To the Graduate Council:

I am submitting herewith a dissertation written by Donald Lewis Johnson entitled "An Analysis of the Determinants of Worker Migration: Implications for the Location of High Technology Industries." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Economics.

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We have read this dissertation
and recommend its acceptance:

Accepted for the Council:

Vice Provost
and Dean of the Graduate School

AN ANALYSIS OF THE DETERMINANTS OF WORKER MIGRATION: IMPLICATIONS FOR THE LOCATION OF HIGH TECHNOLOGY INDUSTRIES

A Dissertation

Presented for the

Doctor of Philosophy

Degree

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ABSTRACT

New technologies are having a widespread impact on work in the office, the factory and the farm. New job skills are emerging and some old ones are becoming obsolete. Employment in high technology industries rose almost 40 percent between 1972 and 1982, almost twice the growth of total U.S. employment. Despite the attention that has been directed to the desirability of attracting high technology industries, until recently very little was known about the locational orientation of high technology firms. Most analysts agree that the major factor influencing the location decisions of high technology firms is the availability of an adequate supply of workers in high technology occupations. Many of these analysts also hypothesize that high technology workers are attracted to metropolitan areas that offer quality of life advantages. This implies that, other things equal, the ability of metropolitan areas to attract high technology firms is dependent on their ability to attract and retain high technology workers. Thus, metropolitan areas which offer a relatively high quality of life should attract high technology firms. If this is true, then the location decisions of high technology firms are amenity-oriented because the location decisions of workers are amenity-oriented.

This study examines the migration decisions of high technology workers in order to determine if they are indeed attracted to metropolitan areas that offer quality of life advantages. An economic model of migration is formulated. This model is expanded to incorporate the metropolitan area characteristics hypothesized to influence the migration decisions of high technology workers. This model is econometrically estimated with micro-data from the 1980 Census of Population and Housing.

The main conclusion is that quality of life considerations play only a minor role in the migration decisions of high technology workers. The higher migration rate of high technology workers can be attributed either to occupation-related differences in such personal attributes as age, education, prior migration experience, marital status, and race or to explanatory variables not included in the model. The empirical results of this study do not support the hypothesis that the location decisions of high technology firms are amenity-oriented.

CHAPTER 1

INTRODUCTION

Over the nation's history, the economy has been dominated by several key industries. Agriculture was the primary economic activity in the nation's first one hundred years. Even as late as 1900, 4 out of every 10 workers in the United States were employed in agriculture (U.S. Bureau of the Census, 1975). By 1980, only 3 percent of the work force was employed in this sector (U.S. Department of Labor, 1981). Employment projections for 1995 indicate that the long-term trend of declining employment in agriculture and the more recent trend of declining employment in manufacturing will continue in the future (National Science Foundation, 1983; Leontief and Duchin, 1983; U.S. Department of Labor, 1982).

New technologies are having a widespread and visible impact on work in the office, the factory, and even the farm. Employment in engineering, computer specialities, and other technical fields is increasing, while employment in some traditional craft fields is declining. New job skills are emerging and some old ones are becoming obsolete (Rumberger and Levin, 1984). This transformation is part of a continuing process of technological change that has been going on throughout the nation's history. Past technical developments reduced the labor requirements of farming and transformed work in the factory. Today's rapid developments in microelectronics, biological sciences, and other "high tech" areas are transforming work in virtually all sectors of the economy. This transformation promises renewed economic prosperity for the nation.

The growth of high technology will increase employment in those industries where high technology products--such as electronic components

and computers--are manufactured. It will also spur employment growth in those occupations related to the design, development, and manufacture of such equipment as well as in occupations where the equipment is used (Rumberger and Levin, 1984).[1] The Bureau of Labor Statistics has projected that employment in high technology occupations will increase by 46 percent between 1982 and 1995 assuming only moderate economic growth (Richie, Hecker, and Burgan, 1983). This compares to a projected 25 percent increase in employment in all occupations between 1982 and 1995. Employment in high technology industries increased by 39.8 percent between 1972 and 1982, while total employment increased only 20.1 percent (Richie, Hecker, and Burgan, 1983).[2]

High technology industry employment can have a large impact on a local economy. Nine states saw high technology jobs account for 10 percent or more of the rise in their total employment. In Table 1-1, the 10 states experiencing the greatest growth of employment in high technology industries are shown. The New England region leads other regions in the proportion of high technology employment growth. Massachusetts, New Hampshire, Vermont, and Maine all enjoy above average high technology employment growth. With the exception of South Dakota, the other four states, Arizona, California, Oregon, and Washington, are located in the

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[1]Workers in high technology occupations require substantial knowlege of technology. Rumberger and Levin (1984) estimate that less than 25 percent of the jobs in high technology industries are jobs in high technology occupations.

[2]The industries that comprise the high technology industries are identified in Chapter 3. Unless otherwise stated, subsequent use of the term "high technology industries" in this chapter refer to the group of industries which the Bureau of Labor Statistics labels "Group II" industries.

Table 1-1. High Technology Industry Employment Growth as a Percentage of Total Nonfarm Employment Growth in Selected States, 1975-1982

State	Percent
Massachusetts	18.3
New Hampshire	15.8
Vermont	11.5
Arizona	10.6
Maine	10.1
California	10.0
Oregon	10.0
South Dakota	10.0
Washington	10.0
Rhode Island	9.1
U.S. Average	5.8

Source: Richard W. Richie, Daniel E. Hecker, and John U. Burgan, "High Technology Today and Tommorrow," Monthly Labor Review, November 1983.

Western United States. The importance of high technology industries to selected state economies can be seen in Table 1-2. High technology industries tend to be more important to state economies in the New England and Western regions than in other regions. Puerto Rico and Kansas are the only two states in Table 1-2 that are not in New England or in the West.

Employment in high technology industries is concentrated in certain states. This concentration of high technology industry employment is conspicuous in Table 1-3. High technology industry employment in the ten states in Table 1-3 represents almost two-thirds of total U.S. employment in high technology industries. High technology industries in California employ almost 1 out of every 4 high technology industry workers in the United States, as of 1983. California is followed by New York, Massachusetts, Texas, New Jersey, Florida, Connecticut, Pennsylvania, Illinois, and Washington. Only California, Massachusetts, and Washington are included in all three tables.

In addition to rapid growth, high technology industries offer certain positive externalities badly needed by regions attempting to revitalize their economic bases. One recent study notes:

> High technology companies bring to a region not only new jobs, but also new ways of managing people to produce a product in a highly competitive environment. Our research brought to life a quiet revolution going on in American industry. Those companies on the cutting edge of technological change are also on the cutting edge of behavioral change. Successful high technology companies are led by enlightened managements. They are disillusioned with traditional corporate structures. They believe there must be a better way to operate a business. The model they provide is one of integrating people with technology to get results.
>
> The ingredients necessary for successful operation of a technology firm are increasingly becoming the same ingredients needed to operate successfully in traditional industries. High technology is a product of the information age. A management

Table 1-2. High Technology Industry Employment as a Percent of Total Nonfarm Employment in Selected States, 1983

State	Percent
New Hampshire	7.1
Connecticut	6.8
Arizona	6.4
California	6.3
Massachusetts	6.3
Vermont	6.3
Washington	4.9
Puerto Rico	4.3
Utah	4.2
Kansas	4.1
U.S. Average	2.8

Source: John U. Burgan, "Cyclical Behavior of High Tech Industries," Monthly Labor Review, May 1985.

Table 1-3. Employment in High Technology Industries for Selected States, 1983

State	Employment (Thousands of Workers)	Percent of Total
California	624.5	24%
New York	202.9	8
Massachusetts	167.2	6
Texas	155.6	6
New Jersey	118.6	5
Florida	107.7	4
Connecticut	97.4	4
Pennsylvania	89.8	3
Illinois	86.1	3
Washington	78.1	3
U.S. Total	2,578.7	

Source: John U. Burgan, "Cyclical Behavior of High Tech Industries," Monthly Labor Review, May 1985.

> style conducive to this age naturally has developed. The age of mass production, standardized, and broad interpretations of customer needs appears to be nearing an end. High technology producers have been forced to operate in a rapidly changing environment early in their development. Companies in traditional industries that recognize the need for a "renaissance" in management style and strategy can successfully embrace new challenges. The presence of a dynamic industry such as high technology may develop a pattern for others to follow. . . (Koch, Cox, Steinhauser, and Whigham, 1983, p. 16).

However, high technology industries are not immune from problems which occur in the economy, including the effects of the business cycle. The high technology industries are comprised primarily of manufacturing industries. The presence of cyclically sensitive manufacturing industries has important consequences when their performance during recent recessions is evaluated.

Several observations can be made from the experience of highly technology industries in the recent recession and in the other post-1972 downturns. First, highly technology industries lost a smaller proportion of prerecession employment during the most recent recession than did manufacturing industries in general. Second, even though the high technology industries are dominated by manufacturing industries, they consistently outperformed the nonfarm industrial sector. Third, industries which have relatively large concentrations of high skilled workers and relatively large R&D expenditures, such as the high technology industries, were less affected by general economic downturns than industries with lesser concentrations of high skilled workers and lower R&D expenditures.[3]

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[3]Supporting evidence is provided in Burgan (1985).

Much attention has been directed to the desirability of attracting high technology industries. A census by the Office of Technology Assessment (1983) identified 150 state government programs with at least some features directed toward high technology industrial development. Of these 150 programs, 38 programs in 22 states were specifically targeted on the creation, attraction, or retention of high technology firms. Most of these programs were initiated on or after 1980. The result of this intense competition among states and local areas for high technology industries could cause increased economic growth for the entire nation. According to a recent study by the Joint Economic Committee of Congress, "State and local policy efforts . . . have the potential to reverse the Nation's decline in productivity, expand its export, and lead to a gain in real per capita income for all States" (Premus, 1982, p. 2).

Until recently, very little was known about the locational orientation of high technology firms. Recent studies have shown high technology firms to be generally footloose in their location decisions. These studies are the subject of Chapter 2. Most analysts agree that the major factor influencing the location decisions of high technology firms is the availability of an adequate supply of workers in high technology occupations. Many of these same analysts hypothesize that high technology workers are attracted to metropolitan areas that offer quality of life advantages. This implies that, other things equal, the ability of metropolitan areas to attract high technology firms is dependent on their ability to attract and retain high technology workers. Thus, metropolitan areas which offer a relatively high quality of life should attract high technology firms. If this is true, then the location decisions of high technology firms are

amenity-oriented because the location decisions of workers in high technology occupations are amenity-oriented. This study examines the migration decisions of high technology workers in order to determine if they are indeed attracted to metropolitan areas that offer quality of life advantages.

However, the identification of the workers in these occupations is dependent upon the industries included in the definition of high technology industries. In Chapter 3, a "consensus definition" of high technology industries is constructed. This "consensus definition" is employed to identify the occupations which are relatively important to high technology industries.

In Chapter 4, an economic model of migration is formulated. This model is expanded to incorporate the metropolitan area characteristics hypothesized to influence the migration decisions of high technology workers. This model is econometrically estimated with micro-data from the 1980 Census of Population and Housing. The empirical results are presented in Chapter 5. Finally, the empirical evidence from Chapter 5 is examined in Chapter 6 to determine if it provides support for the hypothesis that the location decisions of high technology workers are amenity-oriented.

CHAPTER 2

THE LOCATION DECISIONS OF HIGH TECHNOLOGY FIRMS

Location Theory in General

The formal theory of industrial location was first developed by Alfred Weber (1909) and later was integrated with the theory of the firm by Walter Isard (1951) and Leon Moses (1958). The basic theoretical framework revolves around industries which find transportation costs of paramount importance in selecting a location. Industries whose location decisions are dominated by transportation costs are called transport-oriented industries (Alonso, 1975). These industries minimize total transportation costs by locating at the raw material site or market with the dominant ideal weight.[1]

However, not all industries are transport-oriented. For industries with different orientations, other factors may dominate the location decision. Alonso (1975) provides some examples:

> Textiles are usually attracted to places with abundant cheap labor and are called labor-oriented, and aluminum is attracted to cheap electricity and is called power-oriented.
> . . . Industries that have no strong locational preferences, and particularly industries that are not transport oriented, are often called foot-loose, and there is good reason to believe that technical developments are making more industries footloose.
> . . . Foot-looseness simply means that transport costs are relatively less important, not that one place is as good as any other.

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[1]The ideal weight can be expressed as $w_i r_i$, where w_i is the amount of input i necessary per unit of product, and r_i is the cost of moving one unit of this input a given distance. If one of the ideal weights is greater than the sum of all the others, then the location with the least transport costs will be at the source of this dominant material (or at the market, in the case of the product having the dominant ideal weight).

Most analysts believe that high technology industries, as a group, are footloose in their location orientation.[2] This may seem to imply that the location decisions of high technology industries are special cases that fall outside general location theory. Alonso, though, argues that the general location theory applies to high technology industries as well:

> . . . Another type of orientation is emerging that might be called amenity-orientation. Research industries, such as electronics, have small transport costs but need very specialized scientists and engineers. To attract them these firms often locate where there are climatic or cultural advantages.
> . . . It will be noted, however, that these various orientations [labor, power, and amenity] are really instances of the production cost differentials [among possible sites], and that they can be integrated with the analysis of transport costs.

Evidence from surveys of high technology firms suggests that high technology industries, as a group, are indeed foot-loose in the sense that transport costs do not dominate their location decisions. Also, this same evidence implies that high technology industries are amenity-oriented because the firms in these industries believe that location in an area well-endowed with amenities important to the quality of life greatly enhances their ability to attract and retain the professional and technical labor that they require.

Review of Literature

Probably the first formal attempt to identify the factors effecting the location decisions of high technology firms was made by the Federal Reserve Bank of Boston in 1953. Estall (1963) mentions the conclusions of the 1953 study in his review:

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[2]The evidence on the location orientation of the high technology industries is explored later in this chapter.

> In a survey of the New England electronics industry carried out in 1953, the Federal Reserve Bank of Boston asked 76 Boston area firms the reasons for their location in the area. Reasons related to labor skills were cited 42 times. Availability of research facilities and technical experts, and the position of Boston as a main center of electronics activity were together mentioned 31 times (Estall, p. 205).

Estall's own research into the matter reinforces the findings of the 1953 Federal Reserve Bank of Boston study. He rejected the argument that the area's growth in this industry was largely the result of Federal contracts for research, development, and military production. Instead, he points to the prior existence of relevant research and development facilities and of skilled scientists and technicians as the reason the Federal Government awarded firms in the Boston area with the majority of contracts for electronic work.

Roger Schmenner (1982) approached the issue from a wider perspective. Using data from a survey of 410 major U.S. manufacturers (including both high technology and other industries), Schmenner discovered that high technology industries have no particular location-sensitive costs, such as transportation or labor costs, to constrain their location decisions.[3] In the absence of a traditional locational orientation, such industries were free to consider more subjective aspects of the location decision. Because of the competitive demands placed upon their manufacturing operations, many high technology companies feel that the best locations for their plants are those most attractive to their engineers and managers.

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[3]Schmenner cites specific examples from his survey results. He notes that, "Companies such as Motorola, IBM, Burroughs, Perkin-Elmer, and Honeywell are remarkably free to locate their production capacity almost anywhere" (p. 134). Of the high technology plants in Schmenner's survey, only 3 percent indicated that they were seriously impeded by transportation costs.

As Schmenner declares, "After all, broad-ranging and rapid new product development, effective engineering and timely delivery are the salient competitive weapons in these companies, and these weapons are fashioned by a talented, dedicated, and happy corps of engineers and managers. Their plant location decision is one of analyzing where the most attractive places to live are located" (p. 134).[4] Firms in Schmenner's high technology group rated the "quality of life" in an area nearly as high as "favorable labor climate." In fact 5 out of every 8 plants in Schmenner's high technology group perceived the "quality of life" in an area as a major factor in the plant location decision (Schmenner, p. 152). The only other industry group ranking the "quality of life" in an area as an important determinant was the Industrial Machinery/Transportation Equipment group. Schmenner explains that this group is, ". . . perhaps the other group . . . that is most dependent on engineering talent" (Schmenner, p. 152). The other industry groups in the survey ranked "quality of life" considerations very low or not at all.

According to Schmenner, the most common screening mechanism is to consider only the larger metropolitan areas.[5] Approximately 40 percent of the firms in the high technology group were located in the central cities in the late 1970's, and 48 percent were located in the suburbs.

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[4]Schmenner is, in essence, arguing that high technology firms are amenity-oriented.

[5]Schmenner mentions two reasons why high technology firms give primary consideration to metropolitan areas:

(1) the breadth of educational, cultural, and recreational amenities prized by many engineers, managers, and their families is usually found only in metropolitan areas of a certain minimum size;

(2) such corporations often erect large plants designed to employ thousands of workers yet do not usually wish to be the dominant employer in a community.

Only 12 percent were located in rural areas (Schmenner, p. 212). In addition, Schmenner found that proximity to markets is not considered as important to high technology industries as it is to other industrial groups in his survey. Schmenner also noted that the footloose industry groups attach considerable importance to low wage rates.[6]

The late 1970's employment associated with the 410 firms he surveyed totalled over 7,000,000 workers, or 37 percent of the manufacturing employment accounted for by the 1977 Census of Manufacturers. Of this 37 percent, 13.6 percent were employed by industries that form his technology group.[7] Schmenner's results point to the importance of professional and technical workers who possess specialized skills crucial to high technology firms. Not only is the availability of such workers a significant factor in the location decisions of the high technology firms he surveyed, but also the cost of obtaining this specialized labor plays a role as well.

James Howell (1984) traces the evolution of New England's technology base back to colonial times. Howell states that:

> Of all the factors affecting this region's [recent] economic turnabout, the growth in high technology industries clearly stands out. Attempts to trace developments leading to the revitalization of the region generally assume that the technology base of New England emerged somewhere in the post-Sputnick-NASA era of the 1960s. There is much to be said about the technical dynamism of this period and its relationship to the revitalization. To be sure, New England continues

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[6]Other industry groups classified by Schmenner as foot-loose include the industrial machinery/transporation equipment industries and the specialty chemicals/metals industries.

[7]Schmenner's high technology group is made up of the following industries: (1) computers and office equipment, (2) communication equipment, (3) electronic components, (4) guided missles and space vehicles, and (5) instruments.

> to benefit more than other regions from Federally-sponsored research and development funds and Department of Defense contracts: with only 5 percent of the U.S. population, New England receives more than 10 percent of Federal research and development funds and 11 percent of Federal defense contracts awarded. Nonetheless, the reality is that New England has always been on the cutting edge of technology (p. 2).

Howell claims that it takes a variety of resources to foster the growth of high technology industries in a region:

1. A supply of investment or "risk" capital;
2. A relatively large pool of skilled labor;
3. The presence of entrepreneurs.

Howell's emphasis is on the startup of high technology industries that are indigenous to New England. He is less concerned with attracting already existing industries to a region. Yet he identifies the role of skilled labor even in the startup phases of these industries. He points out that, "Start-ups are likely to be more concentrated in existing high-tech centers because they often draw upon the labor and entrepreneurial resources of established firms" (p. 8).

By far the most definitive work in the area has been that of Robert Premus (1982) for the Joint Economic Committee of Congress. Premus sent a detailed questionnaire to 1,750 high technology firms, out of which 691 responded.[8] No similar systematic survey of high technology firms of this magnitude had taken place before. The survey results confirm the hypothesis that high technology companies are footloose in the sense that access to raw materials, to markets, and to transportation are not major locational

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[8]Over one-half of the responding firms were incorporated after 1968, and one-fourth were incorporated after 1975. About 75 percent of the companies reported 500 or fewer employees, about 31 percent reported fewer than 50 employees, and only 18 percent had more than 1,000 employees. Sixty-two percent of the responding firms had 3 or fewer plants, and 28 percent had 6 or more plants.

determinants. Instead, high technology companies are drawn more to highly specialized resources such as labor skills and to factors that make it easier to attract and maintain a skilled labor force. In addition, most of the firms surveyed indicated that they prefer an urban environment to a rural one. The questionnaires which Premus used viewed location decisions in two stages. His survey explicitly separated the factors influencing location choices between regions from factors influencing location choices within a region following the approach used by MacMillian (1965). Each region in the Joint Economic Committee survey contains several states. Thus, the first stage in the location decision involves choosing among groups of states, and the second stage involves choosing among states in the chosen region. In the questionnaire, the respondents were asked to rate each factor as very significant, significant, of some significance, or of no significance. The percent of very significant and significant responses were added together in order to weight the importance of each factor. Table 2-1 presents the survey results for 12 factors that influence the choice of a region.

Clearly, the availability of skilled labor is considered to be the major factor when choosing plant locations among regions. Next, labor costs are rated as significant or very significant by over 72 percent of the responding firms, followed by the regional tax climate, academic institutions, and cost of living. Note that regional cultural amenities and climate are ranked tenth and eleventh, respectively. The factors influencing the intra-regional location decisions of high technology firms are ranked in order of importance in Table 2-2.

Once again, the overriding importance of labor availability is illustrated in Table 2-2. Labor skills and availability, taxes, and

Table 2-1. Twelve Factors that Influence the Regional Location Decisions of High Technology Firms[a]

Rank	Factor	Percent Significant or Very Significant
1	Labor skills/availability	89.3%
2	Labor costs	72.2
3	Regional tax climate	67.2
4	Academic institutions	58.7
5	Cost of living	58.5
6	Transportation	58.4
7	Access to markets	58.1
8	Regional regulatory requirements	49.0
9	Energy costs/availability	41.4
10	Cultural amenities	36.8
11	Climate	35.8
12	Access to raw materials	27.6

[a]Robert Premus, "Location of High Technology Firms and Regional Economic Development," Staff Study prepared for the Subcommittee on Monetary and Fiscal Policy of the Joint Economic Committee of the U.S. Congress, Government Printing Office, 1982, p. 23.

Table 2-2. Twelve Factors that Influence the Location Decisions of High Technology Firms within Regions[a]

Rank	Factor	Percent Significant or Very Significant
1	Availability of workers	96.1%
	Skilled	88.1
	Unskilled	42.4
	Technical	91.1
	Professional	87.7
2	State and local tax structure	85.5
3	Community attitudes toward business	81.9
4	Cost of property and construction	78.8
5	Good transportation system for people	76.1
6	Ample area for expansion	75.4
7	Proximity to good schools	70.8
8	Recreational and cultural amenities	61.1
9	Good transportation facilities for materials and products	56.9
10	Proximity to customers	46.8
11	Energy supplies	45.6
12	Proximity to raw materials and component supplies	35.7

[a]Robert Premus, "Location of High Technology Firms and Regional Economic Development," Staff Study prepared for the Subcommittee on Monetary and Fiscal Policy of the Joint Economic Committee of the U.S. Congress, Government Printing Office, 1982, p. 25.

business climate dominate the location choice. This time firms were able to weight the importance of several types of labor. Proximity to technical workers was rated highest, followed by skilled workers and professionals. According to Premus, the reason for the emphasis on technical workers may be the difference between the geographic mobility of professionals and the geographic mobility of technical workers (Premus, p. 24). Premus claims that engineers and scientists are more mobile than technicians. One possible reason for this suspected difference is that inter-regional recruiting networks are less well developed for technicians than for professionals (Browne, 1983). Premus hypothesizes that high technology firms know about this migration rate differential and attach more importance to locating in areas with adequate supplies of technicians. Any regional shortage of professionals can be overcome by bribing professional workers to relocate.

State and local taxes ranked second in overall importance in the intra-regional location decisions. Premus argues that high technology firms are concerned about taxes because high taxes may discourage professionals from relocating to the area.[9] In fact, many of the factors rated significant relate to "quality of life." Thus, Premus' results support Schmenner's findings that many high technology companies feel that the best locations for their plants are those most attractive to their professional, technical, and skilled labor. The factors related to labor and to "quality of life" considerations seem to dominate both the regional and the intra-regional location decisions of high technology firms.

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[9]Schmenner's survey results show a tendency for low taxes to be valued more highly by the foot-loose industries than by other industrial groups.

The factors mentioned in the inter-regional location decisions related to "quality of life" are, in order of importance, taxes, academic institutions, cost of living, transportation, cultural amenities, and climate. In the intra-regional location decisions, the factors that can be classified as predominantly "quality of life" concerns are, in order of importance, state and local tax structure, good transportation system for people, proximity to good schools, and recreational and cultural amenities.[10]

The Future Location of High Technology Industries

The evidence indicates that the present high technology centers may be reaching the limit of their ability to absorb additional capacity (Business Week, 1980; Michael Knight, 1978; Roland Evans and Robert Novak, 1981; John Quirt, 1978; Robert Lindsay, 1981). High technology firms attempting to expand complain that high wages, congestion, lack of room for expansion, a shortage of skilled labor, excessive regulations, and high taxes are forcing them to look elsewhere for room to expand (Premus, p. 30). The importance attached in the survey results to land and construction costs, to adequate transportation systems for people, and to ample room for expansion all point to the conclusion that many high technology firms are looking for room to grow. As new industries reach a

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[10]Schmenner does not separate the location decisions of the high technology firms in his survey into inter-regional decisions and intra-regional decisions as does Premus. He does identify the "quality of life" factors which influence the location decisions of these firms: (1) cost of living, particularly housing costs, (2) quality of the local school system, (3) numbers and sizes of colleges and universities in the area, (4) cultural amenities such as symphony orchestras, (5) recreational amenities such as sports teams, (6) the quality of the transportation system, and (7) climate.

stage of growth and expansion, competition for scarce factors of production may force a spatial diffusion out of the birthplaces of these industries.

Hekman (1980) examines the likely pattern of future expansion by the computer industry. According to Hekman, the most important locational factor for firms which produce computers is the need for skilled labor and scientific workers. Hekman argues that the location of these specialized resources and ". . . the constantly evolving needs of high technology industries for them are the determining influences in the location pattern . . . The distinguishing feature of industries described as high technology is that some significant part of the design or production of their product is still in the innovation stage, where highly specialized resources are needed" (p. 6). Yet, his research suggests that employment outside the primary centers should grow more rapidly in the future ". . . as more parts of the production process are farmed out" (p. 17). Areas Hekman predicts to benefit are those that have ". . . a fortunate combination of highly skilled engineers to design the equipment and a pool of moderately paid labor to put it together" (p. 16).

Regions with the highest concentrations of high technology plants and permanent offices--New England, the Mideast, and the Far West--are all expected to suffer a decline in their relative shares of high technology industry (Premus, p. 33). The regions expected to experience the largest percentage increase in new plants and permanent offices are the regions that have a relatively small share of high technology industry, such as the Southeast and the Midwest. Premus maintains that the Midwest is the most attractive region to firms seeking to relocate, followed by the Southeast. While the Midwest and the Southeast both offer plenty of room

to grow, relatively low taxes, and favorable business climates, the perceived quality of the Midwest's academic institutions is far higher than the perceived quality of Southeastern academic institutions (Premus, pp. 33-34). Evidently, the biggest impediment to high technology industry growth in the Southeast is the perceived low quality of its academic institutions.

The above discussion illustrates the important relationship which many analysts point to between the high technology industries and academic institutions. Premus states that:

> . . . unlike the more traditional manufacturing companies, high technology companies . . . seek out a community noted for the excellence of its academic institutions . . . [U]niversities provide benefits to high technology companies through their basic research activities and through the intellectual and cultural climate that they provide. More important . . . universities provide skilled labor in the form of faculty consultants, research assistants, and graduating students (p. 34).

Howell (1984) calls universities the glue that holds together the resources necessary for the start-up of new high technology companies. Schmenner (1984) notes that having a college nearby is prized most by firms in the high technology group in his survey. Lynn Browne (1983b) points out that not only is the presence of high quality academic institutions necessary but that the relative emphasis on undergraduate versus graduate education may be important as well. In comparing the universities of the Great Lakes states to the universities of Massachusetts she found that the Great Lakes' universities grant a roughly equal proportion of B.S. and advanced degrees in engineering as do universities in other regions. In 1980-81, the Great Lakes universities conferred 21 percent of the nation's B.S.'s in engineering, 17 percent of the M.S.'s, and 22 percent of its Ph.D.'s . According to Browne, the Great Lakes states--Illinois, Indiana, Michigan,

Ohio, and Wisconsin--contain about 18 percent of the nation's population. Massachusetts, with 3 percent of the nation's population awarded 5 percent of the nation's engineering B.S.'s, 7 percent of the M.S.'s in engineering, and 8 percent of the Ph.D.'s. California, with 10 percent of the nation's population, awarded 8 percent of the B.S.'s in engineering, 14 percent of the M.S.'s and 18 percent of the Ph.D.'s in engineering. Browne claims that, "Many fine engineers from all over the country go on to graduate school at Stanford and MIT and never return to their home regions" (p. 27).

The Location Orientation of High Technology Industries

According to classical location theory, firms will tend to choose a location that allows them to maximize profits. Weber (1909) and Isard (1955) both assume that there are no geographic variations in the prices or the qualities of inputs at alternative locations and that the production function is homogeneous of the first degree.[11] These assumptions lead to the conclusion that there is a single best location for every type of productive activity. Since there are no geographic differentials in production costs, the optimum location is the point of minimum transportation costs. This is a special case. Clearly, resources are not evenly distributed at all locations nor are they available at all locations at uniform prices. Given that these assumptions are violated, then the location choice for a firm becomes one of finding the location which allows production

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[11]This means that no factor substitution in the production process is permitted.

at the lowest possible cost.[12] Other things equal, those industries that are labor-oriented will attempt to find a location that minimizes labor costs, and those industries that are power-oriented will attempt to find a location that minimizes energy costs. The amenity-oriented industries will try to locate in areas that offer a high quality of life through cultural attractions, quality educational opportunities at all levels, relatively low housing costs, and other amenities. By locating in such an area, an amenity-oriented firm can hope to attract top-notch workers who possess the special skills the firm needs and thereby allow the firm to successfully compete with other firms in their industry.

Where do the firms in the high technology industries fit? The surveys by Premus, Schmenner, and the Federal Reserve Bank of Boston and the case studies by Howell and Hekman imply that high technology firms are amenity-oriented. The common thread running through the surveys and the case studies is the emphasis that these firms place on adequate supplies of professional and technical workers in high technology occupations. The three surveys differ in that Premus divided the location decision into two stages--the inter-regional decision and the intra-regional decision--whereas the other two surveys did not. Also, the Federal Reserve Bank of Boston survey covered only Boston area firms while the other two surveys were much broader in scope. It should also be pointed out that many of the quality of life factors rated significant or very significant by the firms Premus surveyed are closely related to the quality of life factors identified by Schmenner.

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[12]Demand is implicitly taken for granted. Alonso notes that, ". . . we have been saying that we know where the markets are and how many units they want" (Alonso, 1975, p. 60).

Howell's case study of the evolution of high technology industry in New England supports Estall's analysis of the development of the electronics industry in the same area. Both cite the importance of an available supply of skilled labor and technical experts as a crucial ingredient in the creation of a high technology industrial base. Hekman's case study of the future expansion of the computer industry points to the continuing importance of the supply of labor in high technology occupations to future location decisions by high technology firms.

Summary

Beginning with the Federal Reserve Bank of Boston report and ending with the Howell case study of the evolution of high technology industry in New England, a readily apparent fact stands out. Those industries identified as the high technology industries consider labor to be the most important factor in their plant location decisions. The types of labor which the high technology firms specifically rate as important factors influencing their plant location decisions are in high technology occupations which require an in-depth knowledge of the theories and principles of science, engineering, and mathematics underlying technology (Richie, Hecker, and Burgan, 1983). Thus, the location decisions of high technology firms cannot be classified as labor-oriented in the general sense. The evidence indicates that these firms are indeed foot-loose in the sense that transportation costs play only a minor role in their location decisions. The survey results of Schmenner and Premus support the hypothesis that quality of life considerations play an important role in the location decisions of these firms. If high technology industries are indeed amenity-oriented, then firms in these industries will tend to locate their

plants in areas relatively well-endowed with these amenities because such a location supposedly enhances their ability to attract and retain the professional and technical labor that they require.

Given that the availability of labor in high technology occupations tends to dominate the location decisions of high technology firms, then the supply of such labor which an area or region possesses becomes a good indicator of its ability to attract high technology industry. However, a region's supply of workers in high technology occupations can be augmented through in-migration and diminished by out-migration. Other things equal, the more attractive an area is to workers in high technology occupations, the more attractive the area to high technology firms.

From the above evidence it appears that the major factor influencing the location decisions of high technology firms is the availability of technical and professional workers in high technology occupations. Other things being equal, the ability of a given region to attract high technology industries is linked with its ability to attract professional and technical workers or to hold onto existing supplies. Certainly the other factors identified by Howell (1984) and Premus (1982) play a role.[13] However, given the hypothesized location orientation of firms in the high technology industries, the identification of the factors which influence the location decisions of technical and professional workers in high technology occupations should be a necessary part of any attempt to examine

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[13]For example, Howell (1984) refers to the role played by the supply of investment or "risk" capital in the birth of new firms and Premus (1982) notes the importance of community attitudes toward business and the cost of property and construction (these two factors are ranked third and fourth by firms Premus surveyed in Table 2-2, p. 18).

the present location pattern of high technology firms or to predict their future location decisions.

The next task is to define and identify the high technology occupations so that the occupational composition of the technical and skilled workers so crucial to the location decisions of high technology firms can be more precisely known. However, the determination of the occupational composition of the high technology occupations first requires a more precise definition of the high technology industries.

CHAPTER 3

IDENTIFYING HIGH TECHNOLOGY INDUSTRIES AND OCCUPATIONS

Characteristics of High Technology Industries

Policy makers have shown an interest in high technology industries because they are often perceived as the dynamic job generating sectors of the economy, with potentially worldwide markets and high growth rates (McQuaid and Langridge, 1984). High technology industries are seen to be those at the leading edge of new innovations and new product development. However, a more specific definition of high technology industries has proven to be elusive.

The terms "high technology," "high technology industries," "high technology products," and "high technology jobs" are applied to a variety of industries, products, production processes, and occupations. However, the exact meaning of the phrase "high technology" is open to some debate. A high technology production process may or may not yield a high technology product. Nor does the use of a high technology production process by an industry necessarily make that industry a high technology industry. The seemingly simple task of identifying the true high technology industries, products, and jobs is far more complicated than it appears at first glance.

Concern over the role played by these industries on the leading edge of innovation and new product development can be traced back to Kondratiev, who noted in his study of 40 to 60 year long cycles called Long Waves that depressed conditions often stimulate human inventiveness (Kondratiev, 1935). These new discoveries and inventions were then

exploited during the rise of the next wave. This strand of thought was echoed by Schumpeter (1939), who suggested that the cyclical pattern of growth in capitalist economies was due largely to the diffusion of major new technologies. Vernon (1966) used the product cycle model to highlight the impact of the early stages of new product development on international trade and investment.

According to McQuaid and Langridge (1984), the first important distinction when defining the high technology industries is that between high technology products and high technology production processes. They cite the examples of the computer industry and the auto industry:

> The assembly of computers may often be labor-intensive and based on low technology production processes, while traditional industries may utilize extremely advanced production processes to make traditional products . . . For example, the auto industry accounted for 40 percent of all industrial robots deployed in the UK in 1981 . . . Hence a definition based on aggregate industries which included [high technology] users would incorporate many industries making traditional products" (McQuaid and Langridge, pp. 4-5).

This user/producer classification scheme forces analysts to make a value judgement as to where to draw the line between those industries using high technology products and those developing such products, with many industries falling somewhere in the middle.

One way to bypass the producer/user dichotomy is to focus solely on new technology. Industrial processes can be classified according to the period in which the technology an industry uses in its production process was developed. However, this leads to the problem of dating the introduction of a new technology, and a new technology may or may not be highly technological in nature (McQuaid and Langridge, p. 8).

A more objective approach to identifying the high technology industries is to describe the characteristics that a high technology

industry should possess and then selecting those that have these characteristics. Three criteria are generally used to classify high technology industries: (1) research and development expenditures, (2) the utilization of scientific and technical personnel relative to total employment, and (3) product sophistication (Richie, 1983). These three criteria are often coupled with such criteria as high growth rates and the number of innovations.

Defining the High Technology Industries

R.D. Norton and John Rees (1979) compared a group of industries that had performed extremely well since the second World War to measures of technological intensity which the National Science Board had developed. They found that, ". . . when sectors with the highest innovations per net sales are compared with those showing the largest number of innovations according to the National Science Board, it is the [high technology] growth sectors that stand out . . . . By most definitions the growth sectors are intuitively recognizable" (Norton and Rees, p. 149). Norton and Rees identified the following industry groups by their Standard Industrial Classification (SIC) codes:

1. (SIC 28) Chemicals;
2. (SIC 30) Plastics;
3. (SIC 35) Machinery;
4. (SIC 36) Electronics;
5. (SIC 37) Transportation.

Although Norton and Rees used 2-digit SIC codes, they were really referring to 3-digit SIC codes in many cases (i.e., computing machinery and aerospace).

Robert Premus (1982) conducted a literature review of the subject for the Joint Economic Committee of Congress and has come up with a 2-digit level definition of high technology industry. This study, undertaken for the purpose of identifying high technology industry and determining what factors influence the location decisions of high technology firms, has so far been the most authoritative of any research into the matter. According to this report, the following 2-digit SIC industry groups qualify as high technology industries:

1. (SIC 28) Chemical and allied products;
2. (SIC 35) Machinery, except electrical;
3. (SIC 36) Electrical and electronic machinery;
4. (SIC 37) Transportation equipment;
5. (SIC 38) Instruments.

Premus admits that ". . . not all jobs in each of the 2-digit SIC code industries can rightfully be classified as high technology jobs, nor can all jobs excluded from the other industries be rightfully excluded. Nevertheless, the fact that few researchers quarrel with the selection of industries as science-based suggests that this measurement is not without merit" (Premus, p. 65). In his definition of high technology industries, Premus points to some attributes which he feels these industries have in common:

1. These industries are labor-intensive because they employ a higher percentage of technicians, engineers, and scientists than do other industries;
2. These industries are science-based in that their success depends on the commercial application of advances in science;
3. Research and development activities are more important to the continued success of these industries.

Later in the study, Premus incorporates the results from a study by Eugene Doody and Helen Munzer of the Massachusetts Division of Employment Security (Doody and Munzer, 1981). Doody and Munzer included the following 3-digit SIC industries in their definition of high technology industry:

1. (SIC 283) Drugs and medicine;
2. (SIC 348) Ordnance and accessories, not elsewhere classified;
3. (SIC 357) Office computing and accounting machines;
4. (SIC 36) Electrical and electronic machinery;
5. (SIC 376) Guided missles and space vehicles;
6. (SIC 38) Instruments.

Notice that all of the 3-digit groups fall into the broader 2-digit groups described earlier by Premus.

The Research and Statistics Division of the Alabama Department of Industrial Relations (1983) has compiled a listing of industries that they feel meet the criteria for high technology industry. According to their report, high technology manufacturing industries should possess the following characteristics:

1. A high ratio of research and development to sales;
2. High value-added products;
3. A high ratio of scientists and engineers in their workforce;
4. High technology products;
5. High growth rates.

Their definition of high technology industry was not limited to manufacturing industries. It was expanded to include nine high technology service industries (Alabama Department of Industrial Relations, 1983).

The Research Department of the Federal Reserve Bank of Atlanta (Koch, 1983) has developed their own definition of high technology industry. They have identified seventeen industries at the 3-digit SIC level as high technology manufacturing industries, but they fail to provide the reasons why these particular manufacturing industries were chosen. Their definition is included here because it is one of the few that includes service industries in a list of high technology industries.

Richard Richie, Daniel Hecker, and John Burgan (1983) of the Bureau of Labor Statistics defined three groups of high technology industries. The criterion for inclusion in the first group was the degree in which high technology workers were utilized. Industries in Group I had a proportion of high technology workers at least 1.5 times the average for all industries. The amount of research and development expenditures was the criterion used to select industries for Group II. If an industry's ratio of research and development expenditures to net sales was at least twice the average for all industries, then the industry was considered to be a high technology industry. This selection method identifies industries heavily involved in developing new products. Thus, only manufacturing industries are in this group. This group is the smallest of the three groups. The selection criteria for Group III are a combination of the criteria used for selecting industries for the other two groups. An industry is included in this group if the proportion of high technology workers relative to total employment in the industry was equal to or greater than the average for all manufacturing industries and the ratio of research and development expenditures to sales was close to or above the average for all industries. The three groups were all defined at the

3-digit SIC level. The Group II classification will be compared to the other attempts to define high technology industries.

These four alternative definitions of high technology industries at the 3-digit SIC level are compared in Table 3-1. Note that only the Alabama Department of Industrial Relations definition and the Federal Reserve Bank of Atlanta definition include service industries. From this comparison, a consensus definition of high technology industries is formed. This consensus group of high technology industries is presented in Table 3-2. To make this list, a manufacturing industry would have to be included in at least three out of the four industry definitions in Table 3-1 at the 3-digit SIC level. Each of the manufacturing industries chosen (with the exception of ordnance) falls into one of the broad 2-digit SIC industry groups classified by Premus as high technology industry. The two service industries chosen were the only two service industries services that the Alabama Department of Industrial Relations report and the Federal Reserve Bank of Atlanta study had in common. This consensus definition is the definition that is employed in this study to determine the occupational composition of the high technology occupations.

The National Science Board (1983) identifies the manufacturing arm of this definition as research intensive:

> Some industries have especially high levels of R&D funding as a percent of their net sales, and can be considered particularly R&D intensive. This is true in particular for office, computing, and accounting machines, aircraft and missles, communication equipment, electronic components, drugs and medicines, and professional and scientific instruments. The aircraft and missles industry alone accounts for 23 percent of all industrial R&D (National Science Board, p. 94).

How significant are the high technology industries in the U.S. economy? Using the consensus definition of high technology occupations in Table 3-2,

Table 3-1. Alternative Definitions of High Technology Industries

Bureau of Labor Statistics (Group II)	Doody and Munzer	Alabama Dept. of Industrial Relations	Federal Reserve Bank of Atlanta
Manufacturing	**Manufacturing**	**Manufacturing**	**Manufacturing**
283 Drugs and medicine	283 Drugs and medicine	283 Drugs and medicine	281 Industrial chemicals
357 Office computing and accounting machines	348 Ordnance	348 Ordnance	282 Plastics
366 Communication equipment	357 Office computing and accounting machines	35 Machinery, except electronic	283 Drugs and medicine
367 Electronic components	36 Electrical and electronic	36 Electrical and electronic machinery	348 Ordnance
372 Aircraft and parts	376 Guided missiles and space vehicles	371 Motor vehicles and equipment	351 Engines and turbines
376 Guided missles and space vehicles	38 Instruments	372 Aircraft and Parts	357 Computers
		373 Ship building	366 Communication equip.
		374 Railroad equipment	367 Electronic comp.
		376 Guided missiles and space vehicles	372 Aircraft and parts
		379 Miscellaneous transportation equipment	376 Guided missiles and space vehicles
		38 Instruments	38 Instruments
		Services	**Services**
		481 Telephone communication	489 Communications services
		483 Radio and TV broadcasting	737 Computer and data processing services
		489 Communication services, not elsewhere classified	
		737 Computer and data processing services	
		806 Hospitals	
		807 Medical and dental lab.	
		891 Engineering, arch. & surv.	
		892 Noncommercial ed., scientific and research organization	
		899 Services, not elsewhere classified	

Table 3-2. Consensus Definition of High Technology Industries[a]

Standard Industrial Classification	Industry
	Manufacturing
283	Drugs and medicine
348	Ordnance
357	Office, computing, and accounting machines
366	Communication equipment
367	Electronic components
372	Aircraft and parts
376	Guided missles and space vehicles
38	Instruments
	Services
489	Communication services, not elsewhere classified
737	Computer and data processing services

[a]Derived by comparing the four alternative definitions of high technology industries in Table 3-1.

employment in the high technology industries accounted for about 4 percent of total U.S. wage and salary employment in 1984. The high technology manufacturing and service industries employed more than 2,900,000 workers and 627,800 workers in 1984, respectively. The 1984 figures represented a 50 percent increase in high technology manufacturing jobs and a 360 percent increase in high technology service jobs since 1972. Overall, employment in the consensus definition of high technology industries increased 68 percent between 1972 and 1984.[1] Employment in these high technology industries grew nearly 2.4 times as fast as the average overall growth in employment for all U.S. wage and salary industries during the 1972-1984 period, and, through 1995, employment in the high technology industries is expected to grow somewhat faster than in the economy as a whole.[2] Clearly, the high technology industries as a group are "growth" industries and are an important source of employment in the U.S. economy (Koch, 1983).

Identifying the High Technology Occupations

Now that the high technology industries have been defined in Table 3-2, the next step is to identify the occupational composition of high

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[1]The employment data for the industries in the consensus definition of high technology industries and for all U.S. wage and salary industries was obtained from Burgan (1985).

[2]The definition of high technology industry which the Bureau of Labor Statistics employed to make these projections is presented in Table 3-1. It excludes the ordnance industry (SIC 348), the instruments industry (SIC 38), and all service industries.

technology occupations. According to Richard Richie, Daniel Hecker, and John Burgan (1983) of the Bureau of Labor Statistics:

> . . . clear definitions of what occupations are included have been lacking . . . . Most workers in these technology-oriented occupations are directly involved in developing or applying new technologies. Their work requires in-depth knowledge of theories and principles of science, engineering, and mathematics underlying technology--a knowledge which distinguishes them from computer operators, computer service technicians, and other high tech machinery repairs, or workers in a wide range of occupations who use word processing machines, computers, or other high technology products, but rarely have--or need--such in-depth knowledge. Workers in these technology-oriented occupations generally need specialized post-high school education in some field of technology--ranging from an associate degree or its equivalent to a doctorate--education with a thorough high school preparation in science and mathematics as a prerequisite (pp. 54-55).

Any approach to identifying high technology occupations must, by necessity, be in some degree arbitrary. The approach employed here is to identify those occupations utilized relatively more intensively by high technology industries. The National Industry-Occupation Employment Matrix developed by the Department of Labor (1981) lists the occupational distribution for 260 industries. It also gives the percentage share a particular occupation has in the total workforce of a given industry. By comparing the relative share of individual occupations in high technology industries with the relative share of those same occupations in other industries, the occupations which are more important to high technology industries will stand out.

Table 3-3 shows the percentage breakdown by occupation for all manufacturing industries and for all service industries. These will be the benchmarks used to gauge whether or not an occupation has a higher relative share in the total workforce of a high technology industry relative to the industry averages. In Table 3-4, the distribution of employment by

Table 3-3. Percent Distribution of Industry Employment by Occupation, 1978

Occupation	Manufacturing Industries	Service Industries
Professional and Technical	9.9	35.3
Engineers	2.8	0.7
Scientists	0.5	0.4
Engineering and science technicians	2.2	0.9
Computer specialists	0.7	0.5
Social scientists	0.2	0.5
Medical workers	0.1	8.1
Teachers	0.1	13.5
Accountants	1.0	1.4
Other	2.3	9.3
Managers	7.0	7.4
Sales	2.4	0.7
Clerical	12.1	18.6
Crafts	19.6	5.2
Operatives	42.3	3.5
Service	1.9	27.5
Laborers	4.8	1.9
Farm	0.0	0.0
Total[a]	100.0	100.0

Source: U.S. Department of Labor, Bureau of Labor Statistics, The National Industry-Occupation Employment Matrix, Vol. 1, 1981.

[a]Detail lines may not add to totals due to rounding.

Table 3-4. Distribution of High Technology Manufacturing Industry Employment by Occupation, 1978

Occupation	Manufacturing Industries (Thousands of Workers)					
	Drugs and Medicine (SIC 283)	Ordnance (SIC 348)	Electronic Computing Equipment (SIC 3573)	Communication Equipment (Radio, TV) (SIC 366)	Aircraft and Parts (SIC 372)	Scientific Instruments (SIC 381)
Professional and Technical	46.2	45.8	105.8	140.6	158.9	38.0
Engineers	3.3	20.7	24.7	58.1	81.5	14.3
Scientists	13.9	1.9	1.3	1.8	3.5	1.2
Engineering and science technicians	11.9	8.1	19.0	37.1	25.8	11.0
Computer specialists	2.0	4.1	36.7	9.0	10.0	2.2
Social scientists	1.3	0.2	3.5	2.4	2.4	0.8
Medical workers	2.4	0.2	0.3	0.6	0.6	0.2
Teachers	0.0	0.2	1.3	1.2	0.6	0.0
Accountants	2.8	2.6	4.8	8.4	10.0	2.6
Other	8.5	8.1	14.2	22.1	24.7	8.4
Managers	18.5	10.9	26.8	35.9	40.5	16.9
Sales	18.9	0.4	5.9	3.6	2.9	3.1
Clerical	35.4	26.7	47.7	95.8	86.2	33.0
Crafts	16.7	28.8	26.8	88.0	143.1	29.5
Operatives	40.6	48.8	50.7	216.1	141.4	70.7
Service	4.3	4.7	3.0	9.0	9.4	2.6
Laborers	5.0	6.6	1.6	10.2	4.7	2.8
Farm	0.0	0.0	0.0	0.0	0.0	0.0
Total[a]	185.4	172.3	268.0	598.5	586.6	196.3

Source: The National Industry-Occupation Employment Matrix, Vol. 2, 1981.

[a]Detail lines may not add to totals due to rounding.

occupation for the manufacturing industries in the consensus definition is shown. Table 3-5 provides the distribution of employment by occupation for the service industries in the consensus definition. Occupational distributions were not available for either the electronic components industry (SIC 366) or the guided missles and space vehicles industry (SIC 376). Since data were available at the 4-digit level for the electronic computing equipment industry (SIC 3573), these data were substituted for the broader industry group of office computing and accounting machines (SIC 357). The occupational distribution of the engineering and scientific instruments industry (SIC 381) was used to represent the various occupational distributions in the instruments industry group (SIC 38). In the absence of data for computer and data processing services (SIC 737), the occupational distribution for computer programming services (SIC 7392) was employed in Table 3-5.

In order to compare the occupational representation in the high technology manufacturing and in the high technology service industries with the manufacturing and service industry averages, the average percentage share of each occupation in total high technology manufacturing employment and in total high technology service employment is calculated.[3] Then this average is divided by either the all manufacturing industry occupational average or the all service industry occupational average. This ratio can be used to identify those occupations that are used more intensively in

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[3]The average percentage share of each occupation in total high technology manufacturing employment or total high technology service employment is calculated by weighting the percentage of employment accounted for by the occupation in a particular industry by the proportion of this industry's employment to either the total high technology manufacturing employment or the total high technology service employment.

Table 3-5. Distribution of High Technology Service Industry Employment by Occupation, 1978

Occupation	Service Industries (Thousands of Workers)	
	Miscellaneous Communication Services (SIC 489)	Computer Programming (SIC 7392)
Professional and Technical	10.0	75.6
Engineers	2.1	4.8
Scientists	0.1	0.6
Engineering and science technicians	3.2	2.9
Computer specialists	0.8	56.5
Social scientists	0.3	1.9
Medical workers	0.0	0.0
Teachers	0.0	1.0
Accountants	0.8	2.3
Other	2.9	5.8
Managers	10.7	24.0
Sales	0.4	4.4
Clerical	26.1	65.1
Crafts	14.7	17.9
Operatives	0.5	3.7
Service	0.8	1.2
Laborers	0.2	0.4
Farm	0.0	0.0
Total[a]	63.4	192.1

Source: The National Industry-Occupation Employment Matrix, Vol. 2, 1981.

[a]Detail lines may not add to total due to rounding.

the high technology industries. These averages and ratios for the manufacturing and service industries are provided in Tables 3-6 and 3-7, respectively. Note that the relative share of workers in professional and technical occupations in the workforce of the high technology manufacturing industries is 2.7 times their share in the workforce of all manufacturing industries.[4] The relative shares of sales workers, craftsmen, operatives, service workers, and laborers in the total workforce of the high technology manufacturing industries are lower than in the total workforce of all manufacturing industries. In particular, laborers represent only 1.5 percent of all workers in the high technology manufacturing industries as compared to a 4.8 percent share of workers in all manufacturing industries. Thus, the relative share of laborers in the workforce of all manufacturing industries is 3.3 times the relative share of laborers in the high technology manufacturing industries.[5]

In the high technology service industries, the relative shares of managers, sales workers, clerical workers, and craftsmen in the total workforce exceeds the relative shares of these workers in total workforce of all service industries combined. The shares of operatives, service workers, laborers, and professional workers in the workforce of the high technology service industries are less than their shares in the total workforce of all service industries. Within the professional and technical occupations, the relative mix of occupations differs markedly between the high technology service industries and all service industries.

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[4]This ratio is derived by dividing the high technology manufacturing industry average (26.8 percent) from Table 3-6 by the all manufacturing industries' average (9.9 percent) in Table 3-3.

[5]This ratio is the reciprocal of the ratio for laborers in the third column of Table 3-6.

Table 3-6. Comparison of High Technology Manufacturing Industry Occupational Shares to All Manufacturing Industry Occupational Shares

Occupation	High Technology Manufacturing Industry Average (%)[a]	Ratio of Relative Occupational Shares[b]
Professional and Technical	26.8	2.7
Engineers	10.1	3.6
Scientists	1.2	2.4
Engineering and science technicians	5.6	2.5
Computer specialists	3.2	4.6
Social scientists	0.5	2.5
Medical workers	0.2	2.0
Teachers	0.2	2.0
Accountants	1.5	1.5
Other	4.3	1.9
Managers	7.4	1.1
Sales	1.7	0.7
Clerical	16.1	1.3
Crafts	16.5	0.8
Operatives	28.2	0.7
Service	1.6	0.8
Laborers	1.5	0.3

[a]Derived by weighting the percentage of employment accounted for by an occupation in one of the high technology manufacturing industries by the proportion of this manufacturing industry's total employment to total high technology manufacturing employment. This is done for all of the high technology manufacturing industries in order to devise the manufacturing industry average. Industry employment and occupational employment by industry was presented in Table 3-4.

[b]This ratio is calculated by dividing the industry average in column 2 of this table by the occupational distribution of manufacturing industry employment from Table 3-3.

Table 3-7. Comparison of High Technology Service Industry Occupational Shares to All Service Industry Occupational Shares

Occupation	High Technology Service Industry Average (%)[a]	Ratio of Relative Occupational Shares[b]
Professional and Technical	33.3	0.9
Engineers	2.7	3.9
Scientists	0.3	0.8
Engineering and science technicians	2.4	2.7
Computer specialists	22.4	44.8
Social scientists	0.8	1.6
Medical workers	0.0	0.0
Teachers	0.4	0.0
Accountants	1.2	0.9
Others	3.4	0.4
Managers	13.6	1.8
Sales	1.9	2.7
Clerical	35.7	4.2
Crafts	12.7	2.4
Operatives	1.8	0.5
Service	0.8	0.0
Laborers	0.2	0.1

[a]Derived by weighting the percentage of employment accounted for by an occupation in one of the high technology service industries by the proportion of this service industry's total employment to total high technology service industry employment. This is done for both high technology service industries in order to derive the service industry average. Industry employment and occupational employment by industry was presented in Table 3-5.

[b]This ratio is calculated by dividing the industry averge in column 2 of this table by the occupational distribution of service industry employment from Table 3-3.

Clearly, both the high technology manufacturing industries and the high technology service industries in the consensus definition have occupational compositions that are distinct from the occupational compositions of manufacturing and service industries in general. For the purposes of this study an occupation in a manufacturing or service industry is considered to be a high technology occupation if its relative share in the workforce of a high technology industry is at least 2.4 times the relative share of that occupation in the total workforce of all manufacturing industries or in the total workforce of all service industries. The cut off of 2.4 was chosen because it is the average of the ratios in Tables 3-6 and 3-7 for all occupations in the high technology industries.

In the manufacturing industries, those occupations with ratios equal to or exceeding 2.4 are the following: engineers, scientists, engineering and science technicians, computer specialists, and social scientists.

In the service industries, those occupations with ratios equal to or exceeding 2.4 are the following: engineers, engineering and science technicians, computer specialists, sales workers, clerical workers, and crafts. Clerical workers are eliminated because they fail to meet the criteria set forth by the Bureau of Labor Statistics (Richie, Hecker, and Burgan, 1983) concerning the definition of a high technology occupation.[6] Craft workers can be excluded since only one of the high technology service

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[6]Richie, Hecker, and Burgan (1983) state that, ". . . workers . . . in technology-oriented occupations are directly involved in developing or applying new technologies. Their work requires in-depth knowledge of theories and principles of science, engineering, and mathematics underlying technology--a knowledge which distinguishes them from . . . workers in a wide range of occupations . . . [who] rarely have--or need--such in-depth knowledge (pp. 54-55)."

industries has a ratio of industry employment to all service industry employment that exceeds 2.4--the miscellaneous communication services industry.

A definition of the high technology occupations is obtained by combining these two lists. This combined list of high technology occupations is presented below in Table 3-8.

Table 3-8. High Technology Occupations[a]

Occupation	Ratio of Relative Occupational Shares (Manufacturing Industries)	Ratio of Relative Occupational Shares (Service Industries)
Engineers	3.6	3.9
Scientists	2.4	0.8
Engineering and Science Technicians	2.5	2.7
Computer Specialists	4.6	44.8

[a]These are occupations whose relative occupational shares in the high technology industrial workforce are at least 2.4 times greater than their shares in either all manufacturing industry employment (Table 3-6) or in all service industry employment (Table 3-7).

Notice the exclusion of social scientists from this list. Economists make up the bulk of social scientists employed by high technology industries. Because this category represents a very small share of these industries' total employment (less than .5 of a percent in the high technology manufacturing industries and less than .8 of a percent in the high technology service industries), this occupation is also excluded.

The professions listed in Table 3-8 represent very broad occupational groups (hereafter "broad occupational definition"). In order to identify

as precisely as possible those occupations that are used relatively more intensively by high technology industries, these broad occupational groups are disaggregated to the maximum extent that the data in the National Industry-Occupation Employment Matrix will allow. Those specific occupations which have a ratio exceeding 2.4 in either the high technology manufacturing industries or in the high technology service industries are presented in Table 3-9.

This list is a very specific definition of the high technology occupations. The advantage of the specific definition relative to the broader definition of the high technology occupations is that it identifies as precisely as possible the true high technology occupations. For example, the engineering profession includes such diverse fields as civil engineering and petroleum engineering. The scientific profession includes the fields of agricultural scientists and marine scientists. The engineering and science technician occupational group includes surveyors and agricultural technicians. It is doubtful that all engineering professions, scientific disciplines, or technicians are important to high technology industries.

One danger, though, of relying on the very specific definition of high technology occupations in Table 3-9 is the possibility that field switching by workers among various fields is ignored.[7] For example, it is known that field switching is quite high among the various engineering fields (Department of Labor, 1982; Baker, 1983). Thus, an engineer who is trained in industrial engineering, which is classified in Table 3-9

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[7]Field switching refers to being employed in a field other than one's degree field.

Table 3-9. Specific High Technology Occupations[a]

Occupation	Ratio of Relative Occupational Shares (Manufacturing Industries)	Ratio of Relative Occupational Shares (Service Industries)
Engineers		
Aeronautical	10.0	2.0
Electrical and Electronic	5.0	7.0
Industrial	2.5	4.1
Other, not elsewhere classified	10.3	4.3
Scientists	3.6	0.5
Engineering technicians		
Electrical and Electronic	5.0	18.4
Industrial	2.5	N/A
Science technicians		
Biological	3.4	-
Mathematical technicians and other technologists and technicians, not elsewhere classified	N/A	N/A
Computer specialists		
Systems analysts	3.2	44.9
Computer programmers	4.4	40.7

[a]These are occupations within the broader occupational groups in Table 3-8 whose relative occupational shares in the high technology industrial workforce are at least 2.4 times greater than their shares in either all manufacturing industry employment or in all service industry employment. The data for the calculation of these ratios are from the National Industry-Occupation Employment Matrix published by the U.S. Department of Labor (1981).

as a high technology occupation, could be working as a mechanical engineer, which is not a high technology occupation. The industrial engineer working as a mechanical engineer would not be considered a high technology worker.[8] In this study, both occupational definitions are employed to examine the migration decisions of workers in high technology occupations.[9]

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[8]This would, in effect, underestimate the number of high technology workers available.

[9]Another possible danger is that the other broad occupational groups already screened out in Table 3-8 could contain specific occupations which have ratios equal to or exceeding 2.4. However, such a finding would conflict with the broad occupational groups identified by Richie, Hecker, and Burgan (1983) as high technology occupations. These technology-oriented occupations are engineers, scientists, mathematical specialists, engineering and science technicians, and computer specialists.

CHAPTER 4

AN ECONOMIC MODEL OF MIGRATION

Migration as an Economic Process

By treating migration as an economic process, an economic model of migration can be formulated. In this model, the geographical mobility of workers is primarily a response to economic incentives resulting from disequilibria across spacially separated labor markets (Bowles, 1970).[1] According to Sjaastad (1962), "This treatment places migration in a resource allocation framework because it treats migration as a means in promoting efficient resource allocation and because migration is an activity which requires resources" (p. 80). As such, the decision to migrate involves comparing the present value of the benefits and costs of moving. Bowles (1970) outlines the general nature of these benefits and costs:

> The benefits of moving may include higher income in the destination, or a more pleasant social or physical environment. The costs include the direct expenses involved in moving, plus the psychic costs involved in breaking old ties. Assuming that risk aversion in a general phenomenon, further costs arise from the fact that one's future situation may be less certain for those who move than for those who do not (p. 356).

Yet, migration cannot be reviewed in isolation. Complementary investments in the "human agent," such as education, training, and work experience are as important in explaining migration (or the lack of) than the migration process itself. Thus, migration is treated as one possible investment,

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[1]Sjaastad (1962) notes that, "The main concern of economists has been with the response of individuals to economic opportunity at a distance" (p. 80).

from among an array of possible investments, in human capital. As Sjaastad (1962) notes:

> These investments, specific to the individual, are subject to depreciation and deterioration both in a physical and an economic sense. If market forces reduce the relative wages of a particular occupation, practitioners of that occupation suffer a capital loss and are faced with the alternatives of accepting the lower earnings or making additional investments in themselves to increase their earnings in a more favorable market. If the relative wages in an occupation are adversely affected locally, migration alone is sufficient; if the adverse effect is national, such as the earnings in agriculture, the entire occupational structure is under stress and migration is feasible only if new skills are acquired by the migrant (p. 87-88).

Empirical Evidence on the Determinants of Migration

Considerable information exists on the determinants of migration and on the characteristics of migrants. The migration decision has been analyzed in terms of personal attributes and in terms of the socio-economic characteristics of the sending and receiving regions. However, most migration studies focus on the movement of workers in the total labor force, of blue collar workers, of minorities, of the unemployed, or upon migration flows into or out of certain areas and regions.[2]

Long (1973) investigated migration differentials by education and occupation with data from the Current Population Surveys. Long's major concern was the joint influence of age, education, and occupation on the decision to move. He found that salaried professional workers and salaried managers and administrators had the highest migration rates across all age groups. Within each of the ten occupational groups he examined, increasing education was strongly associated with higher

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[2]See, for example, the survey of migration studies by Greenwood (1975).

migration rates, particularly for the age group 25-35 years old and when college attendance was involved. Controlling for age, Long's results indicate that education is linearly related to the probability of migrating. For the age group 25-29 years old, Long found that men who went to graduate school are three times as likely to move between states during a year's time as men who did not finish high school. Long claims that education in the United States is a more efficient indicator of migration than the major occupational groups commonly identified in censuses and that, for very broadly defined occupations, the characteristics of individuals may at times be more important in determining who migrates than the nature of the work itself.

Schwartz (1976) discusses the human capital aspects involved in the migration process:

> Formal education provides general skills which are transferable; it also provides some skills which are specific to a given occupation. Furthermore, increased formal education increases the potential of learning over time through experience on the job . . . . These arguements are standard human capital theoretical explanations for the observed phenomena that the earnings function increases with age, that is steeper with higher education, and that the earnings function of more-educated persons dominates the function of less-educated persons soon after they complete their formal education (pp. 703-704).[3]

Schwartz examines migration flows between Census Divisions as reported in the 1960 Census. He regresses the rate of migration on age dummies and a returns-to-migration variable for each of seven education categories. His findings provide empirical support for the human capital model of migration:

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[3]Becker (1962, 1964) provides a comprehensive treatment of human capital theory.

1. For any education level, the rate of migration declines with age;
2. The rate of migration for any age increases with education;
3. The rate of migration varies considerably by educational level for the young; this variation is not observable for the older migrants. Thus, while the rate of migration increases with education, it declines more rapidly with age as education increases;
4. The coefficient for his returns-to-migration variable increases with education. On the surface, this would imply that the higher the education, the more responsive people are to available opportunities. Schwartz offers another interpretation more consistent with human capital theory--the area searched for jobs increases with education, which in turn generates more geographic moves.

Schwartz concludes that, "The shape of the earnings-age function and the way education effects it can explain all the empirically observed relations of migration measures . . . to distance moved, age, and education" (p. 718).[4] Given this conclusion, other assumptions--such as attributing lower risk aversion and higher efficiency of job search to more educated persons, or higher psychic cost of moving to older persons--are no longer necessary to explain the links between migration and distance moved, age, and education.

Herzog and Schlottmann (1984) examined the impact of unemployment on an individual's decision to either leave or stay in the current location.

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[4]As noted previously, the earnings function increases with age. This function becomes steeper as education increases.

The dependent variable for an individual "at risk" to migration was set equal to one if an individual moved to a different state between 1965 and 1970; otherwise, the dependent variable was set equal to zero. They note that personal characteristics of individuals "at-risk" to migration and that economic conditions in the sending state are significant determinants of migration. According to Herzog and Schlottmann, the relevant personal characteristics for an empirical analysis of the migration decision should include age, education, unemployment status, marital status, and prior mobility status. Their results confirm the age selectivity of migration. In fact, the age-migration relationship does not appear to differ significantly among occupations. However, their results indicate that the education selectivity of migration, observed above by Long, does vary by occupation. They suggest that the relationship between age and education appears to depend, at least in part, on occupation. They found that education tends to increase the migration propensity of blue collar workers; however, after controlling for occupation, they found that education does not significantly increase the likelihood of migration of white collar workers. White collar workers tend to be the most educated members of the labor force.

Herzog and Schlottmann also found that prior migration experience significantly increases the likelihood of migration, regardless of occupation; but only among blue collar workers did marital status significantly influence the migration decision.

Economic conditions included in their analysis are the unemployment rate and the average earnings in the state of origin relative to the unemployment rate and average earnings for the U.S. as a whole. Their results show that high rates of unemployment significantly increase the

propensity to migrate, regardless of occupation. For white collar workers, migration is reduced in states with high average earnings while average earnings had no significant impact on the migration decisions of blue collar workers.

All of the studies above agree that the migration decision of individuals "at risk" to migrate is related to their age and education. Migration is more selective of the young and more educated. Thus, they offer support to the human capital explanation of migration. According to Schwartz, the empirically observed relations of migration to age and education can be explained by the shape of the earnings-age function and the way education effects it. However, Long and Herzog and Schlottmann disagree over the role played by the nature of work in the migration decision. Long claims that the characteristics of individuals, particularly education, are more important than occupation in determining who migrates. Herzog and Schlottmann offer evidence to the contrary; while they agree that characteristics of individuals are significant determinants of migration, they found that the education selectivity of migration does vary by occupation. Other individual characteristics considered influential by Herzog and Schlottmann include unemployment status, marital status, and prior mobility experience. Their findings also indicate that economic conditions at the place of origin can significantly affect the likelihood of migration for all occupations.

Empirical Evidence on the Migration Decisions of Workers in High Technology Occupations

Although some information is available concerning the migration decisions of workers in specific occupations, information on the migration

decisions of workers in high technology occupations is scarce. However, there are studies that examine migration decisions of workers in broader occupational groupings that shed some light on the issue.

Ladinsky (1967) examined the migration decisions of workers in professional and technical occupations with data from the 1960 Census. Ladinsky found that professional workers are almost twice as migratory as any other occupational group. In fact, his results indicate that professional and technical workers had the highest lifetime mobility rates of all occupations. Seventy-four percent had moved from their places of birth and 33 percent had moved between 1955 and 1960. This compares to 64 percent and 16 percent between 1955 and 1960, respectively, for all workers. Thus, Ladinsky's results indicate that professional and technical workers are the most mobile segment of the labor force. He also found that only among professional and technical workers was migration between 1955 and 1960 as high or higher than local movement.[5] Their long distance migration rate was double that of any other occupation that Ladinsky examined.[6] Ladinsky regressed 16 independent variables to explain the variation in mobility among professional and technical workers. Age accounted for 12 percent of the variance, while total family income, highest grade of school, and residence in the West in 1960 accounted for most of the rest of the explained variance. His findings show that increased age and increased family size reduce the propensity

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[5]Ladinsky classified individuals who moved as either local movers (those living in a different house but in the same county) or migrants (those living in a different county).

[6]Long distance migrants are migrants from noncontiguous states.

to migrate, while low income and high education stimulate it. Ladinsky also conducted a factor analysis and discovered the following structural determinants of mobility:

1. migrants are females, single or married males with small incomes;
2. migrants are salaried males in extractive, manufacturing, transportation, and trade industries;
3. migrants are highly educated and in recognized old and new professions;
4. migrants are young and have low incomes;
5. migrants are attracted to large urban places;
6. migrants are attracted to the South and West.

Ladinsky concludes that age, sex, marital status, income, and occupation are the major determinants of the migration of professional and technical workers, and that social and economic opportunities for these workers are unevenly distributed across regions and metropolitan areas. He noted that salaried professionals tend to move in regional or national labor markets, whereas salaried workers in the "semi, would-be, and marginal professions" tend to move in local labor markets.[7] He discovered a tendency for mobility rates to be relatively high for established and new professions, and low for technical workers. However, local area mobility was greatest

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[7]According to Reiss (1955), the semi-professionals use technical skills rather than theoretical knowledge directly (nursing, pharmacy, and optometry); the would-be professionals deal in human services and aspire to the status of the established professions (sales engineers and funeral directors); the marginal professionals grew out of the applied aspects of science and mathematics (surveyors, medical, and electronic technicians).

among the technical and marginal professional occupations and lowest for established and new salaried professionals. Ladinsky attributed these distinctions to the degree of specialization. According to Ladinsky, "Labor markets are balkanized by specialties; as labor requirements become more specialized the geographic area of recruitment expands to compensate for . . . the smaller number of workers available locally, and the difficulty and expense of training specialists internally. Thus, salaried personnel in highly skilled professions move in geographically larger labor markets than those in the less skilled professions" (p. 491).

The findings of Herzog and Schlottmann (1984) support those of Ladinsky--the likelihood of migration is related to an individual's occupation. The white collar workers in their sample, particularly those in professional and technical occupations, exhibited higher average probabilities of migration than workers in other occupations. For professional and technical workers, the average probability of migration was 10.8 percent; for white collar workers in other occupations it was 9.2 percent; for blue collar workers it was 6.7 percent.

Schoening and Goss (1984) examined the hypothesis that professionals in high technology occupations are more mobile than technicians in high technology occupations.[8] They hypothesized that experienced technical workers in high technology occupations were less geographically mobile than professionals in high technology occupations for 3 reasons:

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[8]Premus (1982) presents this hypothesis as an explanation for the ranking of technical labor over professional labor by the firms in his survey (see Table 2-2, p. 18).

1. Many technical workers receive considerable on-the-job training which increases their job specific skills that tend to retard their propensity to migrate;

2. High technology professional workers tend to be employed in occupations that are national in scope. They tend to keep in touch with colleagues with whom they have worked, and they attend professional meetings in other localities and establish job contacts at these meetings. This national network of contacts tends to promote the migration of high technology professionals;

3. Technicians in high technology occupations do not have these national networks. These workers find jobs through less formal local networks, such as relying on friends and relatives. Migration from the area would isolate migrants from these informal networks. Thus, the lack of national labor markets for these technicians tends to reduce their propensity to migrate.

Schoening and Goss's results support their hypotheses. They found that non-professional, technically trained workers appear to possess a probability of moving not unlike non-high technology workers, while professional high technology workers have a higher propensity to migrate than other workers.

The implications to high technology firms are twofold. One, if technicians are less likely to migrate than professionals, then the priority given to locating in an area with an adequate supply of technicians is paramount and exceeds the need to locate close to supplies of

professionals. Two, if professionals are to be imported into an area, then high technology firms must locate in an area in which professionals would be willing to live. The more attractive the region, the lower the bribe necessary to get professionals to relocate. Professionals apparently prefer areas which have a high "quality of life," and only metropolitan areas at or above a certain minimum size would be eligible (Schmenner, 1982).

Comay (1973) examined the special case of scientists and engineers migrating from Canada to the United States using data from a 1968 survey of Canadian scientists and engineers. He found that doctorate-holders as a group were significantly more migration prone--possession of a Ph.D. increased the propensity to migrate by 6.8 percent. Migration probabilities were lowered by age, ethnicity, and additional dependents. Comay also found that the migration decision was not significantly affected by either marital status or distance.[9] Employment opportunities in the United States and salary differentials between the two countries were statistically significant in explaining the migration decision but played a relatively small role. Migration probabilities were increased by previous mobility and past graduate work in the United States.

The studies above provide evidence that white collar workers, particularly professionals, have a higher propensity to migrate than other occupational groups. All support the hypothesis that the likelihood of migration is related to an individual's occupation. Schoening and Goss found that non-professional, technically trained workers appear to possess

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[9]In Comay's model, distance can be viewed as increasing travel costs or as increasing information costs.

a probability of moving not unlike non-high technology workers and that professional high technology workers have a higher propensity to migrate than other workers. These results support the Premus hypothesis that professionals in high technology occupations are more mobile than technicians in high technology occupations. In all four studies age, education, and occupation influence the migration decision. Herzog and Schlottmann, Schoening and Goss, and Comay suggest that prior mobility also plays a major role. All four studies control for sex and race. However, only Herzog and Schlottmann consider the impact of economic conditions at the place of residence.

Factors that Influence High Technology Worker Migration

The empirical results represented in the preceding section fail to shed any light on the role played by metropolitan area characteristics on the migration decisions of high technology workers. Although such a link has been speculated upon in the literature on the location determinants of high technology industry, no empirical evidence has been offered to show that workers in high technology occupations prefer areas which have a high "quality of life" and which offer cultural, recreational, and educational advantages. In order to determine if there is a link between metropolitan area characteristics and the migration decisions of high technology workers, the remainder of this study is devoted to the examination of the migration decisions of high technology workers.

The factors expected to have the most impact on the migration decisions of workers in high technology occupations can be separated into two groups: personal attributes and metropolitan area characteristics. Based upon the empirical evidence presented earlier, the following

personal attributes can be expected to exert an influence on the migration decisions of high technology workers: age, education, marital status, prior geographic mobility, sex, and ethnicity. The human capital model of migration predicts that the migration process is selective of the young and the more educated. Thus, for any educational level, the rate of migration should decline with age, while the rate of migration for any age should increase with education, holding other factors constant (Schwartz, 1976). Many studies have found prior mobility status to be one of the most important factors influencing the migration decision. For example, Shoening and Goss (1984) and DaVanzo (1976) found that previous migration experience increases the likelihood of migration. According to Ladinsky (1967), males move somewhat more than females, whites are more mobile than non-whites, and family ties tend to decrease geographic mobility.

Seven metropolitan area characteristics are included to represent, as closely as possible, those high technology industry location factors that also affect the migration decisions of workers in high technology occupations.[10] These location factors were discussed previously in Chapter 2. They include state and local tax structure, cost of living, availability of educational opportunities, recreational facilities, cultural amenities, climate, and transportation facilities. In addition, metropolitan area employment growth is included as an indicator of local economic conditions, and metropolitan area population is included to represent the effects of metropolitan area size on worker migration decisions.

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[10]These seven metropolitan area characteristics are those judged by Premus (1982) and Schmenner (1982) to be indicators of the quality of life in a metropolitan area.

Premus (1982) points out in his survey that the concern of high technology firms about state and local tax structures stems from their belief that high taxes hinder ". . . their ability to attract the type of skilled labor that they require" (Premus, p. 26), not because high taxes raise the total cost of production. Premus also noted that there were no significant regional differences in the response of the high technology firms he surveyed concerning taxes.

Schmenner (1982) identifies cost of living as an important concern of the high technology firms in his survey, and 58.5 percent of the firms in Premus's survey rated the cost of living as an important factor in their regional location decisions (Premus, p. 24). One particular component of the cost of living, housing costs, is seen by some analysts as representing more than just the cost of shelter. A priori, relatively high housing costs in an area should encourage out-migration and discourage in-migration. However, Roback (1982) hypothesizes that rent and occupational wage differentials among regions are explained almost entirely by regional differences in amenities and disamenities. According to Roback, "The theory suggests that the [land price] reveals the marginal social value of the amenity to the community" (p. 1272). Also Roback states, "Because tastes for amenities differ among people . . . we expect those with stronger preferences for amenities to sort themselves into more amenable places and be willing to accept a lower wage" (p. 1267). Rosen (1974) points out that the implicit price of an attribute represents its marginal value to consumers and its marginal cost to firms. In studies of intra-city variation in housing costs, Ridker and Henning (1967) and Polinsky and Rubenfeld (1977) found that higher housing prices are associated with amenities such as clean air and downtown accessibility. It is hypothesized here that

this theory can be extended to inter-city variations in housing costs. That is, inter-city variations in amenities should be implicitly reflected in inter-city variations in housing costs. The amenities included in this analysis are recreational facilities, cultural amenities, educational opportunities, climate, and transportation facilities. These amenities are the ones that Premus (1982) and Schmenner (1982) indicated were important in the location decisions of high technology firms. It is possible that housing prices may reflect the influence of amenities and disamenities omitted from this analysis. Thus, the expected relationship between housing costs and the migration decision is ambiguous.

The discussion in Chapter 2 has already examined the importance of the proximity of good schools and institutions of higher education to the high technology firms surveyed by Premus. Both Howell (1984) and Browne (1983) point to the role played by colleges and universities in the regional development of high technology industry. Thus, it is expected that the nearby location of quality academic institutions of all levels would attract workers in high technology occupations, especially in light of the role that higher education plays in the lives of these professional and technical workers (Richie, Hecker, and Burgan, 1983).

The quality of the transportation system for people was rated significant or very significant by 76.1 percent of the firms in Premus's survey of factors that influence the location of decisions of high technology firms within regions.[11] Schmenner also listed the quality of the transportation system as one of the "quality of life" factors which influence the

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[11]See Table 2-2, p. 18.

location decisions of high technology firms.[12] Other things equal, the better a metropolitan area's ability to accommodate the transportation needs of its residents, the more attractive the area should be to high technology workers.

In Schmenner's survey of high technology firms, recreational amenities and the supply of cultural facilities played an important role in the subjective assessment of an area made by the firms' managements. It is hypothesized here that the quantity of recreational and cultural amenities contributes to the "pull" of competing areas on potential migrants. The greater the supply of cultural facilities and recreational amenities in an area, ceteris paribus, the more attractive the area should be to a worker at risk to migration. Thus, the out-migration decision should be negatively related and the in-migration decision should be positively related to the supply of cultural facilities and recreational amenities in an area.

Analysts have noted in many studies that climatic conditions of an area are significantly related to the migration decision (Cebula and Vedder, 1973; Graves, 1976). However, the exact specification of this relationship between climate and migration has long been disputed. Renas and Kumar (1983) suggest that ". . . individuals do indeed consider climatic conditions in different areas when deciding where to live; people generally prefer areas which have moderate climates to areas which have either extremely hot or extremely cold climates" (p. 76).

Schmenner (1982) notes that only metropolitan areas above a certain minimum size offer the amenities believed to attract high technology

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[12]Schmenner (1982, p. 134).

workers. Metropolitan area population is included to control for the effect of size. It is expected that larger populations are more attractive to workers in high technology occupations. The square of metropolitan area population is also included to examine marginal changes in attractiveness as population varies among metropolitan areas. A priori, it is expected that the attractiveness of metropolitan areas increases as size increases, but at a decreasing rate.

Metropolitan area employment growth is included in the list of area characteristics predicted to have an impact on the migration decisions of high technology workers because it has been shown by past studies to be an important economic determinant of migration (Alperovich, Bergsman, and Ehemann, 1977; Miller, 1973). In fact, Miller contends that the primary economic determinant of out-migration is the rate of growth of employment. He interprets the negative relationship he found between the level of wages and out-migration as being primarily due to the tendency of the higher wage states to be the states where employment is growing relatively faster than in other states.

It is expected that the metropolitan area characteristics which influence out-migration should be the ones that influence in-migration, differing only in the direction of the relationship (Alperovich, Bergsman, and Ehemann, 1977). That is, the direction of the relationship should depend upon whether the in-migration decision or the out-migration decision is being examined. The expected relationships between these metropolitan area characteristics and the migration decision are summarized in Table 4-1. The expected relationships between the personal attributes of potential migrants and the migration decision are expected to be the same, regardless of whether in- or out-migration is being examined.

Table 4-1. Expected Relationships Between Metropolitan Characteristics and the Propensity to Migrate

Metropolitan Characteristics	Expected Impact on Out-Migration	Expected Impact on In-Migration
State and Local Taxes	+	-
Housing Costs	?	?
Area Educational Opportunities	-	+
Quality of Transportation System	-	+
Recreational Amenities	-	+
Supply of Cultural Facilities	-	+
Climatic Variability	+	-
Employment Growth	-	+
Population	-	+
Population Squared	+	-

The above discussion and the discussion in the previous chapters suggest three avenues of investigation:

1. Do workers in high technology occupations move for the same reasons as workers in other occupations? (Can the human capital model of migration explain the migration decisions of high technology workers?)
2. Do metropolitan area characteristics play a role in the migration decisions of high technology workers? That is, do such workers prefer areas which offer a high quality of life and which possess cultural, recreational, and educational advantages?

3. Are professional workers in high technology occupations more geographically mobile than technicians in high technology occupations?

In the following section, a multivariate model is constructed to address the issues discussed above.

The Model

The following model is employed to analyze the migration decisions of workers in high technology occupations:

Y = f(AGE, GRADE, MARSTAT, PRIOR, SEX, RACE, TAX, HOUSING, EDUC, TRANSPORT, CULTURE, RECREAT, CLIMATE, EMPGWTH, POP, POPSQR)

where Y = a binary variable equal to one if the worker migrated between 1975 and 1980; zero otherwise;

AGE = the age of the worker in 1980;

GRADE = the highest year of school attended by the worker;

MARSTAT = a dummy variable equal to one if the worker was married in 1980; zero otherwise;

PRIOR = a dummy variable equal to one if the worker lived in a state in 1975 different than his state of birth; zero otherwise;

SEX = a dummy variable equal to one if female; zero otherwise;

RACE = a dummy variable equal to one if the worker is non-white; zero otherwise;

TAX = the percentage of average household income in a Metropolitan Statistical Area (MSA) paid in state income and state sales tax;

HOUSING = estimated cost of owning a single-family home in a MSA;

EDUC = an index representing the estimated educational effort and opportunities provided by a MSA;

TRANSPORT= an index that measures a MSA's ability to accomodate the transportation needs of its residents;

CULTURE = an index of the supply of cultural facilities in a MSA;

RECREAT = an index measuring the number of man-made recreational facilities in a MSA;

CLIMATE = an index that measures the severity of the climate in a MSA. The lower the index the more extreme and variable the climate in a MSA;

EMPGWTH = the percentage growth in jobs in a MSA from 1975-1979;

POP = the 1980 Census MSA population;

POPSQR = the square of the 1980 Census population in a MSA.

In order to answer questions (1) and (2), this model is estimated with data from a random sample of the 1980 Census of Population and Housing. The sample contains both workers in high technology occupations and workers from other occupations. A dummy variable is used to distinguish between high technology workers and workers in other occupations.[13] In addition, each explanatory variable is multiplied by this dummy variable for each observation to generate slope-shifters for the explanatory variables. The coefficients for these slope-shifters measure the differential impacts of the explanatory variables on the migration decisions of the high technology workers in the sample. If the coefficient for the differential impact of the explanatory variable on the

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[13]The dummy variable is set equal to one if the worker is in one of the high technology occupations defined in Chapter 3, Table 3-8, p. 47. Otherwise, it is set equal to zero.

migration decisions of high technology workers is not statistically significant, then the coefficient for the explanatory variable measures the impact of the explanatory variable on all workers in the sample. In the case of a statistically significant estimate for the coefficient of the differential impact on high technology workers, the coefficient for the explanatory variable measures only its impact on the migration decisions of workers in non-high technology occupations; an estimate of the coefficient for high technology workers can be obtained by summing the coefficient of the explanatory variable and the coefficient for the differential impact of the explanatory variable on high technology workers.[14]

The coefficients for this model are estimated a second time by restricting the sample to high technology workers in order to examine question (3). A dummy variable is included to distinguish between professionals and technicians.[15] Once again, each explanatory variable is multiplied by this dummy variable to generate slope-shifters for each of the explanatory variables. Statistically significant estimates for the coefficients of the slope-shifters imply differential responses by technicians to the explanatory variables.

The data on MSA attributes employed in estimating the model refer to characteristics in the place of residence in 1975. The coefficients of these attributes reflect the impact of these place of residence

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[14]This procedure is discussed in Pindyck and Rubinfeld (1981, p. 114). In essence, the estimated parameters are the same that would be obtained if separate regressions were estimated for workers in high technology occupations and for workers in other occupations.

[15]The dummy variable is set equal to one if the high technology worker is a technician; otherwise, the dummy variable is set equal to zero.

characteristics on the decision to move from or to stay in the 1975 place of residence. In order to shed additional light on question (2), the MSA attributes of the place of residence in 1980 are employed to measure the impact of the 1980 place of residence characteristics on the decision to move. If the place of residence in 1980 differs from the place of residence in 1975, then the individual in question moved. If the place of residence in 1980 does not differ from the place of residence in 1975, then the individual in question did not move. In either case, the coefficients for the MSA characteristics can be interpreted as representing the attractiveness of the 1980 place of residence (as measured by its characteristics included in the model) to the individual "at risk" to migration.

CHAPTER 5

MODEL ESTIMATION AND EMPIRICAL RESULTS

Overview

The model of high technology worker migration formulated in the previous chapter was estimated with data that included both workers in high technology occupations and workers in other occupations. The results are evaluated in terms of the three questions posed earlier concerning the migration decisions of high technology workers. The data with which the model was estimated and the model estimation technique are described below.

The Data

Data about the personal characteristics of the workers in the sample are taken from the B Sample of the Public-Use Microdata Samples of the 1980 Census of Population and Housing. The B Sample is a stratified sample of the population, containing information on one percent of all the households in the Nation--one household for every one hundred households in the Nation is represented (U.S. Bureau of the Census, 1983). The B Sample identifies all metropolitan territory and most Metropolitan Statistical Areas (MSAs) individually. The majority of the households surveyed are located in 282 MSAs of 100,000 or more inhabitants. The remaining 36 MSAs are paired together. The Microdata Samples lend themselves to migration analysis because the metropolitan areas identified apply not only to 1980 residence, but also to place of residence in 1975. However, migration and place of work data are included for only

one-half of the sampled households. Thus, for migration purposes, the B Sample in effect is a 0.5 percent sample of all of the households in the United States.

The data set is restricted to heads of households born in the U.S. who were under the age of 61 in 1975 in order to eliminate retiring workers. If a respondent was not working at a job or business in 1975 and was younger than 16 years of age in 1975, then that observation was also deleted from the data set. Herzog and Schlottman (1984) have shown that if a worker is unemployed, he or she is more likely to migrate than a worker who is employed. By including only employed workers, the influence of unemployment on the migration decision is eliminated.

The metropolitan area data come from two sources. The percentage increase in the number of jobs between 1975 and 1979 in a MSA is obtained from the State and Metropolitan Area Data Book (U.S. Bureau of the Census, 1983). The remaining data about metropolitan characteristics and quality of life indicators come from the Places Rated Almanac (Boyer and Savageau, 1981). Another quality of life rating system is that developed for the U.S. Environmental Protection Agency by Liu (1975). These ratings are somewhat dated and describe SMSA characteristics as they existed in the late 1960s and early 1970s. Places Rated Almanac incorporates data from the time period 1977 through 1980 and thus offers a more current assessment of the quality of life in U.S. metropolitan areas. Places Rated Almanac rates and ranks 277 metropolitan areas by comparing several factors that greatly influence their quality of life: climate, housing, education, the transportation system for people, the tax structure, recreational facilities, and cultural amenities. Details concerning how these quality of life indicators were constructed are presented in

Appendix A. It should be noted that when the Almanac was compiled there were only 277 MSAs. The B Sample identifies 318 MSAs. When the two data sets were merged, 276 MSAs identified in Places Rated Almanac were matched with data from the B Sample. These 276 MSAs are listed in Appendix B.

Model Estimation Technique

A binary choice model is used to estimate the impact of each of the explanatory variables on the decision to migrate. Binary choice models assume that individuals are faced with a choice between two alternatives, and that the choice they make depends on a set of attributes describing the individuals (Pindyck and Rubenfeld, 1981, p. 274). That is, a relationship is sought between this set of attributes and the probability that the individual will make a given choice.[1] It is assumed that individuals make rational choices so as to maximize their utility. Such models are finding wider application because of the recent emphasis on the analysis of survey data (Pindyck and Rubenfeld, p. 273).

According to Amemiya (1981), there are three functional forms of binary choice models: the linear probability model, the probit model, and the logit model. The linear probability model suffers from an inherent defect. The estimated probabilities of the dependent variable are not constrained to lie between zero and one. Attempts to remedy this defect produces kinks at the end points of the distribution of the predicted values of the dependent variable. Also, the standard deviations of

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[1]The relationship of model estimation to the theory of choice is discussed in McFadden (1974) and in Domencich and McFadden (1975).

the ordinary least square estimators are biased because of heteroscedasticity (Amemiya, p. 1487). The probability functions of the probit and logit models are the standard normal distribution function and the logistic distribution function respectively. Being probability distribution functions, both are bounded between zero and one. Amemiya contends that is does not matter much whether the probit model or whether the logit model is used when there are only two alternatives for the individual to choose between (Amemiya, p. 1487). The logit model is employed in this study to estimate the model of high technology worker migration specified in Chapter 4. The dependent variable becomes the logarithm of the odds that a particular choice will be made:

$$\log \frac{(P_i)}{(1 - P_i)}$$

where P_i = the probability that the i-th worker will migrate.

Since the data with which these equations were estimated included both workers in high technology occupations and workers in other occupations, intercept and slope dummy variables were included to capture the differential responses of high technology workers to personal attributes and metropolitan area characteristics.

According to Pindyck and Rubinfeld (p. 294), maximum likelihood estimation of the logit model is appropriate since a unique maximum always exists for the logit model.[2] The signs, magnitude, and statistical significance of estimated coefficients offer clues to the influence of

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[2]The statistical software employed to estimate the logistic regression model of worker migration is the LOGIST procedure developed by Frank Harrell of the Duke University Medical Center. A description of the LOGIST procedure is contained in Harrell (1983).

each of the explanatory variables on the decision to migrate. However, the interpretation of the individual estimated coefficients for the explanatory variables is not straightforward since the left-hand side of the equation is the logarithm of the odds of the choice, not the actual probability. One way of estimating the affect of a percentge change of an independent variable on the dependent variable is to calculate the elasticity of the dependent variable with respect to the independent variable. Elasticities are not constant along the regression curve. They change when measured at different points along the curve. The common practice is to calculate elasticity at the point of the mean of each of the independent variables (Pindyck and Rubenfeld, p. 91). These estimated elasticities allow the relative influence of the independent variables to be ranked according to the magnitude of their influence.

The following formula, provided by Pindyck and Rubenfeld (p. 299), is employed to calculate elasticities for those continuous, independent variables found to have a significant impact on the in-migration decision:

$$dP_i = B_k \overline{X}_k \, [\overline{P}(1-\overline{P})]$$

where P_i = the probability that the i-th worker will migrate

B_k = the estimated coefficient for the k-th explanatory variable

$\overline{X}_k$ = the mean of the k-th explanatory variable

$\overline{P}$ = the migration rate (the percentage of workers "at risk" to migration who actually migrate)

The elasticity estimate for the dependent variable with respect to the k-th independent variable is given by dPi, where d represents incremental change. However, only elasticities involving incremental changes in continuous, independent variables can be estimated; this estimation procedure is not appropriate for dummy variables (Pindyck and Rubinfeld, p. 299).

Migrant Characteristics and Migration Patterns

In Table 5-1, personal characteristics of the migrants and non-migrants in the sample that are in high technology occupations are compared to the personal characteristics of migrants in the sample that are in other occupations.[3] Note that high technology migrants tend to be younger, more educated, more likely to be married, more likely to have moved before, less likely to be females, and less likely to be non-white than migrants in other occupations. Also, the migration rate of high technology workers exceeds that of non-high technology workers. Among high technology workers, migration is selective of both the young and the better educated. In addition, migrants in high technology occupations are less likely to be married and more likely to have prior migration experience than non-migrating high technology workers.

The actual migration flows of high technology workers in the sample between 1975 and 1980 provide a glimpse of the metropolitan areas preferred by these migrants. In Table 5-2, the ten MSAs with the largest net gain of high technology workers and the ten MSAs with the largest net loss of high technology workers between 1975 and 1980 are presented. The three metropolitan areas that suffered the largest net losses of high technology workers are, in order, New York, Los Angeles-Long Beach, and Chicago. These three metropolitan areas are the three most populous metropolitan areas in the United States (U.S. Bureau of the Census, 1982). The three metropolitan areas that enjoyed the largest net gain of high

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[3]Unless specified otherwise, the broad occupational definition of the high technology labor force is the occupational definition employed. The occupations which constitute this broad definition of the high technology labor force were presented in Table 3-8, p. 47.

Table 5-1. Personal Attributes of Migrants and Nonmigrants in High Technology Occupations and in Other Occupations

Personal Attributes	Workers in High Technology Occupations		Workers in Other Occupations
	Nonmigrants	Migrants	Migrants
Age (years)	40.7	33.8[c]	34.7[d]
Education (years)[a]	17.5	18.3[c]	16.4[d]
Married (%)	79.3%	66.6%[c]	60.7%[d]
Prior Geographic Mobility as of 1975[b] (%)	46.1%	58.8%[c]	50.7%[d]
Percent Female	6.5%	7.6%	17.7%[d]
Percent Non-White	6.8%	5.6%	11.2%[d]
Migration Rate, 1975-1980		19.2%	12.1%[d]

Source: Compiled from the B Sample of the Public Use Sample from the 1980 U.S. Census of Population and Housing using the broad definition of high technology occupations.

[a]Years attempted.

[b]Based upon the comparison of state of birth and the reported state of residence of individual respondents.

[c]Indicates a statistically significant difference between high technology migrants and non-migrants at the 5 percent level of significance. The methodology for computing standard errors for mean and percentage estimates is presented in U.S. Bureau of the Census (1983).

[d]Indicates a statistically significant difference between high technology migrants and other migrants at the 5 percent level of significance.

Table 5-2. The Ten MSAs with the Largest Net In-Migration and the Ten MSAs with the Largest Net Out-Migration of High Technology Workers, 1975-1980[a]

Ranking	MSA	Net Loss	MSA	Net Gain
1	New York NY-NJ	-7600 (1734)	Denver-Boulder, CO	5000 (1406)
2	Los Angeles-Long Beach, CA	-5400 (1462)	Houston, TX	5000 (1406)
3	Chicago, IL	-3400 (1160)	Phoenix, AZ	4400 (1318)
4	Syracuse, NY	-2600 (1012)	Oxnard-Simi Valley-Ventura, CA	3600 (1190)
5	Akron, OH	-2000 (882)	Seattle-Everett, WA	3400 (1159)
6	Boston, MA	-2000 (900)	Anaheim-Santa Anna-Garden Grove, CA	2200 (932)
7	Miami, FL	-1800 (844)	Washington, DC-MD-VA	2200 (932)
8	Philadelphia, PA-NJ	-1800 (844)	Riverside-San Bernardino-Ontario, CA	2000 (932)
9	Baton Rouge, LA	-1600 (794)	Sacramento, CA	1800 (844)
10	Dayton, OH	-1600 (794)	Dallas-Fort Worth, TX	1600 (796)

[a]Estimates are obtained by weighting the raw totals from the B Sample by 1/.005. Standard errors of estimates are in parentheses. All of the estimates are statistically different from zero at the 5 percent level of significance. The methodology used to calculate the standard errors is that of the U.S. Bureau of the Census (1983).

technology workers are, in order, Denver-Boulder, Houston, and Phoenix. What makes these three metropolitan areas so attractive to high technology migrants and the other three metropolitan areas so unattractive? It is hypothesized that those metropolitan area characteristics identified by Premus, Schmenner, and others play a significant part in the migration decisions of these workers. For example, New York's state and local tax bite was 10.29 percent of average household income in 1980 while Denver-Boulder's tax bite was only 7.04 percent. Denver-Boulder's climate is less variable than New York's as well. Finally, employment in the New York metropolitan area grew by only 5.4 percent from 1975 through 1979; employment in Denver-Boulder grew by 38.2 percent during this same time period.

Upon examination of Table 5-2, it is obvious that the high technology labor supply of some metropolitan areas was being augmented through in-migration while the supply of such labor in other metropolitan areas was being diminished by out-migration. It remains to be seen, however, whether these flows of high technology migrants are explained by variations in those metropolitan area characteristics hypothesized by analysts to influence the location decisions of these migrants. This is a question more conveniently addressed by the econometric estimation of the parameters of the model of high technology worker migration presented in Chapter 4.

Estimation Results

The Out-Migration Decision

All Occupations

Econometric estimates were obtained for the model of worker migration described in Chapter 4 with the data and estimation technique described

above. The data included both high technology workers (broadly defined) and workers in other occupations. Metropolitan characteristics included in each observation referred to 1975 place of residence. The dependent variable was set equal to one if a worker "at risk" to migration moved from the 1975 place of residence between 1975 and 1980; otherwise the dependent variable was set equal to zero. A dummy variable was set equal to one if a worker "at risk" to migration was in a high technology occupation (broadly defined); otherwise it was set equal to zero. This dummy variable was used to generate coefficients that measure the differential responses of high technology worker migration decisions to variations in personal attributes and in 1975 metropolitan area characteristics. The estimates for the coefficients of the occupational dummy variable and the 16 differential response variables provide information concerning the existence of occupation related differences, if any, in the migration decision.

The binary logit estimates are presented in Table 5-3. The middle column contains estimated coefficients for all workers in the sample; the differential responses of workers in high technology occupations are listed in the right-most column. A statistically insignificant estimate for a differential response by high technology workers implies that the migration decisions of all workers (both high technology and non-high technology) exhibit similar responses to variations in a personal attribute or metropolitan characteristic.

Examination of the estimates in Table 5-3 reveals that increasing age lowers the likelihood of migration for all workers while increasing education enhances it. The likelihood of migration is increased by previous migration experience and diminished for married workers, for females, and for non-white workers. The migration decisions of high technology workers

Table 5-3. Binary Logit Estimates of the Influences on the Out-Migration Decision

Variable	Impact on All Workers	Differential Impact on High Technology Workers[a]
INTERCEPT	-3.1177[b] (26.23)	1.2032 (2.00)
AGE	-0.0585[b] (220.90)	-0.0246[b] (19.13)
GRADE	0.1453[b] (120.97)	0.0136 (0.44)
MARSTAT	-0.4061[b] (19.37)	-0.0079 (0.00)
PRIOR	0.7758[b] (103.58)	-0.0541 (0.27)
SEX	-0.4406[b] (15.21)	0.0606 (0.12)
RACE	-0.6702[b] (25.73)	0.3817[b] (3.90)
TAX	-0.0545[b] (11.80)	0.0245 (1.33)
HOUSING	0.0001[b] (14.42)	-0.0001 (2.32)
EDUC	0.0004[b] (4.78)	0.0000 (0.02)
TRANSPORT	0.0000 (0.96)	0.0000 (0.02)
CULTURE	0.0000 (2.61)	-0.0000 (3.65)
RECREAT	0.0002 (2.37)	0.0003 (2.23)
CLIMATE	0.0002 (0.29)	-0.0003 (0.19)

Table 5-3 (Continued).

Variable	Impact on All Workers	Differential Impact on High Technology Workers[a]
EMPGWTH	-0.0010 (0.10)	-0.0028 (0.39)
POP	-0.0003[b] (16.02)	0.0000 (0.24)
POPSQR	0.0003[b] x 10^{-4} (7.21)	0.0000 (2.06)

The log likelihood ratio test statistic (1644.26) is significant at the one percent level of significance. The null hypothesis that none of the explanatory variables help explain the variation in the dependent variable is rejected.

The t-statistic for each coefficient is given in parentheses.

[a]Broad occupational definition of the high technology labor force. See Table 3-8, p. 47.

[b]Statistically significant at the 5 percent level of significance.

appear to be more sensitive to age and less sensitive to worker ethnicity than the migration decisions of other workers. As a whole, these results support the human capital model of migration outlined in the previous chapter. The migration process is more selective of the young and better educated, with the age selectivity of migration being greater for high technology workers.

Of the seven quality of life indicators hypothesized to influence the out-migration decisions of high technology workers, only state and local taxes, housing costs, and educational opportunities were found to have any significant impact. Other things equal, higher state and local taxes in the 1975 place of residence appear to lower the probability of migrating while higher housing costs and better educational opportunities appear to increase it. The relationships found between taxes, educational opportunities, and the out-migration decision contradicts the expected relationships presented in Table 4-1, p. 68. The expected relationship between housing costs in the 1975 place of residence and the out-migration decision was not known. No statistically significant differential responses by workers in high technology occupations to the quality of life indicators were found.

Employment growth in the 1975 place of residence had no significant impact on the migration decisions of workers, regardless of occupation. As expected, larger populations tended to lower the likelihood of migration. However, the estimate for the quadratic term, population squared, indicates that this population effect itself varies as population varies. The holding power of population is reduced as metropolitan area population increases; eventually, extremely large populations encourage out-migration. No differential response to metropolitan population by

high technology workers is indicated. This finding corresponds to the actual migration flows of high technology workers presented in Table 5-2; the three largest net losers of high technology workers are New York, Los Angeles-Long Beach, and Chicago. These metropolitan areas also have the three largest metropolitan area populations in the United States (U.S. Bureau of the Census, 1982).

The estimated coefficient for the dummy variable (the intercept-shift term), which distinguishes high technology workers from other workers is not statistically different from zero. Apparently, the out-migration decisions of high technology workers are not any different from the out-migration decisions of other workers, except in their differential responses to age and race.

The results presented in Table 5-3 offer some answers to the questions posed earlier in Chapter 4. First, high technology workers do respond differently to certain personal attributes (age and race) when deciding whether or not to leave their 1975 places of residence. Second, only three of the seven quality of life indicators in the 1975 place of residence appear to play a role in the out-migration decision: state and local taxes, educational opportunities, and housing costs. Of these three, taxes and educational opportunities do not have the expected relationship with the out-migration decisions of high technology workers.

It appears that the only difference between the migration decisions of high technology workers and other workers concerns the differential responses to age and race. Thus, the migration rate differential between the two groups of workers is a function of differences in the personal attributes of the two groups of workers.

In order to ascertain the sensitivity of the above results to the occupational definition of high technology workers, the model is re-estimated with data containing only those high technology workers who fall into the more specific occupations presented in Table 3-9, p. 49. The sample of workers in other occupations remains the same. Those workers previously classified as high technology workers but who are not included in the more specific occupational definitions were excluded from the data set. The estimated coefficients for the re-estimated equation are provided in Appendix C.

The only real difference is that the estimated coefficient for the dummy variable which distinguishes high technology workers from other workers is statistically different from zero and is positive. This indicates that the migration rate of workers in the more specifically defined high technology occupations is greater than the migration rate of other workers and that the migration rate differential is not fully explained by the differential responses of high technology workers to differences in personal attributes or variations in metropolitan area characteristics.

High Technology Workers

The third question posed in Chapter 4 concerned the hypothesized difference in the mobility rates of professionals and technicians in high technology occupations. Premus (1982) explained that the preference for technicians by the high technology firms he surveyed was caused by the relative geographic immobility of technicians as opposed to professionals. This hypothesis was supported by Schoening and Goss (1984). Their findings imply that high technology firms would be inclined to locate in areas with adequate supplies of technicians and import needed professionals from other regions that were not available locally.

In Table 5-4, the personal attributes and migration rate of the migrant professional workers in the high technology worker sample (broadly defined) are compared to the personal attributes and migration rate of the migrant technicians in the high technology worker sample. Migrants who are high technology professionals are more likely, on average, to be older, better educated, married, and have previous migration experience and less likely, on average, to be female or non-white than their technician counterparts. The professionals in this sample of high technology workers have a greater migration rate than do the technicians, thereby supporting the findings of Schoening and Goss (1984) and the Premus hypothesis.

In order to determine the extent to which the migration decisions of professionals in high technology occupations differ from the migration decisions of technicians, coefficients for the model are re-estimated with data containing only workers in high technology occupations (broadly defined). A dummy variable was set equal to one if a worker "at risk" to migrate was a technician; otherwise it was set equal to zero. This dummy variable was employed to generate coefficients that measure the differential responses of technicians to variations in personal attributes and in 1975 metropolitan characteristics. The estimates for the 16 differential response variables provide information concerning the occupation-related differences, if any, in the migration decisions of high technology workers.

The binary logit estimates are presented in Table 5-5. The middle column contains estimated coefficients for all high technology workers in the sample; the differential responses of technicians are listed in the

Table 5-4. Personal Attributes of High Technology Migrant Professionals and Technicians

Personal Attributes	Migrants in High Technology Occupations	
	Professionals	Technicians
Age (years)	34.5[c]	32.4
Education (years)[a]	19.2[c]	16.8
Married (%)	70%[c]	59%
Prior Geographic Mobility as of 1975[b]	62%[c]	53%
Percent Female	5%[c]	13%
Percent Non-White	5%[c]	7%
Migration Rate, 1975-1980	22%[c]	15%

Source: Compiled from the B Sample of the Public Use Sample from the 1980 U.S. Census of Population and Housing using the broad definition of high technology occupations.

[a]Years attempted.

[b]Based upon the comparison of state of birth and the reported state of residence of individual respondents.

[c]Indicates a statistically significant difference between high technology professionals and technicians at the 5 percent level of significance. The methodology for computing standard errors for mean and percentage estimates is presented in U.S. Bureau of the Census (1983).

Table 5-5. Binary Logit Estimates of the Influences on the Out-Migration Decisions of Workers in the High Technology Professional and Technical Occupations[a]

Variable	Impact on High Technology Workers	Differential Impact on Technicians
INTERCEPT	0.2294 (0.07)	-3.4265[b] (6.88)
AGE	-0.0935[b] (324.80)	0.0236[b] (7.87)
GRADE	0.1020[b] (12.51)	0.0337 (0.76)
MARSTAT	-0.3755[b] (13.47)	-0.1241 (0.58)
PRIOR	0.6736[b] (57.60)	0.1322 (0.83)
SEX	-0.3124 (2.37)	-0.0583 (0.04)
RACE	-0.1559 (0.65)	-0.2207 (0.59)
TAX	-0.0063 (0.12)	-0.0638[b] (4.65)
HOUSING	0.0000 (2.54)	0.0000 (0.03)
EDUC	0.0001 (0.49)	0.0006[b] (3.82)
TRANSPORT	0.0000 (0.68)	-0.0000 (0.18)
CULTURE	-0.0000 (0.02)	0.0000 (1.19)
RECREAT	0.0000 (0.00)	0.0001 (0.29)
CLIMATE	-0.0001 (0.06)	0.0004 (0.19)

Table 5-5 (Continued).

Variable	Impact on High Technology Workers	Differential Impact on Technicians
EMPGWTH	-0.0057 (2.36)	0.0052 (0.71)
POP	-0.0004[b] (18.83)	-0.0000 (0.04)
POPSQR	0.0004 x 10^{-4}[b] (16.12)	0.0000 (0.11)

The log likelihood ratio test statistic (875.76) is significant at the one percent level of significance. The null hypothesis that none of the explanatory variables help explain the variation in the dependent variable is rejected.

The t-statistic for each coefficient is given in parentheses.

[a]Broad occupational definition of the high technology labor force. See Table 3-8, p. 47.

[b]Statistically significant at the 5 percent level of significance.

right-most column. A statistically insignificant estimate for a differential response by technicians implies that the out-migration decisions of all high technology workers in the sample, regardless of occupation, exhibit similar responses to a variation in a personal attribute or a metropolitan characteristic.

Examination of the estimates reveals that increasing age and being married lower the likelihood of migration by all workers while more education and previous migration experience increase it. The only statistically significant differential response to variations in personal attributes that the technicians in the sample exhibit is their lower age selectivity of migration.

None of the seven 1975 place of residence quality of life indicators hypothesized to play a role in the out-migration decisions of high technology workers seem to have any significant impact on the out-migration decisions of the professionals in high technology occupations. However, the out-migration decisions of the technicians exhibit differential responses to variations in state and local taxes and educational opportunities. Other things equal, it appears that higher state and local taxes lower the likelihood of migration for technicians and better metropolitan area educational opportunities increase it. These results generally correspond to the relationships found between the quality of life indicators and the migration decisions of all high technology workers (broadly defined) discussed previously. The one exception concerns the positive relationship found earlier between housing costs and the out-migration decisions of all workers. However, the estimated coefficient for housing costs in Table 5-3 is only slightly greater than zero; the estimated relationship for the differential response by high technology

workers is of the same magnitude but opposite in direction, but is not statistically different from zero at the five percent level of significance.[4]

The growth of employment between 1975 and 1979 in the 1975 place of residence appears to have no significant impact on the out-migration decisions of high technology workers. In addition, the likelihood of out-migration from the 1975 place of residence decreases, in a quadratic fashion, with metropolitan population. No differential response in the out-migration decisions of technicians to variations in employment growth or population is observed.

The estimated coefficient for the dummy variable (the intercept-shift term), which distinguishes between technicians and professionals in high technology occupations, is statistically significant at the five percent level of significance. This indicates that a significant difference exists between the migration rates of professionals and the migration rates of technicians and that this difference is not fully explained by variable responses to personal attributes or metropolitan area characteristics.

In summary, the out-migration decisions of technicians in high technology occupations tend to be less sensitive to age than the out-migration decisions of professionals. Also, state and local taxes and metropolitan educational opportunities in the 1975 place of residence appear to affect only the out-migration decisions of the technician segment of the high

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[4]Great care must be exercised in interpreting the estimated coefficients for the explantory variables since the dependent variable measures the logarithm of the odds of the probability of migration.

technology workers in the sample. Finally, the greater mobility rate of professionals is not fully explained by the explanatory variables controlled for in the model.

The In-Migration Decision

In order to shed additional light on the first two questions posed in Chapter 4, the model was re-estimated with data that included both high technology workers (broadly defined) and workers in other occupations. Up to this point, the focus has centered on the out-migration decision. Another aspect of the migration decision is the decision to migrate to a particular metropolitan area. This aspect is important from a policy stand-point in that it identifies the metropolitan area characteristics that play a role in attracting the workers needed by high technology firms. In reference to Table 5-2, p. 80, the in-migration model seeks to explain why certain metropolitan areas, such as Denver-Boulder, Houston, and Phoenix, attracted large inflows of high technology workers during the time period from 1975 to 1980. Metropolitan characteristics included in each observation refer to 1980 place or residence. Once again, a dummy variable was set equal to one if a worker "at risk" to migration was in a high technology occupation; otherwise it was set equal to zero. This dummy variable was used to generate coefficients that measure the differential responses of high technology worker migration decisions to variances in personal attributes and in 1980 metropolitan area characteristics. The expected relationships between the personal attributes of potential migrants are expected to be the same, regardless of whether in-or out-migration is being examined. The expected relationships between metropolitan characteristics and the in-migration decision were summarized in Table 4-1, p. 68.

The binary logit estimates are presented in Table 5-6. The middle column contains estimated coefficients for all workers in the sample; the differential responses of workers in high technology occupations are listed in the right-most column. Examination of the estimates in Table 5-6 reveals that increasing age lowers the likelihood of migration by all workers while increasing education enhances it. The likelihood of migration is increased by previous migration experience and diminished for married workers, for females, and for non-white workers. As in the case of out-migration, the in-migration decisions of high technology workers appear to be less sensitive to worker ethnicity than the in-migration decisions of other workers.

Of the seven quality of life indicators, only state and local taxes and housing costs were found to play a role in the in-migration decisions of all workers. Other things equal, higher taxes tend to lower the likelihood of in-migration, while higher housing costs appear to increase the likelihood of in-migration. Note that the likelihood of high technology worker in-migration is affected less by higher state and local taxes than the likelihood of in-migration by other workers.

Higher employment growth in the 1980 place of residence increased the probability of in-migration for all workers. Also, it appears that population size had little impact on worker in-migration, regardless of occupation. No differential responses to employment growth or population by workers in high technology occupations were indicated.

The estimated coefficient for the dummy variable (the intercep-shift term), which distinguishes high technology workers from other workers, is positive and statistically different from zero. The in-migration decisions of high technology workers (broadly defined) appear

Table 5-6. Binary Logit Estimates of the Influences on the In-Migration Decision

Variable	Impact on All Workers	Differential Impact on High Technology Workers[a]
INTERCEPT	-1.6554[b] (9.09)	1.5831[b] (4.20)
AGE	-0.0376[b] (136.63)	-0.0044 (0.96)
GRADE	0.0719[b] (38.76)	-0.0292 (2.76)
MARSTAT	-0.3575[b] (18.37)	-0.0451 (0.16)
PRIOR	0.7695[b] (130.55)	0.0687 (0.55)
SEX	-0.2421[b] (5.91)	-0.0386 (0.06)
RACE	-0.5906[b] (26.87)	0.7290[b] (19.41)
TAX	-0.0570[b] (16.84)	-0.0478[b] (6.56)
HOUSING	0.0001[b] (3.82)	-0.0000 (1.70)
EDUC	0.0001 (0.69)	-0.0004 (2.83)
TRANSPORT	0.0000 (1.21)	0.0000 (2.08)
CULTURE	0.0000 (0.90)	0.0000 (1.83)
RECREAT	-0.0002 (2.08)	0.0001 (0.22)
CLIMATE	-0.0005 (2.05)	0.0004 (0.76)

Table 5-6 (Continued).

Variable	Impact on All Workers	Differential Impact on High Technology Workers
EMPGWTH	0.0180[b] (43.55)	-0.0012 (0.11)
POP	0.0001 (2.49)	-0.0001 (0.46)
POPSQR	0.0000 (1.55)	0.0000 (0.29)

The log likelihood ratio test statistic (1033.91) is significant at the one percent level of significance. The null hypothesis that none of the explanatory variables help explain the variation in the dependent variable is rejected.

The t-statistic for each coefficient is given in parentheses.

[a]Broad occupational definition of the high technology labor force. See Table 3-8, p. 47.

[b]Statistically significant at the 5 percent level of significance.

to be significantly different from the in-migration decisions of other workers. However, their higher migration rate is not explained by variations in personal attributes and metropolitan area characteristics, except in the cases of greater age selectivity and lower sensitivity to ethnicity and state and local taxes.

The only real difference in the in-migration behavior and the out-migration behavior of high technology workers concerns the influence of state and local taxes and area educational opportunities. In Table 5-3, higher state and local taxes appear to lower the likelihood of out-migration by all workers, regardless of occupation, while better educational opportunities and higher housing costs increase the likelihood of out-migration. Metropolitan area educational opportunities appear to have little influence, however, on in-migration. Higher state and local taxes discourage the in-migration of all workers, but the differential response by high technology workers indicates that they are less sensitive to higher state and local taxes than workers in other occupations.

Once again, the results are remarkable in that variations in quality of life indicators do not seem to explain the migration decisions of workers very well. This econometric evidence contradicts the widespread belief that workers, particularly those in high technology occupations, are attracted to metropolitan areas which offer quality of life advantages. Instead, the migration decisions of high technology workers (broadly defined) appear to be not unlike the migration decisions of other workers in that the personal attributes of the workers tend to dominate the decision to migrate, with metropolitan area characteristics coming in a poor second in terms of influence. At this point, it would be useful to compare

the impacts of some of the explanatory variables on the migration decision of high technology workers to determine if this is actually the case.

The coefficients presented in Table 5-6 measure the impact of each explanatory variable on the logarithm of the odds of the probability that an individual will migrate. However, in order to meaningfully compare the relative magnitudes of the estimated coefficients, it is necessary to transform these estimates into elasticities which measure the impact of a marginal change in the value of one of the explanatory variables on the probability that a worker will move. This transformation is performed with the methodology discussed earlier for the statistically significant, continuous explanatory variables in Table 5-6.[5]

These estimated elasticities are presented in Table 5-7. The second column contains the elasticities for all workers. The third column contains the differential responses by high technology workers. The fourth column is the sum of columns two and three. This column provides estimated elasticities for high technology workers, which can be compared to the elasticities for non-high technology workers in column two.

Interpretation of these elasticities is relatively straightforward. For example, a one percent increase in worker age will lead to a .198 percent decrease in the probability of in-migration by all workers. Since the in-migration decisions of high technology workers exhibit the same age selectivity as the in-migration decisions of all workers, the estimated age elasticity for high technology workers is the same. The education elasticity for marginal changes in worker education is the same for

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[5]Elasticities cannot be estimated for the dummy variables since these explanatory variables are not continuous.

Table 5-7. Estimated Elasticities for the Continuous Explanatory Variables Influencing the In-Migration Decisions of High Technology Workers[a]

Variable	Estimated Elasticity for All Workers	Estimated Elasticity of the Differential Impact on High Technology Workers	Net Effect on High Technology Workers
AGE	-0.198	--	-0.198
GRADE	0.147	--	0.147
TAX	-0.007	0.006	-0.001
HOUSING	0.088	--	0.088
EMPGWTH	0.002	--	0.002

[a]Elasticity estimates derived with the methodology presented in Pindyck and Rubinfeld (1981, p. 299). The coefficients on which the elasticity estimates are based were presented in Table 5-6.

all workers. A one percent increase in worker education increases the probability of in-migration by .1467 percent. A one percent increase in state and local taxes will lead to a .007 percent decrease in the probability of non-high technology worker in-migration, but the same one percent increase in taxes will lead to only a .001 percent reduction in the probability of high technology worker in-migration. A one percent increase in housing costs increases the probability of in-migration by .0875 percent. One possible explanation for the role played by housing costs in the migration decision is related to the inclusion of implicit prices of amenities important to the quality of life. The expected negative impact of higher housing costs on the in-migration decision is being offset, to the extent not controlled for by the other explanatory variables in the model, by the inclusion of the implicit price of local amenities in housing costs that were not controlled for in the model. Thus, higher housing costs reflect larger local supplies of these amenities, thereby making areas with higher housing costs more attractive to potential in-migrants. Finally, note that workers in all occupations are attracted to areas that enjoy faster employment growth. A one percent increase in metropolitan area employment growth increases the probability of worker in-migration by .002 percent.

Examination of the elasticities in Table 5-7 leads to two conclusions. First, it appears that the in-migration decisions of high technology workers are not as sensitive to higher state and local taxes as other workers. Second, variances in the two personal worker attributes included in Table 5-7, age and education, have far more influence on the high technology workers' in-migration decisions than do variances in state

and local taxes, metropolitan area housing costs, and metropolitan area employment growth. Other things equal, it appears that the seven quality of life indicators hypothesized earlier to influence the location decisions of high technology workers are poor indicators of the attractiveness of metropolitan areas to high technology workers.

In the next chapter, the econometric evidence presented above is summarized, and its implications for state and local governments attempting to attract high technology firms are discussed.

CHAPTER 6

CONCLUSION

Analysts who have investigated the locational orientation of high technology firms (Alonso, 1975; Premus, 1982; Schmenner, 1982) hypothesize that the location decisions of high technology industries tend to be amenity-oriented because these firms need highly specialized labor that prefers to locate in areas that offer quality of life advantages. In effect, their hypothesis that the location decisions of high technology industries are amenity-oriented implies that the migration decisions of high technology workers are amenity-oriented.

According to the human capital theory of migration, migration is one possible investment in human capital. As such, the decision to migrate involves weighing the present value of the benefits and the costs of migration. Complementary investments in human capital, such as education, training, and work experience, are as important in explaining the migration decision as the migration process itself. These investments in human capital, specific to each individual, are subject to depreciation both in a physical and in an economic sense, just as investments in physical capital are. The worker contemplating migration because of economic incentives resulting from disequilibria across spacially separated labor markets carefully compares the present value of the benefits and costs of alternative investments and chooses the investment which provides the most benefits per dollar of cost.

The human capital model predicts that the migration process is selective of the younger and better educated workers. Younger workers have more years over which to receive benefits and to spread costs resulting

from migration. As Schwartz (1976) noted, formal education increases the potential of learning over time through experience on the job, thereby making the potential benefits greater for more educated individuals. However, the role played by the occupation of the potential migrant in the migration decision is the subject of disagreement. Ladinsky (1967) and Long (1973) found that some occupational groups had higher migration rates than others. Long hypothesized that education is a more efficient indicator of migration than the major occupational groups, broadly defined. Ladinsky attributed much of the migration rate differential to the degree with which occupational specialization leads to labor market balkanization--the more specialized and highly skilled labor requirements become, the more the geographic area of recruitment expands to compensate for the smaller number of workers available locally and the difficulty and expenses of training specialists internally. Herzog and Schlottmann (1984) also presented empirical evidence that the likelihood of migration is related to an individual's occupation. Specifically, they found that the educational selectivity of migration varied by occupation. That is, after controlling for occupation, more education did not significantly increase the likelihood of migration of white collar workers in their sample.

The empirical evidence in Chapter 5 supports the human capital theory of migration. Regardless of occupation, increasing age lowered the likelihood of worker migration while increasing education enhanced it. Thus, these findings confirm the age and education selectivity of the migration process for both high technology workers and workers in other occupations. In addition, the likelihood of migration is increased by previous migration experience and diminished for married workers, for females, and for non-white workers. The migration decisions of high technology workers in

the sample exhibited greater age selectivity and lower sensitivity to race than the migration decisions of other workers. No occupation-related differences in education selectivity of the migration process was indicated. The results are remarkable in that variations in quality of life indicators among metropolitan areas do not appear to explain the migration decisions of high technology workers very well. In the case of the out-migration decision, only variations in state and local taxes, metropolitan area housing costs, and metropolitan area educational opportunities had any significant impact, and two of these, state and local taxes and housing costs, did not have the expected influence on out-migration. The only other metropolitan area characteristic that appeared to have an impact was population. In the case of the in-migration decision, only variations in state and local taxes and metropolitan area housing costs were found to have a significant impact and the magnitude of the impacts were relatively small in comparison to the influence of personal attri butes. The only other metropolitan characteristic that appeared to influence the in-migration decisions of high technology workers was metropolitan area employment growth. Rising employment growth increased the likelihood of in-migration.

The answer to the first question posed in Chapter 4 appears to be a qualified yes and the answer to the second question an unqualified no. Workers in high technology occupations (broadly defined) seem to migrate for the same reasons as workers in other occupations. No special response by the high technology workers in the sample to variations in metropolitan area characteristics were indicated. Their higher migration rate appears

to be a function of occupation-related differences in personal attributes. However, this conclusion is sensitive to the definition of high technology occupations that is employed. As shown in Appendix C, Table C-1, the higher migration rate for this more specifically defined group of high technology workers cannot be explained by variations in the explanatory variables included in the model. Yet, even for this more specifically defined group of high technology workers, quality of life considerations and metropolitan area characteristics do not seem to have any more influence on the out-migration decisions of high technology workers than in the case where the broader definition of the high technology occupations was employed.

The results in Chapter 5 indicated that professionals in high technology occupations have a higher migration rate than technicians and that this difference cannot be explained by variable responses to variations in personal attributes or metropolitan area characteristics. Thus, the Premus hypothesis that professionals are more geographically mobile than technicians is supported. It appears that the technician segment is more sensitive to metropolitan quality of life considerations than are professionals in the high technology occupations and that this sensitivity accounts for much of the response by high technology workers in general to variations in metropolitan area characteristics.

Regardless of which aspect of the migration decision is viewed or which of the definitions of high technology occupations is employed, quality of life considerations seem to play only a minor role in the migration decisions of high technology workers. The human capital model of migration explains the migration decisions of high technology workers

in the same way it explains the migration decisions of workers in other occupations. Personal attributes, such as age, education, prior migration experience, sex, marital status, and race dominate the migration decisions of these workers. The higher migration rate of high technology workers (broadly defined) can be attributed either to occupation-related differences in these attributes or to other variables not included in the model. The major implication for state and local policy makers attempting to attract high technology firms to their states and metropolitan areas is that their ability to influence the migration decisions of high technology workers is minimal, particularly in the case of high technology professionals. However, the results do indicate that local supplies of technicians are less likely to be diminished by out-migration than are local supplies of professionals. This finding, coupled with the evidence from the Premus survey that high technology firms rank the supply of technicians as more significant in their location decisions than the supplies of other labor, suggests state and local officials can have some impact on the location decisions of high technology firms. Also, other factors mentioned in the Premus survey, such as community attitudes toward business, can be influenced by state and local policy efforts.

The empirical evidence presented above and in Chapter 5 casts doubt on whether the locational orientation of high technology firms can truly be classified as amenity-oriented. This classification is dependent on high technology labor being attracted to areas which offer quality of life advantages and little empirical evidence supporting this hypothesis was found in this study.

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APPENDIXES

APPENDIX A

QUALITY OF LIFE INDICATORS

Data for the quality of life indicators were obtained from Boyer and Savageau (1981) for 277 metropolitan statistical areas. The rating scores constructed by Boyer and Savageau from individual statistics were directly utilized without any modifications. The methodology employed in the construction of these quality of life indicators is discussed below:

1. State and Local Tax Bite--A measurement of the relative tax bite in metropolitan statistical areas; it represents the state income and state sales taxes paid by the average household in 1980 as a percentage of average household income;

2. Housing Costs--Three criteria were used to rank metropolitan areas for the basic costs of owning a single-family detached house for one year: (1) annual average utility bill, (2) annual average property taxes, and (3) annual average mortgage payment. The sum of these three items represents the score;

3. Supply of Educational Opportunities--Three criteria were used to calculate scores that measure the abilities of metropolitan areas to provide residents with educational opportunities: (1) student/teacher ratio in the K-12 school system, (2) the portion of metropolitan area income devoted to the support of the K-12 school system, and (3) academic options in high education. Each metropolitan area begins with a base score of zero, to which points are added according to the above criteria;

4. Transportation System for People--Each metropolitan area starts with a base score of zero, to which points are added according to the following criteria: (1) airplane flights, (2) passenger train (Amtrak) departures, (3) interstate highways, (4) urban mass-transit systems, and (5) freeway mileage;

5. Cultural Amenities--Boyer and Savageau evaluate 9 kinds of cultural institutions and facilities: (1) major universities, (2) symphony orchestras, (3) opera companies, (4) dance companies, (5) theatres, (6) public televison stations, (7) fine arts radio stations, (8) museums, and (9) public libraries. Each metropolitan area starts with a base score of zero, to which points are added according to the above criteria;

6. Recreational Facilities--Eleven criteria are used to calculate a score for the access to recreation in a metropolitan area: (1) public golf courses, (2) bowling alleys, (3) money spent per capita on public parks and recreation, (4) movie theatres, (5) neighborhood bars, (6) zoos, (7) aquariums, (8) family theme parks, (9) game seats per capita for professional sports events, (10) pari-mutuel horse and dog racing, and (11) automobile racing. Each metropolitan area begins with a base score of zero, to which points are added according to the above criteria;

7. Climatic Variability--Each metropolitan area is given a base number of 1,000 points, from which points are subtracted for the following negative factors: (1) very hot and very cold months, (2) seasonal temperature variation, (3) heating and cooling degree days, (4) freezing days, (5) zero-degree days, and (6) 90-degree days.

APPENDIX B

LIST OF METROPOLITAN STATISTICAL AREAS

Abilene, TX

Akron, OH

Albany, GA

Albany-Schnectady-Troy, NY

Albuquerque, NM

Alexandria, LA

Allentown, Bethleham-Easton, PA-NJ

Altoona, PA

Amarillo, TX

Anaheim-Santa Anna-Garden Grove, CA

Anchorage, AK

Anderson, IN

Ann Arbor, MI

Anniston, AL

Appleton-Oshkosh, WI

Asheville, NC

Atlanta, GA

Atlantic City, NJ

Augusta, GA-SC

Austin, TX

Bakersfield, CA

Baltimore, MD

Baton Rouge, LA

Battle Creek, MI

Bay City, MI

Beaumont-Port Author-Orange, TX

Billings, MT

Biloxi-Gulfport, MS

Binghamton,, NY-PA

Birmingham, AL

Bloomington, IN

Bloomington-Normal, IL

Boise City, ID

Boston, MA

Bradenton, FL

Bridgeport, CT

Brockton, MA

Brownsville-Harlingen-San Benito, TX

Bryan-College Station, TX

Buffalo, NY

Burlington, NC

Canton, OH

Cedar Rapids, IA

Champaign-Urbana-Rantoul, IL

Charlestown, WV

Charlestown-North Charlestown, SC

Charlotte-Gastonia, NC

Chattanooga, TN-GA

Chicago, IL

Cincinnati, OH-KY-IN

Clarksville-Hopkinsville, TN-KY
Cleveland, OH
Colorado Springs, CO
Columbia, MO
Columbia, SC
Columbus, GA-AL
Columbus, OH
Corpus Christi, TX
Dallas-Forth Worth, TX
Danbury, CT
Davenport-Rock Island-Moline, IA-IL
Dayton, OH
Daytona Beach, FL
Decatur, IL
Denver-Boulder, CO
Des Moines, IA
Detroit, MI
Dubuque, IA
Duluth-Superior, MN-WI
Eau Claire, WI
Elmira, NY
El Paso, TX
Erie, PA
Eugene-Springfield, OR
Evansville, IN-KY
Fall River, MA-RI
Fargo-Moorhead, ND-MN
Fayetteville, NC
Fayetteville-Springdale, AR
Fitchburg-Leominster, MA
Flint, MI
Florence, AL
Fort Collins, CO
Fort Lauderdale-Hollywood, FL
Fort Myers-Cape Coral, FL
Fort Smith, AR-OK
Fort Wayne, IN
Fresno, CA
Gadsden, AL
Gainesville, FL
Galveston-Texas City, TX
Gary-Hammond-East Chicago, IN
Grand Forks, ND-MN
Grand Rapids, MI
Great Falls, MT
Greeley, CO
Green Bay, WI
Greensboro-Winston-Salem-High Point, NC
Greenville-Spartanburg, SC
Hamilton-Middletown, OH

Harrisburg, PA

Hartford, CT

Honolulu, HI

Houston, TX

Huntington-Ashland, WV-KY-OH

Huntsville, AL

Indianapolis, IN

Jackson, MI

Jackson, MS

Jacksonville, FL

Jersey City, NJ

Johnson City-Kingsport-Bristol, TN-VA

Johnstown, PA

Kalamazoo-Portage, MI

Kankakee, IL

Kansas City, MO-KS

Kenosha, WI

Kileen-Temple, TX

Knoxville, TN

Kokomo, IN

La Crosse, WI

Lafayette, LA

Lafayette-West Lafayette, IN

Lake Charles, LA

Lakeland-Winter Haven, FL

Lancaster, PA

Lansing-East Lansing, MI

Laredo, TX

Las Vegas, NV

Lawrence, KS

Lawrence-Haverkill, MA-NH

Lawton, OK

Lewiston-Auburn, ME

Lexington-Fayette, KY

Lima, OH

Lincoln, NE

Little Rock-North Little Rock, AR

Long Beach-Asbury Park, NJ

Longview-Marshall, TX

Lorain-Elyria, OH

Los Angeles-Long Beach,, CA

Louisville, KY-IN

Lowell, MA-NH

Lubbock, TX

Lynchburg, VA

Macon, GA

Madison, WI

Manchester, NH

Mansfield, OH

McAllen-Pharr-Edinburg, TX

Melbourne-Titusville-Cocoa, FL

Memphis, TN-AR-MS

Meriden, CT

Miami, FL

Midland, TX

Milwaukee, WI

Minneapolis-St. Paul, MN-WI

Mobile, AL

Modesto, CA

Monroe, LA

Montgomery, AL

Muncie, IN

Muskegon-Norton Shores-
Muskegon Heights, MI

Nashua, NH

Nashville-Davidson, TN

Nassau-Suffolk, NY

Newark, NJ

New Bedford, MA

New Britain, CT

New Brunswick-Perth Amboy-
Sayreville, NJ

New Haven-West Haven, CT

New London-Norwich, CT-RI

New Orleans, LA

Newport News-Hampton, VA

New York, NY-NJ

Norfolk-Virginia Beach-
Portsmouth, VA-NC

Norwalk, CT

Odessa, TX

Oklahoma City, OK

Omaha, NE-IA

Orlando, FL

Owensboro, KY

Oxnard-Simi Valley-Ventura, CA

Panama City, FL

Parkersburg-Marietta, WV-OH

Pascagoula-Moss Point, MS

Paterson-Clifton-Passaic, NJ

Pensacola, FL

Peoria, IL

Petersburg-Colonial Heightes-
Hopewell, VA

Philadelphia, PA-NJ

Phoenix, AZ

Pine Bluff, AR

Pittsburgh, PA

Pittsfield, MA

Portland, ME

Portland, OR-WA

Poughkeepsie, NY

Providence-Warwick-Pawtucket, RI-MA
Provo-Orem, UT
Pueblo, CO
Racine, WI
Raleigh-Durham, NC
Reading, PA
Reno, NV
Richland-Kennewick-Pasco, WA
Richmond, VA
Riverside-San Bernadino-Ontario, CA
Roanoke, VA
Rochester, MN
Rochester, NY
Rockford, IL
Sacramento, CA
Saginaw, MI
St. Cloud, MN
St. Joseph, MO
St. Louis, MO-IL
Salem, OR
Salinas-Seaside-Monterey, CA
Salt Lake City-Ogden, UT
San Angelo, TX
San Antonio, TX
San Diego, CA
San Francisco-Oakland, CA
San Jose, CA
Santa Barbara-Santa Maria-Lompoc, CA
Santa Cruz, CA
Santa Rosa, CA
Sarasota, FL
Savannah, GA
Scranton-Wilkes-Barre-Hazelton, PA
Seattle-Everett, WA
Sherman-Denison, TX
Shreveport, LA
Sioux City, IA-NE
Sioux Falls, SD
South Bend, IN
Spokane, WA
Springfield, IL
Springfield, MO
Springfield, OH
Springfield-Chicopee-Holoyoke, MA-CT
Stamford, CT
Steubenfille-Weirton, OH-WV
Stockton, CA
Syracuse, NY
Tacoma, WA
Tallahasse, FL

Tampa-St. Petersburg, FL

Terre Haute, IN

Texarkana, TX-Texarkana, AR

Toledo, OH-MI

Topeka, KS

Trenton, NJ

Tucson, AZ

Tulsa, OK

Tuscaloosa, AL

Tyler, TX

Utica-Rome, NY

Vallejo-Fairfield-Napa, CA

Vineland-Millville-Bridgeton, NJ

Waco, TX

Washington, DC-MD-VA

Waterbury, CT

Waterloo-Cedar Falls, IA

West Palm Beach-Boca Raton, FL

Wheeling, WV-OH

Wichita, KS

Wichita Falls, TX

Wilmington, DE-NJ-MD

Wilmington, NC

Worcester, MA

Yakima, WA

York, PA

Youngstown-Warren, OH

APPENDIX C

BINARY LOGIT ESTIMATES FOR NARROWLY DEFINED HIGH TECHNOLOGY OCCUPATIONS

Table C-1. Binary Logit Estimates of the Influences on the Out-Migration Decisions of Workers in Narrowly Defined High Technology Occupations

Variable	Impact on All Workers	Differential Impact on High Technology Workers
INTERCEPT	-3.1177[a] (26.23)	2.8784[a] (8.94)
AGE	-0.0585[a] (222.90)	-0.0267[a] (17.13)
GRADE	0.1453[a] (120.97)	-0.0038 (0.03)
MARSTAT	-0.4061[a] (19.37)	0.0420 (0.10)
PRIOR	0.7758[a] (103.58)	0.0684 (0.35)
SEX	-0.4406[a] (15.21)	0.0518 (0.07)
RACE	-0.6702[a] (25.73)	0.4376[a] (4.19)
TAX	-0.0545[a] (11.80)	0.0333 (2.01)
HOUSING	0.0001[a] (14.42)	-0.0000 (1.42)
EDUC	0.0004[a] (4.78)	-0.0003 (1.28)
TRANSPORT	0.0000 (0.96)	0.0000 (0.05)
CULTURE	0.0000 (3.24)	0.0000 (2.65)
RECREAT	-0.0002 (2.37)	0.0002 (0.83)
CLIMATE	0.0002 (0.29)	-0.0011 (3.12)

Table C-1 (Continued).

Variable	Impact on All Workers	Differential Impact on High Technology Workers
EMPGWTH	-0.0010 (0.10)	-0.0052 (1.13)
POP	-0.0003[a] (16.02)	-0.0000 (0.12)
POPSQR	0.0003 x 10^{-4}[a] (7.21)	0.0000 (1.29)

The log likelihood ratio test statistic (1373.78) is significant at the one percent level of significance. The null hypothesis that none of the explanatory variables help explain the variation in the dependent variable is rejected.

The t-statistic for each coefficient is given in parentheses.

[a]Statistically significant at the 5 percent level of significance.

VITA

Donald Lewis Johnson was born in Oak Ridge, Tennessee on October 16, 1958. He was graduated from Soddy-Daisy High School in June 1976. The following August he entered the University of Tennessee, Chattanooga, and in August 1979 he received a Bachelor of Science degree in Economics. In the fall of 1979, he accepted a research fellowship at the Oak Ridge National Laboratory and began study toward the Doctor of Philosophy degree at the University of Tennessee, Knoxville.

He received the Master of Arts degree in Economics in June 1983. In August 1983 he joined the faculty of Lee College in Cleveland, Tennessee. In March 1986 he received the Doctor of Philosophy degree with a major in Economics.

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