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**THE FORMATION AND EXPANSION OF HIGH
TECHNOLOGY FIRMS IN METROPOLITAN AREAS**

by

OLIVER IKEOTUONYE ORJIAKO

A dissertation submitted in partial fulfillment of the
requirements for the degree of

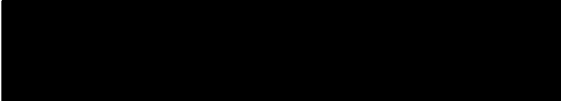
**DOCTOR OF PHILOSOPHY
in
URBAN STUDIES**

Portland State University

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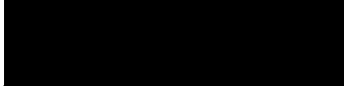
The members of the Committee approve the dissertation of Oliver Ikeotuonye Orjiako presented April 28, 1989.


James G. Strathman, Chairman


Nohad A. Toulan


William A. Rabiega


Colleen G. Acres


Steven R. Kale


Gil Latz

APPROVED:


Nohad A. Toulan, Dean, School of Urban and Public Affairs


Bernard Ross, Vice Provost for Graduate Studies

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AN ABSTRACT OF THE DISSERTATION of Oliver Ikeotuonye Orjiako for the Doctor
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Title: The Formation and Expansion of High Technology Firms in Metropolitan Areas.

APPROVED BY MEMBERS OF THE DISSERTATION COMMITTEE:

[Redacted Signature]

James G. Strathman, Chairman

Nohad A. Toulan

[Redacted Signature]

William A. Rabiega

[Redacted Signature]

Colleen G. Acres

[Redacted Signature]

Steven R. Kale

[Redacted Signature]

Gil Latz

The theme of high-technology economic base and regional development, around
which this research is based, has been receiving increased attention from policy-makers and

researchers in recent years. This partly reflects the reappraisal of the emerging structural changes which have been stimulated by the negative effects of the economic recessions of the past decade.

It also reflects the rapid growth and expansion of high-technology firms in centers like the well-publicized Silicon Valley in California, Route 128 in Massachusetts, and the Research Triangle in North Carolina. Promoting a high-technology economic base thus has been widely adopted as a regional development policy for the 1980s.

The objective of this research is to examine and analyze those attributes of the regional economy that contribute to the start-up and expansion of high-technology activity. It is hypothesized that the forces determining where new firms will locate are different from those determining whether existing firms expand, contract, or move. This study utilizes the product life cycle model as the conceptual framework, and seeks to identify factors and conditions which are critical in determining the growth and locational patterns of high-technology firms.

To address the suggested hypotheses, this study involves an analysis of the 100 largest U.S. metropolitan areas covering the period from 1976 to 1984. High-technology firms were selected as those Standard Industrial Classifications (SICs) with a proportion of technology-oriented workers equal to or greater than the average for all manufacturing industries, and whose ratios of R&D expenditures to sales were close to or above average for all industries.

Data on birth rates, closure rates, expansion rates, contraction rates, and net change in number of firms were used as dependent variables in the analysis. Independent variables were various measures of high-technology employment, total employment, venture capital, research and development, average housing price, state corporate tax rate, tax effort,

average manufacturing wage, industrial incentive, transportation access, climate index, effective property tax rate, unitary tax, and U.S. regions.

A descriptive analysis of the geographic variations in dependent variables, and tests of significance to determine if there are differences in values among U.S. census regions, is reported. The result showed that high-technology firms growth rate is not distributed evenly across the regions. The regional differences in high-tech growth rates are largely due to differences in birth rates. The West South Central, Pacific, and South Atlantic regions have the highest birth rates of high-technology firms; while New England States and Northeast regions have the lowest birth rates of high-tech firms. Expansion and closure rates parallel the same pattern as birth rates, while contraction rates are relatively consistent in all regions.

Multiple regression analysis was employed to test the relationships between dependent and independent variables. Results showed that high levels of high-technology employment was not positively associated with the growth rate of high-technology firms. The high-tech employment variable, however, did not distinguish between the proportion of low and high-tech occupations among high-tech industry grouping and, therefore, may not represent the availability of highly skilled labor. The wage rate variable, which reflects skill levels, indicates a positive relationship with birth and closure rates. This result is an indication that a high level of wage is positively associated with high-tech birth as well as closure, suggesting that the causal relationship may be operating in the opposite direction. That is, high-technology activity drives up wage rates thereby reflecting probable skill levels. Moreover, it appears that high-technology firms are less sensitive to wage rates. Housing price is both positively related and statistically significant to expansion rates. This did not, however imply that the cost of housing may be a cause for expansion, but rather may

represent a growth pressure on the housing supply due to job location. Furthermore, from the results presented in this study, factors such as venture capital, industrial incentives, amenities, and transportation accessibility were found to have very low or negligible association with the growth rate of high-technology firms. Other location factors, such as taxes, were negatively related.

The research findings of this study tended not to support the product cycle model. On the basis of these findings, the present research suggests caution in using the product cycle model for interpreting and explaining the development of high-technology complexes. This study concludes that there may be a need to incorporate market, time, and place-oriented concept to future study that will contribute more to the understanding of high-technology development so that communities seeking to attract high-technology firms can understand the stages of a company's growth, the products it makes, the type of work force it employs, and the attributes of the area.

CHAPTER I

INTRODUCTION

THE GENERAL SCOPE OF THE PROBLEM

The theme of high-technology economic base and regional development has been receiving increasing attention from policy makers in recent years. This partly reflects the reappraisal of emerging structural changes which have been stimulated by the negative effects of the economic recessions of the past decade (Bergman and Goldstein, 1983). It also reflects the rapid growth and expansion of high-technology firms in centers like the well-publicized Silicon Valley in California, Route 128 in Massachusetts, and the Research Triangle in North Carolina.

Promoting a high-technology economic base thus has been widely adopted as a regional development *policy for the '80s* (Mier, 1983; "America Rushes to High Tech," 1983). State and local government leaders are attracted to high-technology initiatives because they believe it promises new jobs, clean industry, and rapid economic growth. Some also believe that high-technology firms can provide a new era of growth in distressed regions.

State and local governments have initiated a variety of programs to promote the development of high-technology firms (Office of Technology Assessment, 1984; National Governors' Association, 1983; Joint Economic Committee, 1982; Dorfman, 1983; Brennan, 1981). Some of these programs are based on strategies to attract relocating or expanding

high-technology firms, while others try to encourage new business start-ups through local innovation and business developments. Little consideration, however, has been given to the feasibility of this policy as it relates to the plant and job creation potential of high-technology firms and their locational characteristics.

The objective of this research is to examine and analyze attributes of the regional economy that contribute to the start-up, closure, expansion, contraction, and net change of high-technology activity. It is hypothesized that the forces determining the birth rates of new firms are different from forces determining whether existing firms expand, contract, or close. This research utilizes the product life cycle theory and locational attributes of areas to identify characteristics associated with growth patterns of high-technology firms.

This study postulates that from 1976 to 1984 the formation, expansion, contraction, closures, and net changes in the number of high-technology firms in 100 large U.S. metropolitan areas were related to some or all of the following variables: high-technology employment as a percent of total metropolitan employment, total employment, the number of venture capital firms, research and development expenditure as a percentage of sales, housing costs, tax effort (ratio of per capita taxes to per capita income), state corporate tax rates, average manufacturing wage rate, amount of industrial incentives, air transportation access, climate, effective property tax rates, and presence or absence of a unitary tax. It is further hypothesized that these relationships have not remained stable through time because these processes are subject to different forces such as competition and economic conditions.

A descriptive analysis of the geographic variations in dependent variables, and tests of significance to determine if there are differences in values among U.S. census regions, were done.

Multiple regression analyses were used to test relationships between variables. The dependent variables are birth rates, closure rates, expansion rates, contraction rates, and net change rates of high-technology firms in the 100 U.S. metropolitan areas for the time period of 1976 to 1984. High-technology-based firms were defined and selected similar to a procedure used by Riche, Hecker, and Bergan (1983). The independent variables consist of business-related costs, governmental activities, and several metropolitan characteristics thought to be related to the growth or decline of high-technology activities.

Data for the change in high-technology firms—formation, expansion, contraction, closure, and net change—were obtained from the U.S. Establishment Longitudinal Microdata (USELM) files developed for the Small Business Administration by the Brookings Institution. The USELM files are condensed from U.S. Enterprise and Establishment Microdata (USEEM), also developed for the Small Business Administration. The USEEM files contain such information as the number of employed, location, age, organizational status, and firm ownership (e.g., independent vs. affiliated) on individual business establishments from 1976 to 1984. The USELM file contains observations on a sample of roughly half of the establishments represented in the USEEM file. Data in both the USEEM and USELM are derived from Dun & Bradstreet's Market Identifiers files and have been edited and supplemented with data from other sources (Boden and Phillips, 1985). The condensed and weighted data (USELM) contain information on measurable growth and such characteristics as the location of the establishment's owner, organizational status (independent vs. affiliated establishment), SIC (four-digit), establishment employment size, number of employees or size grouping, and reporting year. The USELM data are appropriate for this study since they enable longitudinal comparisons of establishment

geographical distribution and changes over time. The further advantage of the USELM data file is that it is ordered by four-digit SIC codes.

ORGANIZATION OF THE STUDY

The following chapters are organized as follows. Chapter II presents a brief discussion of the debate over which factors contribute to regional economic growth and decline, and discusses past studies of high-technology firms' locations. The chapter also reviews how other researchers have defined high-technology firms, and presents the major hypotheses regarding the factors which influence growth rates of high-technology firms.

Chapter III presents the methodology used for the analyses in this study. Included in this chapter are the hypotheses applicable to this research and a description of the data sources used for testing the hypotheses.

Chapter IV presents a descriptive analysis of regional growth rates of high-technology firms. Included in this chapter are discussions about geographic variations in dependent variables and differences in value among regions, and also interpretation of the lists of top 10 and bottom 10 metro areas for each dependent variable.

Chapter V presents the results and analysis of the research findings. The chapter also discusses problems of misspecification and limitations of data and analytic implications. Chapter VI presents the summary and conclusions.

CHAPTER II

REVIEW OF THE LITERATURE

Before developing a model of birth, expansion, closure, contracture, and net change rates of high-technology firms growth process, a brief overview of factors influencing location and the literature related to high-technology firms are reviewed.

PREVIOUS STUDIES OF ECONOMIC FACTORS

INFLUENCING LOCATION

In the late 1970s and early 1980s, state and local government officials placed greater emphasis on development programs to attract industry and accelerate economic growth. These efforts centered, in part, around economic inducements in the form of special incentives, such as revenue bond financing, low interest loans, and lower taxes, which were thought to influence industrial location decisions (e.g., Gray and Spina, 1980, Industrial Development Research Council, 1976).

Systematic analysis dealing with the combination of economic and non-economic factors influencing the location decisions of industries has produced unclear results. Recent attempts to construct indices of a *business climate* in attracting industry have compounded the problem (Fantus Company, 1975; Minnesota Tax Commission, 1978; Alexander Grant and Company, 1981). While the indices attempt to consolidate the factors bearing on plant location, composite business climate scores create interpretational problems and do not indicate what course of action should be taken by any local jurisdiction to enhance its

locational *appeal* when it comes to a specific industry.

Previous studies (Due, 1961; Fuchs, 1962; Thompson and Mattila, 1958; Williams, 1967) have found that state and local taxation have little effect on industry location. Further studies have reached a similar conclusion about the effectiveness of other forms of state and locally provided inducements to business firms (Morgan and Brownlee, 1974; Mulkey and Dillman, 1976; Harrison and Kanter, 1978; Stafford, 1979; Smith, 1981). In effect, public inducements are not major variables affecting industry location because they cannot outweigh regional transportation and other cost differentials. Despite this evidence, plant location consultants working directly with companies searching for new sites have suggested that the availability of grants, subsidies, and inducements from states and foreign countries will become a major locational criterion in the 1980s (Ady, 1981).

Other researchers have suggested that high personal taxes in certain areas may repress the growth of high-technology firms because of difficulties in attracting highly-skilled professionals (Ecker & Syron, 1979). This view is further supported by a 1982 report finding that the tax climate is the third most important of 12 factors influencing regional choices of locations for high-technology companies, and within regions the second most important factor (Joint Economic Committee, 1982).

In sharp contrast to the negative finding of the previous studies on taxes and other policy incentives, studies on regional growth and decline in the United States have emphasized the shifts in resources or in other exogenous sources of product demand (Perloff et al., 1960; North, 1955). It has also been suggested that in manufacturing employment, the divergence of population and employment growth by regions implies that important structural changes were occurring in addition to aggregated growth (Wheaton, 1979). Taking a somewhat different approach, Borts (1960), Kuznets (1964), Muth (1971),

Greenwood (1975), and Steinnes (1978) have emphasized the role that labor plays in economic development. This suggests that perhaps the most significant resources of a region are its work force and existing industrial structure. Other writers such as Chinitz (1961), Berry (1967), and Parr (1973) have advanced the notion that the presence of complementary industries and urban scale are important determinants for growth. It is suggested in several other studies that the diverse labor pools, scales of services, and industrial linkages found in large cities are the most important resources necessary for growth (Alonso, 1971; Richardson, 1972; Mera, 1973).

Researchers have also looked at specific industries and concluded that there are other factors which substantially alter the earlier views about the role of natural resources. For instance, Schnee (1978) has suggested that federal government policies and funding of research and development in electronics, computer, and aerospace industries have provided greater growth in these industries than would have been the case without federal defense and space programs (i.e., federal funding of research and development is central to the creation and maintenance of regional pools of technical labor). This advantage over time (coupled with the existing agglomeration of similar industries) can be critical to economic growth of regions (Clark, 1972; Freeman, 1974).

WHAT IS HIGH TECHNOLOGY?

To date, there is no widely accepted definition of high technology firms. Virtually all sectors of the economy contain some degree of high-technology activity. To some state and local government officials, high-technology firms simply mean electronics industries which have high employment growth potential. Others have based their definition of high-technology firms on the relative intensity of research and development (R&D) activity,

rates of innovation or research expenditures, the relative employment, or a combination of these factors (Riche, Hecker, and Burgan, 1983; Armington, Harris, and Odle, 1983; Glasmeier, Markusen, and Hall, 1983).

For example, Riche, Hecker, and Burgan (1983) identified three groupings of high-technology industries. The first group includes industries where scientific and technical workers as a proportion of total employment was at least 1.5 times the average for all industries. They defined scientific and technical workers as engineers, life and physical scientists, mathematical scientists, engineering and science technicians, and computer specialists. This wide-ranging group contained 48 industries, of which not all would be commonly thought of as high technology.

Group II, the most narrowly defined group, included industries with a ratio of R&D expenditures to net sales at least twice the average for all industries. In this group, only the following six industries met the criterion: drugs, office equipment and computers, communication equipment, electronic components and accessories, aircraft and parts, and guided missiles and space vehicles.

Group III, the next broadest group, was defined to include:

Manufacturing industries with a proportion of technology-oriented workers equal to or greater than the average for all manufacturing industries, and a ratio of R&D expenditures to sales close to or above the average for all industries. Two non-manufacturing industries are also included (Riche, Hecker, and Burgan, 1983, p. 52).

This group included only 28 industries, excluding such mature manufacturing industries as motor vehicles and certain machinery industries.

Although high-technology industries accounted for a relatively small proportion of all new jobs created nationwide during the 1972-1982 period, employment in high-technology industries increased faster than average industry growth (Riche, Hecker, and

Burgan, 1983). The narrowly defined (Group II) of six high-technology industries showed job growth of 39.6 percent between 1972 and 1982, compared to 20.1 percent for all wage and salary workers (see Table 1). Group III employment accounted for 27.3 percent increase, while growth for Group I was 23.6 percent. The BLS projected that employment in these groups will grow between 34 and 38 percent from 1980 to 1995, while employment in all industries will grow between 25 and 32 percent (Riche, Hecker, and Burgan, 1983).

Another definition of high-technology encompassed the notion of innovation in products and processes performed by scientific and technical personnel. Armington, Harris, and Odle (1983) defined high-technology as those industries with more than 8 percent of its employees in scientific, engineering, and technical occupations, and at least 5 percent of industry employment in the more narrow class of scientific and engineering occupations. They identified 29 of the 158 three-digit Standard Industrial Classifications (SICs) in manufacturing and business services as high-technology sectors. These were further broken out into 88 four-digit SICs.

Other researchers used the industry-occupation matrix from the 1980 Occupational Employment Survey and defined high-technology as those industries with more than 8 percent of their employees in scientific, engineering, and technical occupations, and with at least 5 percent in the more narrow class of scientific and engineering occupations (Green, Harrington, Vinson, 1983). These cut-off points were determined by the average proportion of high-technology jobs in durable goods manufacturing, which of the major industrial groups in the economy employs the largest number and highest proportion of technical workers.

Another definition of high technology used input-output analysis and both direct and indirect R&D expenditures to develop an index ranking on the basis of technology intensity

TABLE I
EMPLOYMENT IN THREE GROUPS OF HIGH-TECHNOLOGY
INDUSTRIES, 1972, 1980, 1982

	<u>Employment (in thousands)</u>			<u>Percent Change</u>	
	1972	1980	1982	1972-80	1972-82
All wage and salary workers	76,547.0	92,611.2	91,950.1	21.0	20.1
Group I	9,989.7	12,550.1	12,349.6	25.6	23.6
% of total employment	13.1	13.6	13.4	-	-
Group II	1,819.4	2,486.9	2,543.0	36.7	39.6
% of total employment	2.4	2.7	2.8	-	-
Group III	4,468.9	5,694.8	5,691.1	27.4	27.3
% of total employment	5.8	6.2	6.2	-	-

Source: Riche, Hecker, and Burgan, 1983, p. 53.

(Davis, 1982). Another included industries possessing above-average levels of scientific and engineering skills and capabilities, compared to the other industries, and currently experiencing the accelerating technological growth associated with the germination and evolution stages along with their respective S-curves (Lawson, 1982).

A report of the Congressional Joint Economic Committee (1982) pointed out that:

High-technology industries consist of heterogeneous collections of firms that share several attributes. First, the firms are labor-intensive rather than capital-intensive in their production process, employing a higher percentage of technicians, engineers, and scientists than other manufacturing companies. Second, the industries are science-based in that they thrive on the application of advances in science to the marketplace in the form of new products and production methods. Third, R&D inputs are much more important to the continued successful operation of high-technology firms than is the case for other manufacturing industries (p. 4).

The report went on to say that although analysts have reached no general agreement on a definition of high technology, they have generally agreed that the following SICs qualified: 28, 35, 36, 37, and 38 (Joint Economic Committee, 1982).

To most researchers, high-technology production in general refers to "firms with a relatively large amount of scientific or engineering input to their work, and it encompasses firms that use highly specialized production processes which are not widely diffused" (Hekman, 1980a, p. 35). Weiss (1983) carries this further by suggesting that:

A high technology industry (which may or may not have a U.S. Department of Commerce Standard Industrial Classification) is defined as an above-average percentage of its labor force engaged in engineering, scientific, professional, and technical work (p. 52).

Similarly, Malecki (1984) emphasizes that:

High technology is best defined as non-routine economic activities directed toward developing new products and processes, and toward small-volume production of innovative products and services. High technology relies most heavily on the availability of professional personnel and the diverse cultural, educational, and labor market attributes that attract the personnel (p. 262).

Smith and Borowski (1985) also defined high-technology to mean manufacturing industries that share the characteristics of scientific activity and technological innovation. Similarly, Giese and Testa (1987) used occupational criterion to define high-technology as those industries employing high proportions of scientific, engineering, and technical personnel.

These definitions suggest that the existence of R&D within a region and the availability of skilled manpower tend to attract activities related to high technology. They also suggest that high-technology firms should be looked at in terms of their product type, client characteristics, and production process. These definitions essentially provide a starting point for discussing why high-technology firms are important, and why certain regions are attractive to these firms.

In this research, high-technology firms will be defined similarly to the BLS's group III. This group includes the 28 three-digit industries listed in Table II and excludes such mature industries as motor vehicles. This definition was chosen because (a) it has a logical consistency in measurement and application; and (b) it corresponds closely to two other definitions used to investigate the structure and regional distribution of high-technology firms (one used by the Brookings Institution in conjunction with a Dun & Bradstreet data base, and the other used by the researchers at the University of California at Berkeley in conjunction with data from the Bureau of the Census).

Although the definition in this research attempts to capture aspects of the technological innovation process, high-technology industries are far from homogeneous and are made up of different kinds of jobs and products at different times and places. These industries are at different evolutionary stages, and the determinants of their locational characteristics are the subject of the next section.

TABLE II
HIGH TECHNOLOGY INDUSTRIES

SIC	Industries
281	Industrial inorganic chemicals
282	Plastic materials and synthetics
283	Drugs
284	Soaps, cleaners, and toilet preparations
285	Paints and allied products
286	Industrial organic chemicals
287	Agricultural chemical products
289	Miscellaneous chemical products
291	Petroleum refining
348	Ordnance and accessories
351	Engines and turbines
355	Special industry machinery except metalworking
357	Office, computing, and accounting machines
361	Electric transmission and distribution equipment
362	Electrical industrial apparatus
365	Radio and TV receiving equipment
366	Communication equipment
367	Electronic components and accessories
369	Miscellaneous electrical machinery
372	Aircraft and parts
376	Guided missiles and space vehicles
381	Engineering, laboratory, scientific, and research instruments
383	Optical instruments and lenses
384	Surgical, medical, and dental instruments
386	Photographic equipment and supplies
737	Computer and data processing services
7391	Research and development laboratories

Source: Riche, Hecker, and Burgan, 1983, p. 52.

HIGH-TECHNOLOGY LOCATIONAL CHARACTERISTICS

The process of high-technology firms' formation and growth is generally related to Thompson's (1965) and Pred's (1977) views about urban growth and development. They consider the creation of new firms to be the major force in urban growth. Early studies on the formation of new technology-based firms have been largely in the context of technical research-oriented companies which literally spin off from large complexes of government laboratories, federal defense and space programs, and local technical-oriented universities (Shapero, Howell, and Tombaugh, 1964; Deutermann, 1966; Roberts, 1970; Cooper, 1971; Schnee, 1978). Deutermann (1966) suggests that there are three basic requirements for starting a science-based company, namely:

An engineer or scientist with an idea for a better mousetrap. Second, the man with the idea must want to start his own firm. Third, the community where he is employed must show receptiveness to new ideas by tangible support of fledgling R&D companies (p. 3).

Other researchers suggest that federal R&D facilities are not major sources of start-ups (Shapero, 1971; Cooper, 1971). Schnee (1978) suggests, however, that federal funding of R&D in the electronics, computer, and aerospace industries has provided greater growth in these industries than would have been the case without federal defense and space programs.

Shapero (1972) suggests that favorable local conditions are more influential than are university incubators to start-ups of high-technology firms. Nonetheless, Browne, Mieszkowski, and Syron (1980) note that:

High technology firms employing many professional and technical workers may rate highly the proximity of a major university complex. Not only will it provide a local source of professional workers, but also the intellectual stimulus and the recreational opportunities usually associated with universities (p. 12).

The start-up rate and location of high-technology-based firms can be attributed to other sets of local characteristics. It has been suggested that the location of science-based firms could be related to (a) the presence of potential entrepreneurs; (b) the availability of professional manpower; (c) the proximity to demand for products and services and government demand in particular; (d) ease of communication; (e) venture capital; and (f) community attitudes and amenities (Schimshoni, 1971). Others studying the growth and formation of high-technology industries put heavy emphasis on indicators such as: (a) the pool of potential entrepreneurs; (b) the relative costs of doing business; (c) the level of activity in that industrial sector; (d) regional economic conditions; (e) the quality of the labor force; and (f) the general attractiveness of the city (Armington, Harris, and Odle, 1983).

The technical labor force in a particular locale is perhaps the most critical condition of high-technology start-ups. For instance, studies describing the factors important to high-technology firms in both the Route 128 area near Boston and the Silicon Valley in California argue that these complexes owe much to the stimulation of local technically-oriented universities, a particular person, or firm (Deutermann, 1966; Roberts, 1970; Cooper, 1970; Brennan, 1981; Dorfman, 1983). Freeman (1974) suggests, however, that innovative potential can exist within an enterprise if it possesses certain characteristics combined with a strong R&D department that has connections with the wider research community. It is also suggested that the firm is more likely to innovate if it recruits and trains well-educated personnel who are encouraged to push technology forward in the organization (Langrish et al., 1972; Freeman, 1986). This trend, over time, leads to the comparative advantage of certain regions as R&D activities and high-technology labor mutually attract each other (Clark, 1972; Nelson and Norman, 1977). Clark (1972), Oakey

(1985), and Hall and Markusen (1986), for example, suggest that the pool of scientific manpower and infrastructure in certain areas tends to attract others and finally will produce agglomerations of R&D very similar to the notions of agglomeration economies in manufacturing. Nelson and Norman (1977) similarly assert that the availability of well-educated manpower tends to attract activities related to products and firms in the early stages of their respective life cycles.

Recent literature on high-technology firms postulates a more specific link between their birth and expansion, and such variables as the availability of skilled and scientific-oriented workers. Hekman (1980a) argues that high-technology firms are footloose because they are not tied down to the location of natural resources or energy supplies, and because transportation costs are not a major share of production costs. He further suggests that the most important locational determinants are the need for high skills and scientific workers. Along similar lines, Browning (1980) suggests that the availability of skilled technical and professional workers needed in the non-routine activities is the greatest single locational factor for new products and high technology. Malecki (1984) argues that two patterns are evident in the location of non-routine high-technology activity, namely, "continued agglomeration in established urban centers of high technology, and dispersal to some new, smaller cities that have a set of attractive amenities" (p. 262). Although evidence points to the growth of high-technology firms throughout the country, data from the BLS indicate that most high-technology employment remains in the largest metropolitan areas (Office of Technology Assessment, 1984).

Malecki (1980, 1981) says that agglomeration in R&D results from the preferences of technical personnel for large-city locations and pleasant environmental conditions as well as the attraction of existing R&D pools for corporate research activities. This supports

Pred's (1977) and Thompson's (1965) notions of agglomeration processes as the dynamic mechanisms involved in urban and regional growth. Pred (1977) maintains that innovation, scientific capability, and new firm formation are essential parts of a healthy region. Thomas (1986) carries this further by suggesting that:

Innovations may provide a competitive edge and increased growth prospects for innovative firms and industries. In addition, the presence of innovative industries or their component firms or establishments in a region enhances both the competitive position and economic growth prospects of the region (p. 131).

Along similar lines, Carlton (1979) finds that the creation of new firms is highly dependent on the industry size, or what he calls "agglomeration economies." In this case, the size of the industry can be viewed as the aggregate pool of potential entrepreneurs. Shapero (1975) similarly suggests that the greater the pool of potential entrepreneurs or the aggregate set of "incubator organizations," the greater the number of business start-ups. In other words, certain regions appear to offer a promising environment for new technology-based firms because the locational concentration of resources enhances firm productivity by creating external economies of scale similar to those in larger corporations. As Dorfman (1983) notes, agglomeration of new firms not only retains and attracts skilled professionals in the region, it strengthens and diversifies the technological infrastructure, promotes informal communication, and draws venture capital to the region by creating opportunities for profitable investment. Moreover, agglomeration places entrepreneurs at the center of competition for new markets, thereby encouraging entrepreneurial activity by providing local role models and a supportive atmosphere.

Research by Hekman (1980a) on the computer industry in New England suggests that computer firms have kept their R&D and administrative activities in places like California, Massachusetts, Minnesota, and New Jersey, but have moved their production

facilities to the Southern states and foreign locations to take advantage of lower labor costs. In another study, Hekman (1980b) looked at the medical instruments industry, and asserts that since most of the production in that industry cannot be standardized in large plants, manufacturing takes place near medical research centers such as Boston and Chicago, where the industry's R&D is also concentrated.

A more recent study by Rees and Stafford (1986) named the following variables as key locational factors of high technology firms: (a) skilled labor; (b) academic institutions; (c) quality of life and amenities; (d) market and transportation; (e) taxes; and (f) financial capital. Similarly, Malecki (1986) reviewed the development of high-technology complexes in four U.S. regions: Boston, Silicon Valley, Research Triangle, and Austin. He identified the following factors as important for high-technology locations: (a) skilled labor; (b) research universities; (c) urban size; (d) quality of life; (e) venture capital; and (f) the quality of local infrastructure. Armington (1986) examined the regional patterns of change in the formation of high-technology businesses. Her empirical research of metropolitan growth rates in high-technology business formation found population growth rate, city size, and technical occupation share of the labor force to be positively associated with growth rates, while energy costs, local tax rates, and wage rates were negatively associated. Armington (1986) also found no measurable association of high-tech formation with the share of local employment in high-tech industries, and suggests that, "perhaps it is too highly correlated with the technical occupation share to measure separately, or it may only be detectable with less aggregated industrial groupings" (p. 85).

In another empirical study, Glasmeier, Hall, and Markusen (1983) focus on regional differences in the location of high-tech industries. In their study, the following variables were included: (a) air pollution; (b) airport access; (c) art index; (d) black population; (e)

climate index; (f) defense spending per capita; (g) educational options index; (h) educational spending; (i) Fortune 500 headquarters; (j) freeway density; (k) house sales price; (l) labor force; (m) major university; (n) Spanish population; (o) unemployment rate; (p) percent of unionized state labor force; (q) industrial utility rates; (r) percent voted Republican; and (s) average manufacturing wage. Their analyses of the distribution of high-tech industries at the metropolitan level, however, found positive association with only percent black population and per capita defense spending. This result on defense spending corroborates the findings of Markusen (1986) who argues that the patterns of defense spending and the development of high-technology industry is a function of land, labor, and military bases.

Other researchers have also suggested a similar list of factors as important for high-technology firms location. For example, Oakey and Rothwell (1986) stressed the importance of venture capital in the San Francisco Bay Area of California in facilitating the rapid investment capital for fast-growing firms. Feldman (1985), and Rees and Stafford (1986) suggest that air travel for transportation of employees and high value products are important factor. Glasmeier, Hall, and Markusen (1983) found that airports were significant contributors in explaining high-technology locational changes.

Although all these factors are mentioned in the literature as very important in the locational characteristics of high-technology firms, some studies suggest otherwise. For instance, Stafford (1979) and Schmenner (1982) suggest that amenities are important to highly skilled workers in high-technology firms. Amenities are, however, difficult to measure or evaluate; in most cases, a proxy for amenities is used. For instance, Glasmeier, Hall, and Markusen (1983) used the arts index and found it not to be a significant factor for high-technology firms. Armington (1986) indicated that "demand for most high-tech products is national, rather than regional, and most have such high value to weight ratios

that transportation costs are insignificant" (p. 83). She also argues that "there are local differences in the availability of venture capital, but most expansions of existing high-tech businesses, and formation of new high-tech establishments, do not rely on venture capital, but on internal financing or borrowing through regular channels" (Armington, 1986, p. 83).

In general, these studies suggest that the locational pattern of high-technology activity is consistent with a regional development life cycle. That is, high-technology firms exhibit a pattern in which the highly skilled professional functions remain concentrated in regions where the resource base is characterized by a pool of technical labor and other factors combined with agglomeration economies, while standardized tasks are found at low-wage locations.

THE RELEVANT THEORETICAL FRAMEWORK

The treatment of high-technology development as outlined in this research revolves around the theory of the product life cycle. The product life cycle model relates to the classical industrial location theories (Losch, 1954; Isard, 1956; Weber, 1929), which emphasize demand, supply, and cost factors. The model can also be associated with hierarchical diffusion or filtering down of innovations from urban cores to peripheral areas (Berry, 1972).

The notion that regional growth initially occurs around one or more regional centers can be traced to the work of a French economist, Francois Perroux (1950). Perroux introduced the concept of growth poles in 1955; however, his concept had no explicit geographic basis (Darwent, 1969). The attempt to introduce space in the growth pole theory was later done by Myrdal (1957) and Hirschman (1958). Locational forces suggest that external economies exist (specifically, agglomeration economies), and that the space-

time clustering of innovations is embodied in the process of production. Growth poles are described as foci which emanate centrifugal forces and attract centripetal forces. The polarization of growth, in this case, through technological linkages, accelerates local growth by enhancing the potential for invention and innovation (Pred, 1975). The theory also suggests that in the early stages of development, polarization effects are very strong. Over time, a natural counteraction induces an outward movement of factors of production (Hansen, 1973). Friedman (1972), in his center periphery model, argues that innovation diffusion from the core to the periphery is not only technical as suggested by the growth pole theories, but may also involve changes in society, culture, economy, or political organization.

How does growth pole theory relate to high-technology firms? According to Rees and Stafford (1983):

The growth pole theory recognizes the importance of propulsive high technology sectors in the urban growth process, and explains how such centers can perform as incubators or seedbeds for the birth of new companies (p. 97).

Growth pole theory emphasizes the notion that industrial growth is an urban-dominated paradigm. Investment is concentrated in the major urban centers and filters down over time, spreading income and employment throughout the region. This is the line of argument in two historical studies published in the 1930s: Kuznets' (1930) and Burn's (1934). They conclude that industries appear to pass through a regular development cycle. Their findings are known as the "law of industrial growth"—a tendency for industries to follow a common pattern in their course of development. According to Alderfer and Michel (1957), industries "pass through a period of experimentation, a period of rapid growth, a period of diminished rate of growth, and a period of stability or decline" (p. 13). This process reflects the interplay between the scale of output and the rate of technological

process with industries. This relationship between stages of development and innovation can be conceptualized as is shown in Figure 1.

Alderfer and Michel (1957) emphasized that:

As a result of the period of experimentation, both the product and the process have been materially improved as the industry enters its second phase of growth. The growth is further accelerated by reduction in the price of the product and by improvements in the marketing of it. One improvement leads to another and the price is further reduced. New markets are tapped, and demand swells, and the industry is in a position to manufacture on a large scale and to reduce price still further. More new devices are brought into play, better merchandising demands are established, export sales may be pushed, and the terms of installment selling may be made more attractive. Consequently, the second period is one of rapid progress and growth. The industry passes next to the third stage, diminished growth. The rate of technical process begins to slacken. . . . Usually only refinements of existing processes are affected. . . . During the third period, external forces may be at work counteracting the efforts of the industry to expand, and forcing it into the fourth period, that of stability or decline. Competing industries may be established in foreign countries, and competition from them not only reduces exports but frequently results in reduced domestic sales (p. 15).

It is in this context that Vernon (1966) emphasized the spatial dimensions of an industry's development cycle. Although Vernon's broader thesis centers around technological progress and the changing importance of "external economies" in the context of international trade and location, his observations have been the subject of considerable regional-oriented research. The work of Erickson (1972); Leheron (1972); Krumme and Hayter (1975); Thomas (1971, 1975, 1986); Rees (1979); and Markusen, Hall, and Glasmeier (1986) are good examples.

What does product cycle have to do with high-technology firms? Norton and Rees (1979) interpret the trends in the location of U.S. manufacturing in terms of such cycles and shifts from old to new industries. High-technology activities are characterized according to product cycle theory, and the attributes of the regional economy are examined with respect to the stages of the product cycle.

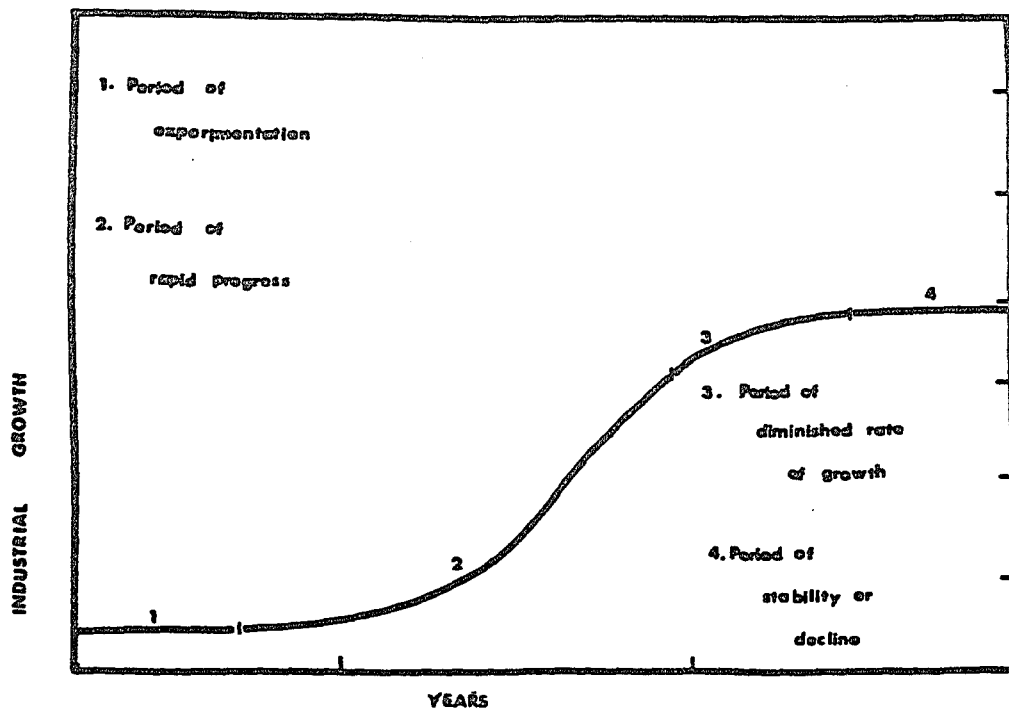


Figure 1. Curve of industrial growth.
Source: Alderfer and Michel, 1957, p. 14.

As Rees and Stafford (1983) point out:

Product life cycle theories recognize that products, firms, and industries have different locational requirements at various stages of their technological development; while new development tends to take place in R&D-intensive locations like Boston or San Francisco, mass production techniques allow product development to take place in more peripheral low-cost areas like the Sunbelt or the Far East (p. 97).

This suggests that the progression from R&D to innovation to technical change and finally economic growth can be viewed as an evolutionary process. This view is parallel to Thompson's (1965, 1975, 1977) and Pred's (1977) broader thesis about urban growth and the locational evolution of industry. For a single industry or product, this process has been defined in terms of stages comprising initial product development, commercialization, and final obsolescence. Vernon (1966) defines this progression as the "product-cycle."

The product cycle-model has a profit maximization and competition dimension. The model also has an explicit locational dimension, since each phase of the product cycle has a different locational requirement (Rees and Stafford, 1986). For instance, the major role of R&D processes and highly-trained technical personnel is apparent in the early stages of the product cycle. As the product becomes mature or standardized, the relative importance of highly-trained labor tends to decline. The heart of the model, therefore, is its treatment of the role of highly educated and skilled labor combined with locational factors that relate to the attributes of the area.

The produce-cycle model has its critics. The viewpoint of several writers (Storper, 1981; Sayer, 1983; Walker, 1985) discussing industrial restructuring is that the product-cycle model is "technological determinism." Structuralists argue that the location of economic activities is based on the ability of entrepreneurs to understand historic trends and associate their activities with macroeconomic fluctuations.

In general, the structuralist model does not differ much from the product-cycle model because both address the notion of competition and profit maximization. The exception is their interpretation of the roles of technology, capital, and labor. By and large, no one model or theory can adequately treat or account for variations in growth and decline of an industry in all areas. As Rees and Stafford (1986) indicate:

There does not appear to be a need for any new theory of regional growth to explain the development of high-technology complexes. There may be a need to extend existing theory, particularly theories of growth poles and product cycles (p. 35).

The product-cycle model, therefore, has some relevance for conceptualizing the processes for variations in high-technology firm activities. Although it has its critics, it is an important model and concept that can be used to understand and explain factors influencing changes in high-technology firms' locational behavior. For example, recent research by Markusen et al. (1986), Barkley (1988), and Smith and Barkley (1988) used the product-cycle model to show that high-technology industries are locating in small urban areas and geographically isolated rural communities.

As discussed earlier, researchers such as Shimshoni (1971); Clark (1972); Nelson and Norman (1977); Malecki (1980a, 1981, 1986); Hekman (1980a); Browning (1980); Joint Economic Committee (1982); Wolff (1982); Dorfman (1983); Armington, Harris, and Odle (1983), Armington (1986), Glasmeier, Hall, and Markusen (1983), Rees and Stafford (1986), and Markusen (1986) have suggested that the list of locational factors includes variables such as availability of skilled technical workers, agglomeration in R&D activities, venture capital, taxes, amenities, and housing costs.

SUMMARY

This chapter's review of several studies analyzing regional economic growth and the location of economic activities shows that models for regional development, especially the produce cycle model, provide a useful framework for analyzing growth of high-technology complexes. For example, Rees (1979) used the model to examine spread effects and changes in locational patterns of firms whose products are at different stages of maturity. He concluded that spatial evidence in the Dallas-Fort Worth area supported the model.

Other writers (Erickson, 1976; Hansen, 1979; Cromley and Leinbach, 1981; Park and Wheeler, 1983) used the product cycle model to examine changes in employment at the state level. Their analyses showed that the availability of highly-skilled labor has helped to keep administrative activities in core areas, whereas modest wages and trainable labor force were the key factors in the location of production facilities in peripheral areas.

Numerous other studies have found that labor often is the most important determining factor in the location of new plants. For example, Borts (1960), Greenwood (1975), Steinnes (1978), Stafford (1980), and Joint Economic Committee (1982) provided evidence that labor plays an important role in economic development. Browning (1980), Hekman (1980b)u, and Malecki (1984, 1986) found that labor costs and the availability of high-skilled technical personnel are important for high-technology-based firms.

Industrial location models have traditionally emphasized the costs of transportation. While transportation is generally a factor of some locational importance, for high-technology firms there is less emphasis on transportation costs because these firms are not tied down to the location of source materials, and their products are not characterized by large amounts of weight. The emphasis is on air travel for transportation of employees and high

value products (Feldman, 1985; Rees and Stafford, 1986). The empirical evidence (Glasmeier, Hall, and Markusen, 1983) found that airports were significant contributors in explaining high-technology locational changes.

The issue of taxes and their effects on plant location is a widely debated one in the literature. However, empirical evidence from previous studies (Due, 1961; Stafford, 1980; Schmenner, 1982; Armington, Harris, and Odle, 1983) has concluded that taxes are minor locational determinants. How taxes influence high-technology firms' locational changes is unclear in view of the fact that taxes are used to pay for services which high-technology firms value.

The effect of agglomeration advantages on high-technology firms' locational behavior is that over time, the existing agglomeration of similar industries can be critical to economic growth of regions (Clark, 1971; Freeman, 1974; Oakey, 1985). However, research by Carlton (1979), and Armington, Harris, and Odle (1983) indicates that there is no measurable association of high-tech growth with the level of activity in that industrial sector.

The other attributes of areas outlined in the literature are quality of life, or amenities, and business incentive variables. Although the amenities factor is believed to be important to highly skilled workers in high-technology firms (Stafford, 1980; Schmenner, 1982), it is difficult to measure or evaluate. Usually a proxy for amenities is used in the studies of growth of high-technology complexes. For example, Glasmeier, Hall, and Markusen (1983) used, among other variables, the arts index and found that a rich cultural environment is not a significant pull factor for high-technology plants.

Another debated issue in the literature concerns the business climate, or incentive variables. Many types of incentives are offered to both new and expanding firms, and these vary across space. In addition, the role of R&D and venture capital in high-technology

firms' growth behavior is not very clear and has not been empirically tested. It is often assumed that venture capital is equally available in every location (Smith, 1981). A recent study (Leinbach and Amrhein, 1987) shows that the venture capital industry in the U.S. is not evenly distributed.

In summary, the determinant variables and locational attributes of areas discussed in this chapter are critical to understanding the growth rates of high-technology firms. Since high-technology firms' locational patterns are described in the context of the product cycle model, each factor discussed in this chapter is expected to vary in its relationship to the growth rates of high-technology firms. Some of the variables in this chapter will be addressed further following discussion of the conceptual development of the methodology for this study.

CHAPTER III

METHODOLOGY

As indicated in Chapter I, the purposes of this study are (a) to formulate and quantify certain changes in the locational distribution of high-technology firms, and (b) to examine selected processes (e.g., formation, expansion, contraction, and closure) that have produced these variations. The approach consists of an overview of general hypotheses, research design and model formulation, definitions of data sources and selected variables, and an analysis of data.

A number of studies (Allman and Birch, 1975; James and Struyk, 1975; Carlton, 1979; Hekman, 1980a; Glasmeier, Hall, and Markusen, 1983; Armington, Harris, and Odle, 1983) provide support for the argument that economic and other forces influencing the birth of new firms will be different from those that influence their expansion, contraction, closure, and net change; and that these processes should be analyzed separately. These studies do not use the product-life cycle model as a conceptual framework; however, their results are consistent with the elements of that model.

Previous studies suggest several lessons about modeling high-technology firms' location and growth patterns. First, one must carefully define high-technology firms. Second, high-technology firms display widely different location patterns and vary widely in plant and job creation potential. This calls for a disaggregated analysis of high-technology firms' formation, expansion, contraction, closure, and net change.

If substantial variation in location of high-technology growth and decline exists, then high-technology job creation strategies may need to be finely tuned to individual phases of the product-cycle interpretation and to location factors that relate to the attributes of areas. Therefore, the search for regularities in the initial and changing location patterns of high-technology manufacturing firms may have importance.

STATEMENT OF HYPOTHESES

There are three general hypotheses in this research:

1. The birth rates of high-technology firms are a function of existing high-technology employment. The contention here is that the birth of new high-technology firms depends heavily on existing technical capability.
2. The expansion of high-technology firms are positively related to the agglomeration economies and business costs. The rationale here is that the expansion of high-technology firms depends on business costs, amenities, and transportation access.
3. The birth, expansion, contraction, closure, and net change rates of high-technology firms are related to some or all of the selected independent variables. As previously mentioned, these processes are subject to different forces. For example, an enlarged skilled labor base in a town will stimulate the growth of new firms, while high labor costs will retard expansion there.

RESEARCH DESIGN

In order to address the suggested hypotheses, this research will seek to analyze how the rates of formation, expansion, contraction, closure, and net change of high-technology firms are related to various economic and noneconomic metropolitan attributes.

These relationships were analyzed from 1976 to 1984 for the largest 100 U.S. metropolitan areas.

The research proceeds on two levels: first, a general study for the sampled metropolitan areas; and second, a disaggregated model to evaluate the stability of regression coefficients with respect to births, closures, expansions, contractions, and net change.

CONCEPTUAL MODEL

The patterns of variation in the rate of birth, expansion, contraction, closure, and net change among high-technology firms in the metropolitan economy can be seen as a function of high-technology employment, total employment, number of venture capital firms, amount of R&D expenditures, housing costs, per capita tax effort relative to income, maximum state corporate income tax, average manufacturing wage rate, industrial incentive scores, effective property tax rates, climate, air transportation access, and the presence or absence of a unitary tax. Stated as a conceptual model:

$$\begin{aligned}
 BR_i &= F(HTE, LEA, VC, R\&Dp_{to}, H1, TE, MSCT, AMW_{to}, INCN, AM, \\
 &\quad TA, ETR, DUT, DDm) \\
 ER_i &= F(HTE, LEA, VC, R\&Dp_{to}, H1, TE, MSCT, AMW_{to}, INCN, AM, \\
 &\quad TA, ETR, DUT, DDm) \\
 CR_i &= F(HTE, LEA, VC, R\&Dp_{to}, H1, TE, MSCT, AMW_{to}, INCN, AM, \\
 &\quad TA, ETR, DUT, DDm) \\
 DR_i &= F(HTE, LEA, VC, R\&Dp_{to}, H1, TE, MSCT, AMW_{to}, INCN, AM, \\
 &\quad TA, ETR, DUT, DDm) \\
 NC_i &= F(HTE, LEA, VC, R\&Dp_{to}, H1, TE, MSCT, AMW_{to}, INCN, AM, \\
 &\quad TA, ETR, DUT, DDm)
 \end{aligned}$$

Where,

BR_i	=	new birth rate in SMSA _i
ER_i	=	expansion rate in SMSA _i
CR_i	=	contraction rate in SMSA _i
DR_i	=	closure rate in SMSA _i
NC_i	=	net rate of change in SMSA _i

and,

HTE_i	=	high-technology employment as a percent of total metropolitan employment
LEA_i	=	level of activity or total employment
VC_i	=	number of venture capital firms
$R\&D_{p_{toi}}$	=	research and development as a percent of sales
$H1_i$	=	housing cost
TE	=	tax effort relative to income
$MSCT$	=	state corporate tax rates
AMW_{to}	=	average manufacturing wage
$INCN$	=	industrial incentives
AM	=	climate
TA_i	=	air transportation access
ETR	=	effective property tax rates
DUT	=	presence or absence of unitary tax
DDm	=	dichotomous variable for U.S. geographic regions
$SMSA_i$	=	standard metropolitan statistical area *

*Some of these independent variables are measured for metropolitan areas.

The literature review and the previously discussed studies indicated that some of the independent variables do and some do not facilitate the growth rate of high-technology firms. Table III illustrates where positive and negative relationships are anticipated for each of the dependent variables and the independent variables.

It has been suggested that the presence of a pool of potential entrepreneurs (HTE), measured here as high-technology employment as a percent of total metropolitan employment, is associated with the formation and location of high-technology firms (Armington, Harris, and Odle, 1983). Shimshoni (1971) and Dorfman (1983) suggest that VC (venture capital) is a very important indicator in the start-up of high-technology firms. Other researchers (Armington, Harris, and Odle, 1983; Thompson and Thompson, 1983) have used $R\&D_{Pto}$ (research and development as a percent of value added) as a measure for high-technology firms' relative size and growth distribution. Wolff (1982) suggests that H1 (housing cost index) measured as an average housing cost is an important factor in the location of high-tech scientific and professional workers. A high TE (tax effort), measured as the ratio of per capita taxes to per capita income, may inhibit the growth of high-technology firms in attracting highly-skilled workers (Ecker and Syron, 1979; Joint Economic Committee, 1982).

Other studies (Shapero, 1975; Pennings, 1982; Armington, Harris, and Odle, 1983; Malecki, 1984) have all emphasized the importance of agglomeration effects on healthy economic activity (LEA—level of economic activity), measured here as total employment, to be an attracting force in high-technology activities. Similarly, researchers such as Carlton (1979); Armington, Harris, and Odle (1983); and Kale (1984) have used variables such as wages, corporate taxes, and industrial incentives as a measure of regional economic cost.

TABLE III

A HYPOTHESIZED SIGN OF THE FACTORS ASSOCIATED WITH HIGH-
TECHNOLOGY FIRMS BIRTH, EXPANSION, CONTRACTION,
CLOSURE, AND NET CHANGE RATES

Variable	Symbol	Coef* of Hypothesized Sign With Dependent Variable				
		Birth Rate	Closure Rate	Expansion Rate	Contraction Rate	Net Change Rate
High-Technology Employment	HTE	+	+	-	-	-
Total Employment	LEA	-	+	-	-	±
Venture Capital	VC	+	-	-	-	±
Research & Development	R&DP _{to}	+	+	-	-	±
Housing Price	H1	-	-	-	-	±
Tax Effort	TE	+	+	-	-	±
State Corporate Tax Rate	MSCT	-	-	+	+	±
Manufacturing Wage	AMW _{to}	+	+	-	-	±
Industrial Incentives	INCN	-	-	+	+	±
Climate	AM	+	+	+	+	±
Transportation Access	TA	+	+	-	-	±
Effective Property Tax Rate	EPTR	+	+	-	+	±
Unitary Tax	DTU	+	+	-	+	±
U.S. Regions	DiDm	±	±	±	±	±

Source: Author

*Expected sign of coefficient.

In this study, a measure for industrial incentive scores (INCEN), maximum state corporate taxes (MSCT), and average manufacturing wages (AMW_{to}) are used to capture relative regional economic conditions. Schmenner (1982), Rees and Stafford (1986), and Malecki (1986) suggest that the quality of life in an area is an important factor, especially attractive environments for engineers and managers of high-technology companies. In this research, climate (AM) is used as a measure for amenities and attractive environment. Feldman (1985), and Rees and Stafford (1986) suggest that air travel (TA), measured here as number of direct and daily flights into and out of metropolitan areas, is an important factor in the location of high-technology firms. DUT represents a dichotomous variable for unitary taxes which will take a value of one for states with unitary tax, and zero otherwise. DDm also represents a dichotomous variable for U.S. geographic regions as follows: New England, West South Central, East South Central, South Atlantic, West North Central, East North Central, Mid-Atlantic, Mountain, and Pacific. See Figure 2 for regions and divisions of the U.S.

OPERATIONAL MODEL

The model takes the following linear form:

$$Y_i = a + bX_{1i} + bX_{2i} + bX_{3i} \dots + BX_{ni} + e$$

where,

- Y_i = i^{th} observation on the dependent variable
- a, b = empirically estimated parameters
- $X_{1i} \dots X_{ni}$ = i^{th} observation on the independent variables
- e = error term

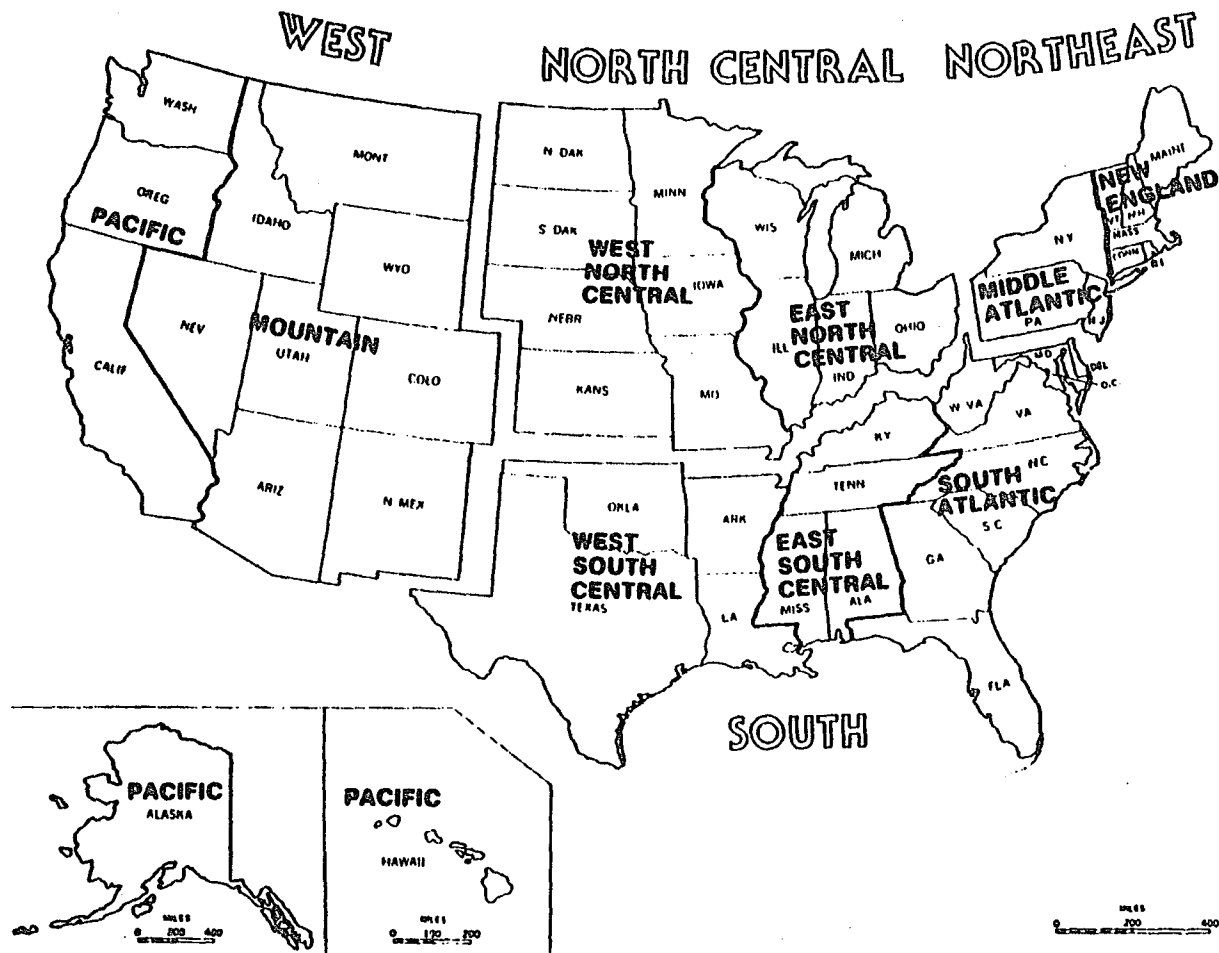


Figure 2. U.S. geographic subdivisions.
Source: U.S. Department of Commerce.

Five models are postulated to estimate the birth, expansion, contraction, closure, and net change processes of high-technology firms' behavior. The estimation of the regression model is based on the method devised in the Statistical Package for the Social Sciences (SPSSX), releases 19, 25, and 35. A number of researchers (Mansfield, 1962; Gudgin, 1978; and Johnson and Catheart, 1979) have analyzed within a multiple regression framework, inter-industry differences in formation rates.

VARIABLE MEASUREMENT AND DATA SOURCES

Dependent Variables

Each dependent variable is operationalized as follows:

- BR_i = the proportionate increase in high-technology employment from new business formation in $SMSA_i$
- ER_i = the proportionate increase in high-technology employment from business expansions in $SMSA_i$
- CR_i = the proportionate decrease in high-technology employment from business contractions in $SMSA_i$
- DR_i = the proportionate loss of high-technology employment from cessation of operations in $SMSA_i$
- NC_i = the proportionate overall change in high-technology employment in $SMSA_i$

The first approach is to measure the birth rates, expansion rates, closure rates, contraction rates, and net change rates of high-technology firms in each of the 100 U.S. metropolitan areas for the time period 1976-84. These births, expansions, closures,

contractions, and net change rates constitute the dependent variables in the series of regression models used to test the hypotheses.

The dependent variables are measured as follows:

$$BR_i = \frac{\sum_t \sum_j \text{New Start Empl}_{ijt}}{\sum_j \text{Empl}_i \text{ 1976}}$$

$$ER_i = \frac{\sum_t \sum_j \text{Expansion Empl}_{ijt}}{\sum_j \text{Empl}_i \text{ 1976}}$$

$$CR_i = \frac{\sum_t \sum_j \text{Contraction Empl}_{ijt}}{\sum_j \text{Empl}_i \text{ 1976}}$$

$$DR_i = \frac{\sum_t \sum_j \text{Closure Empl}_{ijt}}{\sum_j \text{Empl}_i \text{ 1976}}$$

$$NC_i = \frac{\sum_t \sum_j (\text{New Start Empl} - \text{Closure Empl} + \text{Expansion Empl} - \text{Contraction Empl})_{ijt}}{\sum_j \text{Empl}_i \text{ 1976}}$$

where,

BR_i = Birth rate

ER_i = Expansion rate

CR_i = Contraction rate

- DR_i = Closure rate
 NC_i = Net change rate
 t = Time (1976 to 1984)
 j = High-Tech SICs
 i = SMSA
 Empl = Employment

See appendix, Data on Rates of Change for High-Technology Firms in the 100 Largest SMSAs, 1976-84, Table XVII.

Independent Variables

It is postulated that the following independent variables will be associated with the formation and location of high-technology firms. The rationale for their selection is covered in the literature review chapter and briefly in this section.

High Technology Employment (HTE). Total high-technology employment divided by total employment for each metropolitan area. It is a measure reflecting the pool of potential entrepreneurs. Data were extracted from the U.S. Establishment Longitudinal Microdat (USELM) for the base year (1976) employment counts.

Total Employment (TE). The raw count of overall metropolitan employment. This was used as a measure of the size of the local economy and agglomeration effect. Data were collected for 1976 and the source is the 1980 *State and Metropolitan Area Data Book*.

Venture Capital (VC). The total number of venture capital firms in each metropolitan area in 1976. The data were obtained for 1976 from the latest edition of *Guide to Venture Capital Sources*.

Research and Development $R\&D_{io}$. Research and development expenditures as a percent of sales. The data set was created from the firm-level data published annually in *Business Week*, R&D Scoreboard for 1976, and the firm listings in the *Directory of American Research and Technology*.

Housing Price (H1). Average sales price (in dollars) for a home in the metropolitan area in 1976. Data were obtained for 1976 from the U.S. Bureau of the Census annual survey of average house sales price in U.S. metropolitan areas.

State Corporate Tax (MSCT). The state corporate tax rate as applicable to \$250,000 was used to mitigate variations in state tax rates and against potential problems arising from states with graduated tax schedules or complicated formulas. Data were obtained for 1976 from the *State Tax Handbook 1976*.

Tax Effort (TE). The ratio of per capita taxes to per capita income for 1975. Data were obtained from the Advisory Commission on Intergovernmental Relations publication, *Tax Capacity of the Fifty States*, 1982.

Manufacturing Wage (AMW_{io}). Average wage for production workers in 1976 in dollars per hour. Data were obtained from the U.S. Bureau of Labor Statistics, *Employment and Earnings*, 1977.

Industrial Incentives (INCN). A weighted breakdown of incentives for each of the 50 states for 1976. Data were obtained from "The Fifty Legislative Climates," *Industrial Development* (1976), and arrayed according to the Industrial Development Research Council (1977) index of industrial incentives.

Climate (AM). The index comprises the sum of the total number of hot and cold months, the number of freezing days, zero days, the number of 90-degree days, and

seasonal temperature variations. Data were collected for the year 1978 from *Places Rated Almanac*.

Transportation Access (TA). Total number of direct and daily flights into and out of a metropolitan area in 1976. Data were obtained from the U.S. Department of Transportation, FAA, Airport Statistics, Fiscal Year 1979.

Effective Property Tax Rate (ETR). The nominal tax rate divided by the assessment/sales price ratios. Data were collected for the year 1976 from "Property Values and Assessment: Sales Price Ratios," ACIR (1977), published by the U.S. Bureau of the Census.

Unitary Tax (UT). A dichotomous variable which equals one for states with unitary tax, and zero otherwise. Data were collected for 1976 from the *Multistate Tax Commission Review* (December, 1983).

U.S. Regions (DDM). These variables were broken down into eight dichotomous variables representing the census geographic subdivisions.

See appendix, Data on Selected Independent Variables for the 100 Largest SMSAs, Table XX.

Data Source for Dependent Variables

The source of data for the change in high-technology firms' formation, expansion, contraction, closure, and net change was the U.S. Establishment Longitudinal Microdata (USELM) files developed at the Brookings Institution for the Small Business Administration. The USELM files are a condensed data base from U.S. Enterprise and Establishment Microdata (USEEM). The content of the USEEM files has already been stated in Chapter I. Briefly, the USEEM files contain information by firm, such as the

number of employed, location, age, organizational status, and characteristics of its owning firm if it is part of a multi-establishment enterprise (e.g., independent vs. affiliated). The U.S. Establishment Longitudinal Microdata file contains observations on a sample of roughly half of the establishments represents in the USEEM file. The data in both the USEEM and USELM are derived from Dun & Bradstreet's market Identifiers files and have been edited and supplemented with data from other sources (Boden and Phillips, 1985). The condensed and weighted data (USELM) are available for the 1978-80 and 1976-84 periods, and contain information on growth and such characteristics as the location of the establishment (county or SMSA), the location of the establishment's owner (affiliated establishment), organizational status (independent vs. affiliated establishment), SIC (four digit), establishment employment size, number of employees or size grouping, and reporting year.

SUMMARY

In summary, the USELM data are appropriate for this study since they contain sufficient information necessary for the longitudinal comparisons of establishments' geographic distribution and changes over time, which are central to this research. The further advantage of the USELM data file is that it is ordered by four-digit SIC codes.

To test the hypotheses and research questions, the aggregate data and variables for this study were used in a series of regression analyses to examine the relationships between the characteristics of the sample metropolitan areas and the birth, expansion, contraction, closure, and net change of high-technology firms. Each of the independent variables was regressed on the dependent variable through a multiple regression procedure.

This technique estimates a set of equations and a joint generalized least squares procedure by using the co-variance matrix of residuals across equations.

In addition, mean values for each of the dependent variables were calculated and interpreted by region. Tests of significance were used to determine if there are differences in values among regions. The results of this descriptive analysis, and the analysis of regression findings, summary, and conclusion are presented in the following chapters.

CHAPTER IV

GEOGRAPHIC VARIATIONS IN RATES OF GROWTH AND DECLINE FOR HIGH-TECHNOLOGY FIRMS

DESCRIPTIVE ANALYSIS OF REGIONAL GROWTH RATES

To explore the degree to which the growth and decline of high-technology firms vary across metropolitan areas, a list of top 10 and bottom 10 metro areas was developed and interpreted based on the 1976 to 1984 birth, expansion, contraction, closure, and net change rates of high-technology firms for the 100 largest U.S. metropolitan areas.

The birth values for the top 10 and bottom 10 metropolitan areas are provided in Table IV. The lists of the 10 highest birth rate leading areas indicate that SMSAs thought to be high-tech places like Boston, San Jose, and Los Angeles were not among the highest high-technology birth rate areas. Surprisingly, Tacoma, Washington; El Paso, Texas; West Palm Beach, Florida; and Austin, Texas, were the top four highest SMSAs in high-technology firms birth rate. As Table IV shows, places with the highest and lowest high-technology birth rate varies geographically. It appears that greater initial growth of high-technology firms is being experienced in medium-size SMSAs than in large SMSAs like Chicago, New York, or Boston.

The only possible explanation for the high birth rate of high-technology firms in places like Tacoma may be a reflection of the size and attractiveness of the area, or the influence of Boeing, defense spending, and other military related activities. A similar

explanation can be offered in the case of El Paso and Austin, Texas, where space related activities are predominant. Similarly, in West Palm Beach and Orlando, Florida, attraction of high-technology firms may result from, among other factors, the influence of NASA and space-related activities located nearby. Other SMSAs that make up the top 10 areas with the highest birth rate of high-technology firms are Canton, Ohio; Peoria, Illinois; Washington, D.C.; Harrisburg, Pennsylvania; and Portland, Oregon. Factors such as abundant labor resources and availability of large pool of technical and scientific workers may help explain the attraction of high-technology firms in these five SMSAs. As a group, the West South Central and South Atlantic states accounted for five of the top 10 locations while the Pacific and the East North Central each accounts for two locations. The remaining location, Harrisburg, Pennsylvania, is in the Mid-Atlantic region.

The ten metropolitan areas with the lowest high-technology birth rate are predominantly in the East North Central and Mid-Atlantic states. These are primarily older metropolitan areas in the manufacturing belt. The exceptions are Johnson City and Chattanooga, Tennessee; and Albuquerque, New Mexico.

As Table V shows, some of the metropolitan areas with the highest birth rate of high technology firms are among the top ten areas in closure rates. El Paso, Texas; Orlando, Florida; Tacoma, Washington; Canton, Ohio; West Palm Beach, Florida; and Austin, Texas, which are among the ten SMSAs with the highest birth rates of high-technology firms, are also among the top ten metro areas with highest closure rates. Similarly, four metropolitan areas (Cincinnati, Ohio; Toledo, Ohio; Johnson City, Tennessee; and Fort Wayne, Indiana) which are among the ten bottom areas of high-technology firm birth rate are also among the ten bottom metro areas in closure rate. The exception is

TABLE IV
SMSAs WITH THE HIGHEST AND LOWEST
HIGH-TECHNOLOGY BIRTH RATE

<u>Highest Birth Rate</u>			<u>Lowest Birth Rate</u>		
1	Tacoma, WA	4.111	91	Johnson City, TN	0.330
2	El Paso, TX	3.402	92	Toledo, OH	0.330
3	West Palm Beach, FL	3.376	93	Cincinnati, OH	0.324
4	Austin, TX	2.450	94	Jersey City, NJ	0.300
5	Canton, OH	2.442	95	Wilmington, DE	0.258
6	Orlando, FL	2.235	96	Chattanooga, TN	0.255
7	Peoria, IL	2.174	97	Northeast, PA	0.233
8	Washington, DC	1.936	98	Albuquerque, NM	0.218
9	Harrisburg, PA	1.914	99	Fort Wayne, IN	0.179
10	Portland, OR	1.831	100	Flint, MI	0.035

Source: Author

TABLE V
SMSAs WITH THE HIGHEST AND LOWEST
HIGH-TECHNOLOGY CLOSURE RATE

<u>Highest Closure Rate</u>			<u>Lowest Closure Rate</u>		
El Paso, TX	1.803		Albany, NY	0.261	
Lansing, MI	1.708		Cincinnati, OH	0.260	
Orlando, FL	1.581		Toledo, OH	0.252	
Tacoma, WA	1.453		Johnson City, TN	0.240	
Canton, OH	1.407		Omaha, NE	0.232	
Oxnard, CA	1.275		Wichita, KS	0.213	
Fresno, CA	1.267		Fort Wayne, IN	0.203	
Youngstown, OH	1.233		Columbia, SC	0.181	
West Palm Beach, FL	1.212		Peoria, IL	0.138	
Austin, TX	1.162		Knoxville, TN	0.127	

Source: Author

Peoria, Illinois, which is among the ten top metropolitan areas with highest high-technology birth rate, but is the ninth of bottom metros in closure rate.

The rankings by birth rate minus closure rate (see Table VI) also yield a similar result as Table IV. That is, Tacoma, Washington; West Palm Beach, Florida; Peoria, Illinois; El Paso, Texas; Austin, Texas; Canton, Ohio; and Portland, Oregon remain among the ten metro areas in this category. The remaining top three areas are Wichita, Kansas; San Antonio, Texas; and Honolulu, Hawaii; while Orlando, Florida; Washington, D.C.; and Harrisburg, Pennsylvania drops out. Again, the metropolitan areas with the greatest difference in birth rates and closure rates are those of the Pacific and West South Central states, namely, Texas. The exceptions are West Palm Beach, Florida; Peoria, Illinois; Wichita, Kansas; and Canton, Ohio. As a group, these metropolitan areas may be considered medium-size as opposed to places like New York, Los Angeles, Boston, or Chicago. The ten bottom metropolitan areas in this ranking are mainly those of traditional industrial states. The exception is Davenport, Iowa, which is in an agricultural state.

In the case of expansion rate, the top ten metropolitan areas in this ranking are located in the West South Central, Pacific, and South Atlantic states (see Table VII). Six of this group are in the group with the highest birth rates (Austin, Texas; El Paso, Texas; West Palm Beach, Florida; Orlando, Florida; Peoria, Illinois; and Portland, Oregon). The other four are Tucson, Arizona; Seattle, Washington; Worcester, Massachusetts; and Salt Lake City, Utah. Four SMSAs, Tucson, Arizona; Peoria, Illinois; Worcester, Massachusetts; and Salt Lake City, Utah, prevent the Pacific, West South Central, and the South Atlantic states from dominating the top ten SMSAs in expansion rates of high-technology firms.

Unlike the top ten metropolitan areas with the greatest expansion rate which appear to be concentrated in the West South Central, Pacific, South Atlantic, and Mountain

TABLE VI

SMSAs WITH THE HIGHEST AND LOWEST HIGH-
TECHNOLOGY BIRTH-CLOSURE RATE

<u>Highest Birth-Closure Rate</u>		<u>Lowest Birth-Closure Rate</u>	
Tacoma, WA	2.658	Springfield, MA	-0.122
West Palm Beach, FL	2.164	Bridgeport, CT	-0.127
Peoria, IL	1.036	Chicago, IL	-0.154
El Paso, TX	1.599	Gary, IN	-0.167
Wichita, KS	1.297	Wilmington, DE	-0.182
Austin, TX	1.288	Youngstown, OH	-0.263
San Antonio, TX	1.100	Rochester, NY	-0.358
Canton, OH	1.035	Chattanooga, TN	-0.364
Portland, OR	1.031	Flint, MI	-0.405
Honolulu, HI	1.018	Davenport, IA	-0.454

Source: Author

TABLE VII

SMSAs WITH THE HIGHEST AND LOWEST
HIGH-TECHNOLOGY EXPANSION RATE

<u>Highest Expansion Rate</u>		<u>Lowest Expansion Rate</u>	
Austin, TX	3.012	New Brunswick, NJ	0.216
El Paso, TX	2.095	Baton Rouge, LA	0.214
West Palm Beach, FL	1.512	Pittsburgh, PA	0.201
Orlando, FL	1.450	Omaha, NE	0.186
Tucson, AZ	1.333	Sacramento, CA	0.175
Seattle, WA	1.240	Indianapolis, IN	0.170
Peoria, IL	1.220	Louisville, KY	0.167
Portland, OR	1.165	Wilmington, DE	0.162
Worcester, MA	1.151	Jersey City, NJ	0.116
Salt Lake City, UT	1.117	Gary, IN	0.064

Source: Author

regions, the bottom ten SMSAs in high-technology firms' expansion rate are not concentrated. It appears, however, that SMSAs in the West South Central, South Atlantic, Mountain, and Pacific are experiencing more high-technology expansion than Mid-Atlantic and East North Central States. Sacramento, California, is the only Pacific metro area with an expansion rate in the bottom ten. Overall, the pattern of expansion rates across metropolitan areas may be indicative of peripheral location among expanding high-technology firms, and factors such as labor force characteristics and wages may explain the differences in expansion rate.

As Table VIII shows, contraction rates of high-technology firms are relatively less geographically concentrated than birth, expansion, closure, and net change rates. The lists of top ten and bottom ten metro areas in contraction rate rankings are geographically dispersed and no particular region dominates.

The top ten metropolitan areas for net change rates in high-technology firms are similar to those metro with the highest birth rates in high-technology. Most of these *make sense* in that they are in areas *thought* to be experiencing high-tech growth—and may support the idea of product-cycle in that they are somewhat *remove* from major centers of high-tech growth either in terms of deconcentration from larger metro to smaller metro, or in terms of dispersion from large metro to nearby smaller metro. These are Austin, Texas; West Palm Beach, Florida; El Paso, Texas; Peoria, Illinois; Tacoma, Washington; Portland, Oregon; and Orlando, Florida. Three other metropolitan areas (San Antonio, Texas; Worcester, Massachusetts; and Salt Lake City, Utah) make up the list.

The bottom ten metropolitan net change rates are predominantly in the manufacturing belt, with the exception of Sacramento, California. As Table IX shows,

TABLE VIII

**SMSAs WITH THE HIGHEST AND LOWEST
HIGH-TECHNOLOGY CONTRACTION RATE**

<u>Highest Contraction Rate</u>		<u>Lowest Contraction Rate</u>	
Harrisburg, PA	1.224	Hartford, CT	0.151
Indianapolis, IN	0.837	Albuquerque, NM	0.144
Akron, OH	0.596	Bridgeport, CT	0.136
Fort Wayne, IN	0.582	Austin, TX	0.131
Sacramento, CA	0.566	Baton Rouge, LA	0.126
Louisville, KY	0.513	Jacksonville, FL	0.118
Dayton, OH	0.509	Peoria, IL	0.104
Portland, OR	0.496	Greensboro, NC	0.104
Davenport, IA	0.475	Rochester, NY	0.088
Oklahoma City, OK	0.469	Knoxville, TN	0.071

Source: Author

TABLE IX

**SMSAs WITH THE HIGHEST AND LOWEST
HIGH-TECHNOLOGY NET CHANGE RATE**

<u>Highest Closure Rate</u>			<u>Lowest Net Change Rate</u>		
1	Austin, TX	4.168	91	Wilmington, DE	-0.182
2	West Palm Beach, FL	3.460	92	Dayton, OH	-0.251
3	El Paso, TX	3.247	93	Jersey City, NJ	-0.274
4	Peoria, IL	3.157	94	Sacramento, CA	-0.291
5	Tacoma, WA	2.622	95	Louisville, KY	-0.327
6	Portland, OR	1.699	96	Fort Wayne, IN	-0.336
7	Orlando, FL	1.697	97	Indianapolis, IN	-0.347
8	San Antonio, TX	1.636	98	Chattanooga, TN	-0.368
9	Worcester, MA	1.557	99	Gary, IN	0.442
10	Salt Lake City, UT	1.534	100	Flint, MI	-0.585

Source: Author

three of the metropolitan areas with low rates (Fort Wayne, Indianapolis, and Gary) are in Indiana, which is near the core of the manufacturing belt.

The profiles of the ten highest and ten lowest metropolitan areas in terms of birth, closure, expansion, contraction, and net change rates of high-technology firms shows that metro areas experience variations in the process of growth and expansion of high-technology firms. This may lead to questions as to why some places like Tacoma, Washington; El Paso, Texas; and Peoria, Illinois are leaders in births and net change of high-technology firms? The high incidence of high-technology firms birth and net change rates found in these metropolitan areas may be an indication of dispersion of high-technology activities from big SMSAs such as New York, Chicago, Boston, or Los Angeles, to smaller SMSAs like Tacoma or Peoria. The significance of this finding may simply reflect the size of SMSA, region, and the degree of diversity of high-technology activities from one place to another. For instance, most of the top ten birth rates are in smaller SMSAs.

A number of reasons such as size, region, large pool of technical workers, abundant labor resources, and other regional characteristics may help explain variations in births and net change rate of high-technology firms across metropolitan areas. The leading high-technology places are in the West South Central, Pacific, and South Atlantic, while the lowest birth rate places are in the East North Central and Mid-Atlantic regions. This result is consistent with findings of Glasmeier, Hall, and Markusen (1983) that most of the top leading high-technology centers are found in metropolitan areas of the Midwest and South, while lowest high-technology centers are in older Northeastern industrial metropolitan areas. Similarly, Barkley's (1988) study of regional employment shifts in high-technology industries found that the metropolitan and non-metropolitan counties in the South and West experienced rapid and positive employment shifts, while the urban and rural areas in the

Mid-Atlantic and East South Central region had slow and negative growth rates.

The previous discussion has provided an overview of the dispersion of high-technology firms at the metropolitan level. It is equally important to explore if the differences in growth rates of high-technology firms across metropolitan areas are applicable at the regional level and, if so, to identify the trend.

REGIONAL HIGH-TECHNOLOGY GROWTH PATTERNS

In examining the degree to which the birth, closure, expansion, contraction, and net change rates of high-technology firms vary across U.S. regions, the issue is which region is experiencing a wider range of high-technology firms spatial behavior process as defined in this study, and how these processes have produced the changes. Such an analysis of regional growth rate differences will provide further evidence of the decentralization process of high-technology firms.

To explore if regional differences exist, and if the patterns of growth rates hold across regions, the differences in mean values of each measure (i.e., birth, closure, expansion, contraction, and net change rates) across the nine U.S. census regions as defined in this study were calculated (see Table X).

Over the period studied (1976 to 1984), means of the five dependent variables (birth, closure, expansion, contraction, and net change rates) of high-technology firms vary considerably across regions (Table X). The West South Central has the highest birth rate, rate of expansion, and net change in comparison to other regions. It also has the highest closure rate. The Pacific region has the second largest birth, net change, and closure rates. The South Atlantic region has the third largest birth, net change, and closure rates. and the second lowest contraction rate.

TABLE X

THE MEAN VALUES OF BIRTH, CLOSURE, EXPANSION, CONTRACTION, AND
NET CHANGE RATES OF HIGH-TECHNOLOGY FIRMS BY REGIONAL
LOCATION OF THE 100 LARGEST SMSAs (1976-1984)

U.S. Regions	Birth Rate	Closure Rate	Expansion Rate	Contraction Rate	Net Change Rate
New England	.689	.614	.606	.233	.477
West South Central	1.390	.841	1.106	.307	1.348
East South Central	.683	.462	.446	.257	.409
Pacific	1.352	.831	.705	.303	.922
Mountain	.826	.511	.840	.243	.913
South Atlantic	1.116	.730	.655	.236	.804
West North Central	.846	.576	.537	.340	.466
East North Central	.777	.608	.361	.343	.188
Mid-Atlantic	.649	.542	.360	.344	.122

Source: Author

Greatest variations in rates are for birth and expansion; variations in closure and contraction are less, suggesting that net change is due more to birth and expansion than to closure and contraction—which supports research of others (e.g., Allaman and Birch, 1975). Regions with high rates of birth and expansion also tend to have high closure and contraction rates, suggesting a relatively more dynamic economy with respect to high-technology growth and decline—but net result is overall growth higher than in more stagnant regions.

In contrast, the New England, East North Central, East South Central, West North Central, Mountain, and Mid-Atlantic regions have low birth rates of high-technology firms. Low net change rates in these traditional manufacturing regions appear to be attributable to lower birth rates of high-technology firms. Birth rates were highest in the West South Central, Pacific, and South Atlantic regions, and lowest in the Mid-Atlantic, East South Central, New England States.

These mean rates were also mapped across the regions (see Figures 3 through 8). The results presented in Table X and Figures 3 through 9 show that certain differences exist among the regions and that there is a great deal of volatility in the process of birth, expansion, closure, contraction, and net change rates of high-technology firms. For instance, the pattern of birth and expansion rates shows a movement toward the West South Central, Pacific, South Atlantic, and Mountain regions. New England States, which is thought of as leading high-technology region did not exhibit a high incidence of high-technology firms birth rate. Among the nine regions, New England States ranks fifth in both expansion and net change rate, and fourth in closure rate. Similarly, other traditional manufacturing regions of East North Central, East South Central, West North Central, and Mid-Atlantic did not experience strong birth rates of high-technology firms. This further provides

support of the produce cycle model. The low incidence of the rate of high-technology births in these regions may indicate that the decentralization of high-technology growth is occurring from older manufacturing belt to the West South Central, Pacific, and South Atlantic regions. It is important to note that the analyses of the regional dispersion patterns of high-technology firms are based on rates alone, and that birth rate of high-technology firms accounts for much of the differences in overall regional performance. Contraction rates, on the other hand, are fairly constant across regions.

An additional t-test for significant difference between two means was carried out to determine if there are patterns of differences in values among the regions. The results of the test are presented in Tables XI through XV, and analysis of the statistical tests of significant differences between the values in the dependent variables is discussed next.

Figure 9 helps show greater levels of activity in more *dynamic* regions and lower levels in manufacturing belt and other less dynamic regions.

The result presented in Table XI shows that between the regions, the difference in the means of high-technology firms birth rate is only statistically significant at the .05 level between New England and Pacific, East South Central, Pacific and Mid-Atlantic, and South Atlantic and Mid-Atlantic. It is apparent that the picture that emerges here indicates that differences in the mean of birth rate is significant in only four regions. Birth rate differences among the other regions are insignificant.

Table XII shows that there are statistically significant differences in the expansion rate of high-technology firms between New England and Mid-Atlantic, West South Central and East North Central, as well as Mid-Atlantic, Pacific, and both East North Central and Mid-Atlantic. Statistically significant differences exist between Mountain and South Atlantic,

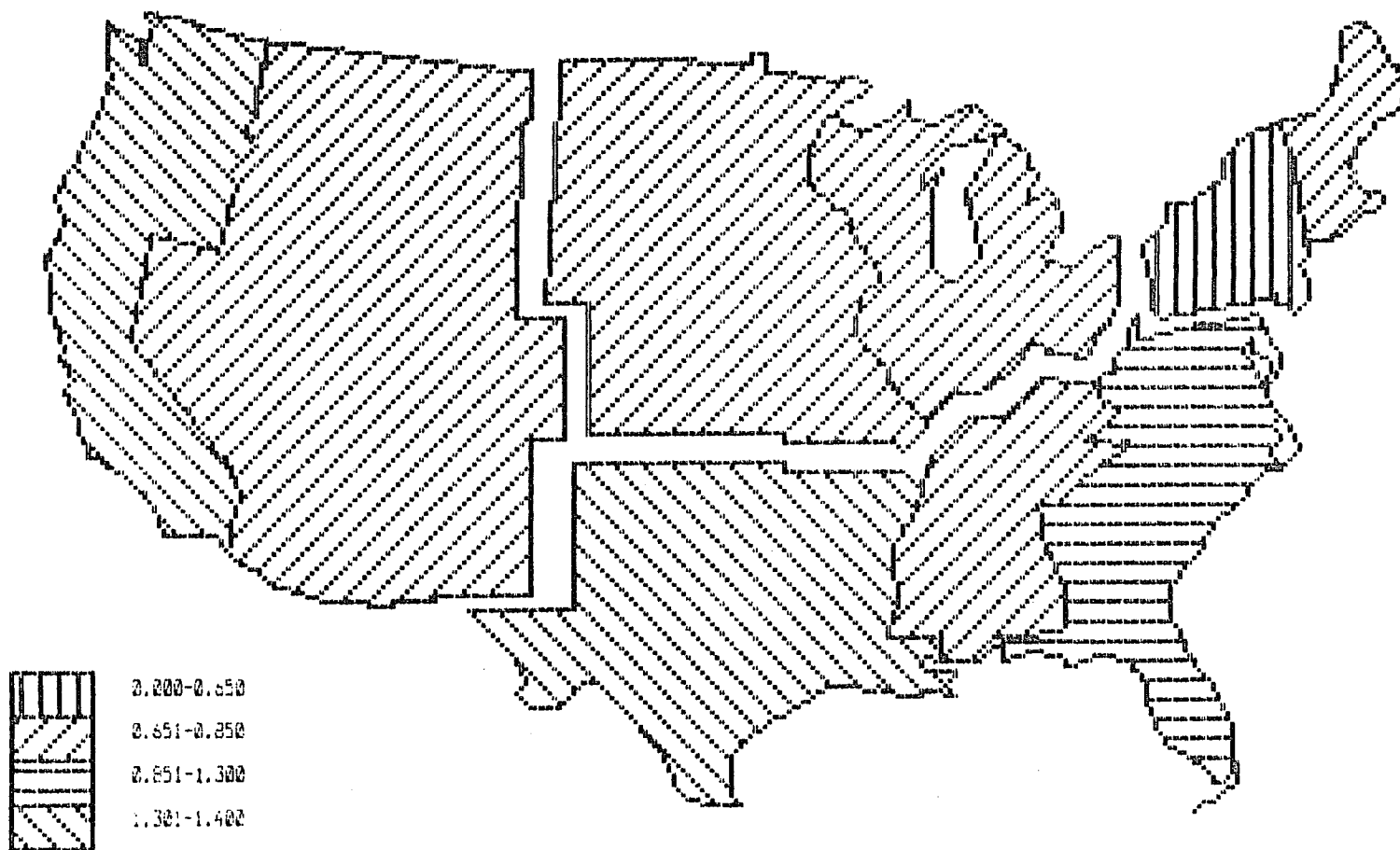


Figure 4. The mean values for birth rate of high-technology firms by region.
Source: Author.

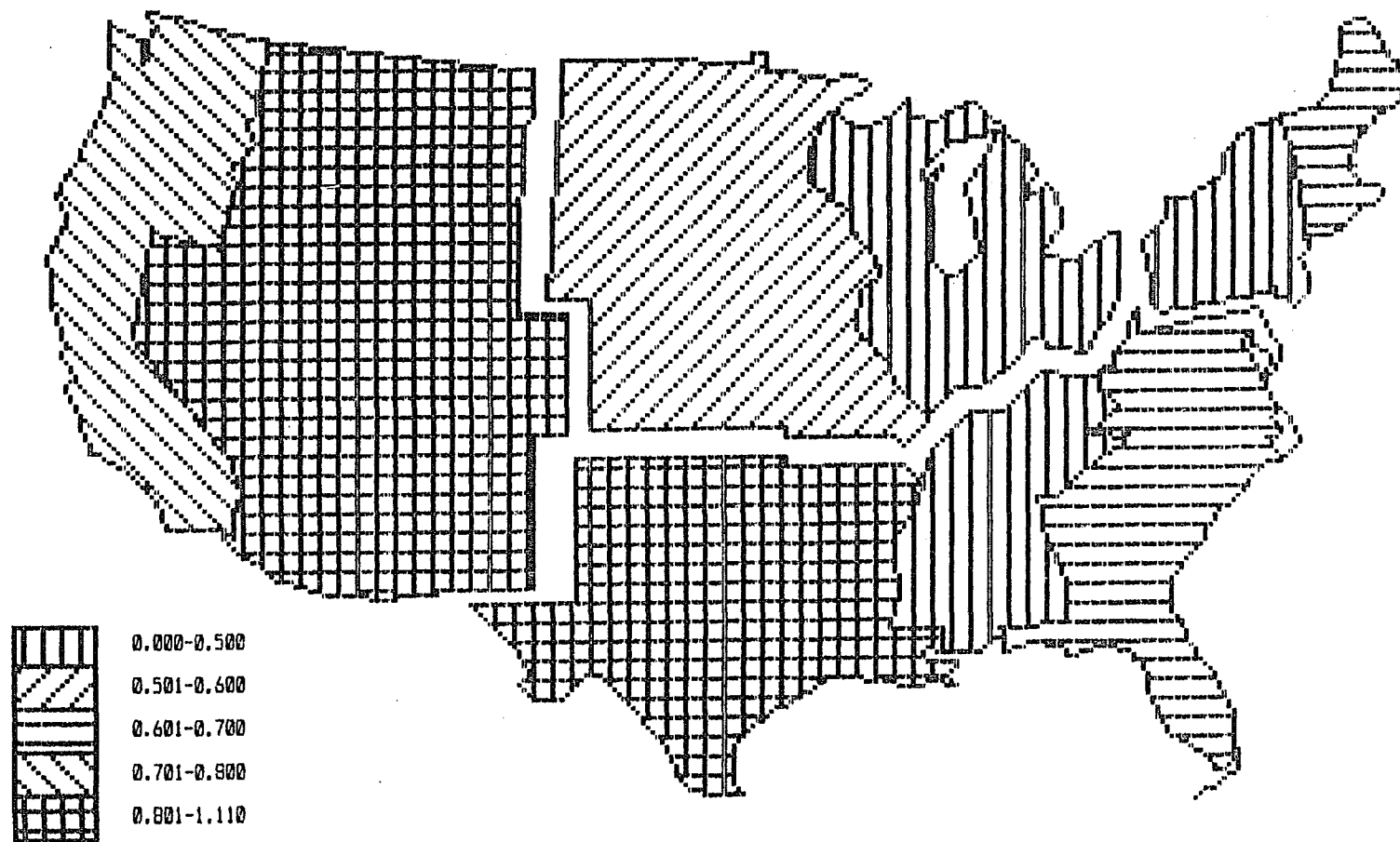


Figure 5. The mean values for closure rate of high-technology firms by region.
 Source: Author.

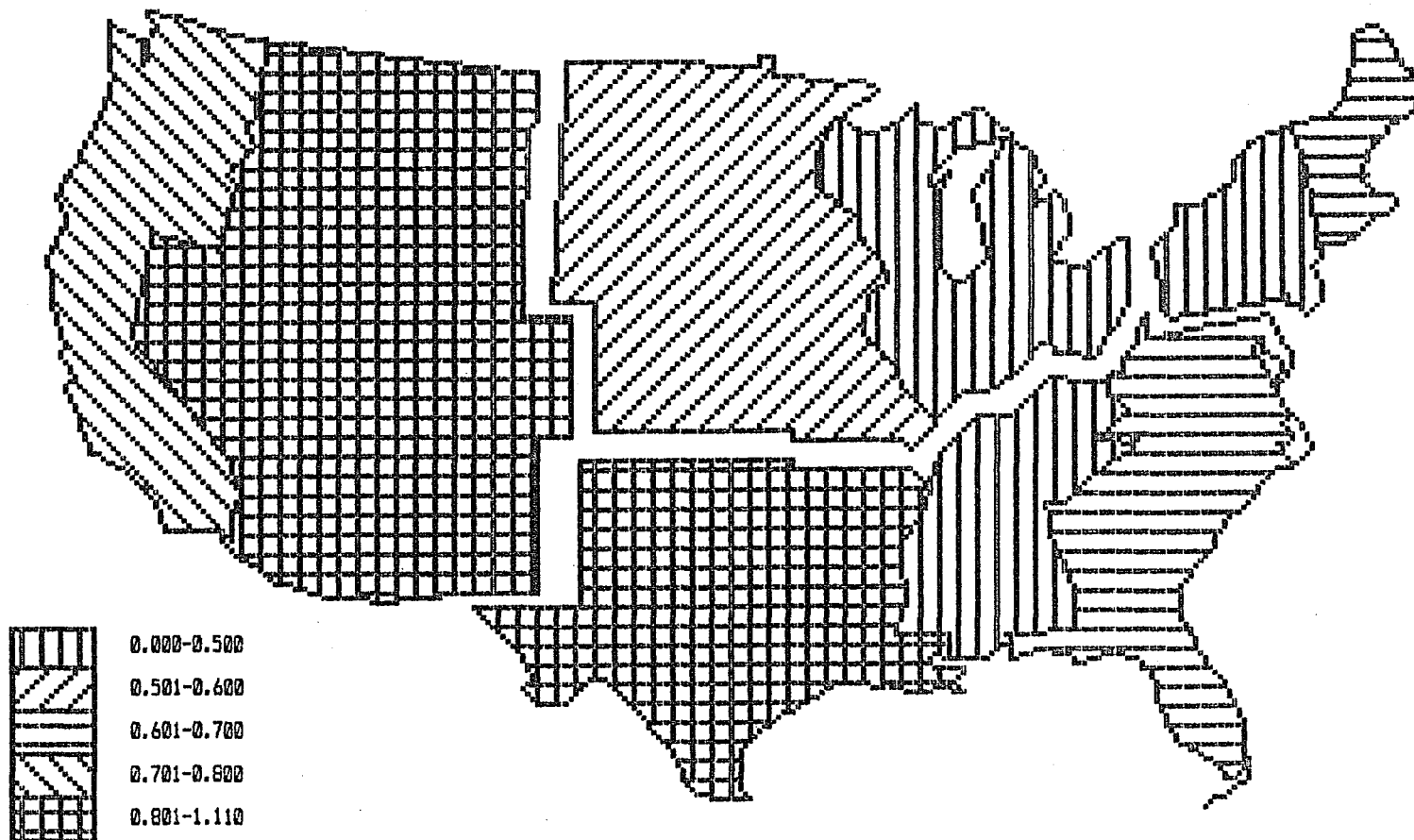


Figure 6. The mean values of expansion rate of high-technology firms by region.
 Source: Author.

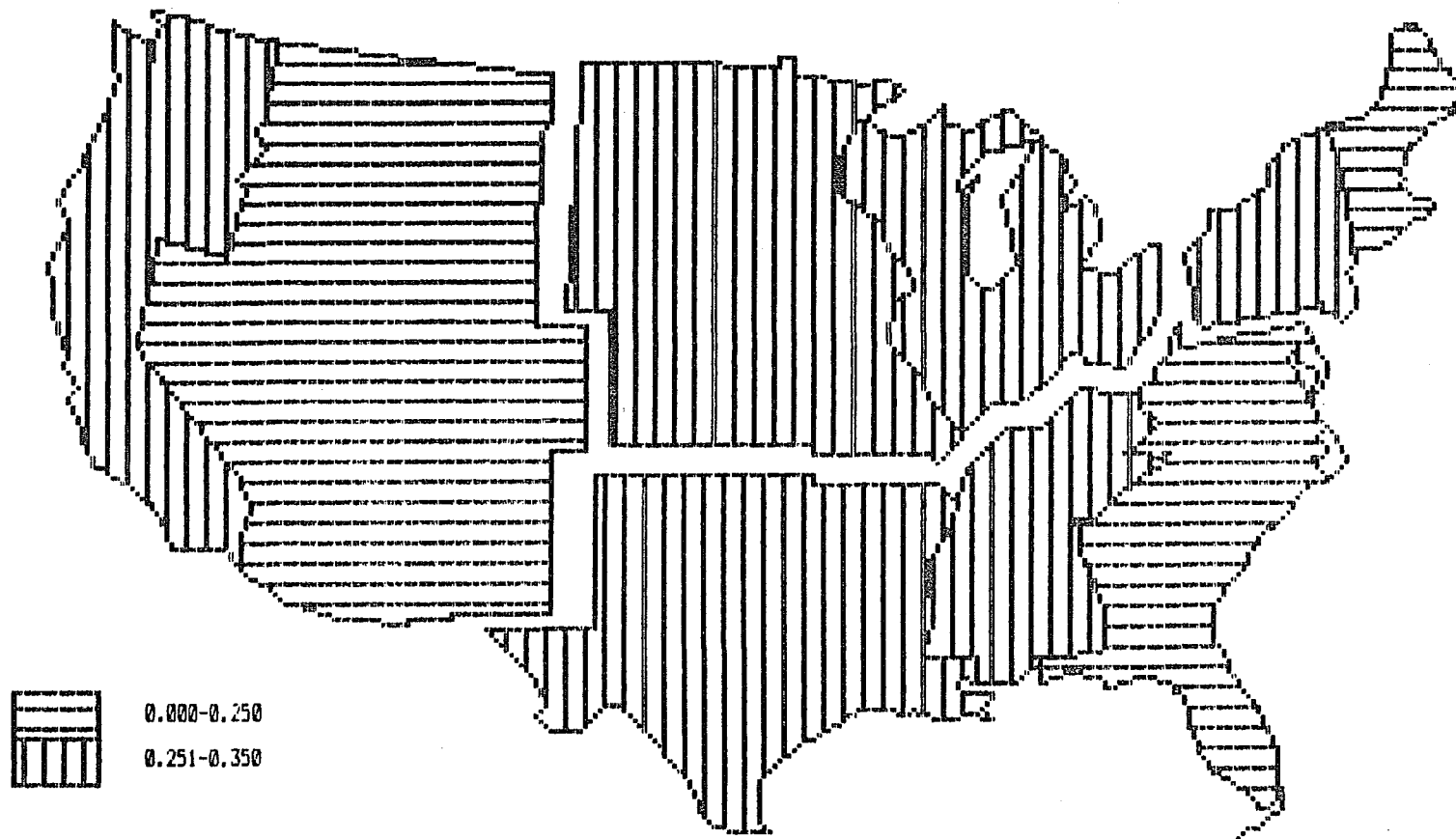


Figure 7. The mean values for contraction rate of high-technology firms by region.
Source: Author.

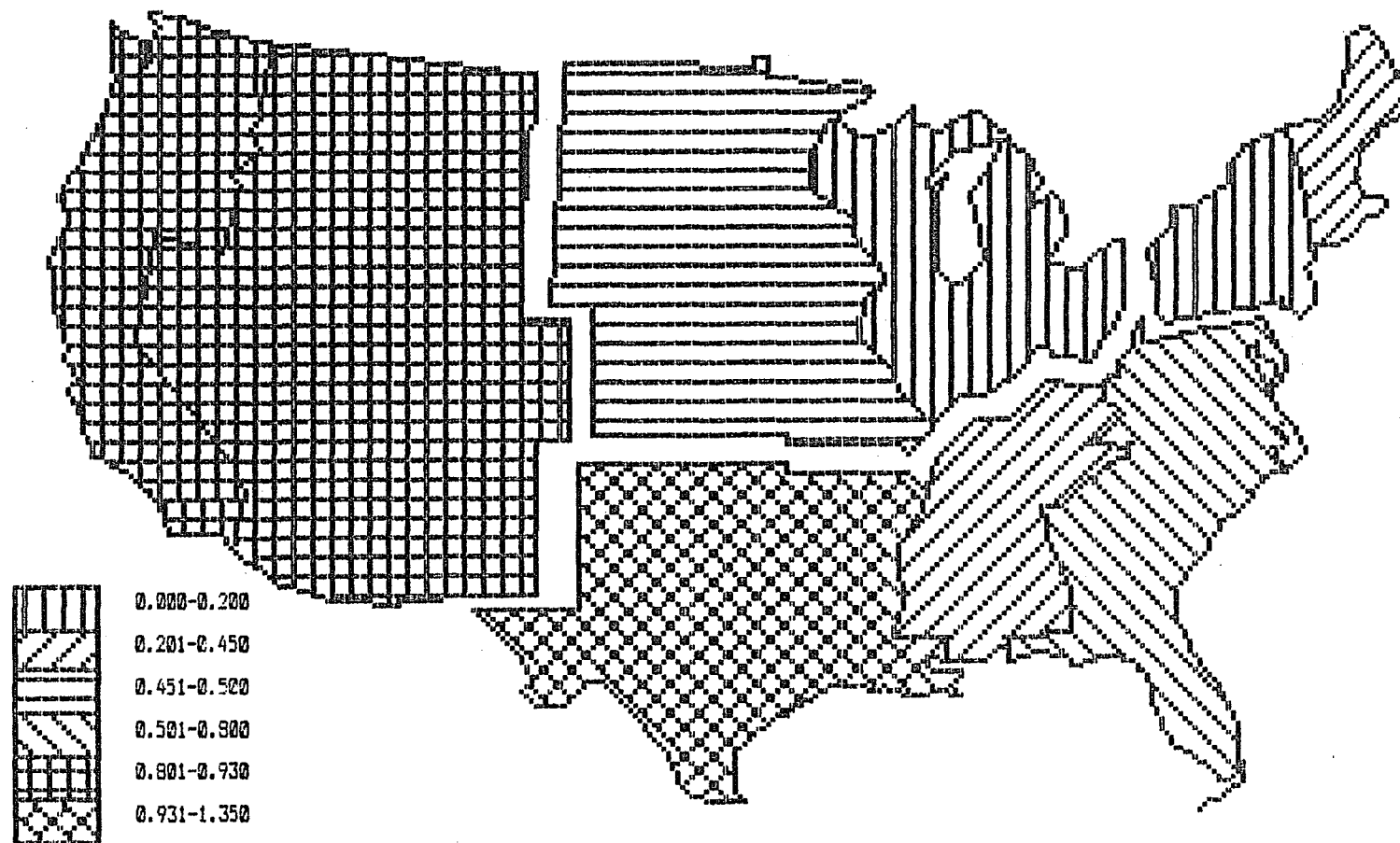
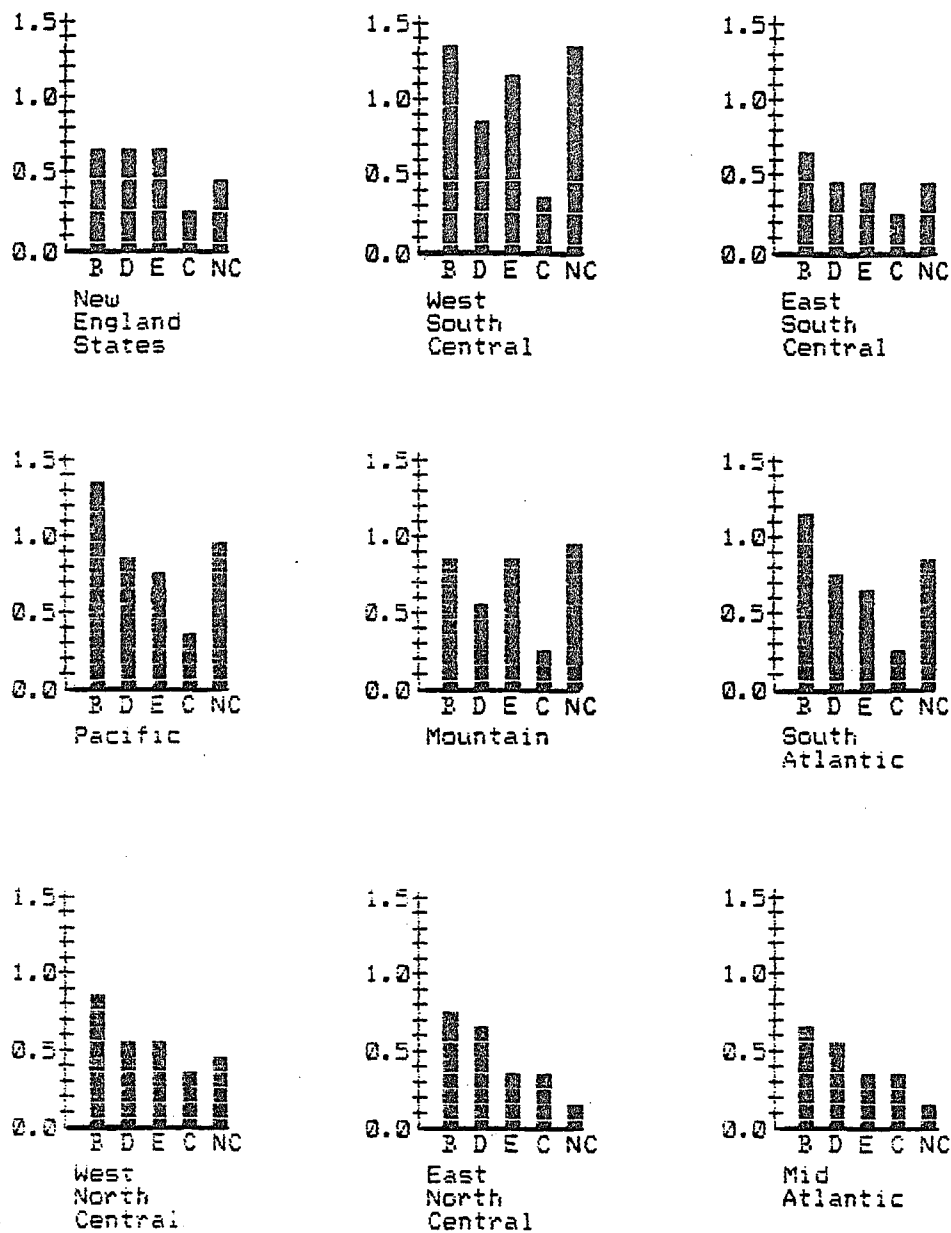


Figure 8. The mean values for net change rate of high-technology firms by region.
Source: Author.



B = Birth Rate; D = Closure Rate; E = Expansion Rate; C = Contraction Rate; NC = Net Change Rate.

Figure 9. The mean values for each of the dependent variables by region.
Source: Author.

TABLE XI

T-TEST RESULTS BY DIFFERENCES IN BIRTH RATE MEANS BY REGIONS

	<u>New England States</u>	<u>West South Central</u>	<u>East South Central</u>	<u>Pacific</u>	<u>Mountain</u>	<u>South Atlantic</u>	<u>West North Central</u>	<u>East North Central</u>	<u>Mid- Atlantic</u>
New England States		-2.00	.03	-2.28*	.55	-1.84	-.76	-.41	.23
West South Central			2.05	.09	1.47	.74	1.53	1.71	2.19
East South Central				-2.35*	-.59	-1.93	-.82	-.46	-.21
Pacific					1.59	.75	1.69	1.91	2.54**
Mountain						-1.03	-.08	.19	.76
South Atlantic							1.12	1.38	2.18*
West North Central								.31	1.06
East North Central									.67
Mid-Atlantic									

*Significant at .10 (two-tailed test)

**Significant at .05 (two-tailed test)

***Significant at .01 (two-tailed test)

Source: Author

TABLE XII

T-TEST RESULTS BY DIFFERENCES IN EXPANSION RATE MEANS BY REGIONS

	<u>New England States</u>	<u>West South Central</u>	<u>East South Central</u>	<u>Pacific</u>	<u>Mountain</u>	<u>South Atlantic</u>	<u>West North Central</u>	<u>East North Central</u>	<u>Mid- Atlantic</u>
New England States		-1.61	1.17	-.75	1.22	-.38	.38	2.16	2.33*
West South Central			2.15*	1.30	.78	1.46	1.71	2.47*	2.49*
East South Central				-1.97*	-2.05*	-1.61	-.51	.75	.81
Pacific					-.71	.40	.96	3.22***	3.49***
Mountain						.99	1.35	2.71**	2.79*
South Atlantic							.68	2.80**	3.05***
West North Central								1.09	1.13
East North Central									.02
Mid-Atlantic									

*Significant at .10 (t-two-tailed test)

**Significant at .05 (t-two-tailed test)

***Significant at .01 (t-two-tailed test)

Source: Author

TABLE XIII

T-TEST RESULTS BY DIFFERENCES IN CLOSURE RATE MEANS BY REGIONS

	<u>New England States</u>	<u>West South Central</u>	<u>East South Central</u>	<u>Pacific</u>	<u>Mountain</u>	<u>South Atlantic</u>	<u>West North Central</u>	<u>East North Central</u>	<u>Mid- Atlantic</u>
New England States		-1.47	1.66	-2.23*	.87	-1.13	.25	.05	1.02
West South Central			2.28*	.06	1.81	.64	1.28	1.29	1.92
East South Central				3.10***	-.37	-2.23*	-.69	-1.12	-.87
Pacific					2.27*	.79	1.49	1.61	2.79**
Mountain						-1.55	-.36	-.65	-.27
South Atlantic							.90	.88	1.79
West North Central								-.18	.22
East North Central									.57
Mid-Atlantic									

*Significant at .10 (t-two-tailed test)

**Significant at .05 (t-two-tailed test)

***Significant at .01 (t-two-tailed test)

Source: Author

TABLE XIV

T-TEST RESULTS BY DIFFERENCES IN CONTRACTION RATE MEANS BY REGIONS

	<u>New England States</u>	<u>West South Central</u>	<u>East South Central</u>	<u>Pacific</u>	<u>Mountain</u>	<u>South Atlantic</u>	<u>West North Central</u>	<u>East North Central</u>	<u>Mid- Atlantic</u>
New England States		-1.31	-.41	-1.47	-.99	-.07	-1.85	1.96	-1.56
West South Central			.76	.07	1.10	1.40	-.50	-.56	-.47
East South Central				-.79	.24	.40	1.24	-1.31	-1.10
Pacific					1.21	1.65	-.64	-.70	-.57
Mountain						.15	1.63	-1.72	-1.39
South Atlantic							-1.99	-2.13*	-1.62
West North Central								-.04	-.04
East North Central									-.01
Mid-Atlantic									

*Significant at .10 (t-two-tailed test)

**Significant at .05 (t-two-tailed test)

***Significant at .01 (t-two-tailed test)

Source: Author

TABLE XV

T-TEST RESULTS BY DIFFERENCES IN NET CHANGE RATE MEANS BY REGIONS

	<u>New England States</u>	<u>West South Central</u>	<u>East South Central</u>	<u>Pacific</u>	<u>Mountain</u>	<u>South Atlantic</u>	<u>West North Central</u>	<u>East North Central</u>	<u>Mid- Atlantic</u>
New England States		-1.75	.14	1.71	-1.44	-1.33	-.07	.95	1.58
West South Central			1.82	.82	.80	1.06	1.73	2.25*	2.54**
East South Central				-1.80	-1.53	-1.43	-.21	.79	1.33
Pacific					.03	.43	1.69	2.62**	3.72***
Mountain						.34	1.41	2.23*	2.91**
South Atlantic							1.29	2.26*	3.33***
West North Central								1.04	1.75
East North Central									.31
Mid-Atlantic									

*Significant at .10 (t-two-tailed test)

**Significant at .05 (t-two-tailed test)

***Significant at .01 (t-two-tailed test)

Source: Author

and East North Central and Mid-Atlantic. In Table XIII, the effect of closure is significant between New England and Pacific, and West South Central and East South Central. The same is the case between East South Central and both Pacific and South Atlantic; and similarly between Pacific, Mountain States, and Mid-Atlantic. The difference in the mean of closure rate among the other regions is insignificant.

As Table XIV shows, it is immediately apparent that the mean difference in contraction rate of high-technology firms between the regions are fairly insignificant. The exception is between South Atlantic and East North Central. In other words, contraction rate appears not to be the dominant force for decline of high-technology activity between the regions. In Table XV, net change rate between regions is significant in West South Central and East North Central plus Mid-Atlantic. The net change rate is also significant between Pacific and both East North Central and Mid-Atlantic, Mountain States and Mid-Atlantic, South Atlantic and East North Central, as well as Mid-Atlantic. The difference in net change rate between the other regions is not significant.

The results presented here indicate that the minuses are greater than the pluses. Although there are regional differences in the patterns of birth, expansion, closure, and net change rates of high-technology firms, contraction rate appears fairly even across the regions. The incidence of high-technology firms birth, expansion, net change rates are much more apparent in the West South Central, Pacific, and South Atlantic regions, while much less in the New England, East North Central, East South Central, and Mid-Atlantic regions.

The degree of change has important implication for the analysis of high-technology firms' locational behavior. The geographic variations in birth, expansion, closure, contraction, and net change rates of high-technology firms described here across the regions may result from a number of factors. Apart from simply reflecting economic trends,

individual regional characteristics may be more relevant and attractive to high-technology firms in particular. Such factors would include those locational advantages and attributes as outlined in the literature chapter such as large pool of highly skilled and technical workers, wages, and quality of life.

From the above descriptive analysis, it would appear in general that labor related factors may explain the ability of a metropolitan area or region to generate and attract high-technology firms. A regression analysis was used to further examine the relationship between the characteristics of the metropolitan areas and the birth, expansion, closure, contraction, and net change rates of high-technology firms. The analysis of findings, summary, and conclusions are presented in the following chapter.

CHAPTER V

RESULTS OF MULTIPLE REGRESSION ANALYSES

Multiple-regression analysis was used to test relationships between the dependent and independent variables used. To address the suggested hypotheses and the research question, birth rate, closure rate, expansion rate, contraction rate, and net change rate were used as dependent variables. High-tech employment, venture capital, average housing price, tax effort, average manufacturing wage, industrial incentive, transportation access, climate index, unitary tax, and U. S. regions were used as the independent variables.

In the context of the aggregate effects of the independent variables under question, the general model performs poorly in terms of how it relates the rates of birth, closure, expansion, contraction, and net changes to relevant explanatory variables. The evaluation of the overall performance of variables indicates that (a) colinearity of independent variables may exist because the number of independent variables in the models is large, (b) other underlying assumptions of the model have not been met due to either misspecification or error in the distribution of the observations, or (c) proxy measures for some of the variables may not adequately represent the variables in question. Multicollinearity, for example, may affect the standard errors parameter estimates in regressions with a large number of independent variables. For instance, the tax measures (effective property tax rate and corporate tax) were colinear with other measures of regional economic strength, such as tax effort and industrial incentives. The tax measures were well above 0.70. Moreover, total employment and high-technology employment were

colinear to one another. The research and development variable was also colinear to venture capital. These intercorrelations are above 0.65. See Appendix A-3 for the correlation matrix of variables.

A check also was made on the distribution of dependent and independent variables. The distribution of the variables showed a large number of cases with very low scores and also significant positive skewness values. This partly may be a reflection of the differences in the distribution of the dependent as well as in the independent variables (i.e., high-tech employment, wages, and taxes), and particularly in the metropolitan observation, because these are not normally distributed.

Moreover, the result of a scatter plot of dependent variables against each of the independent variables indicates that the data may be better analyzed in another scale, for example, a logarithmic or other transformation. Consequently, a logarithmic transformation was performed on five independent variables: high-technology employment, average housing price, average manufacturing wage, industrial incentive, and transportation access because the distribution is skewed and the group mean is not a good indicator of the central tendency of the scores in the distribution. To reduce skewness and the influence of outlying cases to at least approximate normality, the logged variables were used in multiple linear regression format. The form of the equations estimated for each of the dependent variables is as follows:

$$Y_t = a + b_1 \ln X_t + b_2 X_t + b_3 \ln X_t + b_4 X_t + b_5 \ln X_t + b_6 \ln X_t + b_7 \ln X_t + b_8 X_t \\ + b_9 X_t + b_{10} X_t + b_{11} X_t + b_{12} X_t + b_{13} X_t + b_{14} X_t + b_{15} X_t + b_{16} X_t + \\ b_{17} X_t + e$$

Where Y_t = the dependent variable

a = the constant

b	=	the parameter to be estimated
X_t	=	the independent variables
ln	=	logged variable
e	=	error

Because of possible multi-collinearity, the second model of the equation omitted state corporate tax rate and effective property tax rate, but retained tax effort and industrial incentives. Total employment and research and development also were dropped because they are already embodied in the definition of high-technology firms; including them in the equation will make it impossible to adequately distinguish their effects. Central to the issue, therefore, is whether industrial formation and expansion is more the result of such factors as wage rates, housing price, agglomeration economics, and climate factors, or traditional location factors such as taxes, transportation access, labor costs and availability, venture capital, and industrial incentives.

INTERPRETATION OF REGRESSION RESULTS

Results of the re-specified regression analysis are shown in Table XVI. Overall, the level of explained variation increased in the second set of regressions. For example, unadjusted R^2 values show that the model accounts for 43% of the birth rate, 40% of closure rate, 37% of expansion rate, 20% of contraction rate, and 37% of the net change rate of high-technology firms from 1976 to 1984. Regression coefficients for the high-technology employment coefficient indicated a negative association with every phase of the high-technology firms' growth behavior, suggesting that high levels of high-tech employment were not positively associated with birth, closure, expansion, contraction, and net change rate of high-technology firms' location. This supports the product cycle hypothesis,

TABLE XVI

REGRESSION RESULTS USING HIGH-TECHNOLOGY BIRTH, CLOSURE,
EXPANSION, CONTRACTION, AND NET CHANGE RATES,
1976-1984, AS THE DEPENDENT VARIABLE

Variable	Birth Rate	Closure Rate	Expansion Rate	Contraction Rate	Net Change Rate
High-Technology Employment»	-0.3883 (-5.45)***	-0.2101 (-5.80)***	-0.1026 (-2.24)**	-0.0017 (-0.09)	-0.2785 (-3.39)***
Venture Capital	0.0030 (0.47)	0.0039 (1.24)	-0.0007 (-0.18)	-0.0001 (-0.07)	-0.0016 (-0.21)
Average Housing Price»	0.4440 (1.26)	0.1641 (0.92)	0.4115 (1.83)*	-0.0876 (-0.94)	0.7907 (1.84)*
Tax Effort	-0.0092 (-1.75)*	-0.00007 (-0.03)	-0.0009 (-0.29)	-0.0028 (-1.99)**	-0.0074 (-1.14)
Average Manufacturing Wage»	0.1029 (0.19)	0.1147 (0.43)	-0.5174 (-1.57)	-0.1060 (-0.77)	-0.4380 (-0.68)
Industrial Incentive»	0.2930 (0.73)	-0.2820 (-1.40)	0.2380 (0.93)	-0.0113 (-1.38)	0.8252 (1.69)*
Transportation Measure»	0.1584 (1.81)*	0.1239 (2.78)**	0.01345 (0.61)	-0.0041 (-0.18)	0.0713 (0.66)
Climate Index	0.0007 (0.85)	-0.0001 (-0.26)	-0.0002 (-0.44)	0.00004 (0.19)	0.0005 (0.50)
Unitary Tax	0.1003 (0.65)	-0.0352 (-0.45)	0.0927 (0.94)	0.0837 (2.07)**	0.1423 (0.76)
West South Central	0.0096 (0.03)	0.0125 (0.06)	0.3265 (1.32)	-0.273 (-0.27)	0.3671 (0.77)
East South Central	-0.7497 (-1.99)**	-0.3128 (-1.64)	-0.3252 (-1.35)	-0.0638 (-0.64)	-0.6988 (-1.52)
Pacific	-0.0862 (-0.27)	-0.2087 (-1.30)	-0.1371 (-0.68)	0.0843 (1.01)	-0.0956 (-0.25)

TABLE XVI

REGRESSION RESULTS USING HIGH-TECHNOLOGY BIRTH, CLOSURE,
EXPANSION, CONTRACTION, AND NET CHANGE RATES,
1976-1984, AS THE DEPENDENT VARIABLE
(continued)

Variable	Birth Rate	Closure Rate	Expansion Rate	Contraction Rate	Net Change Rate
Mountain	-0.5118 (-1.34)	-0.4214 (-2.17)**	-0.0368 (-0.15)	-0.0825 (-0.82)	-0.0478 (-0.10)
South Atlantic	-0.3494 (-0.13)	-0.1605 (-1.02)	-0.2080 (-1.05)	-0.1127 (-.38)	-0.2863 (-0.75)
West North Central	-0.2310 (-0.58)	-0.2374 (-1.18)	-0.1195 (-0.47)	0.0353 (0.34)	-0.1505 (0.31)
East North Central	-0.2179 (-0.69)	-0.2314 (1.44)	-0.1471 (0.73)	0.0688 (0.83)	-0.2009 (0.52)
Mid-Atlantic	-0.2266 (0.84)	-0.1731 (-1.26)	-0.3273 (-1.89)*	0.1366 (1.91)*	-0.5175 (1.56)
R ²	.43	.40	.37	.20	.37
Adjusted R ²	.31	.27	.24	.03	.24
Standard Error	0.58763	0.29853	0.37657	0.15512	0.71976
Number of Cases	100	100	100	100	100

***Significant at .01 (t-statistics in parentheses)

**Significant at .05

* Significant at .10

» Logged variables

Note 1: Statistics not in parentheses are estimated coefficients
Source: Author

especially the second and third phases. Moreover, the coefficients were statistically significant for birth rate, closure rate, and net change at the .01 level and for expansion rate at the .05 level.

Venture capital turned out to be positively associated with birth rate and closure rate, but negatively associated with high-tech expansion, contraction, and net change rate. The coefficients were not significant; however, it suggests that venture capital may be an important factor in the birth of high-technology firms as well as in their closure, but less important in the expansion and contraction phases.

Housing prices were positively associated with high-technology firms' birth rate, closure rate, expansion rate, and net change rate, but were statistically significant only in the case of expansion and net change rate at the .10 level. This may suggest that the availability of housing may not be a cause for expansion and net change, but rather may represent a growth pressure on the housing supply due to job location.

Surprisingly, when state corporate tax and effective property tax rate were dropped in the second model of the equation, it did not affect the overall outcome of the coefficients of tax effort and unitary tax which were retained in the equations. The coefficients representing the tax effort variable indicate a negative association in all of the phases of the high-technology firms' growth process. However, tax effort was statistically significant for birth rate and contraction rate at the .10 and .05 levels respectively. This may suggest that the proportionate increase in tax effort may result in smaller contraction rate and birth rate. On the other hand, the implication of tax effort as among the determinant factor in the location of high-technology firms is that taxes are sensitive to public services. The result of the tax effort could be an indication of the amount of money

spent on education, for example, and other government services which may appear not to be a deterrent to industrial growth if the benefits from such tax efforts are localized.

Although the coefficients of industrial incentive indicates a positive association with rates of birth, expansion, and net change of high-technology firms, it is, however, statistically significant only in the case of net change rate at the .10 level. This may suggest that industrial incentives alone cannot stimulate the rates of birth, closure, expansion, and contraction processes of high-technology firms.

The transportation accessibility coefficient was found to be positively associated at the .10 and .05 levels for birth and closure rates, respectively. It is insignificant in expansion and net change rate, suggesting that airport access may be more important in innovative and start-up phases of high-tech firms and the causal relationship may be operating in the opposite direction in the case of closure rate. It appears also that, due to the fact that high technology firms are not material-oriented, large urban areas are likely to have adequate transportation accessibility so that the relationship to rates of expansion and net change processes of high-technology firms will appear to be less important.

The climate index coefficients are not positively related to the rates of birth, contraction, and net change, while negatively associated with expansion and closure rate. In any case, neither coefficient was statistically significant. The finding may indicate that although climate is positively associated with high-tech birth, contraction, and net change rates, it is not a strong factor in explaining the rates of high-technology firms' locational change.

Meanwhile, the coefficient representing unitary tax shows a small, but positive relationship to birth, expansion, contraction, as well as net change rates, but only statistically

significant at the .05 level with contraction rate. This finding may imply that, overall, firms strongly tied to their locations can be influenced by this form of taxation.

Significant in rates of birth, closure, expansion, contraction, and net change of high-technology firms among U. S. regions are not very apparent in the equations. The estimated coefficient of the dummy variables for explaining geographic variations in the rates of birth, closure, expansion, contraction, and net change, shows that these growth rates are not all that different, or that there are regional effects. For example, in West South Central, the result shows that it has a small positive rate of birth, closure, expansion, and net change, but lacks statistical significance. Similarly, East South Central shows a negative, but significant, rate of birth. The same pattern emerged in Mountain region which has negative, but significant, closure rate. This applies also in Mid-Atlantic region where only contraction rate is positive and statistically significant. In almost all the regions, the coefficient lacks statistical significance, indicating that the incidence of birth, closure, expansion, contraction, and net change rates of high-technology firms could not be explained by these variables in terms of how these processes vary across the regions. This may result from a number of factors. For example, it is likely that other exogenous variables such as buildable land might be important. Moreover, some relevant omitted variables and state level data may bias the results of regional differences.

REGRESSION FINDINGS AND THE RESEARCH HYPOTHESES

The hypotheses stated earlier, which were derived from the theoretical discussion in the literature chapter, suggest that the growth pattern of high-technology firms reflects the product-cycle model. This model is based upon those stages in a product's life cycle, namely, (a) innovation, (b) growth, and (c) standardization. Using the product-cycle

framework, it is hypothesized that birth rates are positively related to the following variables: high-tech employment (reflecting the pool of potential entrepreneurs), wages (which captures product/skill), tax effort (for services and amenities that attract technical workers), climate and venture capital. The same pattern is hypothesized to be negatively associated for closure rates, except venture capital, which is expected to be negatively related.

For expansion and contraction rate, which parallels the second phase, and to some extent the third phase high-tech employment, wages (for seeking low cost areas), and unitary tax are expected to be negatively related, while industrial incentive is expected to be positively associated because these are used to target industry. Net change, on the other hand, exists outside the framework of the product cycle model.

As shown in Table XVI, several observations are apparent. The hypotheses that the birth of new high-technology firms depends heavily on existing technical capability, amenities, and high unit costs of production, is not supported by the statistical results of this study. The logged high-technology employment coefficients did not take the expected signs or relate positively in the directions postulated. Negative coefficients do, however, support hypotheses about second and third phases of product cycle model. Moreover, t-statistics (at the .10 level), as the results indicate, would reject the null hypothesis that the sign is not the expected one. The hypotheses that, over time, as profits decline and production becomes more standardized, the expansion and contraction rates will relate positively to business costs and some locational advantage showed mixed results. For expansion and contraction rate, housing price and tax variables had opposite signs. On the other hand, high-tech employment and industrial incentive had the expected sign; however,

these are not statistically significant. Climate and wage rates were negatively related, while access variable was positive for expansion phase.

In overall fit of the hypothesized direction, the results of the dummy regional variables for also explaining geographic variation in the birth, closure, expansion, contraction, and net change rates of high-technology firms growth processes did not exhibit a pattern that reflects the spread effects of the product cycle model. The regional variables did not capture the spatial aspects of the model that industries disperse through the urban hierarchy, with innovation occurring at large urban core centers because of highly skilled labor, while routine production takes place in smaller peripheral centers as a result of lower production costs. The heart of the model is its explicit locational dimension and its treatment of the role of highly-skilled labor combined with locational factors that relate to the attributes of the area. In this study, high-tech employment is not positively associated with high-technology birthing, and across the regions, there is no strong evidence from the regression results of high-tech birthing, or expansion which reflects the incubator effect or that routine production takes place in regions with lower wages and other pools of lower-cost which may be present.

The empirical result presented in this research did provide some support of the product cycle model. It would appear that there is a historical chance element, and market effects which may also exert influence on the growth path of firms. While this study did not explain the generation of innovation using the product cycle model framework, it explains the determinants of factors associated and not associated with the birth rates and further growth process of high-technology firms.

The results are consistent with the findings of other researchers. For instance, Armington, Harris, and Odle (1983) found that local tax rates were negatively associated

with growth rates of high-technology firms. Similarly, Glassmeier, Hall, and Markusen (1983) found that airports were significant contributors in explaining high-technology locational decisions.

LIMITATIONS OF DATA AND ANALYTIC IMPLICATIONS

It is possible that the absence of a more detailed measure of occupational composition of employees working in research and development and activity, and production may create a problem of identifying how labor force characteristics are associated with the product cycle model. Moreover, although the definition of high-technology firms in this research is based on the relative intensity of both research and development activity and employment of scientific and engineering personnel, the broad grouping of the selected industries did not allow differentiation of product type.

The implications of these problems is that the hypothesized relationships between variables may be affected. In some cases, the measures used (e.g., venture capital) may not adequately reflect the conceptual variables. Furthermore, the high-tech employment variable which does not distinguish between the proportion of low-tech and the proportion of high-tech occupations among the high-technology industry groupings, probably underrepresents the availability of highly skilled labor. In other words, it is likely that while some metro areas may have relatively high proportions of employment in high-tech industries, they may also have high levels of low-tech occupations.

Another data limitation of this study is that other measures used (e.g., incentives) do not specify which incentives are important for high-technology firms. In addition, the tax effort variable is an index of all state and local taxes per capita and may not be a good measure of actual tax burden. Similarly, average manufacturing wage for all production

workers was used and this may not account for differences in wages or reflect accurately the wages of high-technology workers.

Despite these shortcomings, the overall findings of this research suggest that the product cycle model is useful in understanding the growth behavior of high-technology firms. The findings also appear to support the conclusions of other researchers that have used the product cycle model to explain production location change and industrial growth. For example, Smith and Barkely (1988) used the product cycle model to explain changes in manufacturing employment and production location changes in metropolitan employment and non-metropolitan areas. They found that high-tech unit plants did not conform to the filtering down process. Other researchers, such as Erickson (1976), Hansen (1979), Norton and Rees (1979), Hekman (1980a, 1980b), Cromley and Leinback (1981), and Park and Wheeler (1983) have concluded that the availability of high-skilled labor has helped to keep firms' research and development and administrative activities in core areas, but have moved their production facilities to southern states and foreign locations to take advantage of lower labor costs. These studies, however, looked at branch plant relocation. This study includes much more than relocations or branch plants; it focuses more on small businesses, which respond to different locational considerations than do relocations or branch plant locations.

From the results of study, however, it is apparent in using this framework that the model is useful in analyzing the formation and growth rates of high-technology firms. It did explain that the spatial locations of high-technology firms were chosen in response to the product cycle model. It proved to be more appropriate for explaining changing location of firms whose products have different locational requirements. Evidence from this research did reinforce empirically all the premises of the product cycle model. It provides much to

our understanding of why variations in the innovation process and location may occur as firms grow and change location.

SUMMARY

In summary, no consistent pattern of high-technology firms' birth, closure, expansion, contraction, and net change rates emerged from the regression coefficients. In some cases the direction of association is not consistent and when it is, the association generally lacks statistical significance. Overall, it appears that existing employment in high-tech SICs is not positively related to the rates of high-technology firms' birth, closure, expansion, contraction, and net change processes. However, high-tech employment is negatively associated with birth, closure, expansion, and contraction rates which, in essence, supports expansion and contraction phases and may also suggest an overall higher level of activity in smaller SMSAs (i.e., a more dynamic economy but one where net change in employment is greater in more peripheral areas such as South Atlantic, Mountain, and West South Central regions). Despite all the attention given to venture capital, research and development, and amenities as outlined in the literature, this study finds little evidence that these factors are powerful in interpreting high-technology firms' growth rates.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this research has been to examine and analyze those attributes of the regional economy that contribute to the start-up, expansion, closure, and contraction of high-technology firms. The significance of this study has been to provide a better understanding of which factors and conditions are critical in determining the growth and locational patterns of high-technology firms in U.S. metropolitan areas covering the period from 1976 to 1984.

Differences in mean rates of birth, closure, expansion, contraction, and net change of high-technology firms across U.S. regions were calculated and interpreted to determine geographic variations in the incidence of high-technology firms. The descriptive analysis shows that the West South Central, Pacific, and South Atlantic states have the highest birth rates of high-technology firms. In contrast, the New England, East North Central, East South Central, West North Central, Mountain, and Mid-Atlantic regions have the lowest birth rates of high-technology firms. These results support the product cycle model of spatial decentralization. Much of the decline in these traditional manufacturing regions, especially New England, East South Central, and Mid-Atlantic, is attributable to high-technology birth rates that are lower than those elsewhere. The same pattern (as birth rates of high-technology firms) exists for closure rates, while expansion rates were highest in the West South Central, Mountain, and Pacific regions. There were no major variations in contraction rates across the regions.

The greatest variations in rates are for birth and expansion; variations in closure and contraction are less, suggesting that net change is due more to birth and expansion than to closure and contraction. This finding supports research of others (e.g., Allaman and Birch, 1975) which indicates that regions with high rates of birth and expansion also tend to have high closure and contraction rates. This suggests a relatively more dynamic economy with respect to high-technology growth and decline, and that the net overall growth is higher than in more stagnant regions.

From the results presented in this study, there are several implications for explaining the determinant factors associated with the growth behavior of high-technology firms. Differences in regional growth rates are examined by the regression analysis, which measures the relative importance of certain factors in influencing high-technology growth and decline. The amount of existing high-tech employment is statistically significant in high-tech birthing, closures, expansion, and net change rates, and is negatively related to the rates of high-technology firms' birth, closure, expansion, contraction, and net change processes. Negative coefficients support hypotheses about second and third phases of product cycle model. Birth and expansion rates of high-technology firms in an area can be constrained relative to large concentrations or lack of qualified skilled workers. Areas with large concentrations of high-technology employment may experience lower growth, whereas growth rates in high-technology activities are higher in regions where the level of existing employment is low.

These findings do not necessarily suggest that high-tech employment is less important in relation to growth of high-technology firms. It is likely that while some metro areas may have relatively high proportions of employment in high-tech industries, they may also have high levels of low-tech occupations.

Another variable, venture capital, indicates a positive, though statistically insignificant, relationship for birth and closure rates. Again, the insignificant showing of venture capital did not support the assertion that venture capital is an important factor in the start-up or birth of high-technology firms (Cross, 1981; Storey, 1982; Dorfman, 1983). The relationship with venture capital is the opposite of what might be expected; this may in part, be due to how venture capital is measured—number of firms in an area, not expenditures in the area. This may ignore factors such as firm size, location, and amount of investments. It may also indicate that internal funds are more important than venture funds, especially for small businesses.

The air transportation coefficients were positive and statistically significant for birth and closure rates, and insignificant in expansion and net change. This suggests that airport access may be more important in the start-up phase than in expansion.

The housing price variable appears not to be a deterrent of high-technology growth rates away from certain areas. In other words, there is little statistical support to suggest that housing does or does not deter growth of high-technology firms. It also appears that high-technology firms are not sensitive to wage rates. The tax variables, especially tax effort coefficients, are negatively associated with both phases of high-technology firms' growth process. Other tax variables, such as unitary tax, were found to be positively associated with the rate of birth, expansion, and net change, which is the opposite of what is expected in terms of policy implications. Unitary tax was also positive and statistically significant in contraction rate, which may suggest that firms strongly tied to their locations can be influenced by this form of taxation.

The climate and industrial incentives coefficients indicate a positive but statistically insignificant relationship with rates of birth and net change. This does not imply that

industrial incentives alone can stimulate the rates of birth and net change, or that climate factors explain the rates of high-technology firms' locational change.

From the summary of findings, several conclusions about the formation and expansion rates of high-technology firms may be presented.

1. From the results presented in this study, there are geographic variations in the incidence of high-technology firms. The West South Central, Pacific, and South Atlantic states have the highest birth rates of high-technology firms, while the lowest birth rate is in the Northeastern manufacturing region. This finding may support the product cycle model, which suggests that employment in this sector will decentralize as these industries mature and production processes are standardized. Moreover, this implies that the agglomeration effect is not important. This finding supports research of others (e.g., Armington, 1986) which indicate that there is no association of high-tech formations with the share of location employment in high-tech industries. It is quite clear from this study that the birth of new high-tech firms is found in locations outside the historic manufacturing belt. This may imply, as other studies (e.g., Joint Economic Committee, 1982) suggest, that a diffusion process is in effect, and this can be related to the product cycle model.
2. The results indicate that the climate factor does not influence rates of growth or decline in high-technology firms. From the results presented in this study, venture capital effects were not statistically significant. It is important to note that, in the early stages, most new businesses are financed with private funds of individual entrepreneurs, their families and friends,

and venture capital as measured in this study, did not capture that, nor did it capture the actual amount of venture capital investments or availability.

3. It appears that taxes have little direct influence on any phase with the exception of unitary tax which was positive and significant for contraction rate. Overall, the result is consistent with the findings of other previous researchers (e.g., Due, 1961; Hunker, 1974; Schmenner, 1982; Armington, Harris, and Odle, 1983) that taxes have little effect on industrial location.
4. The incentive factor is positively related to births and net change rates; however, the relationship is not significant. One possible conclusion for this observation may deal with the fact that new business formation and expansion are infrequent events. Most of the incentives for INC are tax incentives, not financial. The implication is that the availability and type of tax incentives occur frequently, and such changes may be insignificant for firms looking for places to relocate or expand. It should be noted, however, that in cases where location decisions are narrowed to a few sites, or where firms are moving long distances, incentive considerations may be more important. Also, industrial incentives alone may not stimulate the rates of growth and expansion processes of high-technology firms because incentives probably are less important for small businesses, which tend to start-up where the owner lives.

One of the problems encountered in this research is the definition and selection of high-technology industries. After examining a number of studies, a working definition based on the relative intensity of both research and development (R&D) activity and employment of scientific and engineering personnel in the firm was used. This definition

corresponds closely to two other definitions used to investigate the structure and regional distribution of high-technology firms (one used by the Brookings Institution in conjunction with a Dun & Bradstreet data base, and the other used by the researchers at the University of California at Berkeley in conjunction with data from the Bureau of the Census). The available data provided for this study by the U.S. Small Business Administration made the definition and disaggregation of high-technology firms as used in this research more applicable.

It is important to note that, in this study, rates were not broken down for firm size, affiliated firms, and independent firms. It is possible that if the data had allowed rates to be broken down into firm size, branch plants, and independent firms, the impact of organizational distribution and composition of high-technology employment growth would be realized. For instance, different types of firm size would allow differentiation of employment growth behavior within the high-technology sector. In other words, disaggregation would show that most of the employment in the high-technology sector is in affiliates, which are mainly branch plants. Most employment in affiliates would be in large firms, while most smaller firms are independent, although they tend to grow faster in high-tech. Analysis of rates for affiliated and non-affiliated firms should be a topic for further research.

THE SIGNIFICANCE OF THIS STUDY

The significance of this study starts with the geographic variations of high-technology firms. The literature suggests that high-technology firms are not tied down to certain locations by reason of specific raw materials or markets. In other words, they can locate anywhere within a broad market area. The results of this study show that the greatest

variations in rates are firm birth and expansion, and that high-technology firms appear to cluster in few regions. This spatial variation illustrates how these favored locations are detached from, or are peripheral to, the older industrial manufacturing belt. This leads to the conclusion that a relatively few places will experience a modest growth rate of high-technology firms and the jobs associated with them.

Furthermore, the results of this study are consistent with the findings of Armington, Harris, and Odle (1983) who found that local tax rates and wages have no significant effect on growth rates of high-technology firms. Similarly, the results are consistent with the findings of other researchers. For instance, Rees and Stafford (1986a) suggest that air travel for transportation of employees and high value products is an important factor. Glasmeier, Hall, and Markusen (1983) found that airports are significant contributors in explaining high-technology locational decisions. The results on taxes also corroborate the findings of other researchers (e.g., Due, 1961; Fuch, 1962; Thompson and Mattila, 1958; Hunker, 1974; Carlton, 1979) that taxes have little effect in influencing industrial location. Despite all the attention to venture capital, research and development, and amenities as detailed in the literature, this research finds little evidence that these variables are powerful in explaining high-technology firms' growth rates.

THEORY IMPLICATIONS

In the case of the research hypotheses, the findings of this study provide limited empirical support for the product cycle model. The notion that high-technology firms exhibit a pattern in which the highly skilled professional functions remain concentrated in regions where the resource base is characterized by a pool of technical labor and other

factors, combined with agglomeration economies, while standardized tasks are found at low-wage locations, was explained in this research especially in the second and third stage of the product cycle. In this study, existing high-technology employment is negatively related to high-tech birthing, and there are indications that expansion of high-technology activity is occurring in low-wage locations. Regional mean rates of change in the growth rates of high-technology firms suggest the spread effects of the product cycle model. This study does not include data to differentiate regional location of highly skilled and less skilled labor; rather it looks at regional differences in growth and decline which suggests support for the product cycle model.

In this study, the research paradigm served as a valid model on the basis of how to explain the locational behavior process of high-technology firms. The model offers an explanation of growth and decline in terms of location and suggests that industrial change is fundamentally a matter of location, whereby firms will seek a location at which they are afforded a comparative advantage. In other words, economic activity is dynamic and not static across an economic landscape, as resources are continually shifted among competing opportunities in response to changing market and locational considerations. For example, lack of consistency may be an indication that different factors influence these separate components of change thereby creating imbalance.

A further reference to the model and its implications has to do with differences in locational considerations of small businesses and those of relocations or branch plant locations. The inference here is that the locational decisions of small businesses and those of branch plants vary because small businesses tend to remain close to a source of skilled labor and specialized inputs, while branch plants shift to relatively lower-labor wage areas. In addition, branch plants are much more sensitive to labor force proximity than small

businesses are. They are able to internalize many more functions than small businesses and, as a result, they are foot loose in their choice of location. Internalization is not a locational consideration for small businesses because of their scale. Further considerations of small businesses are attractiveness and desirability of the location. In other words, relocation cost considerations are more important. These locational considerations will create imbalance between births, expansions, closures, and contraction processes of firms.

There remains a need for a paradigm that can account for short and long-term trends and can be used to interpret unbalanced growth successfully. Perhaps a model to explain and predict changes in high-technology firms' growth behavior should incorporate the concepts of market structure such as product costs and trade flows, and impact on the production process of essentially a detailed single product firm. The ability of a firm to innovate, and statements about differences in location between firms in different competitive environments with varying resources and constraints, can be made by integrating variables that are place-oriented (e.g., education, economies, recreation, crime, and environment). This further calls for stratification of high-technology firms by SIC groupings, as well as firm size, affiliated, and independent firms, to allow some regional trends to emerge.

POLICY IMPLICATIONS

The growth of high-technology firms and desire of state and local governments to develop a strong economic base in fast-growing high-technology firms, will continue to be an important topic for researchers and policy-makers. State and local governments will continue to encourage and promote the development of high-technology firms as well as programs to attract relocating or expanding high-technology firms well into the 1990s.

While economic growth and stability will probably be the goal, some areas will experience rapid growth and others will face stagnation and mixed results.

From the results presented in this study, the ability of a region to capitalize on one or a combination of the different phases of high-technology activities is likely to be dependent on the general characteristics of a particular region. This study has shown that the existing employment in high-tech SICs is negatively related to the rates of high-technology firms' birth, closure, expansion, contraction, and net change processes.

Therefore, it does not imply that regions lacking concentration of high-skilled labor should abandon efforts or policies geared toward training and improving the quality of the education system. Nor does it indicate that regions with large concentrations of high-technology employment are likely to lose out in the technology innovation process because of saturation of highly-skilled labor. In general, the critical mass of highly-skilled labor will enable incoming firms to recruit the kind of labor they need for production operations.

Another implication of this study is that conditions traditionally considered important to location and formation of high-technology firms appear not to increase the rate of new births. The relationship of venture capital and climate to birth rates appears to be negligible. Finally, the tax variables did not provide evidence to support the view that they substantially affect locational activity.

Several policy implications are suggested by the findings of this study.

1. The labor effect is likely to be very different in each specific high-tech growth process because high-tech firms have specialized demands for labor. The results of this study indicate that high-tech employment is negatively related to the rates of high-technology firms' growth and decline processes, suggesting that high-technology firms move through the product cycle and,

as a result, their employment requirements vary. Therefore, there is need to consider labor when considering development programs targeted at high-tech firms. An important issue is that it may be possible to develop a successful policy to influence the location of high-technology activities through manpower and training because quality education and training can be an important factor in influencing firms and employees in high-technology sectors.

2. Tax efforts were found to have no significant effect on the formation and growth processes of high-technology firms. This provides further support to the findings of other studies that taxes are not very important in explaining differing levels of industry location. Other tax variables, especially the unitary tax, were found to be positively associated with the rate of birth, expansion, and net change, which is the reverse of what was expected in terms of policy implications. Another policy variable is industrial incentives. The results presented in this study indicate that industrial incentives alone may not stimulate the rates of growth and expansion processes of high-technology firms.
3. The policy implications are that state and localities have a wide range of strategies for attracting high-technology firms. However, for a given region, the strategy depends on comparative advantages of the region, and the number of competitors. For example, if the competitors are a national firm and a foreign firm, the region's strategies may be quite different. For a national firm, the interest may be in profit, while a foreign firm's emphasis may be in sales and market share as opposed to control. Therefore, it is

important to understand the underlying motivations of prospective incoming firms. Policies encouraging overall economic growth might be preferable to targeting development efforts on high-technology firms.

4. Most of future high-technology developments need not require or emphasize on the traditional locational factors such as taxes and industrial incentives because these mechanisms are not explaining or contributing to the birth rates of high-technology firms. The greatest importance will be in a highly-skilled labor force because high-technology firms have specialized demand for labor. Moreover, air transportation accessibility is a very important requirement because an adequate and rapid transportation system enhances high-technology development.
5. For communities seeking to attract high-technology firms, the greatest impact of high-technology development is not likely to be in highly standardized mature high-tech firms. The overall emphasis should be investment in all sectors, especially improvement in education and training so that the community will be less vulnerable to business cycles. Moreover, each community should assess its comparative strengths and weaknesses and pursue policies of industrial development that conform to new realities which will enable them to understand the critical resources required, and the stages of a company's growth, the products it makes, and the type of work force it employs.

In conclusion, it is important to view the industrial development systems in terms of past, present, and future. A significant number of variables in this study were found not to exhibit a statistically significant relationship to high-technology firms. Central to the issue

may be variation in time and space. For example, in the past, the emphasis of industrial development was on the industries of steel, coal mining, shipbuilding, and textiles; and past studies of the location of industrial activity were explained in terms of Weberian location factors such as transportation costs, material inputs, and agglomeration economies. The implications are that traditional policies have tended to focus on land, labor, and capital.

In the late 1970s, the divergence of population and employment growth by regions implied that important structural changes were occurring. To adjust to changes in resource availability, emphasis on industrial development has shifted to newer growth industries such as high-technology firms. On the other hand, high-technology firms have not developed the same way older industries did. In the case of high-technology firms, technological innovation process, product, production, fragmentation, and competition through start-up companies with new products, quick obsolescence, and organizational changes in terms of ownership and source of capital, are very complex.

In the 1980s, the accessibility consideration and taxes may be less important than in early years. This suggests that variables important in the 1940s and 1960s were less so in the 1970s, and may have even less effect in the 1980s. The implication is that, as the location decision becomes extremely complex, variables that were the most critical to early industrial development may contribute less importantly to future locational decisions. Future attempts to interpret the growth behavior of high-technology firms will have to refocus on a set of variables and activities that are for the most part market-oriented. As Rees and Stafford (1986) suggest, "there does not appear to be a need for any new theory of regional growth to explain the development of high-technology complexes. There may be a need to extend existing theory, particularly theories of growth poles and product cycles" (p. 35).

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APPENDIX
SUPPLEMENTARY TABLES

TABLE XVII

DATA ON RATES OF CHANGE FOR HIGH-TECHNOLOGY FIRMS IN THE 100 LARGEST SMSAs, 1976-84

SMSA	Birth Rate	Death Rate	Expansion Rate	Contraction Rate	Net Change Rate
New York, NY-NJ	0.589	0.045	0.431	0.342	0.043
Chicago, IL	0.475	0.154	0.271	0.254	-0.136
Los Angeles-Long Beach, CA	0.851	0.014	0.409	0.207	0.186
Philadelphia, PA-NJ	0.495	0.087	0.253	0.275	-0.103
Detroit, MI	0.640	0.047	0.321	0.200	0.074
San Francisco-Oakland, CA	1.084	0.717	0.592	0.235	0.723
Washington, DC-MD-VA	1.936	1.100	0.938	0.421	1.353
Boston, MA	0.566	0.548	0.609	0.163	0.306
Nassau-Suffolk, NY	0.580	0.026	0.563	0.230	0.306
Dallas-Fort Worth, TX	1.222	0.996	0.979	0.318	0.887
St. Louis, MO-IL	1.005	0.702	0.312	0.214	0.400
Pittsburgh, PA	0.524	0.410	0.210	0.359	-0.043
Houston, TX	1.138	0.960	0.589	0.222	0.544
Baltimore, MD	0.636	0.572	0.530	0.164	0.429
Minneapolis-St. Paul, MN-WI	0.824	0.095	0.869	0.214	0.559
Newark, NJ	0.575	0.032	0.354	0.310	0.011
Cleveland, OH	0.810	0.683	0.325	0.264	0.187
Atlanta, GA	1.172	0.751	0.750	0.202	0.969
Anaheim-Santa Ana-Garden Grove, CA	1.144	0.962	0.821	0.222	0.781
San Diego, CA	1.058	0.698	0.859	0.358	0.860

TABLE XVII

DATA ON RATES OF CHANGE FOR HIGH-TECHNOLOGY FIRMS IN THE 100 LARGEST SMSAs, 1976-84
(continued)

SMSA	Birth Rate	Death Rate	Expansion Rate	Contraction Rate	Net Change Rate
Miami, FL	0.817	0.091	0.687	0.215	0.381
Denver-Boulder, CO	0.925	0.780	0.711	0.169	0.687
Milwaukee, WI	0.334	0.300	0.262	0.349	-0.052
Seattle-Everett, WA	0.765	0.523	1.240	0.308	1.173
Cincinnati, OH-KY-IN	0.324	0.260	0.371	0.183	0.257
Tampa-St. Petersburg, FL	0.940	0.809	0.736	0.232	0.635
Buffalo, NY	0.924	0.749	0.354	0.333	0.196
Kansas City, MO-KS	0.458	0.364	0.285	0.302	0.076
Riverside-San Bernadino-Ontario, CA	0.721	0.525	0.737	0.365	0.568
Phoenix, AZ	0.798	0.421	0.607	0.298	0.685
San Jose, CA	0.708	0.434	0.992	0.329	0.936
Indianapolis, IN	0.629	0.309	0.170	0.837	-0.347
New Orleans, LA	0.652	0.538	0.903	0.224	0.793
Portland, OR-WA	1.831	1.031	1.165	0.496	1.699
Columbus, OH	0.372	0.298	0.316	0.266	0.123
San Antonio, TX	1.614	1.100	0.969	0.432	1.636
Rochester, NY	0.265	0.358	0.305	0.088	-0.141
Providence-Warwick-Pawtucket, RI-MA	0.816	0.716	0.568	0.321	0.346
Louisville, KY-IN	0.366	0.348	0.167	0.513	-0.327
Sacramento, CA	0.626	0.526	0.175	0.566	-0.291

TABLE XVII

DATA ON RATES OF CHANGE FOR HIGH-TECHNOLOGY FIRMS IN THE 100 LARGEST SMSAs, 1976-84
(continued)

SMSA	Birth Rate	Death Rate	Expansion Rate	Contraction Rate	Net Change Rate
Memphis, TN-AR-MS	0.721	0.585	0.488	0.185	0.439
Fort Lauderdale-Hollywood, FL	1.141	0.891	0.751	0.287	0.714
Dayton, OH	0.401	0.373	0.229	0.509	-0.251
Albany-Schenectady-Troy, NY	0.365	0.261	0.479	0.213	0.370
Birmingham, AL	1.007	0.753	0.440	0.372	0.322
Salt Lake City-Ogden, UT	1.514	0.758	1.117	0.338	1.534
Toledo, OH-MI	0.330	0.252	0.417	0.466	0.030
Norfolk-Virginia Beach-Portsmouth, VA-NC	1.217	0.457	0.406	0.419	0.747
Greensboro-Winston-Salem-High Point, NC	0.388	0.288	0.452	0.104	0.447
Nashville-Davidson, TN	0.646	0.381	0.863	0.216	0.912
Oklahoma City, OK	0.831	0.548	0.759	0.469	0.574
Hartford, CT	0.575	0.592	0.505	0.151	0.337
Honolulu, HI	1.776	1.018	0.676	0.238	1.455
Jacksonville, FL	1.290	1.109	0.345	0.118	0.408
Akron, OH	1.080	0.736	0.434	0.596	0.182
Syracuse, NY	0.777	0.492	0.685	0.305	0.665
Gary-Hammond-East Chicago, IN	0.663	0.167	0.064	0.339	-0.442
Northeast Pennsylvania	0.233	0.306	0.253	0.345	-0.165
Allentown-Bethlehem-Easton, PA-NJ	0.489	0.321	0.219	0.168	0.218
New Brunswick-Perth Amboy-Sayreville, NJ	0.601	0.436	0.216	0.388	-0.006

TABLE XVII

DATA ON RATES OF CHANGE FOR HIGH-TECHNOLOGY FIRMS IN THE 100 LARGEST SMSAs, 1976-84
(continued)

SMSA	Birth Rate	Death Rate	Expansion Rate	Contraction Rate	Net Change Rate
Charlotte-Gastonia, NC	0.975	0.574	0.405	0.244	0.561
Tulsa, OK	0.685	0.470	0.436	0.397	0.254
Richmond, VA	0.346	0.368	0.321	0.292	0.006
Orlando, FL	2.235	1.581	1.450	0.406	1.697
Jersey City, NJ	0.300	0.276	0.116	0.414	-0.274
Omaha, NE-IA	0.709	0.232	0.186	0.382	0.281
Grand Rapids, MI	0.406	0.394	0.568	0.379	0.201
Springfield-Chicopee-Holyoke, MA-CT	0.339	0.122	0.410	0.194	0.094
Youngstown-Warren, OH	0.970	1.263	0.456	0.196	-0.003
Greenville-Spartanburg, SC	0.510	0.263	0.266	0.255	0.258
Flint, MI	0.035	0.405	0.083	0.193	-0.585
Wilmington, DE-NJ-MD	0.258	0.182	0.162	0.162	-0.182
Long Branch-Ashbury Park, NJ	1.242	0.769	0.652	0.259	0.865
Raleigh-Durham, NC	0.674	0.518	0.739	0.167	0.727
West Palm Beach-Boca Raton, FL	3.376	2.164	1.512	0.216	3.460
Paterson-Clifton-Passaic, NJ	0.510	0.609	0.227	0.245	-0.116
Fresno, CA	1.367	1.267	0.510	0.173	0.436
Lansing-East Lansing, MI	1.722	1.708	0.388	0.240	0.162
Tucson, AZ	0.677	0.266	1.333	0.264	1.480
Oxnard-Simi Valley-Ventura, CA	1.532	1.275	0.739	0.162	0.834

TABLE XVII

DATA ON RATES OF CHANGE FOR HIGH-TECHNOLOGY FIRMS IN THE 100 LARGEST SMSAs, 1976-84
(continued)

SMSA	Birth Rate	Death Rate	Expansion Rate	Contraction Rate	Net Change Rate
Knoxville, TN	0.881	0.127	0.226	0.071	0.909
Harrisburg, PA	1.914	0.915	0.447	1.224	0.137
El Paso, TX	3.402	1.599	2.095	0.447	3.247
Tacoma, WA	4.111	2.658	0.249	0.284	2.622
New Haven-West Haven, CT	0.720	0.824	0.388	0.194	0.088
Baton Rouge, LA	0.520	0.580	0.214	0.126	0.028
Mobile, AL	1.255	0.644	0.841	0.285	1.166
Johnson City-Kingsport-Bristol, TN-VA	0.330	0.240	0.324	0.194	0.219
Canton, OH	2.442	1.035	0.337	0.209	1.162
Austin, TX	2.450	0.288	3.012	0.131	4.168
Bridgeport, CT	0.377	0.127	0.608	0.136	0.345
Chattanooga, TN-GA	0.255	0.364	0.217	0.223	-0.368
Wichita, KS	1.510	1.297	0.461	0.454	2.303
Albuquerque, NM	0.218	0.111	0.433	0.144	0.177
Worcester, MA	1.431	0.652	1.151	0.374	1.557
Fort Wayne, IN	0.179	0.203	0.269	0.582	-0.336
Charleston-North Charleston, SC	1.687	1.117	0.828	0.156	1.242
Davenport-Rock Island-Moline, IA-IL	0.572	1.026	11.108	0.475	0.178
Columbia, SC	0.488	0.181	0.509	0.192	0.624
Peoria, IL	2.174	2.036	1.220	0.104	3.157

Source: Computed from the U.S. Small Business Data Base

TABLE XVIII
DESCRIPTIVE STATISTICS

Number of Observations = 100; Number of input variables = 26; Using Observations 1 through 100

Variable Name	Number	Mean	Standard Deviation	Variance	Minimum	Maximum
brthrt	1	.94038	.70718	.50011	.35000E-01	4.1110
dthrt	2	.65148	.35021	.12265	.12700	1.8030
emprr	3	.58390	.43166	.18633	.64000E-01	3.0120
conrt	4	.29753	.15791	.24935E-01	.71000E-01	1.2240
ncrt	5	.57694	.82761	.68494	-.58500	4.1680
htemp	6	.40662E+05	.58177E+05	.33846E+10	947.00	.32847E+06
toemp	7	512.78	758.77	.57574E+06	117.80	6275.1
vencap	8	3.8300	11.117	123.58	.00000	101.00
rd	9	11.691	13.868	192.33	.00000	76.800
avghp	10	.63548E+05	.21201E+05	.44947E+09	.39820E+05	.16957E+06
sctr	11	5.7670	2.7809	7.7331	.00000	10.800
taxeft	12	97.422	21.267	452.29	63.300	159.60
avgmw	13	5.4425	.89275	.79701	3.6600	7.6100
indinc	14	1215.2	295.85	.87527E+05	767.00	1850.0
trnmeu	15	126.24	147.41	.21730E+05	9.0000	842.00
clmind	16	596.55	102.32	.10470E+05	378.00	911.00
mdptr	17	1.8250	.95694	.91573	.41000	4.9400
unitax	18	.47000	.50161	.25162	.00000	1.0000
reg1	19	.90000E-01	.28762	.82727E-01	.00000	1.0000
reg2	20	.80000E-01	.27266	.74343E-01	.00000	1.0000
reg3	21	.11000	.31447	.98889E-01	.00000	1.0000
reg4	22	.50000E-01	.21904	.47980E-01	.00000	1.0000
reg5	23	.18000	.38612	.14980E-01	.00000	1.0000
reg6	24	.60000E-01	.23868	.56970E-01	.00000	1.0000
reg7	25	.18000	.38612	.14909	.00000	1.0000
reg8	26	.16000	.36845	.13576	.00000	1.0000

TABLE XIX
CORRELATION MATRIX OF VARIABLES

Number of Observations = 100

1.0000							
0.72800	1.0000						
0.55181	0.89904	1.0000					
0.74871	0.74834	0.68577	1.0000				
0.33161	0.81900	0.29993	0.28653	1.0000			
0.15991	0.96990E-01	0.14114	0.33988	0.30972	1.0000		
0.25145	0.21752	0.20887	0.39923	0.40246	0.59203	1.0000	
0.10863	0.67086E-01	0.60992E-02	0.11863	0.34105E-01	-0.11909	0.24374	1.0000
-0.15534	-0.54191E-01	-0.10747E-01	-0.15840	-0.25220	0.35456E-01	0.12251	-0.21419
1.0000							
0.63729	0.63766	0.43981	0.52953	0.32366	-0.12027E-02	0.52985E-01	0.20364E-01
-0.92510E-01	1.0000						
0.20449	0.17102	0.17466	0.18590	0.61292	0.30106	0.26541	-0.74640E-01
-0.23747	0.16657	1.0000					
0.29919	0.22575	0.23743	0.38729	0.32643E-01	0.46741	0.65484	0.17081
0.83343E-01	0.68484E-01	0.19651E-01	1.0000				
0.13953	0.13111	0.15758	0.18415	0.22451	0.23933	0.32493	-0.33552E-01
-0.18150	0.69493E-01	0.48836E-01	0.84068E-01	1.0000			
-0.68222E-01	-0.25759E-01	-0.10962E-01	-0.15832	-0.20287	-0.45341	-0.36478	-0.18499
0.19213	0.22356E-01	-0.26426	-0.24790	-0.15613	1.0000		
-0.13167	-0.10606	-0.88779E-01	-0.19615	-0.020483	-0.48438E-01	-0.20115	-0.13320
0.42008	-0.11081	0.52860E-02	-0.27525	-0.20384	-0.92737E-01	1.0000	
0.99726E-01	0.73820E-01	0.54525E-01	0.13156	0.57033	0.13703	0.27785	0.15192
-0.26554	0.89636E-01	0.53302	-0.63609E-01	0.181.22	-0.11056	-0.10367	1.0000
-0.67551E-01	-0.51677E-01	-0.42105E-01	-0.13385	0.82065E-01	-0.12993	-0.15634E-01	-0.11377
-0.111079	0.51554E-01	-0.81009E-01	-0.13854	0.24362	-0.72148E-01	-0.67651E-01	-0.80654E-01
1.0000							
-0.17452	-0.78227E-01	-0.79870E-01	-0.24001	-0.31998E-01	0.42276E-01	-0.29780	-0.40452
-0.20946E-01	0.69154E-01	0.53459E-01	-0.31329	0.13247	-0.14734	-0.13816	-0.16471
-0.10749	1.0000						
-0.16517E-01	-0.44280E-02	-0.26572E-01	0.32816E-01	-0.13692	-0.41120E-01	-0.45633E-01	0.17942
0.53218E-01	0.15663E-01	-0.33224	0.23439E-01	0.99553E-01	-0.79453E-01	-0.74501E-01	-0.88820E-01
-0.57961E-01	-0.11837	1.0000					
0.85274E-01	0.24407E-01	-0.56337E-01	0.32184E-01	-0.19235	-0.40457	-0.10344	0.55309
-0.38605	-0.54183E-01	-0.21141	-0.17769E-01	-0.18045	-0.14734	-0.13816	-0.16471
-0.10749	-0.21951	-0.11837	1.000				
0.10923	0.15571	0.15714	0.19658	0.12801E-01	0.46165	0.46310	0.52204E-02
0.31899	0.52370E-02	0.35366E-02	0.67152	-0.83072E-01	-0.13725	-0.12870	-0.15343
-0.10013	-0.10448	-0.11026	-0.20448	1.0000			

TABLE XX
DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs

SMSA	High-Tech Employment	Total Employment	Venture Capital	R&D Expenditure as Percent of Sales	Average Housing Price	State Corporate Tax Rate
New York, NY-NJ	198,328	6,275.1	101	76.8	93,402	8.7
Chicago, IL	328,470	3,003.3	23	72.2	74,367	4.0
Los Angeles-Long Beach, CA	313,525	3,108.9	16	58.3	113,985	9.0
Philadelphia, PA-NJ	185,387	805.3	7	25.7	64,975	7.2
Detroit, MI	76,865	1,628.4	3	8.9	56,777	2.3
San Francisco-Oakland, CA	56,344	1,362.6	30	24.8	127,478	9.0
Washington, DC-MD-VA	46,432	1,361.6	11	13.3	94,348	6.5
Boston, MA	236,092	1,269.3	30	44.6	65,805	8.3
Nassau-Suffolk, NY	60,692	802.2	0	14.4	82,452	10.0
Dallas-Fort Worth, TX	90,929	1,131.2	11	16.5	47,581	0.0
St. Louis, MO-IL	61,145	927.0	4	16.9	47,000	4.5
Pittsburgh, PA	62,848	860.8	2	20.1	50,549	9.5
Houston, TX	75,643	1,097.5	9	10.9	65,738	0.0
Baltimore, MD	36,079	846.3	1	16.8	63,204	7.0
Minneapolis-St. Paul, MN-WI	73,974	928.1	9	27.9	65,158	1.7
Newark, NJ	110,054	859.8	2	9.2	85,089	7.5
Cleveland, OH	75,906	860.0	7	14.0	67,344	4.0
Atlanta, GA	36,485	775.0	4	13.5	62,935	6.0
Anaheim-Santa Ana-Garden Grove, CA	98,056	610.0	6	18.3	122,190	9.0
San Diego, CA	49,584	502.0	4	20.0	107,060	9.0

TABLE XX

DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

SMSA	High-Tech Employment	Total Employment	Venture Capital	R&D Expenditure as Percent of Sales	Average Housing Price	State Corporate Tax Rate
Miami, FL	14,002	596.0	6	3.9	74,239	5.0
Denver-Boulder, CO	37,189	631.5	4	10.4	78,112	5.0
Milwaukee, WI	84,369	605.8	5	21.6	78,810	2.3
Seattle-Everett, WA	23,653	587.9	4	4.9	76,622	0.0
Cincinnati, OH-KY-IN	54,701	541.9	1	5.0	57,704	5.2
Tampa-St. Petersburg, FL	22,807	425.7	0	3.0	48,245	5.0
Buffalo, NY	27,008	490.1	2	11.0	64,242	10.0
Kansas City, MO-KS	46,026	570.8	2	16.7	44,603	4.7
Riverside-San Bernadino-Ontario, CA	12,737	346.7	1	113.7	68,018	9.0
Phoenix, AZ	39,998	450.9	2	3.0	65,140	2.5
San Jose, CA	175,196	499.8	2	8.2	119,860	9.0
Indianapolis, IN	88,066	470.0	1	9.5	47,074	3.0
New Orleans, LA	8,297	438.1	4	0.0	64,077	4.0
Portland, OR-WA	13,773	461.2	2	10.1	68,670	6.5
Columbus, OH	42,988	456.2	3	15.9	56,950	4.0
San Antonio, TX	8,854	331.6	3	7.9	40,878	0.0
Rochester, NY	74,583	388.2	0	18.4	57,637	10.0
Providence-Warwick-Pawtucket, RI-MA	28,843	379.0	3	18.3	63,360	8.1
Louisville, KY-IN	27,951	356.8	1	4.0	50,883	3.5
Sacramento, CA	15,614	332.2	0	19.9	77,702	9.0

TABLE XX
DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

SMSA	High-Tech Employment	Total Employment	Venture Capital	R&D Expenditure as Percent of Sales	Average Housing Price	State Corporate Tax Rate
Memphis, TN-AR-MS	12,356	327.2	1	0.0	55,046	5.0
Fort Lauderdale-Hollywood, FL	14,306	245.5	1	1.0	72,452	5.0
Dayton, OH	43,196	370.7	0	17.8	50,287	4.0
Albany-Schenectady-Troy, NY	14,056	313.0	0	5.3	67,420	10.0
Birmingham, AL	5,565	320.6	1	0.5	51,013	5.0
Salt Lake City-Ogden, UT	17,910	332.2	1	3.9	68,173	6.0
Toledo, OH-MI	16,497	282.6	0	14.0	48,071	3.1
Norfolk-VA Beach-Portsmouth, VA-NC	7,687	251.2	2	0.0	60,850	6.0
Greensboro-Winston-Salem- High Point, NC	19,811	343.1	0	0.0	53,053	6.0
Nashville-Davidson, TN	11,549	316.1	0	5.5	51,720	6.0
Oklahoma City, OK	16,100	315.2	1	0.2	39,820	4.0
Hartford, CT	46,814	339.8	8	23.5	59,251	10.0
Honolulu, HI	1,799	291.2	2	0.0	169,571	5.8
Jacksonville, FL	5,228	259.2	1	3.4	50,605	5.0
Akron, OH	8,978	247.3	0	0.9	55,750	4.0
Syracuse, NY	11,394	238.1	1	16.0	44,915	10.0
Gary-Hammond-East Chicago, IN	8,151	239.0	0	6.4	48,434	3.0
Northeast Pennsylvania	14,670	230.2	2	11.7	41,200	9.5
Allentown-Bethlehem-Easton, PA-NJ	18,213	255.1	2	20.0	53,393	7.2

TABLE XX
DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

SMSA	High-Tech Employment	Total Employment	Venture Capital	R&D Expenditure as Percent of Sales	Average Housing Price	State Corporate Tax Rate
New Brunswick-Perth Amboy- Sayreville, NJ	35,812	246.0	1	17.8	77,274	7.5
Charlotte-Gastonia, NC	15,230	279.5	1	2.4	59,698	6.0
Tulsa, OK	28,067	244.1	1	3.1	44,713	4.0
Richmond, VA	18,054	286.9	3	10.5	58,869	6.0
Orlando, FL	8,298	213.8	1	0.9	51,552	5.0
Jersey City, NJ	26,876	230.9	2	7.1	40,332	7.5
Omaha, NE-IA	12,594	242.8	1	0.9	53,936	6.1
Grand Rapids, MI	14,646	227.9	0	5.3	44,074	2.3
Springfield-Chicopee-Holyoke, MA-CT	14,731	212.1	2	53.4	57,707	9.1
Youngstown-Warren, OH	947	203.5	0	0.0	55,750	4.0
Greenville-Spartanburg, SC	27,838	234.8	0	0.0	53,912	6.0
Flint, MI	40,903	181.6	0	4.7	40,882	2.3
Wilmington, DE-NJ-MD	31,322	206.8	1	9.1	75,248	10.8
Long Branch-Ashbury Park, NJ	10,834	139.5	1	4.3	81,762	7.5
Raleigh-Durham, NC	23,676	219.4	1	6.3	59,375	6.0
West Palm Beach-Boca Raton, FL	5,981	145.3	1	0.0	72,243	5.0
Paterson-Clifton-Passaic, NJ	24,659	177.1	1	19.7	70,582	7.5
Fresno, CA	2,253	155.8	0	12.5	71,605	9.0
Lansing-East Lansing, MI	1,234	172.3	0	1.7	45,465	2.3
Tucson, AZ	6,420	147.3	0	0.9	68,063	2.5

TABLE XX

DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

SMSA	High-Tech Employment	Total Employment	Venture Capital	R&D Expenditure as Percent of Sales	Average Housing Price	State Corporate Tax Rate
Oxnard-Simi Valley-Ventura, CA	11,246	117.8	4	25.8	103,387	9.0
Knoxville, TN	25,362	177.8	1	3.0	47,600	6.0
Harrisburg, PA	6,975	202.8	1	9.0	51,445	9.5
El Paso, TX	2,641	140.4	0	1.6	48,147	0.0
Tacoma, WA	2,782	120.3	0	7.2	78,564	0.0
New Haven-West Haven, CT	23,685	173.1	1	21.6	49,464	10.0
Baton Rouge, LA	12,825	172.2	2	0.0	47,114	4.0
Mobile, AL	3,654	133.2	0	6.4	41,462	5.0
Johnson City-Kingsport-Bristol, TN-VA	26,683	138.6	0	0.0	44,512	6.0
Canton, OH	4,076	145.9	0	8.0	48,699	4.0
Austin, TX	9,583	188.2	0	2.5	51,397	0.0
Bridgeport, CT	68,539	148.8	2	13.1	58,107	10.0
Chattanooga, TN-GA	5,402	159.6	0	0.7	48,927	6.0
Wichita, KS	25,038	175.2	0	7.0	43,523	4.5
Albuquerque, NM	16,570	151.7	2	0.0	75,881	5.0
Worcester, MA	13,377	147.2	1	11.8	55,026	8.3
Fort Wayne, IN	25,479	157.5	2	14.1	48,060	3.0
Charleston-North Charleston, SC	3,125	122.2	1	0.0	52,605	6.0
Davenport-Rock Island-Moline, IA-IL	2,484	153.4	0	12.4	58,485	5.0
Columbia, SC	7,431	148.8	0	0.0	54,502	6.0
Peoria, IL	6,080	144.2	0	7.5	63,480	4.0

TABLE XX
DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

SMSA	Tax Effort	Average Manufacturing Wage	Industrial Incentives	Transportation Index	Climate Index	Effective Property Tax Rate
New York, NY-NJ	131.2	5.13	1,508	384	654	3.51
Chicago, IL	99.1	5.94	869	842	528	1.61
Los Angeles-Long Beach, CA	119.4	5.20	847	568	905	2.56
Philadelphia, PA-NJ	97.9	5.56	1,254	196	530	2.58
Detroit, MI	106.3	7.23	1,042	262	550	2.94
San Francisco-Oakland, CA	119.4	6.82	847	423	911	2.15
Washington, DC-MD-VA	96.3	5.44	767	361	631	1.25
Boston, MA	128.6	5.26	1,118	290	637	4.33
Nassau-Suffolk, NY	159.6	5.05	1,770	348	657	3.40
Dallas-Fort Worth, TX	63.3	4.67	1,423	453	456	1.56
St. Louis, MO-IL	91.3	6.01	947	279	543	1.88
Pittsburgh, PA	93.0	6.43	1,263	273	596	1.95
Houston, TX	68.3	5.85	1,423	297	505	1.10
Baltimore, MD	105.6	5.80	1,323	93	598	1.31
Minneapolis-St. Paul, MN-WI	116.2	5.86	1,598	214	378	2.06
Newark, NJ	102.8	5.44	1,246	175	531	3.77
Cleveland, OH	79.5	6.22	805	190	589	1.51
Atlanta, GA	88.6	5.08	1,293	724	595	1.23
Anaheim-Santa Ana-Garden Grove, CA	119.4	5.18	847	42	800	1.56
San Diego, CA	119.4	5.62	847	114	906	1.65

TABLE XX
DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

SMSA	Tax Effort	Average Manufacturing Wage	Industrial Incentives	Transportation Index	Climate Index	Effective Property Tax Rate
Miami, FL	73.9	3.88	1,226	369	664	1.16
Denver-Boulder, CO	90.1	5.71	807	401	509	1.35
Milwaukee, WI	114.9	6.26	520	114	492	3.14
Seattle-Everett, WA	191.1	6.51	1,207	179	811	0.95
Cincinnati, OH-KY-IN	85.3	5.65	1,136	103	588	1.25
Tampa-St. Petersburg, FL	73.9	4.55	1,226	189	540	1.12
Buffalo, NY	159.6	6.55	1,770	101	583	3.90
Kansas City, MO-KS	84.2	5.84	1,026	182	519	2.12
Riverside-San Bernadino-Ontario, CA	119.4	5.78	847	50	700	1.84
Phoenix, AZ	107.8	5.15	1,400	160	555	1.31
San Jose, CA	119.4	6.06	847	79	727	1.35
Indianapolis, IN	92.0	5.99	1,064	105	556	2.16
New Orleans, LA	86.7	5.36	1,529	151	565	0.54
Portland, OR-WA	98.5	5.99	1,215	106	778	2.40
Columbus, OH	79.5	5.64	805	75	566	1.18
San Antonio, TX	68.3	3.84	1,423	87	580	1.02
Rochester, NY	159.6	6.11	1,770	55	566	3.44
Providence-Warwick-Pawtucket, RI-MA	120.4	4.15	1,146	32	700	2.12
Louisville, KY-IN	88.2	5.89	1,282	86	520	1.33
Sacramento, CA	119.4	6.09	847	57	576	1.82

TABLE XX
DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

SMSA	Tax Effort	Average Manufacturing Wage	Industrial Incentives	Transportation Index	Climate Index	Effective Property Tax Rate
Memphis, TN-AR-MS	84.2	5.00	1.562	218	524	1.14
Fort Lauderdale-Hollywood, FL	73.9	4.31	1.226	126	530	0.93
Dayton, OH	79.5	6.28	805	63	563	1.23
Albany-Schenectady-Troy, NY	159.6	5.55	1.770	40	510	4.13
Birmingham, AL	78.9	5.46	1.850	61	602	0.55
Salt Lake City-Ogden, UT	89.2	4.71	931	112	489	0.98
Toledo, OH-MI	92.9	6.32	923	26	534	1.30
Norfolk-VA Beach-Portsmouth, VA-NC	86.4	4.52	974	42	662	1.29
Greensboro-Winston-Salem-High Point, NC	85.8	4.13	971	50	642	1.04
Nashville-Davidson, TN	78.9	4.55	1.799	97	602	1.02
Oklahoma City, OK	73.0	4.81	1,181	66	490	0.98
Hartford, CT	98.7	5.60	1,221	92	528	2.27
Honolulu, HI	119.1	5.06	1,363	182	717	0.66
Jacksonville, FL	73.9	5.28	1.226	54	539	1.03
Akron, OH	79.5	6.02	805	15	565	1.35
Syracuse, NY	159.6	5.53	1,770	52	566	3.12
Gary-Hammond-East Chicago, IN	92.0	7.61	1,064	28	528	2.14
Northeast Pennsylvania	93.0	4.25	1,263	27	515	3.05
Allentown-Bethlehem-Easton, PA-NJ	97.9	5.42	1,254	14	568	2.00
New Brunswick-Perth Amboy-Sayreville, NJ	102.8	5.73	1,246	75	630	2.75

TABLE XX
DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

SMSA	Tax Effort	Average Manufacturing Wage	Industrial Incentives	Transportation Index	Climate Index	Effective Property Tax Rate
Charlotte-Gastonia, NC	85.8	3.80	971	92	644	1.28
Tulsa, OK	73.0	5.25	1,181	59	462	0.91
Richmond, VA	87.1	5.13	978	44	585	1.56
Orlando, FL	73.9	4.44	1,226	132	457	1.41
Jersey City, NJ	102.8	5.30	1,246	175	643	4.94
Omaha, NE-IA	88.9	5.33	1,222	59	428	2.13
Grand Rapids, MI	106.3	5.64	1,042	33	529	1.97
Springfield-Chicopee-Holyoke, MA-CT	113.8	4.79	1,169	92	552	2.01
Youngstown-Warren, OH	79.5	7.02	805	12	585	1.11
Greenville-Spartanburg, SC	85.2	3.90	1,593	24	655	0.88
Flint, MI	106.3	7.52	1,042	14	566	2.58
Wilmington, DE-NJ-MD	91.1	6.22	1,258	196	520	1.59
Long Branch-Ashbury Park, NJ	102.8	5.33	1,246	75	530	2.83
Raleigh-Durham, NC	85.8	4.26	971	53	647	1.27
West Palm Beach-Boca Raton, FL	73.9	5.06	1,221	60	595	1.00
Paterson-Clifton-Passaic, NJ	102.8	5.08	1,246	75	600	3.88
Fresno, CA	119.4	5.16	847	30	452	1.77
Lansing-East Lansing, MI	106.3	7.16	1,042	23	525	2.36
Tucson, AZ	107.8	5.33	1,400	57	589	1.31
Oxnard-Simi Valley-Ventura, CA	119.4	5.00	847	47	883	1.43

TABLE XX
DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

SMSA	Tax Effort	Average Manufacturing Wage	Industrial Incentives	Transportation Index	Climate Index	Effective Property Tax Rate
Knoxville, TN	78.9	4.98	1,799	32	672	0.75
Harrisburg, PA	93.0	4.79	1,263	10	579	3.29
El Paso, TX	68.3	3.66	1,423	51	592	1.40
Tacoma, WA	101.1	6.42	1,207	79	800	1.25
New Haven-West Haven, CT	98.7	5.16	1,221	52	660	2.39
Baton Rouge, LA	86.7	6.52	1,539	19	514	0.60
Mobile, AL	78.9	5.32	1,850	28	523	0.41
Johnson City-Kingsport-Bristol, TN-VA	92.2	4.68	1,388	27	665	1.26
Canton, OH	79.5	6.18	805	15	585	0.95
Austin, TX	68.3	4.32	1,423	47	435	1.56
Bridgeport, CT	98.7	5.26	1,221	17	656	2.94
Chattanooga, TN-GA	83.7	4.45	1,546	20	579	1.03
Wichita, KS	84.9	6.71	1,754	53	436	1.35
Albuquerque, NM	85.0	4.11	827	66	661	1.30
Worcester, MA	128.6	4.83	1,118	9	575	3.92
Fort Wayne, IN	92.0	6.60	1,064	20	529	1.59
Charleston-North Charleston, SC	85.2	4.42	1,593	28	616	0.94
Davenport-Rock Island-Moline, IA-IL	96.1	6.69	1,124	25	472	1.94
Columbia, SC	85.2	3.94	1,593	25	516	1.10
Peoria, IL	99.1	7.56	869	27	513	1.83

TABLE XX
DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

	Unitary Tax	West S. Central Region 1	East S. Central Region 2	Pacific Region 3	Mountain Region 4	South Atlantic Region 5	West N. Central Region 6	East N. Central Region 7	Mid- Atlantic Region 8
New York, NY-NJ	1	0	0	0	0	0	0	0	1
Chicago, IL	1	0	0	0	0	0	0	1	0
Los Angeles-Long Beach, CA	1	0	0	1	0	0	0	0	0
Philadelphia, PA-NJ	0	0	0	0	0	0	0	0	1
Detroit, MI	0	0	0	0	0	0	0	1	0
San Francisco-Oakland, CA	1	0	0	1	0	0	0	0	0
Washington, DC-MD-VA	0	0	0	0	0	1	0	0	0
Boston, MA	1	0	0	0	0	0	0	0	0
Nassau-Suffolk, NY	1	0	0	0	0	0	0	0	1
Dallas-Fort Worth, TX	0	1	0	0	0	0	0	0	0
St. Louis, MO-IL	0	0	0	0	0	0	1	0	0
Pittsburgh, PA	0	0	0	0	0	0	0	0	1
Houston, TX	0	1	0	0	0	0	0	0	0
Baltimore, MD	0	0	0	0	0	1	0	0	0
Minneapolis-St. Paul, MN-WI	1	0	0	0	0	0	1	0	0
Newark, NJ	0	0	0	0	0	0	0	0	1
Cleveland, OH	0	0	0	0	0	0	0	1	0
Atlanta, GA	0	0	0	0	0	1	0	0	0
Anaheim-Santa Ana-Garden Grove, CA	1	0	0	1	0	0	0	0	0
San Diego, CA	1	0	0	1	0	0	0	0	0

TABLE XX

DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

	Unitary Tax	West S. Central Region 1	East S. Central Region 2	Pacific Region 3	Mountain Region 4	South Atlantic Region 5	West N. Central Region 6	East N. Central Region 7	Mid- Atlantic Region 8
Miami, FL	1	0	0	0	0	1	0	0	0
Denver-Boulder, CO	1	0	0	0	1	0	0	0	0
Milwaukee, WI	0	0	0	0	0	0	0	1	0
Seattle-Everett, WA	0	0	0	1	0	0	0	0	0
Cincinnati, OH-KY-IN	0	0	0	0	0	0	0	1	0
Tampa-St. Petersburg, FL	1	0	0	0	0	1	0	0	0
Buffalo, NY	1	0	0	0	0	0	0	0	1
Kansas City, MO-KS	0	0	0	0	0	0	1	0	0
Riverside-San Bernadino-Ontario, CA	1	0	0	1	0	0	0	0	0
Phoenix, AZ	1	0	0	0	1	0	0	0	0
San Jose, CA	1	0	0	1	0	0	0	0	0
Indianapolis, IN	1	0	0	0	0	0	0	1	0
New Orleans, LA	0	1	0	0	0	0	0	0	0
Portland, OR-WA	1	0	0	1	0	0	0	0	0
Columbus, OH	0	0	0	0	0	0	0	1	0
San Antonio, TX	0	1	0	0	0	0	0	0	0
Rochester, NY	1	0	0	0	0	0	0	0	1
Providence-Warwick-Pawtucket, RI-MA	0	0	0	0	0	0	0	0	0
Louisville, KY-IN	1	0	1	0	0	0	0	0	0
Sacramento, CA	1	0	0	1	0	0	0	0	0

TABLE XX
DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

	Unitary Tax	West S. Central Region 1	East S. Central Region 2	Pacific Region 3	Mountain Region 4	South Atlantic Region 5	West N. Central Region 6	East N. Central Region 7	Mid- Atlantic Region 8
Memphis, TN-AR-MS	0	0	1	0	0	0	0	0	0
Fort Lauderdale-Hollywood, FL	1	0	0	0	0	1	0	0	0
Dayton, OH	0	0	0	0	0	0	0	1	0
Albany-Schenectady-Troy, NY	1	0	0	0	0	0	0	0	1
Birmingham, AL	0	0	1	0	0	0	0	0	0
Salt Lake City-Ogden, UT	1	0	0	0	1	0	0	0	0
Toledo, OH-MI	0	0	0	0	0	0	0	1	0
Norfolk-VA Beach-Portsmouth, VA-NC	1	0	0	0	0	1	0	0	0
Greensboro-Winston-Salem-High Point, NC	1	0	0	0	0	1	0	0	0
Nashville-Davidson, TN	0	0	1	0	0	0	0	0	0
Oklahoma City, OK	1	1	0	0	0	0	0	0	0
Hartford, CT	0	0	0	0	0	0	0	0	0
Honolulu, HI	0	0	0	1	0	0	0	0	0
Jacksonville, FL	1	0	0	0	0	1	0	0	0
Akron, OH	0	0	0	0	0	0	0	1	0
Syracuse, NY	1	0	0	0	0	0	0	0	1
Gary-Hammond-East Chicago, IN	1	0	0	0	0	0	0	1	0
Northeast Pennsylvania	0	0	0	0	0	0	0	0	1
Allentown-Bethlehem-Easton, PA-NJ	0	0	0	0	0	0	0	0	1
New Brunswick-Perth Amboy-Sayreville, NJ	0	0	0	0	0	0	0	0	1

TABLE XX

DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

	Unitary Tax	West S. Central Region 1	East S. Central Region 2	Pacific Region 3	Mountain Region 4	South Atlantic Region 5	West N. Central Region 6	East N. Central Region 7	Mid- Atlantic Region 8
Charlotte-Gastonia, NC	1	0	0	0	0	1	0	0	0
Tulsa, OK	1	1	0	0	0	0	0	0	0
Richmond, VA	1	0	0	0	0	1	0	0	0
Orlando, FL	1	0	0	0	0	1	0	0	0
Jersey City, NJ	0	0	0	0	0	0	0	0	1
Omaha, NE-IA	1	0	0	0	0	0	1	0	0
Grand Rapids, MI	0	0	0	0	0	0	0	1	0
Springfield-Chicopee-Holyoke, MA-CT	1	0	0	0	0	0	0	0	0
Youngstown-Warren, OH	0	0	0	0	0	0	0	1	0
Greenville-Spartanburg, SC	0	0	0	0	0	1	0	0	0
Flint, MI	0	0	0	0	0	0	0	1	0
Wilmington, DE-NJ-MD	0	0	0	0	0	1	0	0	0
Long Branch-Ashbury Park, NJ	0	0	0	0	0	0	0	0	1
Raleigh-Durham, NC	1	0	0	0	0	1	0	0	0
West Palm Beach-Boca Raton, FL	1	0	0	0	0	1	0	0	0
Paterson-Clifton-Passaic, NJ	0	0	0	0	0	0	0	0	1
Fresno, CA	1	0	0	1	0	0	0	0	0
Lansing-East Lansing, MI	0	0	0	0	0	0	0	1	0
Tucson, AZ	1	0	0	0	1	0	0	0	0
Oxnard-Simi Valley-Ventura, CA	1	0	0	1	0	0	0	0	0

TABLE XX
DATA ON SELECTED INDEPENDENT VARIABLES FOR THE 100 LARGEST SMSAs
(continued)

	Unitary Tax	West S. Central Region 1	East S. Central Region 2	Pacific Region 3	Mountain Region 4	South Atlantic Region 5	West N. Central Region 6	East N. Central Region 7	Mid- Atlantic Region 8
Knoxville, TN	0	0	1	0	0	0	0	0	0
Harrisburg, PA	0	0	0	0	0	0	0	0	1
El Paso, TX	0	1	0	0	0	0	0	0	0
Tacoma, WA	0	0	0	1	0	0	0	0	0
New Haven-West Haven, CT	0	0	0	0	0	0	0	0	0
Baton Rouge, LA	0	1	0	0	0	0	0	0	0
Mobile, AL	0	0	1	0	0	0	0	0	0
Johnson City-Kingsport-Bristol, TN-VA	0	0	1	0	0	0	0	0	0
Canton, OH	0	0	0	0	0	0	0	1	0
Austin, TX	0	1	0	0	0	0	0	0	0
Bridgeport, CT	0	0	0	0	0	0	0	0	0
Chattanooga, TN-GA	0	0	1	0	0	0	0	0	0
Wichita, KS	1	0	0	0	0	0	1	0	0
Albuquerque, NM	1	0	0	0	1	0	0	0	0
Worcester, MA	1	0	0	0	0	0	0	0	0
Fort Wayne, IN	1	0	0	0	0	0	0	1	0
Charleston-North Charleston, SC	0	0	0	0	0	1	0	0	0
Davenport-Rock Island-Moline, IA-IL	1	0	0	0	0	0	1	0	0
Columbia, SC	0	0	0	0	0	1	0	0	0
Peoria, IL	1	0	0	0	0	0	0	1	0