in each case gained more than five hundred jobs.

Table 4.5 lists industries which added at least ten new plants in rural counties over the ten-year period. The distribution is surprisingly similar to that of employment with the following exceptions. First, unlike employment where almost half the industries were declining overall, rural plant additions occurred primarily in industries growing at a national level. This raises questions about a strict interpretation of rural high tech industries as the result of industry product cycles. According to the model, industrial filtering and hence job gains should occur in mature industries growing slowly at a national level, and yet our analysis suggests plant growth occurred in many dynamic industries. One possible explanation for this result relates to problems inherent in the SIC codes system. Even at a four-digit level, there is heterogeneity among plants given specific SICs. It is likely that plants locating in rural areas produce more mature components of fast-growing industries. But because the industry is growing overall, it is impossible to detect declining sub-components within a single industry.

Adding plants were primarily the non-electrical machinery and electronics industries. Two industries--machine tools (SIC 3544) and miscellaneous electronic components (SIC 3679)--were consistent plant generators across the range of rural counties. Just these two industries were responsible for 23 percent of total new plant additions in rural counties. Both industries are found wherever manufacturing is also done. For example, anyone operating a production plant occasionally needs a part repaired. Local machine shops can provide this type of service.

There is some cause for concern, however, regarding the significant presence of plants in SIC 3679 (miscellaneous electronic components), in rural counties. Employment and plants in this industry are particularly vulnerable to both foreign competition and pressures to automate to keep prices of components in line with international markets. The outcome in both instances is likely to be loss of jobs.

SIC 3679 is a particularly heterogeneous industry group which grew rapidly over the study period. More recently, however, the electronics component industry--particularly production of printed circuitry--has been suffering from significant overcapacity (U.S. Industrial Outlook, 1987). Future advances in the industry will most assuredly include employment reductions. Given that the technology is moving toward greater miniaturization and automation, employment growth in this industry is not likely to excel at anywhere near past rates.

Returning to a more general discussion of rural plant additions, industries which added ten or more plants are a distinct subset of all high tech industries. The greatest

Table 4.5

Industries that Gained 10 or More Plants in Rural Counties 1972-1982

	Rural Continuum Categories					
	4	5	6	7	8	9
INDUSTRIES	-2813	3569	2819	2869	3544	3544
	2819	3613	2851	3531		3679
	-2899	3662	2869	3532		
	3531	3679	2873	3535		
	3533	3842	2899	3544		
	3541	3531	3531	3545		
	3544	3532	3532	3561		
	3569	3533	3533	3564		
	3573	3544	3535	3569		
	3622	3545	3544	3613		
	3662		3545	3662		
	3677		3563	3679		
	3679		3569	3728		
	3728		3613	3842		
	3823		3662			
	3842		3674			
			3679			
			3728			
			3842			

\- = negative growth rate over the 1972-1982 period

Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

variety of plant additions occurred in rural counties adjacent to metropolitan areas with an urban population of less than 20,000. These results suggest that increasing diversity within these industries occurs in relatively small counties with ready access to metropolitan amenities. Similarly, rural counties with no obvious urban concentration appear to show little evidence of attracting high tech plants or employment.

Section V
HOW THE NUMBERS ADD UP: AN AGGREGATE VIEW OF RURAL HIGH TECH

A number of factors influence the probability that a rural country will experience growth of jobs and plants in high tech industries. Chief among them is the geographic proximity of rural counties to metropolitan areas. To determine the importance of proximity, this section examines high tech industries at the level of country aggregates. We focus specifically on the importance of rural country proximity to metropolitan areas. We also examine the distribution of employment in the CEC and DDS sectors in rural counties. The discussion highlights where high tech industries were in the earlier period and how they have since grown and changed their locations.

General Facts About Rural High Tech Industries

From 1972 to 1982, high tech employment in rural counties increased from 620,725 to 770,477 jobs. Rural high tech jobs grew more slowly than national or metropolitan levels. Metropolitan counties gained 1.07 million jobs and grew at the national rate of 28 percent, while rural counties experienced an increase of only 150,000 jobs, representing a growth rate of 24.1 percent (Figure 1).

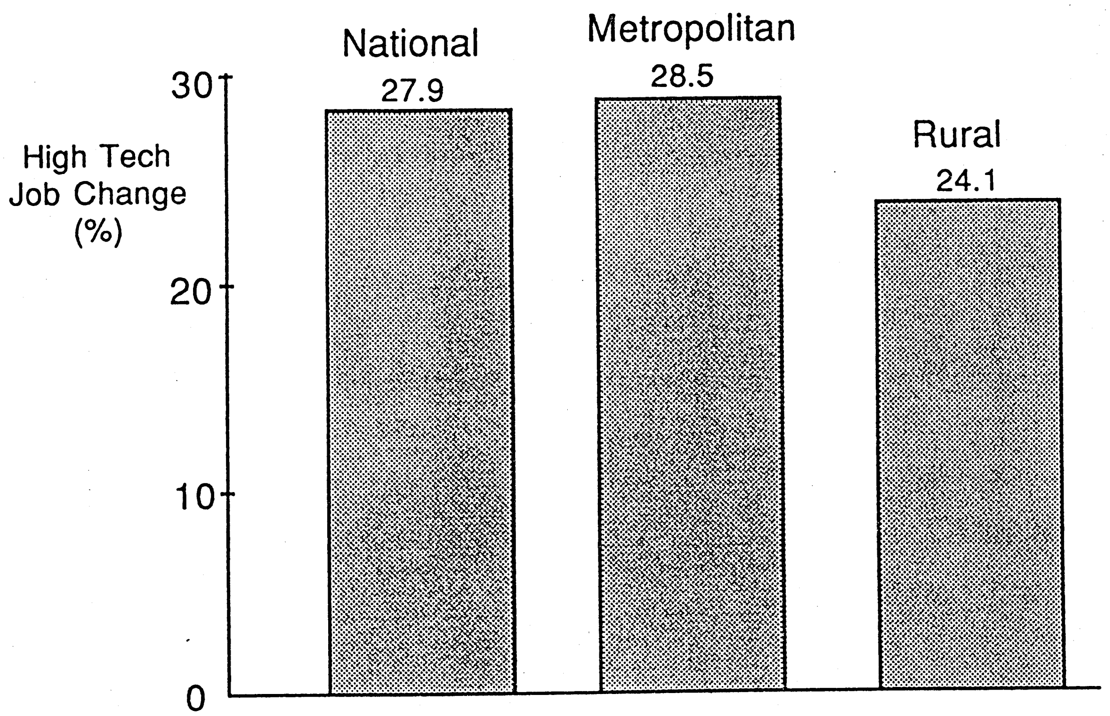
Still, over the same time period, high tech industry employment in rural counties did grow twice as fast as other rural manufacturing industries. From 1972 to 1982, rural communities added 400,000 manufacturing jobs, increasing employment by 9.5 percent. This represents a larger percentage increase than comparable figures for both the nation and metropolitan areas, which grew by only 6 and 4.8 percent respectively.

While rural job growth was below the national rate of employment change, plant gains in rural communities, both absolutely and on a percentage basis, were far more substantial (Figure 2). Plant numbers increased in rural counties by 2250 new additions from 1972 to 1982. Unlike employment, percentage change in rural plant growth exceeded the national rate (30% vs. 45%).

The importance of this finding relates to the role plant growth can play in establishing an economic base with a potential for further expansion over time. Unlike employment growth, which can represent many different things--for example, short-term fluctuations in demand and, hence, temporary expansion of output or shifts of employment from one plant to another--plant growth signifies a commitment on the part of either an entrepreneur or a corporation to invest in a local area. Thus, the high rate of plant growth in rural areas is one hopeful signal of future growth potentials.

figure 1

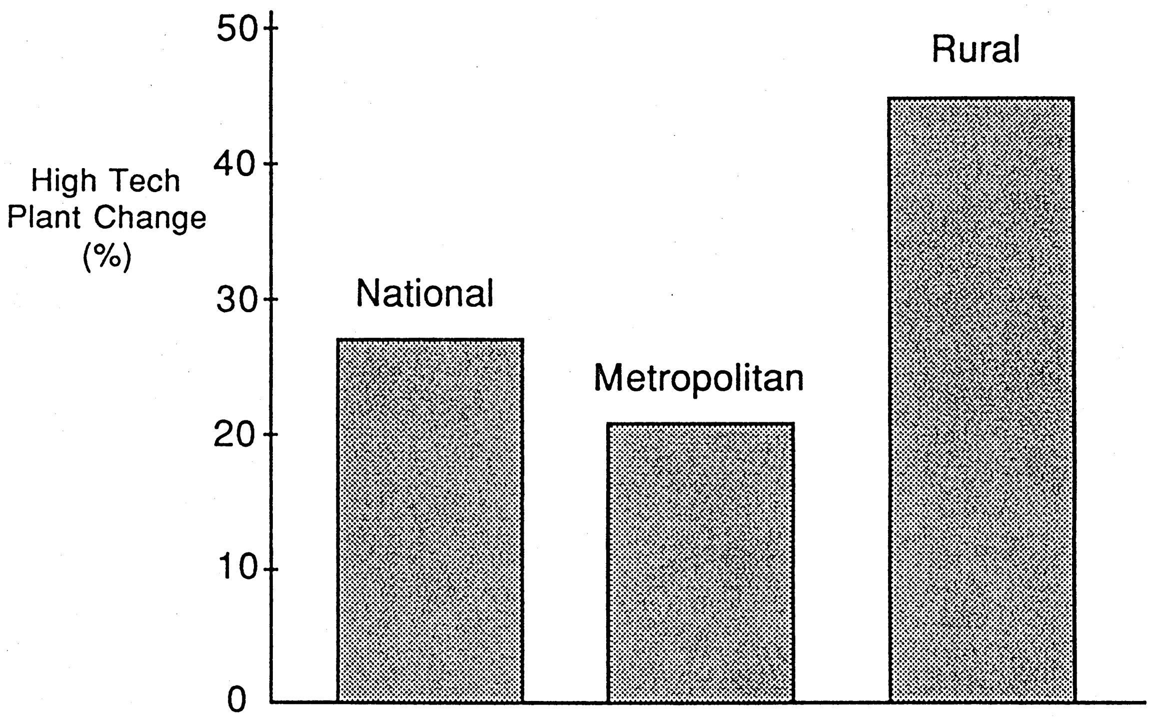
Comparison of National, Metropolitan, and Rural High Tech Job Change 1972-1982



Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

figure 2

Comparison of National, Metropolitan, and Rural High Tech Plant Change 1972-1982



Source: Bureau of the Census, 1986, <u>Census of Manufactures, Plant Location Tape</u> (1972, 1977, 1982).

Adjacency Matters

The distribution of high tech jobs and plants among non-metropolitan counties shows a clear bias toward those rural counties located adjacent to metropolitan areas. In 1972, 61 percent of all rural high tech industry employment was found in adjacent counties. Though these figures changed slightly over the ten-year period, in 1982, 59 percent of all high tech employment was still in rural-adjacent counties (Table 5.1). This contrasts with the population distribution in rural counties. That is, 51 percent of the population lives in non-adjacent counties, whereas the remaining 49 percent live near metropolitan areas.

Nor was growth in high tech jobs evenly distributed. During a period of rapid growth, non-adjacent counties gained only 31 percent of new high tech jobs, below their relative share of rural high tech employment. Plant growth in non-adjacent counties, on the other hand, grew at approximately the same rate for total rural high tech job change.

Guns and Butter: Defense-Dependent Sectors (DDS)

An important subset of high tech industries are tied to national defense policies. These industries have rather erratic patterns of growth; nonetheless, together they were consistent job generators over the 1972-1982 period. Department of Defense ties mean their locational behavior is not regulated by traditional forces such as access to markets or resources and therefore these industries are perhaps more amenable to locating in rural areas. But given their dependence on skilled labor, production jobs for these industries are still highly concentrated in metropolitan areas.

In 1982, rural counties held 56,800 jobs and 296 plants in DDS sectors of high tech industry (Table 5.2). As noted above, and similarly for the nation, the rural share of DDS employment remained essentially constant over the 1972-82 period. Rural counties' share of DDS employment was approximately six percent in 1972 and seven percent in 1982. Plant shares were lower 3.6 and 4.1 percent, respectively (Figure 3).

Over the ten-year period, DDS employment and plants in rural counties grew rapidly. Employment increased by 50 percent and plants by 63 percent. This constituted 12 percent of the total rural high tech employment change, and 21 percent of total rural high tech plant change. In light of the significant employment change it is important to remember that DDS represents only seven percent of rural high tech employment, or a total of 56,825 jobs, as compared with the nation's 14 percent (Figure 4).

Like high tech employment as a whole, DDS high tech employment is concentrated in rural-adjacent counties. In 1982, 78 percent of rural DDS employment was in rural counties adjacent to metropolitan areas. Conversely, DDS plants were more evenly spread among adjacent and non-adjacent counties. In 1982, 42 percent of rural DDS plants were in non-adjacent counties. This figure declined from the earlier period.

Table 5.1

Distribution of Total High Tech Jobs Among Adjacent and Non-Adjacent Rural Counties,1982

	Rural Adjacent Metropolitan Counties	Rural Non-Adjacent Metropolitan Counties
	(percent of total)	
1982 High Tech Employment[1]	59	41
1980 Population[2]	49	49
1972-1982 High Tech Job Growth[2]	50	50

Sources:

1 Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

2 State and Metropolitan Data Book. U.S. Department of the Census, Government Printing Office, Washington D.C. 1986.

Table 5.2

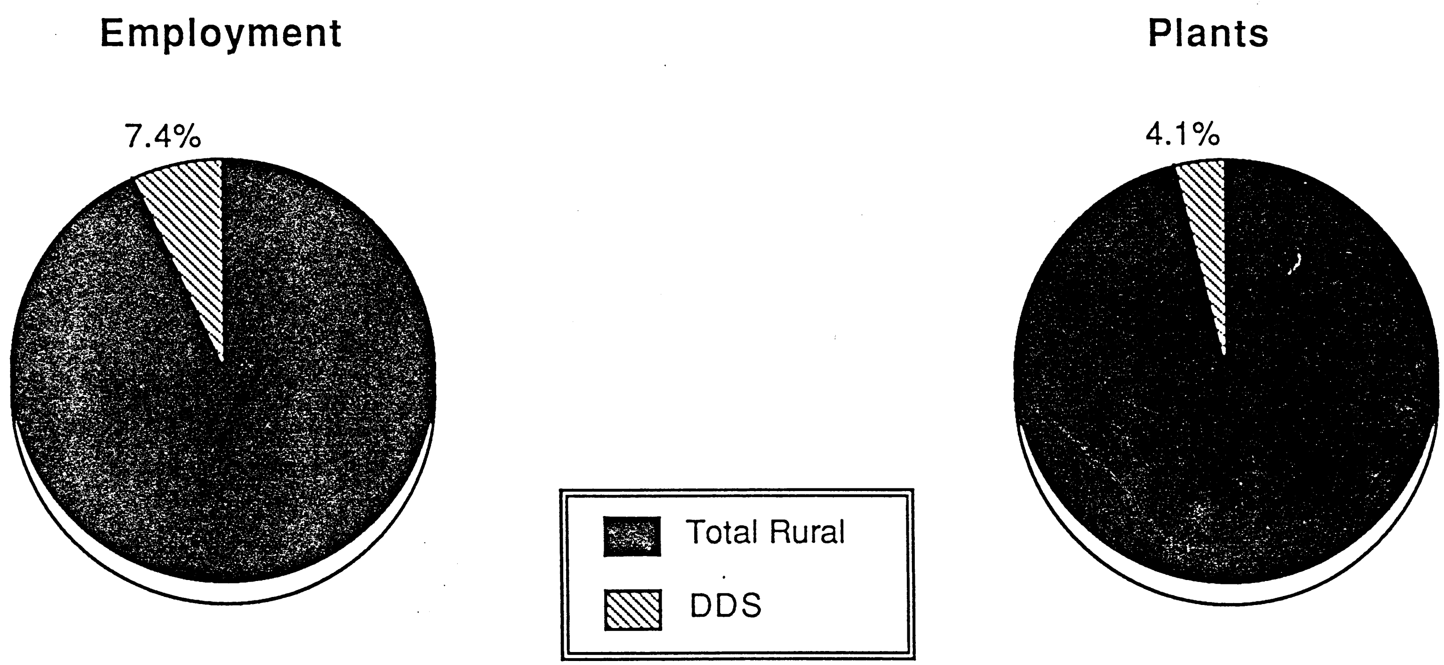
Defense Dependent Sector Employment and Plant Change in Rural Counties 1972-1982

	1972	1982	Percent Change
Employment	37,892	56,825	50
Plants	182	296	62

Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

figure 3

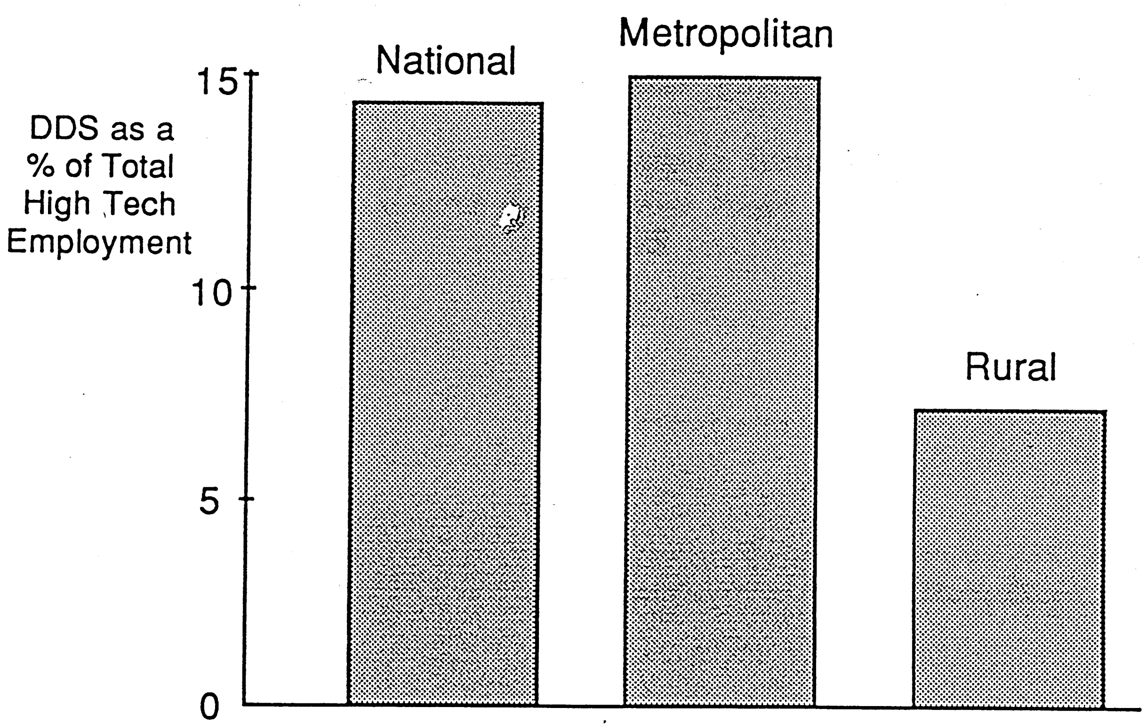
Defense-Department Sector Employment and Plants as a Share of Total Rural High Tech Employment and Plants 1982



Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

figure 4

The Share of Defense-Department Sector Employment to Total National, Metro and Rural High Tech Employment 1982



Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

Computer-Electronics and Communications Industries (CEC)

In 1972, approximately 42,000 jobs in these four key high tech industries were found in rural counties. Of these jobs, approximately one-fourth were found in non-adjacent rural counties. Plants were more evenly distributed between adjacent and non-adjacent counties. Of the 279 rural plants, 37 percent were found in non-adjacent counties.

By 1982, rural counties gained approximately 25,000 jobs and new plants increased by 344 for these four industries. Both employment and plants became more evenly distributed between adjacent and non-adjacent counties, with 34 percent of employment and 41 percent of plants in non-adjacent counties (Figure 5).

During the period studied, percentage growth in plants and employment in the CEC sectors in rural counties exceeded the nation's. Employment over the ten-year period increased by 59 percent and plants increased by 123 percent, compared with rates of change at the national level of 49 and 91 percent, respectively. Rates of growth were highest in non-adjacent counties. This result is not surprising given that the more remote locations began the period with small numbers of high tech jobs and plants. As noted earlier, a small absolute change represents a substantial percentage change.

However, this dramatic change obscures a number of important facts about distribution of the CEC industries. First, rural shares of CEC employment declined over the ten-year period from 6 to 5.3 percent and plant shares increased by just 1 one percent. Second, the rate of change in adjacent county employment was below the national level.

Third, and perhaps more important, changes in shares of national employment and plants were substantially below rural population change over the same period. Furthermore, the composition of total rural high tech plant and employment growth was weighted toward less technical industries. Whereas, at a national level, these industries accounted for 49 percent of employment growth and 27 percent of plant change, comparable figures for rural areas were substantially less--17 and 6 percent, respectively (Figure 6). Moreover, whereas CEC sectors constitute 22 percent of total high tech employment, in rural counties the comparable figure is only 9 percent.

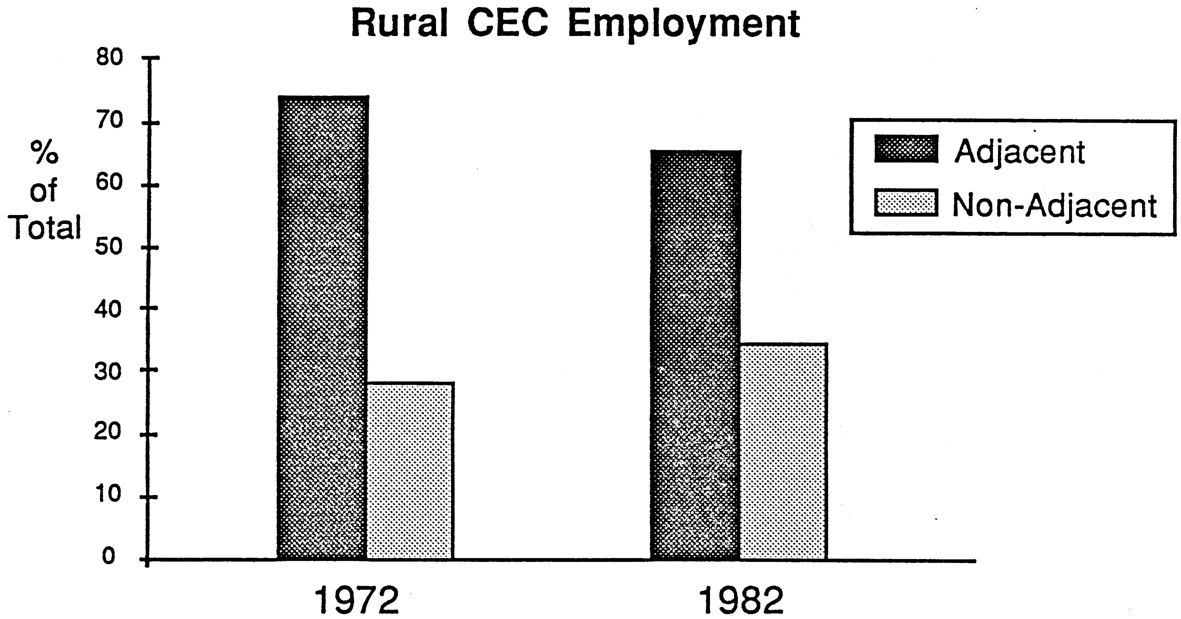
On the High Tech Bandwagon: Rural Job Gains, and Population and Manufacturing Shifts

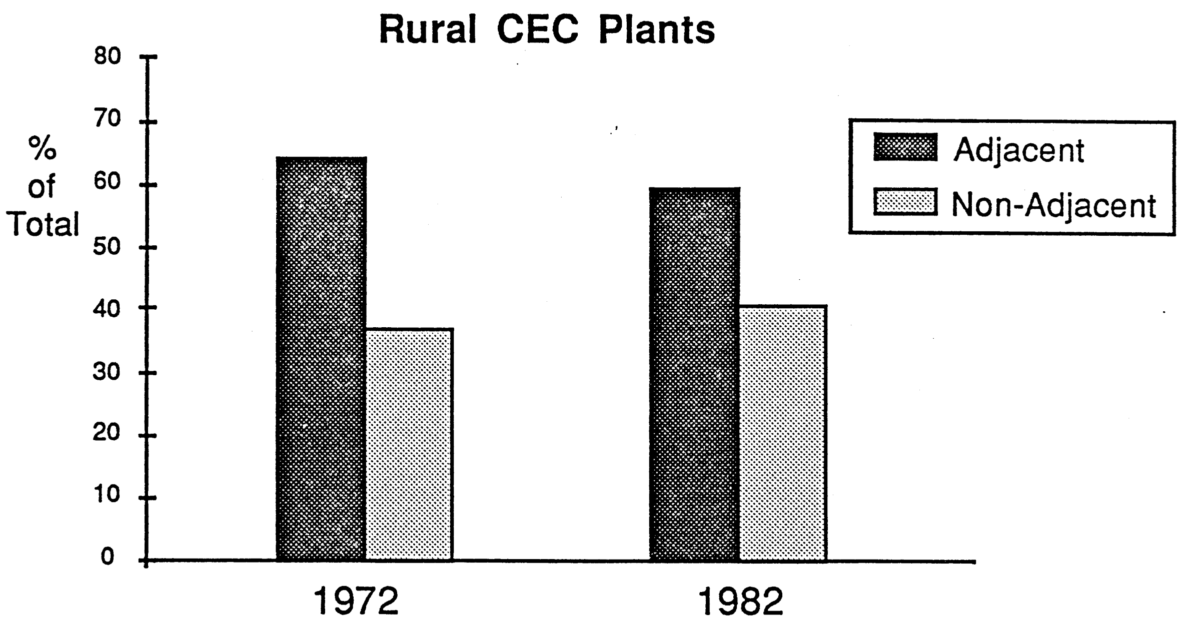
The growth of high tech jobs and plants in rural communities should be seen in context with overall changes in population and manufacturing in rural counties over the 1972-82 period. In 1980, rural counties held approximately 25 percent of the nation's population and gained 29 percent of the national population growth since 1970.

In 1982, rural counties were responsible for 20 percent of the nation's manufacturing jobs, up from 18 percent in 1972. Over this same time period, rural counties experienced a nine percent change in manufacturing employment, which equalled 30 percent of the total national change.

figure 5

Share of Employment and Plants in the Computer Electronics and Communications Industries within Adjacent and Non-Adjacent Rural Counties 1972 and 1982

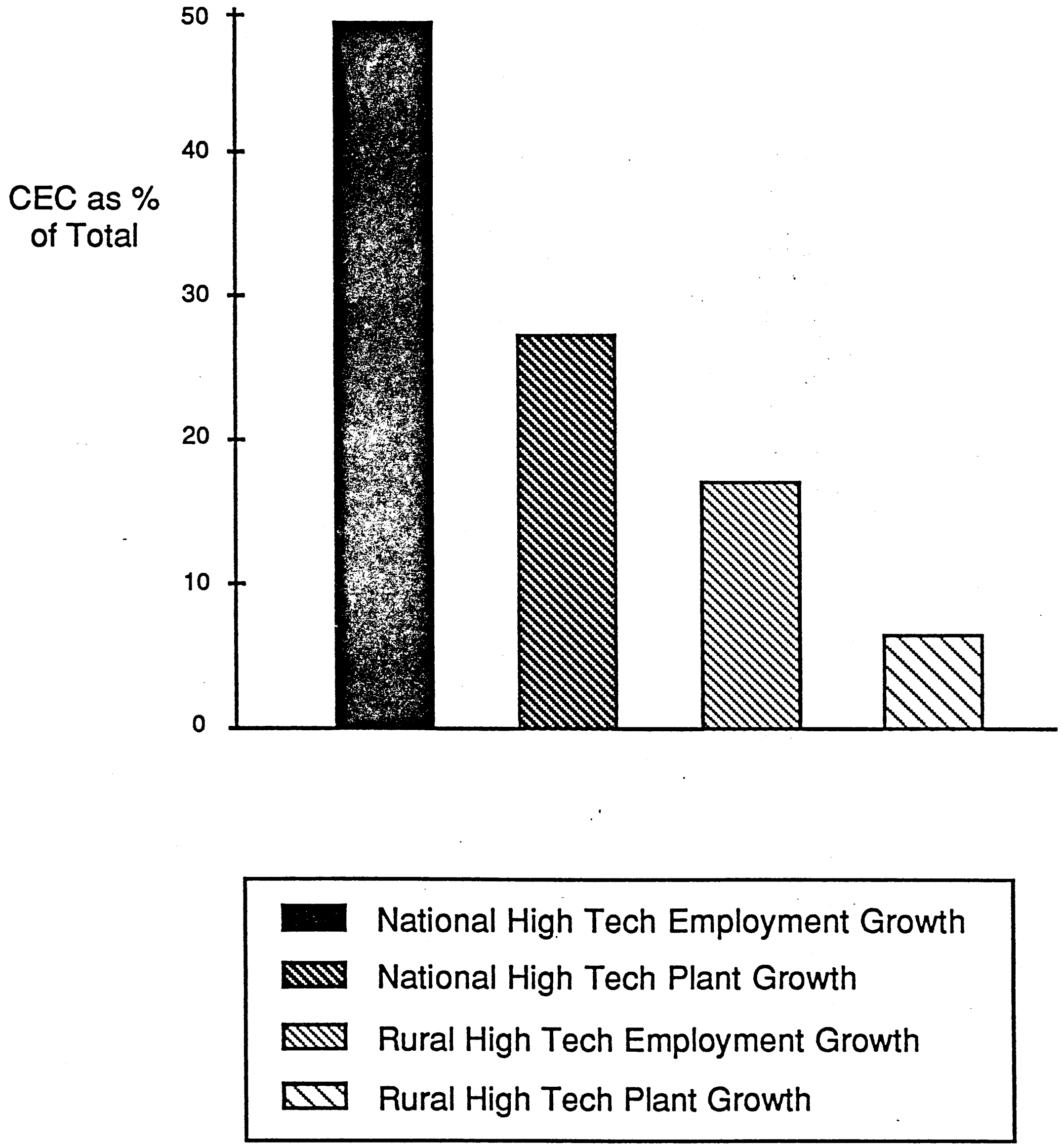




Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

figure 6

The Share Of Total High Tech Plants and Employment Growth Accounted for by the Computer-Electronics-Communications Sector for the Nation and Rural Counties 1972 and 1982



Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

High tech job gains in rural counties, while slightly above percentage changes in overall manufacturing employment (12 versus 9 percent), were considerably less than comparable gains in total manufacturing (30 vs. 12 percent) in terms of the absolute share of total new high tech jobs created over the ten-year period. While rural counties gained 30 percent of the increase in total manufacturing jobs, they received only 12 percent of total high tech job gains over the same period. Thus, in comparison with both national population and manufacturing shares and with gains in these indicators over the same period, rural high tech job shares and growth in employment over the 1972-82 period appear rather meager.

Section VI
RURAL GAINS MIRROR REGIONAL PAINS: RURAL HIGH TECH INDUSTRY, PLANTS AND EMPLOYMENT

America's rural communities are selectively distributed across the nation. That is, they are concentrated within specific regions. Historically, rural manufacturing reflects this same pattern. High tech jobs in rural counties of America's large census regions are distributed in a manner to overall rural manufacturing, although important exceptions will be noted.

The next section addresses questions of regional performance in attracting high tech and their relationship to a region's share of total high tech (metro and non-metro) and manufacturing employment. We begin with the basics by referencing a number of facts about rural America.

Where is Rural America?

In 1980, the South was America's most rural region. Almost half the nation's rural population reside within its 17 state borders. The Midwest's share of the country's rural population was also substantial, constituting 30 percent of the total. The Northeast and West, by contrast, are quite metropolitan in character, with only 17 and 12 percent of the nation's rural population.

Individual region shares of population in rural counties also indicates the rural character of the South and Midwest. Both the South and the Midwest have a considerable portion of their total population in non-metropolitan counties. In 1980, 33 percent of the South's population resided in rural counties, while in the Midwest the comparable figure was 29 percent. Again, the Northeast and West are more decidedly urban in character, with only 21 and 16 percent of their respective populations in rural counties.

A similar pattern exists in the distribution of manufacturing employment in rural counties. In 1982, 52 percent of the nation's rural manufacturing was located in the South. The Midwest also had a significant share of the nation's rural manufacturing, approximately 29 percent of the total. By contrast, the West had only 6.4 percent of the nation's rural manufacturing, while the Northeast had a slightly larger, yet still modest share of manufacturing in rural areas (11%).

On a regional basis, again the South and Midwest stand out with large shares of their manufacturing employment in rural counties. In 1982, the South had 32 percent of its manufacturing jobs concentrated in rural counties, followed by the Midwest with a smaller yet substantial share (22%). The Northeast and West had comparable shares of manufacturing in rural counties (10%).

Significantly, changes in this pattern reflect increasing concentrations of rural manufacturing in the South. Over the 1972-82 period, all regions except the South declined in shares of rural manufacturing. The Midwest experienced the most profound negative shift of manufacturing jobs. Over the period studied, national manufacturing growth was essentially static. Hence, these changes were reflected as absolute increases in the South's share of the nation's rural manufacturing employment from 49 to 52.1 percent (Table 6.1).

Regional Shifts: Regional Distribution of Rural High Tech Employment

Regional shifts in high tech industry mirror overall population change moving away from the Northeast and Midwest and toward the South and West. The location of high tech industries clearly reflects these larger trends.

While in 1972, total high tech employment was concentrated in the Midwest and Northeast, by 1982 the South emerged as the region with the single largest concentration of high tech jobs in the Nation (Table 6.2). The location of rural high tech jobs also follows this pattern, although a few exceptions are noted.

In 1972, rural high tech employment was almost evenly divided between the Midwest and South, with the Northeast and West capturing the residual (Table 6.3). By 1982, the Midwest, in particular, had lost its position of prominence, and fell significantly behind the South as the locus of the nation's rural high tech manufacturing employment.

The South contains 45 percent of the nation's rural high tech employment (Figure 7). This figure is up <u>substantially</u> from 1972, when the South accounted for only 37 percent of the nation's total rural high tech employment. While this is clearly below the region's share of rural manufacturing, nonetheless, the South's share of the nation's rural <u>high tech</u> is substantially above its share of total high tech employment (43 vs. 26%).

In contrast, the Midwest's share of the nation's rural high tech jobs declined over the period studied. Over the ten-year period, the region's share of rural high tech fell by almost five percentage points (37 vs. 33 percent). Still, high tech jobs in rural areas of the Midwest are slightly above the region's share of rural population (32%). Importantly, given these shifts, the Midwest's share of national rural high tech is still above its share of all high tech jobs (33% vs. 25%).

The long-term consequences of this pattern are worrisome. That both metropolitan and rural high tech employment in the Midwest declined since 1972 indicates just how intimately tied rural high tech is to overall regional trends in high tech employment. Rural communities in the Midwest enjoyed growth in high tech industries as companies fled their historic metropolitan locations. This pattern of metropolitan abandonment has

Table 6.1

Percent of Total Rural Manufacturing in the Four Census Regions 1972 and 1982

Census Region	1972	1982
Northeast	12.4	11.2
Midwest	30.3	29.0
South	49.4	52.0
West	8.0	8.6

Source: Bureau of Economic Analysis Compiled for the Economic Research Service, United States Department of Agriculture, Washington D.C. 1986.

Table 6.2

Proportion of High Tech Employment in Four Census Regions 1972, 1977 and 1982

Census Region	1972 (% of nation)	1977 (% of nation)	1982 (% of nation)
Northeast	29.72	27.79	25.95
Midwest	31.03	29.97	25.21
South	22.63	24.23	26.25
West	16.63	18.00	22.59

Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

Table 6.3

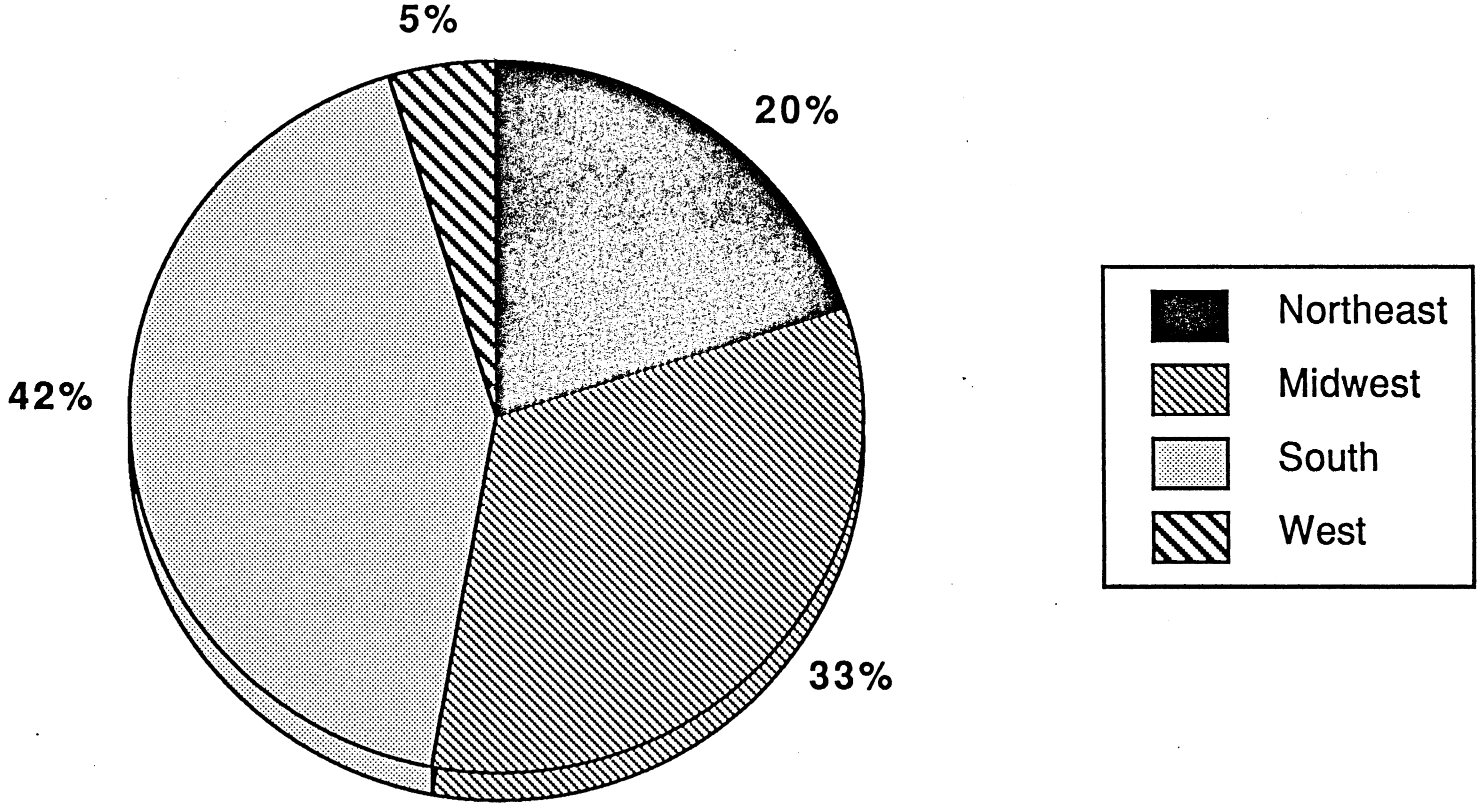
Regional Shares of Rural High Tech Emplyment 1972 and 1982

Census Region	1972	1982
Northeast	23	20
Midwest	37	33
South	37	43
West	3	5

Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

figure 7

Regional Shares of High Tech Employment 1982



Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

abated now, and thus rural communities in the Midwest may not be able to count on further decentralization to bring high tech jobs their way.

The Northeast and the West exhibit different trends in the distribution of high tech jobs in rural areas than either the Midwest or the South. Over the ten-year period, states in the Northeast lost manufacturing jobs overall, falling from 27 to 23 percent of the nation's manufacturing employment. A similar, but less dramatic shift occurred in rural manufacturing, which declined from 12.5 to 11 percent.

Given the overall decline in manufacturing, the Northeastern region's manufacturing base actually became proportionately more high tech (28 vs. 31%). That is, declining jobs in traditional industries were, in part, replaced by the growth of high tech industries. The same can also be said of rural manufacturing within the region, which declined overall and yet experienced rising shares of high tech jobs.

The percentage of high tech jobs in rural areas of the Northeast approximately equals the percentage of the region's population (10%) in rural areas, and is also essentially the same as the percentage of the region's share of the national rural population. Over the ten-year period, the share of that region's high tech employment in rural counties remained constant, at 11 percent.

The West presents its own unique pattern of high tech jobs in rural areas. Differing from the other regions, the West has a much larger proportion of total high tech jobs to population--only 18 percent of the nation's population, yet 23 percent of the nation's total high tech jobs.

The same pattern cannot be said to reflect the ratio of population to rural high tech jobs shares. Sixteen percent of the Western region's population resides in rural areas. But the West's share of total rural high tech employment and plants is only five percent. This figure showed very modest change over the ten-year period. In 1972, the West had a percent of the nation's rural high tech jobs and, by 1982, this figure had increased to 4.8 percent. Thus, there is a great divergence in the West's share of rural high tech in comparison with the region's rural population.

Even more remarkable, only three percent of the Western region's total high tech jobs are in rural counties. These figures are far below what would be expected based solely on manufacturing distribution in the region. By way of comparison, rural areas in the West contain 8 percent of the region's total manufacturing jobs. This is particularly noteworthy as the West contains over 20 percent of the nation's total high tech jobs, and gained 45 percent of all new high tech jobs created in the nation over the 1972-82 period.

Figure 7.1 provides a graphic summary of the importance of high tech jobs in rural counties of the four large census regions. We calculated location quotients for total high tech jobs. This measure accounts for industry specialization relative to some aggregate; in this case, rural population.[6] The striking finding is the rare instance where the share of a state's rural high tech is above its share of rural population. And in those cases, the explanation relates more to the state's overall population--which is decidedly rural--than it does to an inordinate amount of high tech jobs found in rural areas. In the case of all high tech industries, we see two states in the Midwest, two in the Middle Atlantic region, and one in the South with high tech jobs above the state's share of rural population. This only reiterates what has already been said regarding the modest presence of high tech jobs in rural communities of the U.S.

Where are the Factories? Plant Distribution in Rural Counties

Contrasting patterns between the distribution of high tech plants and measures of regional population and manufacturing employment are also apparent. The West has far fewer numbers of plants in rural areas than expected based on either population or manufacturing. In contrast, the Midwest and Northeast have levels of plants close to their shares of the nation's population and manufacturing.

By this measure--plant distribution compared to population and manufacturing employment--the South exhibits the greatest divergence between plants and other measures of regional size. The South has only 20 percent of the nation's rural high tech plants as compared with 43 percent of the nation's total rural high tech employment. This means, on average, high tech plants are larger in the South relative to other regions. This pattern is characteristic of Southern manufacturing, which has predominantly consisted of modest plant growth and significant employment change. Over the last 20 years, the South has been a primary target of branch plant location (Armington, Harris and Odle 1983; Malecki 1985; Glasmeier 1987). This suggests that the South has emerged as the quintessential region of production in the country. As with other measures previously discussed, high tech has tended to mirror aggregate trends rather than setting new ones.

Explanations for Rural High Tech Industry Distribution

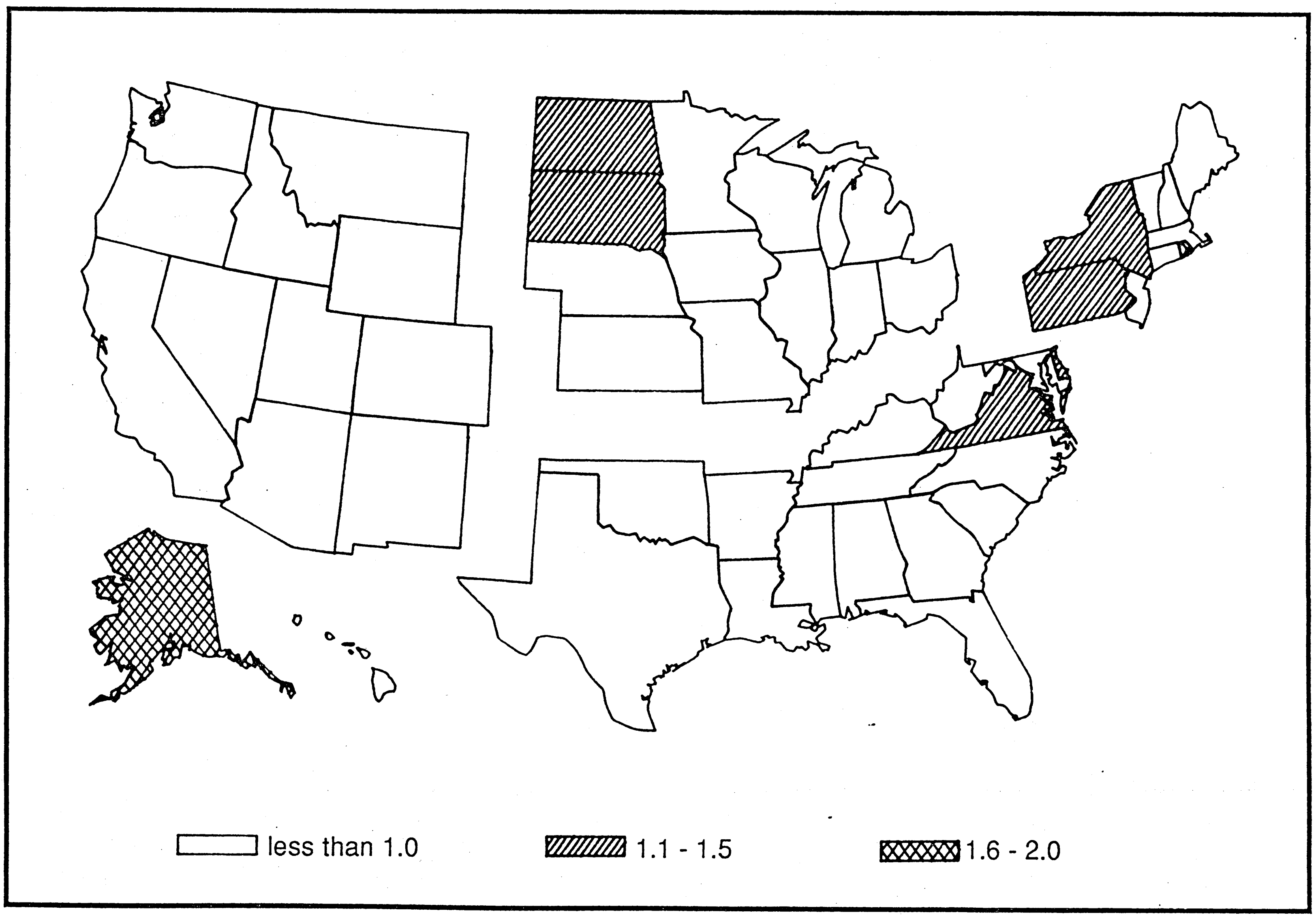
This distribution among regions--rural high tech concentrated in the Midwest and South, yet almost completely absent in the West--has at least two explanations. First, there are the early attempts to decentralize manufacturing, including high tech, in traditional manufacturing regions of the Northeast and, more importantly, the Midwest. General manufacturing in the Midwest has been decentralizing toward the region's rural counties for some time. Over the 1972-82 period alone, rural manufacturing as a percent of the regional total increased from 19 to 23 percent in the Midwest. No other region exhibited a similar trend of increasing manufacturing in rural areas.

While general manufacturing levels are high in rural counties of the South, the region's relative under-representation of high tech plants and employment may be due to labor constraints. These constraints limit the region's ability to sustain significant levels of high-skilled and lower-skilled production jobs of the type needed for high technology production. Firms have also increasingly chosen some alternative options--including offshore production and decentralization within the home region (to suburban and nearby rural hinterland locations in the Midwest and Northeast) and, finally, automation of existing production capacity--rather than shifting jobs to the South.

In striking contrast, the West contains little rural high tech employment or plants, in spite of its major role as the nation's premier region for new high tech growth. Companies have obviously chosen among several locational options for carrying out low-skill production. They shift low-skill jobs abroad, completely bypassing the region, or job shifts occur between regions, most notably between the West and South. Companies have also chosen to capital-intensify their production processes and thereby reduce entirely their need for low-skilled labor inputs. All of these alternatives explain, in part, the poor showing for high tech in Western rural areas. Later analyses, discussed in following sections, confirm this trend.

figure 7.1

Location Quotients of Rural High Tech Employment by States within Census Regions



Section VII
STRATEGIC SECTORS' SHORTCOMINGS CONFRONT RURAL COMMUNITIES

The previous section presents a sweeping view of high tech industries in rural counties of the United States. At an aggregate level, high tech industries mirror changes underway in the overall organization of population and economic activity in the country. But what of the truly dynamic sectors within high technology industries--those few which were unmitigated job generators over the ten years? Has location of these industries followed the course of high tech industries overall, thus adding to the pre-existing base of rural communities in the country, or do they march to another tune?

The following section looks in detail at defense-dependent and electronics-related high tech industries in rural counties. This discussion is then extended to the level of individual states. There it becomes apparent that rural high tech jobs and plants are concentrated in a distinct minority of states within the U.S.

The Military-Industrial Complex: Defense-Dependent (DDS) Rural High Tech

A regional examination of DDS employment reveals a highly skewed pattern where almost 40 percent of the nation's total employment in these industries is concentrated in the Western United States. The Northeast is a distant second in terms of national shares (24%). The Midwest and South have levels far below their share of total high tech employment (19 and 21%).

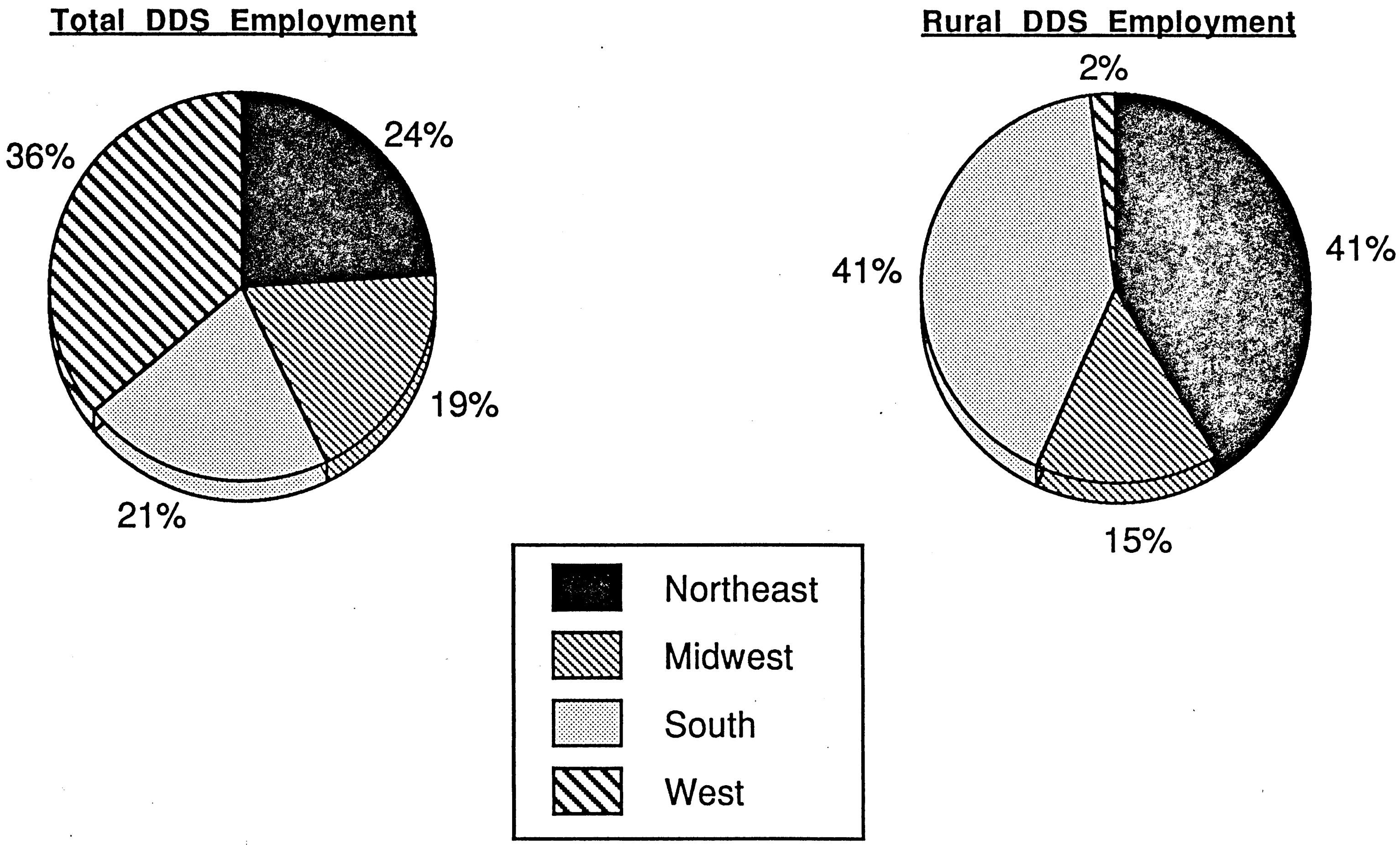
Regional shares of total rural DDS employment, on the other hand, run counter to the aggregate regional distribution of total DDS employment (Figures 8.1 and 8.2). The Northeast and South each contain 41 percent of DDS rural employment. The Midwest has a much smaller share, 15 percent, and the West, an insignificant two percent. This result is surprising given the significant concentration of these industries in the Western U.S. This divergence is one indication of major differences in both the composition and maturity of DDS employment across regions, and thus deserves comment.

The West has long been a center of strategic R&D and so DDS employment in the region is more likely to be technical in nature in comparison with that of the Midwest and South. By contrast, the South contains more mature and mundane aspects of DDS employment, a point made in work by other authors (Schlessinger et. al. 1983). With a few noted exceptions, such as aircraft production in Georgia and missile assembly in Alabama, defense-dependent production in the South consists of routine equipment assembly.

Regardless of the regional distribution of rural DDS employment, no more than 15 percent of total regional DDS employment is located in rural areas for any one region. That is, in all four regions, DDS is a highly metropolitan phenomenon. For example, the Midwest and West each have less than six percent of their total DDS employment in rural areas. The Northeast and South have approximately 15 percent of their employment in rural areas. It is therefore unlikely that rural communities can count on this source of employment to offset losses in other sectors. (Figure 8.3 identifies states in which the

figure 8.1

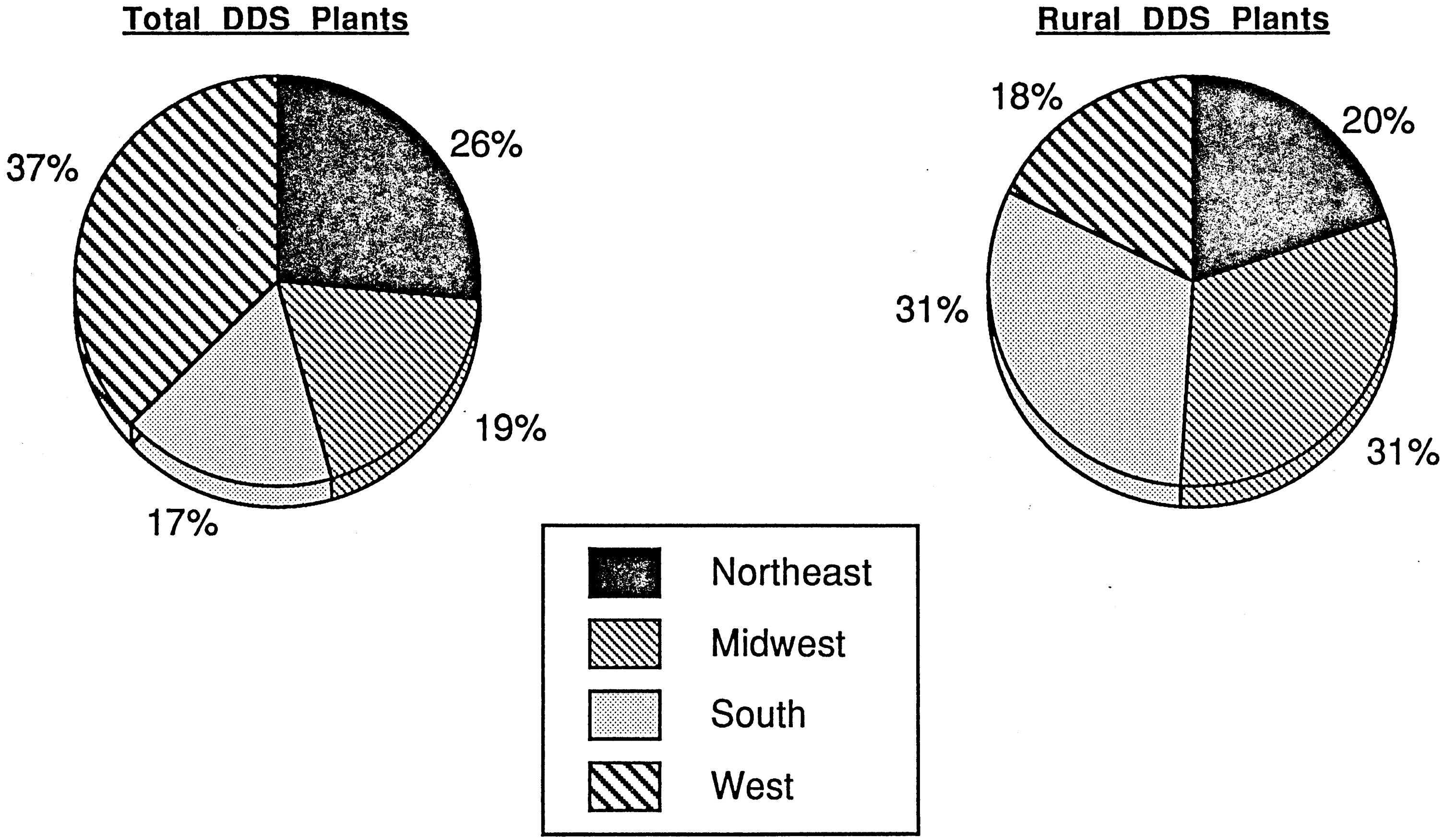
Regional Shares of Total DDS Employment and Rural DDS Employment



Source: Bureau of the Census, 1986, <u>Census of Manufactures, Plant Location Tape</u> (1972, 1977, 1982).

figure 8.2

Regional Shares of Total DDS Plants and Rural DDS Plants



Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

figure 8.3

Location Quotients of Defense-Dependent-Sector Employment in Rural Counties by States within Census Regions

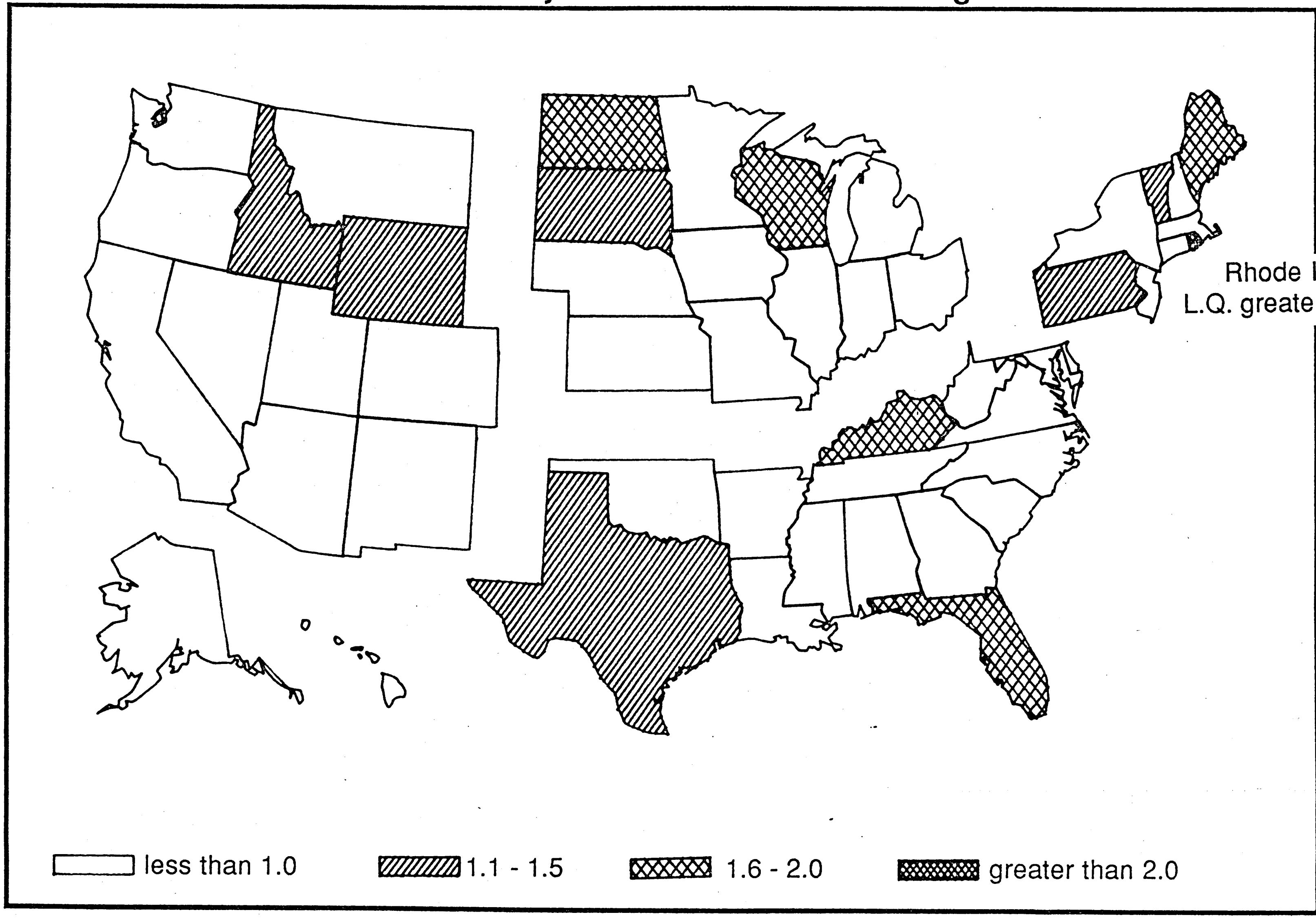
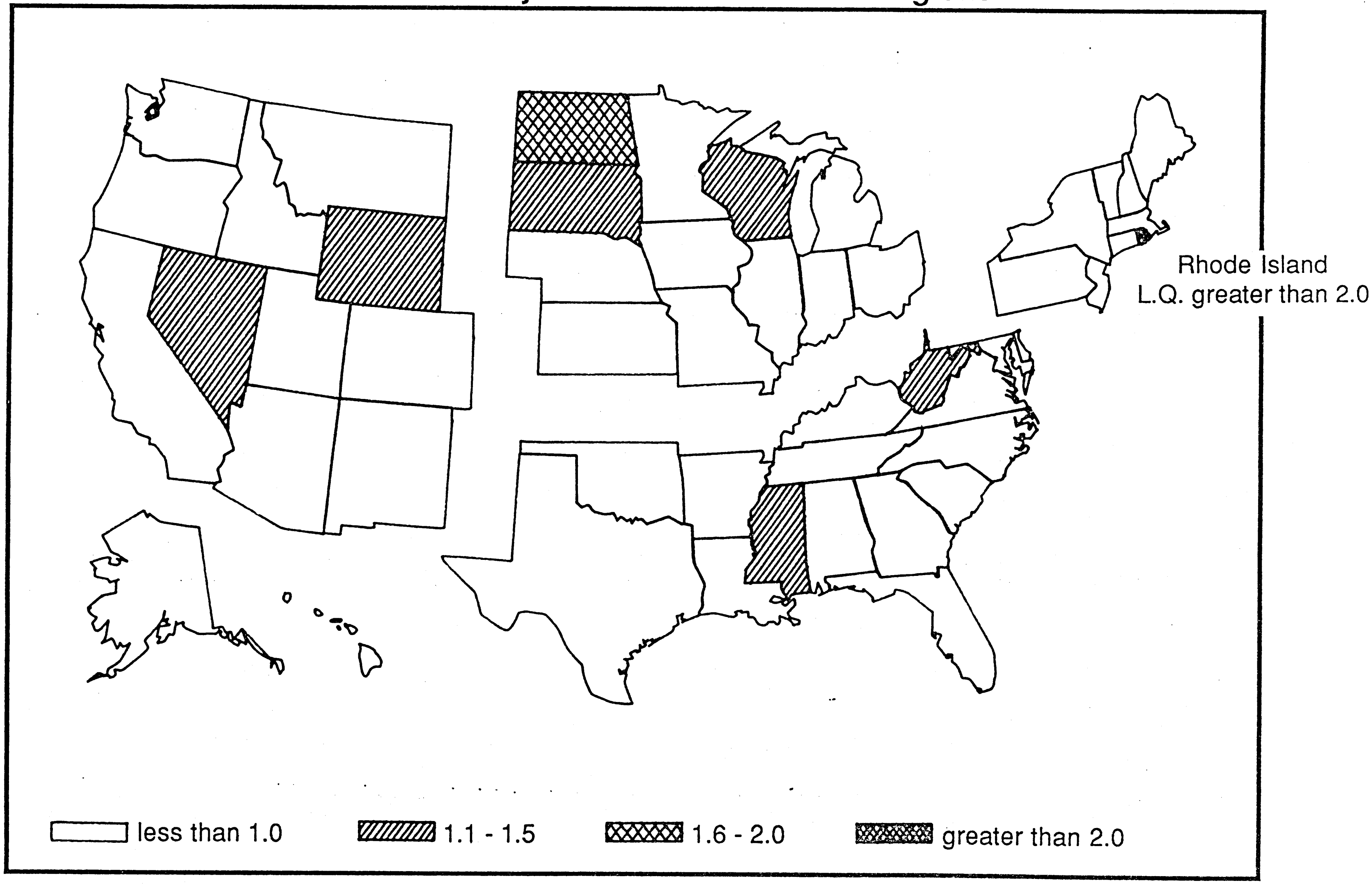


figure 8.4

Location Quotients of Computer-Electronics-Communication Employment in Rural Counties by States within Census Regions



ratio of Defense-Dependent employment to rural population is greater than a comparable ratio at the national level).

In spite of national policies of the 1940s and 50s to decentralize defense-dependent employment and plants throughout the country, rural communities appear to have benefited very little. Given that these sectors, at least theoretically, are more amenable to political debate and pork-barrel procedures in Congress, it is particularly alarming that rural areas have gained so little of the employment and plants in DDS-related high tech industries.

Computer Clusters: Computer-Electronics-Communications (CEC) Sectors

Like defense-dependent high tech sectors, employment in the computer-communications and electronics (CEC) complex are highly concentrated in the West. Forty percent of total CEC employment and plants is in the West and this pattern of concentration has only increased over time. The Northeast, by comparison, contains approximately 30 percent of the nation's employment and plants in these sectors. The residual is shared among the South and Midwest, with 21 and 12 percent of the nation's total employment and plants (Table 7.1).

However, the distribution of CEC industries within rural areas of the four regions is quite low. The Midwest, for example, has the highest proportion of regional employment and plants in rural areas, 15 percent, followed by the South with 7 percent and the Northeast with 6 percent of the region's total CEC employment in rural areas. Again, as with the other industry groupings, the West's insignificant share of total regional industry employment in rural areas (1.3%) suggests two very distinct components of these industries are distributed differentially among regions--first, management and R&D largely located within metropolitan areas within the West and Northeast and second, production branch plants located in rural-adjacent communities of the Midwest and the South. (Figure 8.4 identifies states in which the ratio of Computer Electronics-Communications employment to rural population, is greater than the national ratio).

The West is a longstanding center of innovation in these industries. To the extent there has been regional-based decentralization, corporations headquartered in the Midwest and Northeast have both shifted lower-skilled jobs into their rural hinterlands and higher- and lower-skilled jobs and branch plants to the South.

Data analyzed here do not allow confirmation of specific shifts. For these, it would be necessary to track individual company relocation decisions over time. Other researchers, however, using data on enterprises, do show that the South's high tech employment consists primarily of branch plants of companies headquartered in the Midwest and Northeast (Malecki 1985, Armington, Harris and Odle 1983). Anecdotal evidence also substantiates branch plant shifts from companies headquartered in the West. These shifts represent largely inter-metropolitan relocations, as opposed to shifts from metropolitan to non-metropolitan areas.

Table 7.1

Regional Shares of CEC Emplyment and Plants in Rural Counties 1982

Census Region	Employment	Plants
Northeast	27	12
Midwest	12	43
South	21	32
West	40	12

Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

PART III

Section VIII
UNMASKING HIGH TECH LOCATION

Rural High Tech Jobs, Individual States

From this analysis, we can see just how similar rural high tech location and change has been to larger developments within the nation as a whole. But to simply stop here would obscure the highly concentrated nature of high tech employment location within the United States. Left with only a regional view, policy makers might erroneously conclude that rural areas within any region have an equal chance, or an equally slim chance, of attracting these industries. By turning now to the state level, we will show the quite specialized location of these industries and dispel any misconception that high tech jobs are randomly distributed among U.S. regions.

Using a broad definition of high tech, each of 20 states had 2 percent or more of the nation's rural high tech employment. Ten states in the South and eight in the Midwest make up a majority in the group (Figures 9.1 and 9.2). In fact, just three states in the Midwest, IN, IL, OH, account for 16 percent of the nation's rural high tech manufacturing. The remaining 5 states account for an additional 31 percent. More striking still, 10 states in the South account for 35 percent of the nation's rural high tech. Clearly, using a broad definition of high tech, the dual pattern of decentralization--from metro areas in the Midwest and, secondarily, the Northeast to their rural hinterlands and interregional shifts of jobs from the Northeast and Midwest--is very apparent.

DDS and CEC Rural Employment, State View

More restrictive definitions of high tech reveal a far more concentrated pattern of rural high tech employment distribution. In the case of DDS, 10 states account for 73 percent of DDS rural employment (Figure 10.1). Three states in the Northeast and three in the South contain 63 percent of total DDS employment in rural counties. Although states in the Midwest are modestly more represented in this group (4 states), their share of rural DDS is much less significant (10.6%). In spite of the West's clear dominance in overall shares of DDS employment and plants, not one state in that region contains more than 2 percent of the nation's rural DDS employment.

Shares of DDS plants are more widely distributed than employment. Sixteen states accounted for 59 percent of DDS rural plants (Figure 10.2). As expected, states in the Midwest and South dominate the group (with 5 states each) and together account for 40 percent of rural DDS plants. In contrast with the results on employment, two states in the West, OR and WA, together account for 6 percent of the national's rural DDS plants.

The final group of industries in the CEC sectors suggests an even more concentrated distribution of rural manufacturing in states in the Northeast and Midwest. Sixteen states account for 76 percent of rural CEC employment. Twenty-eight percent of the

figure 9.1

States' Share of National Rural High Tech Employment

1982

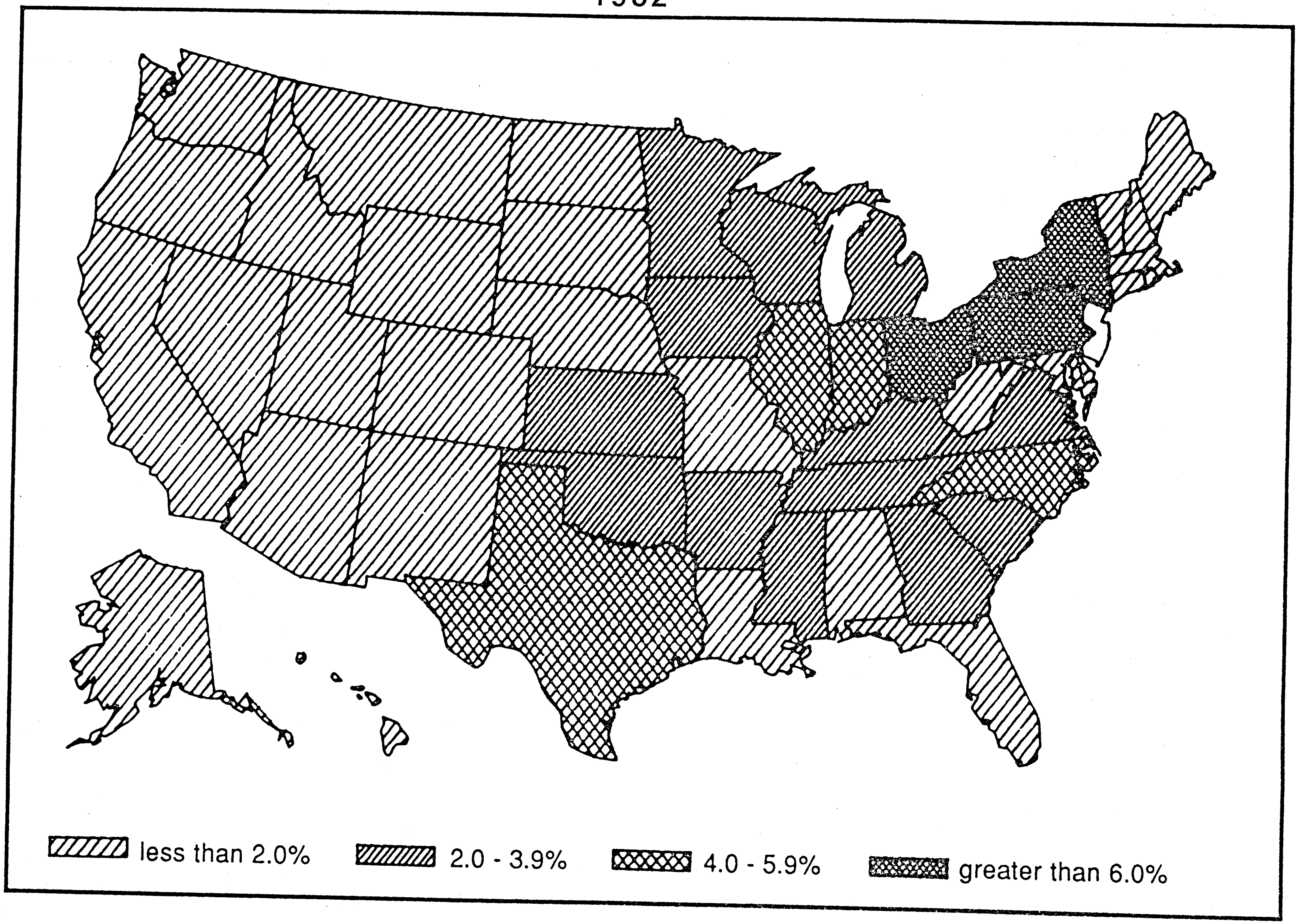


figure 9.2

States' Share of National Rural High Tech Plants 1982

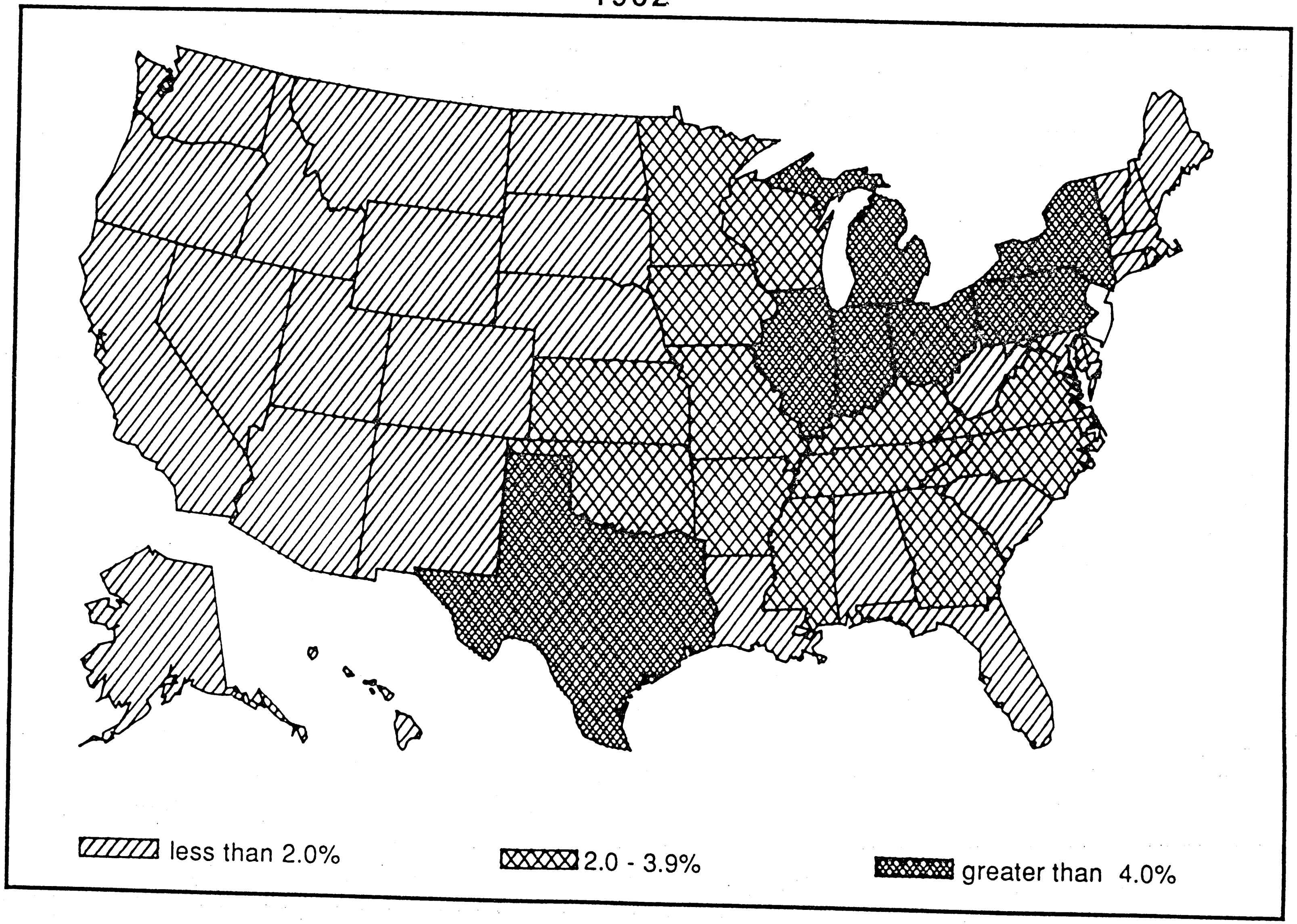


figure 10.1

States' Share of Rural Defense-Dependent Sector Employment 1982

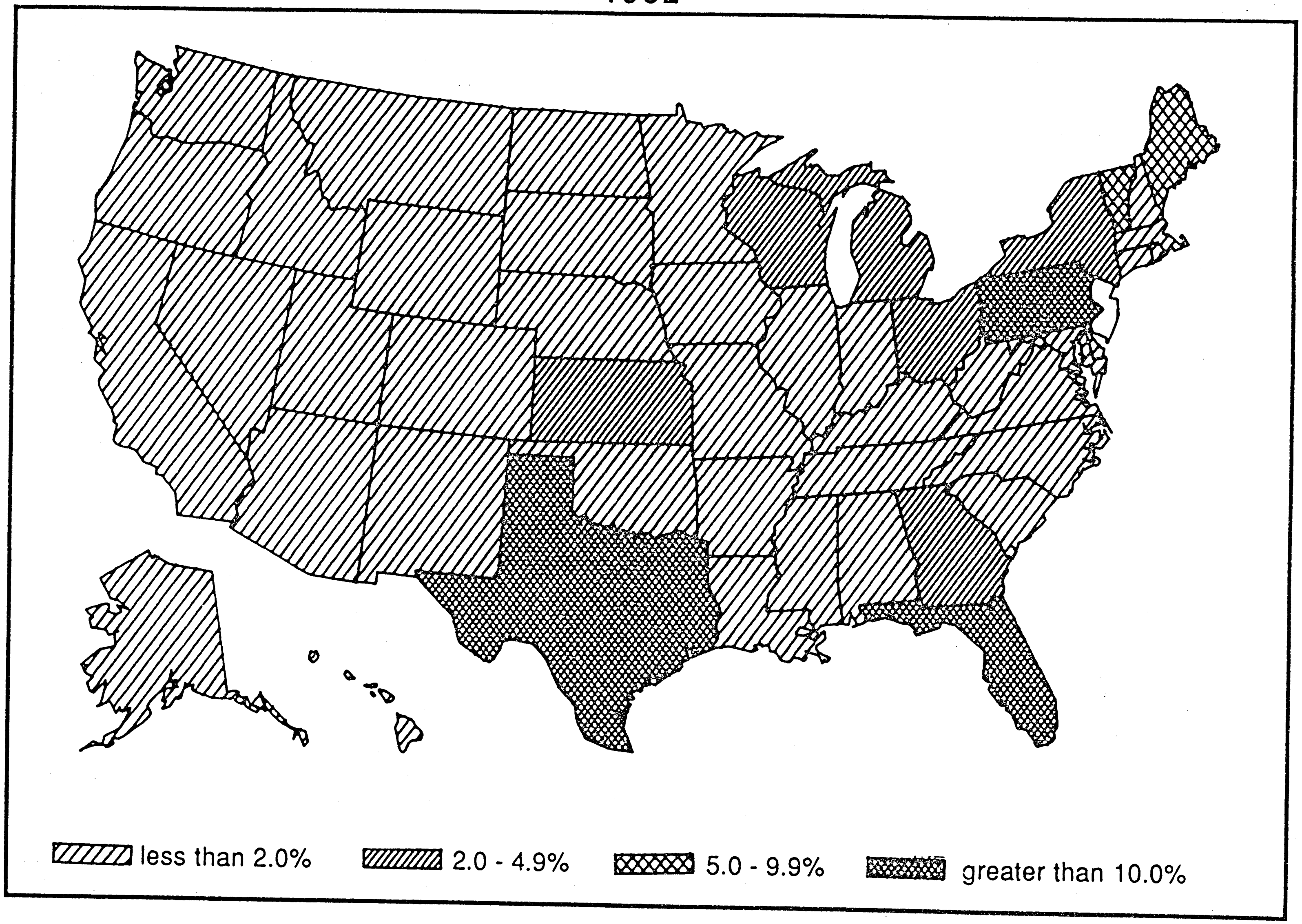
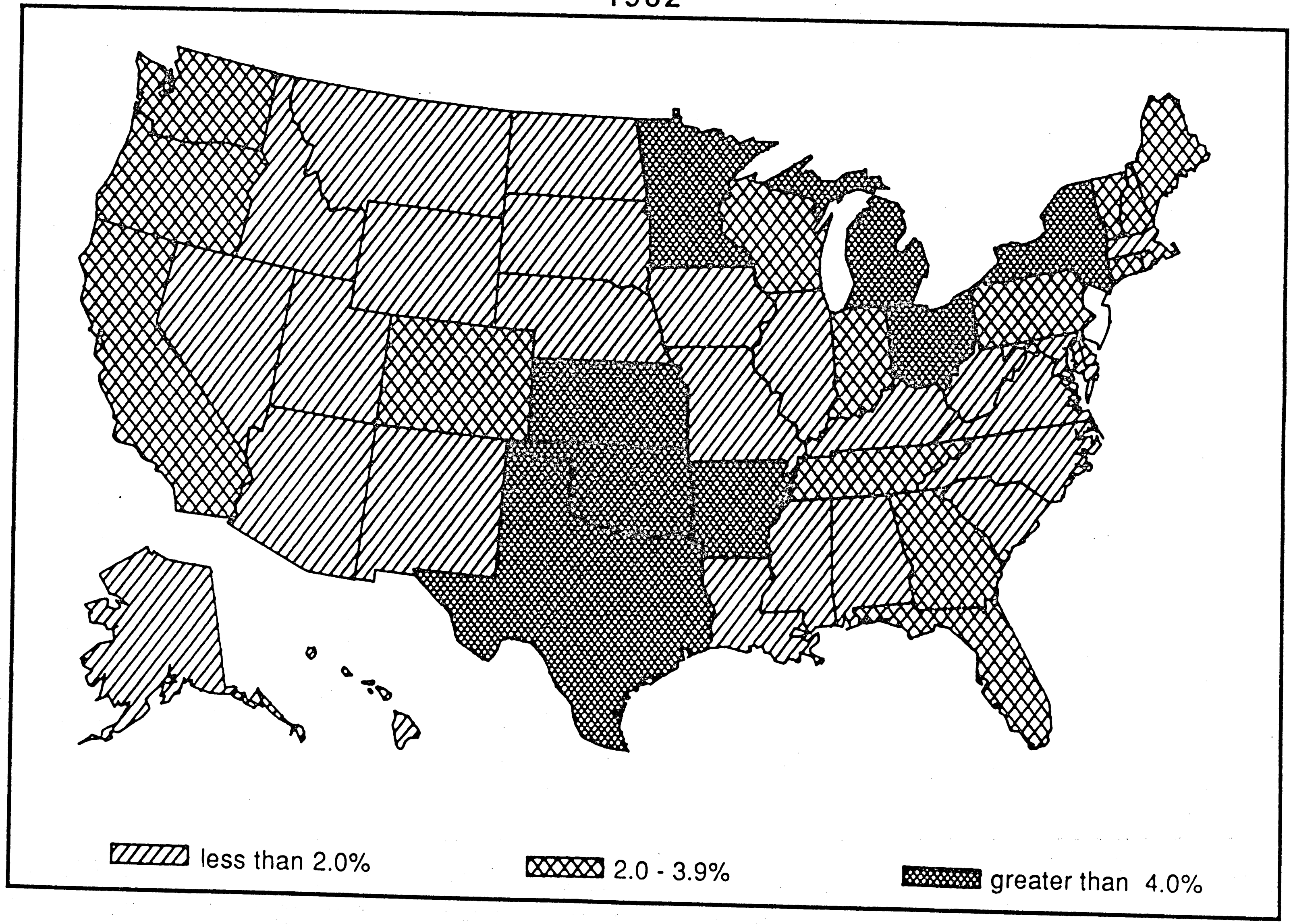


figure 10.2

States' Share of Rural Defense-Dependent Sector Plants 1982



nation's rural manufacturing in the CEC sectors is concentrated in Northeastern states (Figure 11.1 and 11.2). New York alone has 11 percent of the nation's total rural CEC employment. States in the Midwest comprise 25 percent of all CEC rural manufacturing, half in one state alone, Minnesota.

Three states in the South comprise 15 percent of the nation's rural CEC manufacturing, with almost nine percent of the nation's rural CEC employment in Virginia. Only two states contain two percent or more of the nation's rural CEC employment in the West. California, while having 36 percent of the nation's total employment in the CEC sectors, has only 3.3 percent of the nation's rural manufacturing in these sectors.

This highly skewed distribution among only a few states can be attributed to the influence of individual companies. In New York, IBM has long had a policy of plant location in relatively undeveloped areas outside metropolitan centers. In Minnesota, Control Data Corporation also has a similar locational policy--placing plants in rural-adjacent counties. The concentration of CEC employment in Virginia is directly related to federal government communications operations located there and its proximity to the Nation's capitol.

The lack of randomness in these locational distributions suggests that rural CEC is not distributed in an unbiased fashion. This enduring pattern of concentrations, in fact, suggests that existing policies to spread CEC employment more evenly around the country have had little influence in the past and small chance of success in the future. Rural CEC location is tied either to unique circumstances of individual corporate decisions, or to federal government installations. Both conditions are outside the domain of local policy.

Are there any efforts a local policy makers could undertake to attract employment in CEC sectors? It seems doubtful that many rural communities have the necessary prerequisites to catch a high tech firm locating a plant in the CEC sectors. However, communities can support local entrepreneurs like Don Hamer of State of the Art Inc. Support of local entrepreneurs and existing manufacturing might produce greater returns than those derived simply from branch plant location decisions, by providing greater growth in employment and a better base for further development.

figure 11.1

States' Share of Rural Computer Electronics and Communications Sector Employment
1982

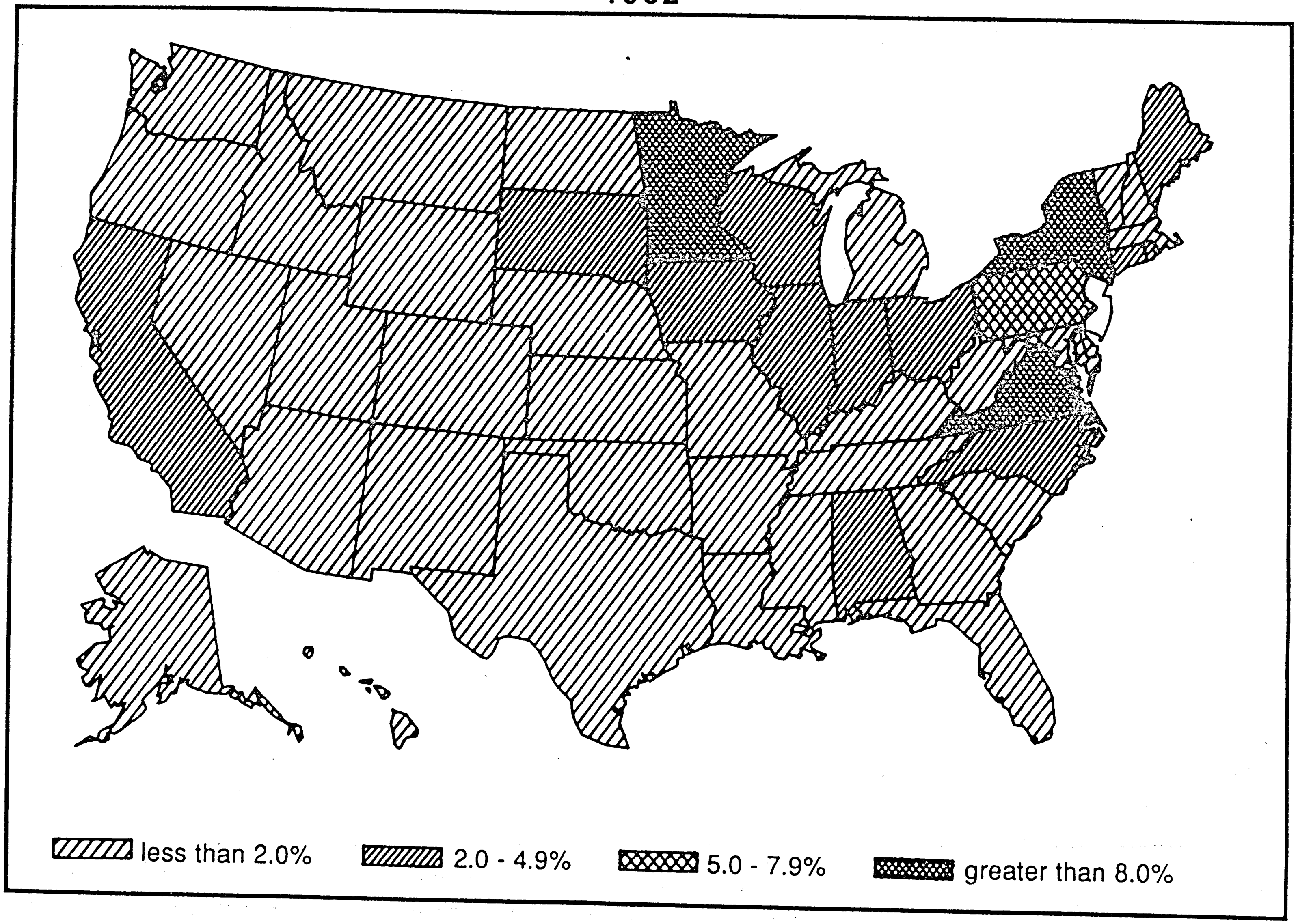
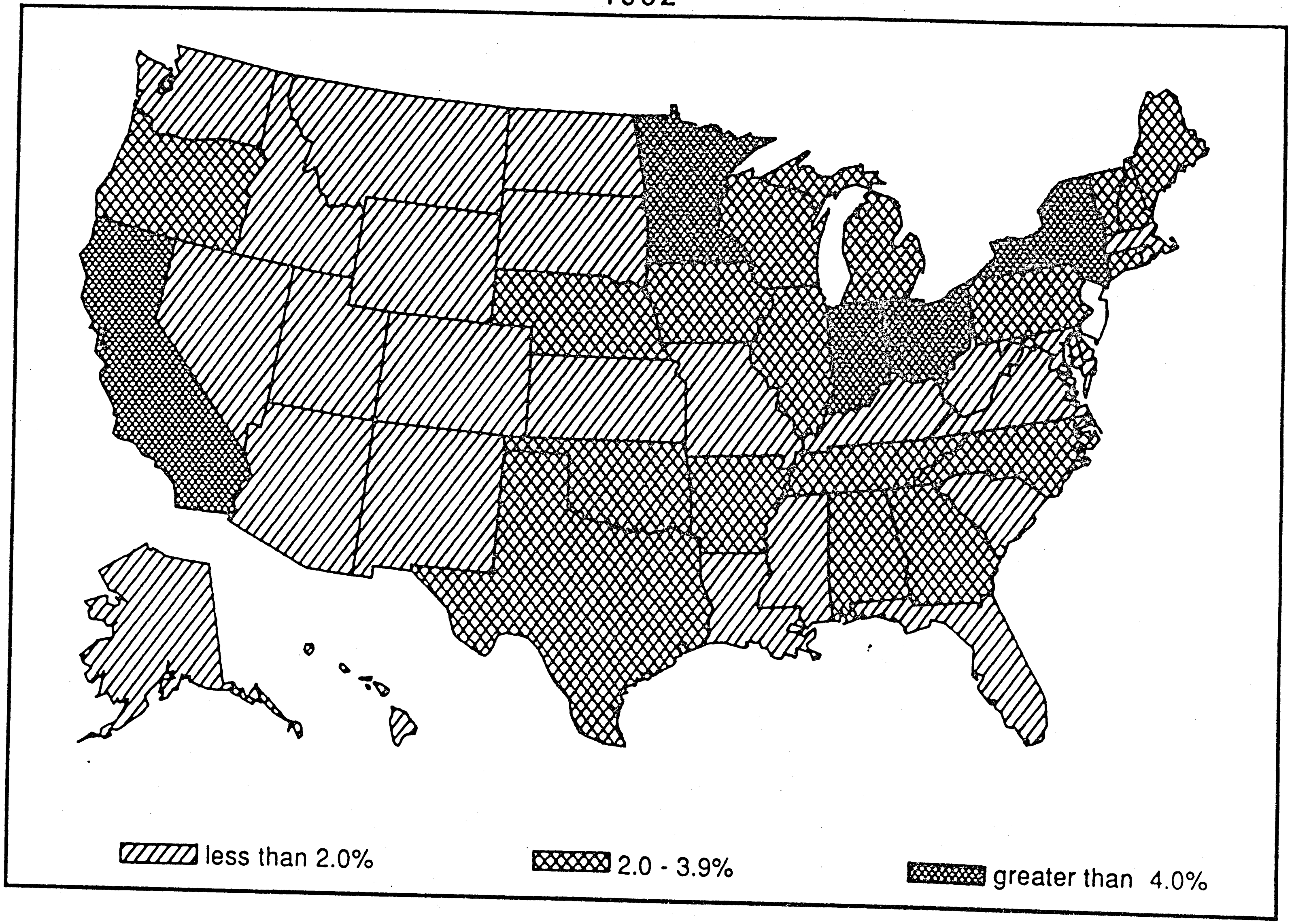


figure 11.2

States' Share of Rural Computer Electronics and Communications Sector Plants
1982



Section IX
FACTORS INFLUENCING RURAL HIGH TECH PLANT AND EMPLOYMENT LOCATION

Introduction

Previous sections alluded to a dual pattern of high tech manufacturing decentralization--within regions to their hinterlands and, more recently, toward markets and labor supplies in the South and West. There are obvious implications for rural communities based on this pattern of decentralization. If, earlier rounds of high tech growth indeed consisted of shifts from metro to non-metro counties in the industrial heartland, we should be able to detect this by examining the relationship between rural-adjacent high tech manufacturing[8] and characteristics of metropolitan areas. The product cycle model, is central to this prospect. Similarly, if labor quality in more recent times became more central in determining high tech location, then changes in the location of rural-adjacent high tech employment should reflect this new development. In this case, insights from the spatial division of labor thesis apply.

The implications of such a two-fold development are straightforward. First, what drove rural high tech location in the past, toward outlying counties in the Northeast and Midwest, cannot be counted on to provide a flow of manufacturing jobs to rural areas of America's industrial heartland in the future. This limited period of decentralization occurred as firms searched initially for low-wage, non-union environments. The composition of these high tech jobs was importantly related to the maturation of products. Thus, jobs which did decentralize fit a product cycle model of development wherein firms shifted jobs to rural areas in industries past their prime. Even shifting jobs toward low-cost areas was not enough to stave off further declines in these industries, and many rural communities in these two regions continued to lose high tech jobs. In the future, given recent cost-cutting efforts and resulting plant closures, there is likely to be little employment of this type suitable for decentralization to rural counties.

The more recent period of decentralization emphasizes labor markets capable of providing adequate pools of low <u>and</u> high skilled workers. This means rural communities closer to metropolitan areas will stand the best chance of attracting high tech in the future. Long-standing problems of rural areas--inadequate infrastructure, poorly skilled workers, and a lack of critical mass of both population and jobs--will only heighten the uneven distribution of high tech jobs among rural communities.

This section reports results of regression analyses of the relationship between rural-adjacent high tech employment and plants and their coterminous metropolitan areas. The analysis summarizes the relationship between metropolitan and non-metropolitan areas in the contemporary period, and it evaluates the effect particular policy-relevant variables, such as two- and four-year post secondary institutions, might have on rural-adjacent high tech growth of employment and plants.

Hypotheses Guiding the Analysis

The regression study was guided by the two central conclusions noted in previous sections. Two periods of decentralization resulted in high tech jobs locating in rural counties of the U.S. The first emphasized labor costs and the costs of doing business and led to intra-regional shifts of high tech jobs from metropolitan to non-metropolitan areas. The more recent period of decentralization emphasizes labor characteristics and access to high- and low-skilled labor. This resulted in intra-regional decentralization toward pools of these types of workers concentrated in selected metropolitan areas and adjacent rural counties primarily in the South and West.

Given early rounds of manufacturing decentralization within traditional manufacturing states, we expect absolute levels of metropolitan non-metropolitan relationships to be characterized by factors associated with the in-place costs of doing business--for example, levels of unionization.

At the same time, the analysis includes variables measuring the "health" of metropolitan areas--e.g. population growth, income growth and job growth--and we would expect these factors to be negatively correlated with the absolute distribution of high tech employment and plants. That is, cities with large concentrations of high tech jobs and plants in adjacent rural areas should have high relative levels of unionization and experience slow or negative growth in population, income and migration over the period studied. We might also find that size of city--as measured by surrogates such as air service or the availability of arts--would also be associated with rural-adjacent high tech jobs and plants. Given that the largest cities in states in the industrial heartland experienced losses of manufacturing jobs--presumably at least some of which decentralized to rural areas--we expect high levels of rural-adjacent high tech jobs and plants surrounding these cities.

Negative correlations between metropolitan characteristics and high tech distribution are expected since high tech plants and employment are concentrated in regions which have recently fallen on hard times due to global economic restructuring. In the earlier period of decentralization, then, firms' motives were primarily to reduce costs of production and, in many instances, to escape unions.

The second trend--a shift toward new markets and labor supplies in the South and West--corresponds to the more recent round of high tech decentralization, largely reflecting interregional shifts. In this instance, high tech industries in the more recent period are also constrained by labor requirements restricting location to cities where both skilled and unskilled labor are available. As high tech companies in the Midwest and Northeast reached a size where they considered new facilities, they followed general manufacturing trends and shifted production toward the Sunbelt. Thus, more recent shifts occur in search of lower-cost locations and labor but importantly, also in search of new markets.

This dual shift can easily be seen by the regional location of metropolitan areas with high absolute and absolute differences in high tech jobs and plants. In the case of absolute shares (Table 9.1) and in the case of absolute employment, metropolitan areas in the Northeast and Midwest dominate the top 20 metropolitan areas which have adjacent rural high tech employment and plants.

Table 9.1

Adjacent Rural Counties: Absolute Levels of Employment 1982

Top 20 MSAs	1982
Binghamton, NY	10534.2
Milwaukee, WI	9905.0
Williamsport, PA	9096.6
Portland, ME	8960.7
Hartford-New Britain-Middleton-Bristol, CT	8092.0
Fort Pierce, FL	7901.8
Elmira, NY	7443.0
Erie, PA	7355.7
Manchester-Nashau, NH	7076.6
Aurora-Elgin, IL	6707.0
Syracuse, NY	6513.4
Hagerstown, MD	6294.0
Pittsburgh, PA	6136.9
Charlotte-Gastonia-Rock Hill, NC-SC	5771.4
Appleton-Oshkosh-Neenah, WI	5706.3
Asheville, NC	5445.2
Greenville-Spartanburg, SC	4843.9
Beaver County, PA	4402.7
Baton Rouge, LA	4251.5
Rochester, NY	3748.5

Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

Table 9.2

Adjacent Rural Counties: Absolute Employment Change 1982

Top 20 MSAs	1982
Portland, ME	8960.70
Binghamton, NY	5392.84
Asheville, NC	4743.98
Milwaukee, WI	3304.93
Greenville-Spartanburg, SC	2676.69
Manchester-Nashua, NH	2478.72
Columbia, SC	2327.67
Eugene-Springfield, OR	1945.37
Baton Rouge, LA	1560.51
Atlanta, GA	1521.44
Akron, OH	1325.82
Charlotte-Gastonia-Rock Hill, NC-SC	1283.95
Santa Barbara, CA	1231.01
Hartford-New Britain-Midddletown-Bristol, CT	1226.07
Oklahoma City, OK	1192.95
Hagerstown, MD	1141.36
Dayton-Springfield, OH	1100.68
Cincinatti, OH-KY-IN	1099.59
Elkhart-Goshan, IN	1088.15
State College, PA	1063.59

Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

Plants in adjacent rural communities are even more concentrated, with 91 percent located near Northeast and Midwest MSAs, or metropolitan areas (Table 9.2). In contrast, the top 20 cities with high absolute differences indicating gains in high tech plants and employment are more recently concentrated in the Southern and Western regions (Tables 9.3 and 9.4).

These contemporary trends--the search for lower-cost production and for new markets--is seen in the changing distribution of plants and employment. Given the implications of plant growth, I give particular emphasis to this relationship between metropolitan characteristics and plant differences in adjacent rural counties. Plant growth is an important sign of larger trends in the economy, such as population shifts and the general movement of economic activity among regions. While firms can shift employment relatively easily among production sites, the decision to open a new plant is far more serious. Companies have to commit to a much longer time horizon when planning a new facility and must be convinced of the merits of such a location decision. New plant growth signifies investment in a community and indicates that firms have some expectation that conditions surrounding this decision will also hold true for some period into the future.

Thus, while both employment and plants are examined in the regression study of metropolitan characteristics and rural-adjacent high tech development, I pay particular attention to plant levels and changes in these over time. The following reports the results of a series of stepwise regressions of economic, social and demographic characteristics of metropolitan and rural-adjacent areas in relation to the distribution of high tech employment and plants.

Model Construction

The selection of variables used in the analysis is based on prior studies of high tech industry location (Markusen, Hall and Glasmeier 1986; Armington, Harris and Odle 1983) and studies of general industry locational behavior. Appendix D lists the variables used in the analysis. For the current study, I have selected variables partly on the basis of standard factors thought important to firm location decisions--for example, labor market, demographic and economic characteristics, as well as factors thought to be directly associated with high tech industry location.

With the advent of concern about high tech industry location, researchers have included measures of local amenities and of federal and governmental impacts on local economies, primarily in the form of personnel and defense procurement decisions. The inclusion of amenities as a possible determinant of location decisions is based on the belief that industries hiring large numbers of technical and professional employees must locate where there is access to colleges and other cultural amenities.[9] Since these workers are highly mobile, corporations select locations with nice environments.

Growth of high tech industries also solidified interest in factors measuring the cost of doing business in different areas. Some analysts have argued that "bad" business climates effectively chased industry from traditional centers of manufacturing where property taxes and wages are high and unions strong.

Table 9.3

Adjacent Rural Counties Absolute Levels of Plants 1982

Top 23 MSAs	1982
Hartford-New Britain-Middletown-Bristol, CT	128
Erie, PA	106
Milwaukee, WI	76
Beaver County, PA	74
Manchester-Nashua, NH	55
Pittsburgh, PA	53
Kalamazoo, MI	45
Aurora-Elgin, IL	42
Binghamton, NY	40
Dayton-Springfield, OH	38
Grand Rapids, MI	37
Gary-Hammond, IN	37
Elkhart-Goshen, IN	36
Poughkeepsie, NY	34
Ann Arbor, MI	33
Cleveland, OH	32
Santa Barbara, CA	28
Portland, ME	28
Rochester, NY	25
Columbus, OH	25
Oklahoma City, OK	25
Albany-Schenectady-Troy, NY	25
La Crosse, WI	25

Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

Table 9.4

Adjacent Rural Counties: Absolute Plant Change 1982

Top 23 MSAs	1982
Hartford-New Britain-Middletown-Bristol, CT	33
Erie, PA	31
Milwaukee, WI	26
Santa Barbara, CA	21
Binghamton, NY	19
Houston, TX	18
Sacramento, CA	16
Oklahoma City, OK	15
Manchester-Nashua, NH	14
Asheville, NC	13
Grand Rapids, MI	12
Eugene-Springfield, OR	12
Columbia, SC	12
Greenville-Spartanburg, SC	11
Columbus, OH	11
Dallas, TX	10
Atlanta, GA	10
Portland, ME	10
Salem, OR	10
Huntsville, AL	10

Source: Bureau of the Census, 1986, Census of Manufactures, Plant Location Tape (1972, 1977, 1982).

Concern with the role of defense/military expenditures in high tech development stems from the early importance of government spending for cutting-edge technologies in semiconductors and aircraft production. More recently, some scholars (Markusen 1986) argue that the central variable shaping high tech industry location is federal procurement contracts.

The analysis here conforms both to prior studies of industry location and to recent research on high tech industry location. The configuration of variables is not the same in all cases. Variables included here were configured using standard methods. In cases where a variable's distribution was highly skewed, the natural log of the variable was taken.

The analysis consists of four dependent variables and 22 independent variables. The dependent variables include the log of the absolute distribution of high tech jobs and plants in rural-adjacent counties.[10] A second set of two dependent variables measures the absolute difference of high tech jobs and plants, or absolute plant and employment change, which occurred in rural-adjacent counties over the 1972-82 period.

Individual observations in the regression analysis consist of 158 MSA's. This group is reduced from a total of 266 MSA's with rural-adjacent counties, as the residual 108 MSA's had rural counties with no high tech employment. Early regression analyses contained all 266 cases, but examination of them showed additional cases served to confuse rather than clarify the results.

The regression analysis here used a standard stepwise entry procedure. Each variable was entered in the regressive analysis based on a significance level of .10 for each variable. In situations where individual cases had missing values on particular variables, a means substitution procedure was used. The mean for each variable then was substituted for missing data. This way, all cases entered into the regression rather than analyzing a reduced set for each. The analysis consists of the entire population of rural-adjacent counties as identified in 1985.

Regression Results

The first set of regressions examines the relationship between metropolitan characteristics and high tech plants and employment in rural-adjacent counties. Tables 9.5 and 9.6 list the significant coefficients, their size, and the amount of explained variation. Metropolitan area characteristics which are associated with high levels of rural high tech plants include high levels of unionization, availability of air service, and negative rates of group migration.

The association between rural-adjacent high tech employment and metropolitan characteristics reveals similar findings--with one exception--rural high tech employment also appears to concentrate in places with moderate climates. This may reflect the fact that decentralization has resulted in shifts of jobs to places with relatively mild climates. Such a result may also signify that the early and later periods of high tech decentralization were not entirely separate and distinct. That is, over the ten-year period there was a blurring of the shifts both within and among regions. More likely, it signifies that both conditions were operating simultaneously and that, over the long run,

Table 9.5
Stepwise Regression Analysis for Rural Adjacent Counties

Plants
1982

Dependent Variable	High Tech Plants 1982 (Logged) Beta	Significance
Manufacturing Unions	.3859	0.01
Air Service	.3375	0.01
Migration	-.2011	0.01

$R^2 = .29$

Employment
1982

Dependent Variable	High Tech Employment 1982 (Logged) Beta	Significance
Manufacturing Unions	.3173	0.01
Air Service	.2664	0.01
Migration	-.1867	0.03
Climate	.1437	0.04

$R^2 = .21$

Table 9.6
Stepwise Regression

Employment Difference, 1972-1982

Variable	Beta	Significance
Manufacturing Unions	-.2359	0.006
Climate	.1555	0.009
Unemployment	-.1919	0.020
Population Growth	-.1577	0.080

$R^2 = .12$

Plant Difference, 1972-1982

Variable	Beta	Significance
L Service (logged)	.24	0.090
Property Tax	.17	0.030
Arts	-.43	0.003
4 College	.32	0.020
Housing	.16	0.070

$R^2 = .15$

the emphasis was on inter-regional decentralization. Both additional research and more complex modeling would be necessary to confirm this hypothesis.

It is important to keep in mind that the climate measure in this analysis reflects the absence of extreme climate variations and not an absolute "pleasantness" of climate as perceived by individuals. Again, all variables are significant at the .05 level, and the signs were those expected.

The second set of regressions analyze the relationship between high tech plant and employment change, in absolute terms, and metropolitan characteristics. The amount of explained variation is lower in this set. The variables are, however, significant at the .10 level.

In the case of rural high tech employment change, low levels of unions, a mild climate, low unemployment, and low relative levels of population growth explain 12 percent of the variation in the model. The significance of the first three variables conforms to our original hypothesis that growth in high tech jobs in adjacent rural counties is associated with shifts of jobs to low-cost Sunbelt locations. The unexpected finding of high tech growth in association with slower growing metropolitan areas deserves comment. One explanation for the relationship between slower population growth in metropolitan areas and significant gains in rural-adjacent high tech employment relates to the distribution of population growth among cities in the Sunbelt. The fastest growing metropolitan areas in the Sunbelt--in terms of rates of change--were often the smaller metropolitan areas. From previous work, we know that high tech industries are attracted primarily to larger metropolitan areas which have a strong base of support services needed for efficient production. Thus, on a relative basis, high tech job growth was occurring around larger metropolitan areas which were slower growing then their smaller counterparts.

Regression results of absolute differences in the plants in adjacent rural counties over the 1972-82 period explain a slightly higher proportion of the variation in the model (15%). Places with positive levels of new plant additions are characterized as having high levels of services employment, high relative property tax rates, lower levels of arts, the presence of four-year colleges, and relatively high housing prices. These results synchronize with a picture of many medium-size Southern or Western metropolitan areas. Union levels are low, taxes supporting schools are relatively high, and there is the availability of four-year college education and, as many of these places grew rapidly over the period studied, housing prices are high, a probable result of population-induced growth over the same period. The negative association between plant difference and high levels of arts may reflect the fact that plant growth was not occurring around the largest metropolitan areas but, rather, occurs adjacent to medium-size metropolitan areas with only a minimum amount of arts available.

Of significance are a number of variables which did not enter the regression equation. Two are particularly important given the literature on the metropolitan location of high tech industries--neither per capita defense dollars, nor the log of federal employees, entered the regression model. While earlier analysis by Markusen et. al., 1986, indicated a modest significance between defense spending and high tech location in 1977, our results failed to confirm its importance to rural-adjacent high tech location. One explanation relates to the overall distribution of defense spending, which is highly skewed toward the largest metro areas in the U.S. and, in particular, toward those in the West. A second explanation is that a majority of these larger metro areas share no borders with rural-adjacent counties. Either way, this analysis indicates that changes in defense spending, whether positive or negative, are unlikely to affect rural-adjacent high tech development.

PART IV

Section X
STATE POLICIES, RURAL REALITIES: HIGH TECH DEVELOPMENT POLICIES

Introduction

State governments are active participants in programs encouraging the formation and growth of high tech industries. Over thirty states have some type of high tech program (Clarke 1986). Few, however, have high tech development programs either targeted or applicable for rural economic development. In fact, as this analysis will suggest, state programs are normally biased against rural communities. If state-level programs are to address problems of rural economies, then they need to be significantly restructured to pay greater attention to improving the competitive position of existing rural industries. These provide the necessary foundation for further high tech development in rural communities. The purpose of this section is to review state programs in general and identify components of high tech economic development efforts applicable for rural community development.

The material reviewed here is based on a comprehensive mail survey of state high technology industry development programs. Responses to the survey were received from twenty-eight states (See Table 10 for a condensed review of these programs).

Characterization of Existing Programs

State technology programs generally serve to strengthen the existing technological infrastructure in three broad areas--education, research, and industrial facilities. More narrowly, programs are designed to further the development of existing high technology industry and to integrate new technologies into existing industries (Plosila 1987; Rees 1987).

Development programs fall into seven categories according to emphasis:

Policy Development: Cultivating a plan to encourage technology-based industries to locate in an area.

Education and Training: Improving local educational facilities to prepare employees for technology-based jobs and to serve as centers of research.

Research and Development: Investing in either university-based or independent research and development facilities.

Entrepreneurship Training and Assistance: Developing local businesses through education or subsidization of their enterprise.

Assistance to Specific Firms: Investing in firms with desired qualities to encourage their location in the local community.

Technology and Information Transfer: Facilitating transfer of basic research techniques and information to the industrial arena, so that it may be applied to production.

Research Parks and Incubator Facilities: Sponsoring industrial research parks and/or operating subsidized facilities to support businesses in their embryonic stages of growth, to create an atmosphere attractive to technology-based firms.

Survey Results, Existing Programs

While they may possess common objectives, programs differ in the pursuit of goals. Some programs are designed to achieve long-range objectives while others are of a more immediate nature (Rees 1987). The most common type of high technology industry program consists of technology councils set up within state governors' offices. The other six program areas were also found operating in a large number of states (see Marianne Clarke, 1986, for a complete survey of programs). A great majority of programs currently on the books receive only modest financial support through state governors' offices (Merrill 1984). Thus, their success is significantly circumscribed by the availability of resources.

A number of these program elements hold potential for rural communities. However, important problems of rural economies place serious limitations on their ability to compete for inclusion in technology development programs (Rosenfeld 1987). The non-applicability of high technology programs to rural economic development problems is important because the overwhelming majority of technology development initiatives are used to strengthen and retain already established research facilities, not to develop them (OTA, 1984). For this reason rural communities, which usually lack sophisticated facilities, are not considered for funding.[11]

High Tech Development Programs: Rural Applicability

Recognizing the limitations of rural communities infrastructure, a number of high tech development programs may still find applicability in rural areas:

"Policy Development" program funding could be utilized to direct rural areas toward realistic goals for technology-based economic development.

"Entrepreneurship Training and Assistance" programs hold potential for retaining local talent, avoiding the "brain drain" many rural communities suffer.

"Education and Training" programs can help create a labor force attractive to industry, as well as provide training for displaced workers.

Table 10
State High Tech Development Programs

State	High Tech Emphasis: Policy	High Tech Emphasis: Programs	High Tech Emphasis: Non-HT	Rural Emphasis: HT Rural	Rural Emphasis: HT Non-Rural	Rural Emphasis: Rural Non-HT
CA		*			*	
GA		*			*	
HI		*			*	
ID			*			*
IL	*					*
IN		*			*	
LA	*					*
ME		*		*◊		
MD			*			
MA		*		*		
MI	*					
MN	*			*◊		
MO	*					*
MT	*					
NB	*					
NJ	*			*◊		
NY		*				
NC	*					*1
ND	*				*	
OH	*				*	
OR	*				*	
PA			*		*	
PR	*			*◊ 2		
TN			*			*
TX		*				*
VT	*					*3
VI			*			*4
WA			*			*5
WV			*		*	
WI			*		*	

◊ NOTE: Maine, Minnesota, New Jersey and Puerto Rico each have special programs to apply new technologies to agricultural and/or fishing or other non-urban industries.

1 North Carolina targets programs to "distressed counties"; programs are not nesessarily rural or high tech in emphasis

2 Puerto Rico also targets "high unemployment" areas but programs have an agricultural vs. high tech emphasis.

3 Vermont and Virginia each have rural job development programs, but the programs are not high tech in emphasis.

4 See Note #3.

5 However, the Washington State Legislature has directed the Community Development agency to undertake a study of the feasibility of "office-intensive" industry in rural WA counties.

While these programs are appropriate for rural technology development, rural areas are seldom considered for participation. In order to be considered for a full spectrum of state program assistance, rural communities would have to strengthen their hand by addressing their fundamental deficiencies of small size, lack of leadership, and lack of technological infrastructure. Acting alone, and with severe limitations, rural communities have few options other than recruitment programs to garner technology-based industries. However, a number of existing high tech development programs, with minor modifications, hold potential for rural communities.

Models of Rural Technology Development Programs

This section discusses the reality of state funding for rural technology development by highlighting state programs whose emphasis is specifically "rural." The following is based on a review of high technology program documentation provided by state economic development departments:

Washington State passed House Bill 373 authorizing $42,000 to study the availability of its telecommunications system in rural areas. This program is designed to study the feasibility of introducing "office-intensive" industries to agriculture-based rural communities through the use of de-tariffing or complete deregulation of industries in certain regions. This type of program is characterized as "Financial Assistance to Firms" and "Policy Development".

California's Rural Economic Development Infrastructure Program (REDIP) (Senate Bill 2117) encourages the creation of permanent, private sector jobs in manufacturing, service, R&D, production, assembly, warehousing, or industrial distribution facilities in rural areas. The incentive takes the form of public infrastructure development to the site--water, wastewater and storm sewer systems, bridges and parking facilities. Development is restricted to new facilities; a firm may not relocate from another part of the state. This program is classified as "Financial Assistance to Firms" and, also "Entrepreneurship Assistance" (since a new firm must be established).

The State of Texas has implemented the Industrial Development Loan Fund to encourage construction of manufacturing facilities in incorporated communities of 20,000 population or less. Up to 40% of a project's construction costs are loaned to a non-profit organization which builds the facility, then leases or sells it to a manufacturer. This program is classified as "Financial Assistance to Firms."

Puerto Rico has undertaken a full-fledged recruitment program, aimed specifically at encouraging the location of high technology firms in this basically rural territory. Among their offerings to high technology firms are: training supervisory personnel; government salaries for instructors and technical personnel while production workers are trained; rent paid by the government during start up; full or partial payment of freight on machinery and equipment to Puerto Rico; and, other negotiated costs.

The Southern Growth Policies Board created a Southern States Technology Council, to facilitate regional technology transfer and to develop the leadership capabilities of the region. Its stated purposes are: to act as a regional forum to share technology program information and evaluations to initiate and manage co-operative technology arrangements; to better educate legislators about technology policy; to facilitate technology transfer to the private sector; to inventory state programs, policies, and activities; and, to identify the impact of technology on education and training needs.

The Greater Minnesota Corporation will form partnerships with education, business, labor and agriculture entities to fund applied research and development projects in non-urban areas. The corporation provides matching grants to universities for research, as well as contract research, to impact growth of applied research. It constructs research facilities, currently participates in as many as four Regional Research Institutes located near major universities, and also plans to take equity positions in new products and ventures researched and developed at the corporation's facilities. In addition, it provides loans to technology-oriented businesses. This program could be classified as " Education and Training," "Research and Development," "Research Parks and Incubator Facilities," and "Entrepreneurship Training and Assistance."

The State of Idaho has one program which has applicability and potential for enhancing rural high tech development. The University of Idaho's Simplot/Micron Center has satellite uplink and video production facilities which have been used to develop advanced courses for rural high schools such as calculus. This example can be classified as improvements in "Education and Training."

Summary

In summary, there are few state-administered high technology industry programs targeted toward rural communities. Fewer still offer improvements to communities' underlying infrastructure. Some states are aware of the urban-bias of high tech programs and the need to better link high tech policies to an existing industrial base rather than attempt to create one anew. There does appear to be some correlation between the "ruralness" of a state and the presence of state policy emphasizing incorporation of high tech into traditional industries. While such programs are a distinct minority in the overall policy environment encouraging high tech development, they form important models for rural high tech development.

Section XI
CONCLUSIONS

Over a period of rapid national high tech growth, rural counties had some success attracting high tech industries. Though growth rates were less than the national average, both new jobs and plants were added to the existing rural base.

In light of our findings, however, it is important to consider the composition of rural high tech employment and plants. Both absolutely, and in terms of new growth, rural high tech growth and development is significantly tied to the fortunes of traditional rural industries. Thus, growth in one should clearly stimulate the other. The reverse is also likely to be true; declines in traditional rural industries will most likely lead to negative changes for rural high tech industries.

Growth in high tech industries in rural counties exhibits more variety than the present base of rural high tech industries. Yet, this too is not without problems. Rural growth of employment and plants has been quite concentrated in only a few industries. A more favorable distribution, one which includes many different industries, would insulate a community from the decline of a single sector. As it stands now, the lack of diversity increases each county's vulnerability to industry changes at national and, increasingly, at global levels.

This analysis indicates the need to adjust our understanding of industrial filtering by recognizing the limitations of the SIC code system. Even using data disaggregated to a four-digit level hides the type of product being produced in industrial plants. While it can't be said conclusively that rural high tech growth occurs only in mature industries, neither can we be sure of individual plant experiences. Thus, another major finding of this study relates to the need for case study analysis of high tech growth in rural counties.

Growth of high tech industries is not distributed evenly across all rural counties. The most isolated rural areas have simply not benefited from high tech growth over the study period. Real winners are those rural counties with small but significant urban centers of their own, located both adjacent and non-adjacent to larger metropolitan counties. This departs from experiences of traditionally rural industries, such as textiles, which do show a significant presence and past successes in the smaller, more isolated, rural counties.

Since the early 1970s, high tech industry location has followed the shifts in population and total manufacturing already underway among the nation's regions. The Midwest declined in shares of the nation's population, manufacturing and high tech jobs. This redistribution appears to have benefited the South, and to a lesser extent, the West. Manufacturing in the Northeast was becoming more high tech as it continued to shed its older manufacturing industries. This same pattern was also evident in the region's rural areas. The West is clearly the most polarized region, given its very large share of total national high tech employment relative to population and overall manufacturing, and yet only an imperceptible presence of high tech jobs in rural counties. As in the Northeast, the persistence of this pattern is noteworthy.

The similarity of the pattern of high tech location and other regional aggregates, such as population and manufacturing, has significant implications for rural areas. Conditions which sparked the initial redistribution of economic activity among America's regions have subsided. Manufacturing employment has to some extent stabilized among regions, firms are no longer setting up branch plants at the pace characteristic for the 1970s, and even high tech industry growth itself has slowed dramatically. This implies that the circumstances which unleashed the subsequent pattern of high tech location are no longer operative and, thus, rural gains in high tech employment will likely be modest in the future.

The dynamic high tech sectors, and those most influenced by national policies (DDS), contribute little to development of a technological base of employment in rural counties. While there have been modest increases in the presence of these industries within the nation's rural communities, still, the share of CEC and DDS sectors is substantially below comparable figures for the nation. All regions show small amounts of this type employment within rural areas. It is doubtful, however, that these dynamic sectors will play a significant role in changing the long-standing composition of high tech jobs in rural areas--i.e., the concentration of rural high tech jobs in counties located adjacent to metropolitan centers--and their ties to traditional rural industries.

Rural counties in the United States have very modestly benefited from the growth of high tech jobs and plants at a national level. The Midwest and the South have been almost the exclusive beneficiaries of rural high tech growth at the regional level. As I have tried to argue, this pattern reflects a dual decentralization tendency both in earlier and more recent periods--to regional hinterlands within the Midwest and toward rural areas of the South. In the case of the Midwest, rural high tech growth corresponds to early efforts by companies to escape metropolitan areas where manufacturing workers were highly unionized. The South, by contrast, reflects a more recent shift of high tech to large market locations and toward rural areas surrounding cities where both high- and lower-skilled labor can be found.

These two tendencies--the shift to the hinterlands for lower-cost labor and the shift to the South toward markets and appropriate labor pools--were tested in a series of regression analyses. This exercise related rural-adjacent county employment and plants to changes in employment and plant configuration over time, with metropolitan characteristics.

Rural counties with high absolute levels of plants and employment are adjacent to MSAs, metropolitan centers where union levels are high and growth in population through migration is slow. Additionally, high levels of air service signify that absolute levels of high tech jobs and plants in adjacent rural counties occurred near large metropolitan areas, as opposed to smaller ones. In contrast, those rural counties which experienced absolute gains in plants and employment were adjacent to MSAs with low levels of unions and, in the case of plants, with four-year colleges.

The findings of the regression analysis present some indications of how existing high tech development policy will influence further growth of these industries in rural areas.

The results suggest, first, that rural high tech location is influenced by larger economic trends associated with the costs of doing business in manufacturing. There are only a few state programs designed to both increase the quality of the labor force--thus reducing the costs of production--while accelerating the development of new products and processes.

Many states with more enlightened programs do not have an explicit rural focus to their high tech efforts. Thus, the best rural communities can expect is that benefits of high tech policy will trickle-down over time, as a state's manufacturing base becomes more competitive. A process of industrial filtering is essential in this case. But, as we have suggested, filtering of jobs to rural areas, particularly, high tech jobs, is tied to labor characteristics and firms' needs to find suitable pools of both low-skilled, but well-educated, workers and skilled labor. Few rural communities outside the influence of metropolitan areas have suitable labor pools matching these requirements. This returns us to long-standing problems of rural economic development.

Defects in rural economies keep rural communities from full participation in state programs. Rural economies tend to depend on a single source of economic development, such as agriculture or mining. These basic sectors do little to broaden the skill base of rural communities. The lack of adequate basic infrastructure--constant electricity sources, digital telecommunications, high quality roads, airports--also limits the type of industry which can successfully operate in rural communities. Low levels of general skills in the population and small numbers of technically trained personnel available further restrict high tech location in rural areas.

Programs that do target rural areas are predominantly recruitment-type programs. Limited economic development resources and the short-term time horizon of local politicians reinforce industrial recruitment as the major option for rural economic development (See Feller for a critique of high tech programs, 1984). Other, riskier efforts, such as local support for small firms and entrepreneurship training, are viewed as too costly and the payoff too long-term to be effective in rural areas. But it is the latter programs which present rural areas with the greatest opportunities.

These problems--a narrow economic base, limited infrastructure, low levels of skill in the population, and dependence on industrial recruitment--simply preserve the cycle of non-participation by rural communities. Given that cities are currently the most likely location where new technologies and industries will be developed, state high tech development programs may, in fact, be far more necessary and important for rural areas than they are for metropolitan areas.

Thus, we return to where we began--isolating those factors which, in combination, produce high tech success stories in rural communities. In both examples, the characteristics of "place" were key determinants of successful rural high tech companies. The presence of a university in rural communities is important, not because they necessarily create the seeds of rural high tech firms, but because they create economic and social climates--economies of agglomeration--conducive to successful firm growth. Places with universities tend to have higher quality educational systems at primary and secondary levels. It is from this pool of individuals that high tech firms will draw their labor. Universities are also important as they increase the availability of cultural and retail options for local consumers. Many of these same benefits can be had by firms operating in rural counties adjacent to metropolitan areas with their own distinct characteristics.

The role of the entrepreneur is also a critical component of positive high tech development. While rural communities have had some success in attracting high tech branch plants, we have a number of reasons to believe that this source of economic development may be unstable. Our example of successful cases concluded that corporate policy and enlightened management are important ingredients. Gore and Associates, as a branch plant, is relatively unique in this regard. Branch plants are not widely known to share many of the staying qualities that a local entrepreneur often has with the communities in which he/she operates a business.

Traditional location factors, such as access to markets or material inputs, do not appear to limit rural high tech development. While their absence probably means rural high tech firms function as free-standing operations independent of other local firms, the absence of these locational constraints increases the potential for rural high tech development. The lack of inter-firm links is importantly tied to the type of product successfully produced in rural locations. In both cases, interregional and international trade, rather than local exchange was an important, if not the important key to both firms' success.

Herein lies a wholely new line of economic development inquiry. If success of rural high tech is importantly dependent on trade, then the process of growth must be viewed from a new perspective. Economic development models conceptualize the process of development as dependent on the eventual formation of local linkages and, hence, on local inter-firm transactions. In the case of rural high tech, this expectation may mis-characterize what one can expect from such development and also misguide policy attempts to create clusters of inter-linked firms. It may be far more important to assist firms in distributing their goods than to facilitate their acquisition of inputs. A firm can have the best product in the world but if it can't find a market to sell it to, then its reason for existence becomes irrelevant. High tech products have, by their very nature, global markets which transcend strictly local trade. Trade strategies are therefore a vital component of economic development policy which needs careful review. Recent work on the role of distributors and distribution in economic development suggests that these under-studied components of the economy may hold important promise for rural high tech development.

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Appendix A

DATA SOURCES

The analysis presented throughout this study is derived from a data base consisting of industry plant counts and employment estimates. The data base was developed using the Census of Manufactures plant location file which consists of four-digit industry plant counts for all counties in the country. Plants are arrayed in employment size categories and are used to construct employment estimates.

The results reported in this study represent aggregations of high tech employment for regions, states, and rural counties. The data span ten years and are reported on the basis data for five-year intervals from the 1972, 1977 and 1982 Census of Manufactures. A more detailed explanation of the data base used in this study can be found in Appendix A.

An obvious limitation of the data base used in this study is the terminal date, 1982. The recession of 1982 was the most severe since the Great Depression of 1929. Unfortunately due to the reporting requirements of the census, more recent data were unavailable. Readers should be advised that there could be some bias, particularly as it relates to regional conditions, in this analysis. However, it is important to note that the low point in high technology industry growth did not occur until 1983-1984. Therefore, to the extent that there is a downward bias in the employment figures this is somewhat mitigated by the fact that high tech job growth remained strong during the intense downturn of 1982.

The data used in the regression analysis reported in section VI are taken from two sources--the census of population and housing and Places Rated. A more complete description of the independent variable construction is found in Appendix B.

Appendix B

High Tech Industry Growth Performance: 1972-1982

sic	establishments 1972	establishments 1977	establishments 1982	percent growth 1972-77	percent growth 1977-82	percent growth 1972-82	employment 1972	employment 1977	employment 1982	percent growth 1972-77	percent growth 1977-82	percent growth 1972-82
2812	48.	49.	51.	2.1	4.1	6.3	13357.	11833.	8654.	-11.4	-26.9	-35.2
2813	503.	562.	563.	11.7	0.2	11.9	9863.	7398.	7538.	-25.0	1.9	-23.6
2816	114.	106.	106.	-7.0	0.0	-7.0	14904.	12000.	13116.	-19.5	9.3	-12.0
2819	384.	564.	645.	46.9	14.4	68.0	63808.	78203.	86464.	22.6	10.6	35.5
2821	323.	397.	440.	22.9	10.8	36.2	54612.	57107.	58925.	4.6	3.2	7.9
2822	59.	63.	78.	6.8	23.8	32.2	12589.	11545.	14712.	-8.3	27.4	16.9
2823	18.	25.	18.	38.9	-28.0	0.0	20508.	16229.	14679.	-20.9	-9.6	-28.4
2824	61.	66.	70.	8.2	6.1	14.8	79158.	74065.	63758.	-6.4	-13.9	-19.5
2831	182.	310.	370.	70.3	19.4	103.3	10959.	18468.	26905.	68.5	45.7	145.5
2833	140.	177.	228.	26.4	28.8	62.9	9440.	15725.	18124.	66.6	15.3	92.0
2834	756.	756.	683.	0.0	-9.7	-9.7	112100.	126400.	131905.	12.8	4.4	17.7
2841	642.	638.	723.	-0.6	13.3	12.6	31499.	32641.	38174.	3.6	16.9	21.2
2842	1108.	1022.	807.	-7.8	-21.0	-27.2	26080.	22920.	25961.	-12.1	13.3	-0.5
2843	178.	175.	210.	-1.7	20.0	18.0	6957.	6839.	9309.	-1.7	36.1	33.8
2844	645.	693.	639.	7.4	-7.8	-0.9	48134.	50800.	68519.	5.5	34.9	42.3
2851	1599.	1579.	1441.	-1.3	-8.7	-9.9	66901.	61297.	57306.	-8.4	-6.5	-14.3
2861	139.	119.	92.	-14.4	-22.7	-33.8	6039.	4721.	4554.	-21.8	-3.5	-24.6
2865	174.	191.	189.	9.8	-1.0	8.6	28087.	35514.	29983.	26.4	-15.6	6.7
2869	514.	569.	688.	10.7	20.9	33.9	101994.	112400.	118682.	10.2	5.6	16.4
2873	73.	152.	143.	108.2	-5.9	95.9	9563.	12447.	11227.	30.2	-9.8	17.4
2874	145.	91.	110.	-37.2	20.9	-24.1	15801.	15706.	15561.	-0.6	-0.9	-1.5
2875	627.	673.	544.	7.3	-19.2	-13.2	11415.	12489.	9849.	9.4	-21.1	-13.7
2879	388.	409.	330.	5.4	-19.3	-14.9	12575.	15168.	17804.	20.6	17.4	41.6
2891	463.	573.	684.	23.8	19.4	47.7	15053.	16672.	20260.	10.8	21.5	34.6
2892	92.	97.	114.	5.4	17.5	23.9	16998.	11549.	15155.	-32.1	31.2	-10.8
2893	407.	446.	467.	9.6	4.7	14.7	9701.	10100.	10021.	4.1	-0.8	3.3
2895	37.	31.	25.	-16.2	-19.4	-32.4	3017.	2600.	2318.	-13.8	-10.8	-23.2
2899	1606.	1639.	1443.	2.1	-12.0	-10.1	37885.	35299.	44464.	-6.8	26.0	17.4
2911	323.	349.	433.	8.0	24.1	34.1	100543.	102399.	120856.	1.8	18.0	20.2
3031	20.	21.	25.	5.0	19.0	25.0	1115.	1007.	780.	-9.7	-22.6	-30.0
3482	62.	65.	0.	4.8	-100.0	-100.0	13867.	12187.	0.	-12.1	-100.0	-100.0
3483	95.	81.	0.	-14.7	-100.0	-100.0	54992.	20581.	0.	-62.6	-100.0	-100.0
3484	82.	112.	0.	36.6	-100.0	-100.0	16000.	17500.	0.	9.4	-100.0	-100.0
3489	76.	89.	0.	17.1	-100.0	-100.0	25407.	19037.	0.	-25.1	-100.0	-100.0
3511	75.	83.	88.	10.7	6.0	17.3	46286.	40964.	36394.	-11.5	-11.2	-21.4
3519	178.	232.	253.	30.3	9.1	42.1	69947.	88800.	84566.	27.0	-4.8	20.9
3531	748.	922.	939.	23.3	1.8	25.5	133700.	155199.	127548.	16.1	-17.8	-4.6
3532	240.	344.	369.	43.3	7.3	53.8	21700.	31299.	28262.	44.2	-9.7	30.2
3533	315.	478.	1015.	51.7	112.3	222.2	35872.	58499.	106270.	63.1	81.7	196.2
3534	154.	152.	165.	-1.3	8.6	7.1	15839.	10201.	13869.	-35.6	35.9	-12.4
3535	492.	616.	699.	25.2	13.5	42.1	27138.	32927.	39940.	21.3	21.3	47.2
3536	188.	242.	276.	28.7	14.0	46.8	17168.	15800.	16779.	-8.0	6.2	-2.3
3537	380.	475.	489.	25.0	2.9	28.7	25901.	28386.	27924.	9.6	-1.6	7.8
3541	894.	919.	942.	2.8	2.5	5.4	56980.	59463.	60196.	4.4	1.2	5.7
3542	383.	426.	452.	11.2	6.1	18.0	24095.	23145.	21143.	-3.9	-8.6	-12.2
3544	6616.	7152.	7255.	8.1	1.4	9.7	97807.	106108.	110875.	8.5	4.5	13.4
3545	1231.	1412.	1620.	14.7	14.7	31.6	46572.	54257.	61656.	16.5	13.6	32.4
3546	88.	124.	203.	40.9	63.7	130.7	22926.	27676.	24411.	20.7	-11.8	6.5
3547	47.	63.	63.	34.0	0.0	34.0	9232.	8530.	6115.	-7.6	-28.3	-33.8
3549	393.	534.	446.	35.9	-16.5	13.5	13937.	19141.	24052.	37.3	25.7	72.6

High Tech Industry Growth Performance: 1972-1982 (continued)

	establishments			percent growth			employment			percent growth		
sic	1972	1977	1982	1972-77	1977-82	1972-82	1972	1977	1982	1972-77	1977-82	1972-82
3561	559.	613.	626.	9.7	2.1	12.0	55718.	63055.	76908.	13.2	22.0	38.0
3562	135.	149.	162.	10.4	8.7	20.0	50830.	50288.	47742.	-1.1	-5.1	-6.1
3563	84.	175.	282.	108.3	61.1	235.7	22373.	31900.	35343.	42.6	10.8	58.0
3564	396.	482.	502.	21.7	4.1	26.8	24202.	28430.	34728.	17.5	22.2	43.5
3565	1021.	1002.	996.	-1.9	-0.6	-2.4	8502.	9399.	11387.	10.6	21.1	33.9
3566	346.	327.	309.	-5.5	-5.5	-10.7	27059.	24547.	26148.	-9.3	6.5	-3.4
3567	266.	327.	353.	22.9	8.0	32.7	14692.	16263.	18265.	10.7	12.3	24.3
3568	155.	226.	293.	45.8	29.6	89.0	27353.	32559.	30976.	19.0	-4.9	13.2
3569	901.	1646.	1458.	82.7	-11.4	61.8	38441.	58554.	67346.	52.3	15.0	75.2
3573	602.	932.	1739.	54.8	86.6	188.9	144661.	192514.	348821.	33.1	81.2	141.1
3574	79.	64.	70.	-19.0	9.4	-11.4	19365.	15460.	17874.	-20.2	15.6	-7.7
3576	97.	103.	128.	6.2	24.3	32.0	7154.	6712.	7141.	-6.2	6.4	-0.2
3579	217.	218.	232.	0.5	6.4	6.9	34501.	42412.	50895.	22.9	20.0	47.5
3612	216.	279.	293.	29.2	5.0	35.6	45900.	43360.	41567.	-5.5	-4.1	-9.4
3613	568.	668.	649.	17.6	-2.8	14.3	69412.	72225.	75671.	4.1	4.8	9.0
3621	425.	447.	472.	5.2	5.6	11.1	90241.	96971.	96191.	7.5	-0.8	6.6
3622	590.	726.	913.	23.1	25.8	54.7	51006.	56428.	69989.	10.6	24.0	37.2
3623	166.	176.	182.	6.0	3.4	9.6	15233.	17400.	16865.	14.2	-3.1	10.7
3624	72.	74.	90.	2.8	21.6	25.0	11683.	12083.	13559.	3.4	12.2	16.1
3629	258.	223.	323.	-13.6	44.8	25.2	20127.	16475.	18281.	-18.1	11.0	-9.2
3651	372.	581.	458.	56.2	-21.2	23.1	86500.	74601.	52012.	-13.8	-30.3	-39.9
3652	567.	709.	574.	25.0	-19.0	1.2	21221.	23102.	18295.	8.9	-20.8	-13.8
3661	203.	264.	333.	30.0	26.1	64.0	74088.	124310.	146442.	67.8	17.8	97.7
3662	1773.	2121.	2388.	19.6	12.6	34.7	317556.	332923.	491821.	4.8	47.7	54.9
3671	25.	146.	102.	484.0	-30.1	308.0	10515.	36800.	36469.	250.0	-0.9	246.8
3672	75.	0.	0.	-100.0	0.0	-100.0	15211.	0.	0.	-100.0	0.0	-100.0
3673	53.	0.	0.	-100.0	0.0	-100.0	20285.	0.	0.	-100.0	0.0	-100.0
3674	327.	545.	766.	66.7	40.6	134.3	97389.	114001.	184019.	17.1	61.4	89.0
3675	113.	118.	130.	4.4	10.2	15.0	27588.	28643.	32930.	3.9	15.0	19.5
3676	86.	101.	103.	17.4	2.0	19.8	20264.	24923.	19929.	23.0	-20.0	-1.7
3677	248.	294.	386.	18.5	31.3	55.6	24326.	22425.	24245.	-7.8	8.1	-0.3
3678	91.	133.	198.	46.2	48.9	117.6	19648.	26013.	44967.	32.4	72.9	128.9
3679	1844.	3118.	3770.	69.1	20.9	104.4	98340.	125966.	226362.	28.1	79.7	130.2
3721	168.	176.	165.	4.8	-6.3	-1.8	231919.	222800.	264295.	-3.9	18.6	14.0
3724	232.	269.	340.	15.9	26.4	46.6	95563.	106200.	134530.	11.1	26.7	40.8
3728	694.	728.	966.	4.9	32.7	39.2	102414.	101934.	137201.	-0.5	34.6	34.0
3743	163.	201.	200.	23.3	-0.5	22.7	50859.	56399.	33225.	10.9	-41.1	-34.7
3761	70.	40.	29.	-42.9	-27.5	-58.6	118309.	93929.	112417.	-20.6	19.7	-5.0
3764	29.	26.	27.	-10.3	3.8	-6.9	21018.	17014.	26276.	-19.1	54.4	25.0
3769	48.	42.	49.	-12.5	16.7	2.1	20952.	10193.	21981.	-51.3	115.6	4.9
3795	22.	24.	44.	9.1	83.3	100.0	5319.	12120.	16753.	127.9	38.2	215.0
3811	739.	786.	771.	6.4	-1.9	4.3	36482.	42197.	47448.	15.7	12.4	30.1
3822	131.	201.	245.	53.4	21.9	87.0	30600.	39100.	30361.	27.8	-22.3	-0.8
3823	187.	426.	627.	127.8	47.2	235.3	35446.	46499.	66223.	31.2	42.4	86.8
3824	61.	111.	145.	82.0	30.6	137.7	8271.	16019.	13440.	93.7	-16.1	62.5
3825	645.	671.	749.	4.0	11.6	16.1	55232.	66601.	96100.	20.6	44.3	74.0
3829	595.	670.	717.	12.6	7.0	20.5	26480.	32200.	40206.	21.6	24.9	51.8
3832	494.	545.	638.	10.3	17.1	29.1	19637.	29906.	53348.	52.3	78.4	171.7
3841	506.	651.	859.	28.7	32.0	69.8	34873.	43226.	63069.	24.0	45.9	80.9
3842	872.	1154.	1367.	32.3	18.5	56.8	40545.	53991.	75998.	33.2	40.8	87.4
3843	429.	550.	485.	28.2	-11.8	13.1	12609.	16637.	17544.	31.9	5.5	39.1
3861	627.	780.	795.	24.4	1.9	26.8	95903.	111557.	112335.	16.3	0.7	17.1
total	44147.	52101.	56131.	18.0	7.7	27.1	4379777.	4760507.	5601503.	8.7	17.7	27.9

Appendix C

Definition of "Rural" Used in this Study

The designation of "rural" used in this study is based on a classification scheme developed by Calvin Beale of the U.S. Department of Agriculture. The criteria for designating a county to be urban or rural are based on population size, commuting patterns of residents in individual counties, and the county's spatial position relative to a metropolitan area. Urban status is that announced by the Office of Management and Budget in June of 1983 using 1980 census population figures. Each county is coded based on its population size and spatial orientation.

The classification scheme consists of 10 urban-rural categories. Categories 0-3 identify counties that are metropolitan in nature, metropolitan being defined as counties with populations between 50,000 and 1 million or more. Both central counties and fringe counties of a metropolitan area are separately identified.

Rural counties are classified based on population and adjacency to a metropolitan area. Categories 4-9 classify counties on the basis of population size, 20,000 or more, 20,000 or less and completely rural, and on the basis of whether they are adjacent to a metropolitan area.

Appendix C (continued)

Rural-Urban Continuum Code 1980

Code

Metropolitan Counties

0 Central counties of metropolitan areas of 1 million population or more

1 Fringe counties of metropolitan areas of 1 million population or more

2 Counties in metropolitan areas of 250,000 to 1 million population

3 Counties in metropolitan areas of less than 250,000 population

NonMetropolitan Counties

4 Urban population of 20,000 or more, adjacent to metropolitan area

5 Urban population of 20,000 or more, not adjacent to metropolitan area

6 Urban population of less than 20,000 adjacent to metropolitan area

7 Urban population of less than 20,000, not adjacent to metropolitan area

8 Completely rural, adjacent to a metropolitan area

9 Completely rural, not adjacent to a metropolitan area

Notes: Metropolitan status is announced by the Office of Management and Budget in June 1983, when the current population criteria were first applied to results of the 1980 Census. Adjacent was determined by physical boundary adjacency and a finding that at least 2 percent of the employed labor force in the nonmetropolitan county commuted to metropolitan central counties.

Code prepared in Economic Development Division, Economic Research Service, USDA.

Appendix D

The dependent variables consist of six groups of variables. These include: labor market characteristics, demographic characteristics, variables measuring local amenity levels, the cost of doing business, economic variables describing the local economic situation and governmental and military variables. While a complete description of all variables is presented in the appendix, the following list contains the 22 independent variables that are part of this analysis.

Labor Market Variables

Blue collar-A variable measuring deviation in occupational distribution in metropolitan areas from the national average of blue collar workers, including craftsworkers, operators,laborers, etc.

White collar-A variable measuring deviation in occupational distribution in metropolitan areas from the national average of professional workers, including technical, administrative and clerical occupations

Unemployment-The metropolitan unemployment rate

Wages-The average manufacturing wage in metropolitan areas

Unionization-The state level of unionized workers in manufacturing

Demographic Variables

Social Security-The number of persons receiving social security payments in the population

High School Education-Percent of the population with a high school education

College Education-The percent of the population with four or more years of college education

Poverty Rate-Percent of the population living below the poverty line

Migration-Percent of the population living in a different state prior to 1980

Appendix D (continued)

Amenity Characteristics

Arts-An index which measures the availability of cultural amenities such as museums, public radio and television, etc.

4-year Colleges-The number of 4-year colleges

2-year Colleges-The number of 2-year colleges

Climate-An index of mild climate, including degree days, temperature extremes, etc.

Institutions-The total number of educational institutions awarding degrees in a local area

Crime-An index of the number of violent crimes and crimes against property

Cost of Doing Business

Housing Price-The average cost of a house in a metropolitan area

Property Tax-Average property tax bill for residences

Dollars Per Pupil-The average per-capita expenditure for primary education

Economic Characteristics

Service Industry Employment-The number of workers in service industries

Job Growth-Percentage increase in total number of jobs, 1978-82

Population-Percentage change in population, 1970-80

Government/Military Variables

Procurement-Procurement contracts awarded by the federal government divided by the population

Federal Employment-The number of federal employees in the metropolitan area

Endnotes

1. Industrial filtering refers to the process whereby industries of increasingly more mature and stable varieties move plants from metropolitan to rural areas.

2. Personal conversation with Sabina Detrich, BRIE Project, University of California, Berkeley, 1988.

3. As most of the researchers in the field of urban and regional economic development will admit, this working definition is not without flaws, a few of which should be pointed out. First, the definition concentrates on industries which produce high tech products. Thus, the economic benefits of high tech production processes are unaccounted for.

Second, data limitations associated with occupational employment statistics require that selection of industries occur at a three-digit industry level. But the majority of industries popularly considered high tech and ultimately analyzed in this study, are actually distinguishable at finer levels of disaggregation .

Finally, a definition of high tech ideally should be based on firm-level data which identify what is being done in individual establishments. Otherwise, it is possible to identify plants at a local level that produce a product called "high tech" which represents a more mature product within a larger group of products, e.g. the difference between discrete semiconductor devices and microprocessors.

Lacking a solution to these three major problems, researchers have settled on a working definition of high tech based on the human capital component of the labor process. This study conforms to that definition.

4. Two other sectors, Communications Equipment, SIC 3662 and Computers, SIC 3573, also sell a substantial part of their output to the Defense Department. SIC 3662 is a defense-dependent sector; however, it is also part of the computer-electronics complex and is therefore discussed in these sections.

5. The urban-rural continuum is a geographic system which classifies counties on the basis of population size and population commuting patterns. The continuum has become somewhat of a standard in rural research using counties as the basic unit of analysis. The continuum was developed by Calvin Beale of the Department of Agriculture. Appendix A provides a detailed accounting of the continuum.

6. <u>Methodology</u>

The choice to examine rural-adjacent (i.e., located in rural areas just outside metropolitan areas) manufacturing employment and metropolitan characteristics was made for several reasons. First, and perhaps foremost, state-level economic development policy exhibits a clear bias toward metropolitan areas. If these policies have any influence on rural high tech development, it would seem most probable in rural counties adjacent to metropolitan areas. A second reason is that the overwhelming majority of rural high tech manufacturing is concentrated in adjacent counties. A third factor is the availability of data to analyze the location behavior of rural high tech. A large number of the variables studied in this project are only collected systematically at the level of metropolitan areas. The choice was made to expand the characteristics of places examined which limited the analysis to a study of adjacent high tech development.

7. Determining Rural-Adjacent Counties

This analysis uses Calvin Beales's urban-rural continuum. Using this classification scheme, all 3140 counties were classified either adjacent or non-adjacent. In order to proceed with the current analysis, rural-adjacent counties had to be teamed up with appropriate metropolitan areas. To determine adjacent counties (using 1985 definitions), maps were used to initially identify them.

As part of the identification process, I also had to contend with instances where counties were adjacent to more than one metro area. Again, as with adjacent counties, those bordering one metropolitan area, coterminous counties were identified using maps. Once coterminous counties were identified, unpublished Census inter-county commuting data were obtained and dominant metropolitan areas identified on the basis of the metro area to which a majority of rural-adjacent county workers commuted.

Out of the 1673 rural-adjacent counties, 331 shared boundaries with more than one metro area. These counties were selected out and then attached to the corresponding metropolitan area.

8. There is, however, an element of follow-the-leadership and, thus, the importance of amenities as a primary determinant for location is still open to debate. Even companies that are not high tech are now saying amenities are important to attract non-technical employees. In other words, amenities have simply become indiscriminately used buzz words and are part of the pervasive jargon of local economic development without actually being important to the extent they are touted.

9. The log of the dependent variables was taken to adjust for order of magnitude variations in the variables. For example, some adjacent rural counties had 10,000 high tech jobs and some only 100. To account for this skewed distribution, the log is often taken to standardize the range of values for variables.

10. This section does not detail the common use of Community Development Block Grants for rural infrastructure development. Numerous states indicated in the study that they used this program for rural development. In addition, no mention is made here of services provided by the Agricultural Extension Service, although there is certainly potential for collaboration between this long-standing extension program and other technology development programs.