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MAINE AGRICULTURAL EXPERIMENT STATION
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TABLE OF CONTENTS

LIST OF TABLES

THE GROWTH AND CHANGE OF HIGH TECHNOLOGY INDUSTRIES IN THE STATE OF MAINE: IMPLICATIONS FOR STATE AND LOCAL DEVELOPMENT POLICY†

Dennis A. Watkins and Thomas G. Allen[1]

INTRODUCTION

An increasingly important component of the manufacturing base in New England consists of high technology industries. However, the degree of impact and the amount of economic vitality created in the region is, at best, extremely uneven. The largest portion of employment benefit has accrued to the southern New England States, namely Connecticut, Rhode Island, and Massachusetts. Although less than ten percent of New England's high technology employment is located in the northern New England States of Maine, New Hampshire and Vermont, there is increasing evidence to suggest that a fundamental change in the technological base of the region is occurring. The change may result in the diffusion of high technology innovation and employment benefit within the region. For example, Doody and Munzer, (1981); and Wyckoff and O'Connor, (1983) found that since 1975, the yearly growth rate of high technology industries in northern New England has averaged 65 percent compared with an average net change of 23 percent for the southern New England states.

A cursory examination of the Doody and Munzer data suggests that high technology industries have developed primarily in the more urbanized settings of southern New England. A significant movement toward northern New England has occurred only since 1975. Undoubtedly, southern New England,

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†This research was supported in part by funds provided by the Hatch Act and administered by the Maine Agricultural Experiment Station, University of Maine at Orono.

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with its highly urbanized centers, will continue as the focus for high technology innovation, yet indications are that the holding capacity of these centers may have been reached (Premus, 1982). The result is an outflow of new industry into the less populated but adjacent regions of New England, namely, the more northern states. New Hampshire, with the greatest percentage growth of high technology employment in New England from 1975 to 1979 and the highest ratio of high technology employment to total employment in 1979, might be considered a prime example of this outflow toward northern New England. The focus of this study was on the extent to which and under what conditions Maine has participated in and might continue to benefit from this development in high technology industries.

Knowledge of high technology growth patterns could be extremely helpful to the economic development profession. The current enthusiasm and popularity of high technology has created impressions of exaggerated benefit to local communities and claims of rapid growth opportunities for localities seeking an expanded tax base. In part, this study contributes to the growing body of high technology knowledge which should help an economic development professional make more realistic and sound decisions.

Issues in High Technology Research

Underpinning the current research in high technology are several issues, the resolution of which would lend considerable clarity to an understanding of the role of high technology in economic development. The most relevant issue is the lack of a precise definition of high technology. Variation exists among researchers and therefore results in faulty comparisons of one study to another. In fact, contradictory arguments about the impact of high technology are not uncommon. The second issue relates to the factor of job generation. Specifying the primary characteristics of firms known to have created significant numbers of new jobs has become the focus for research efforts. Thirdly, greater knowledge of the growth process and location needs of high technology is needed. Using previous research efforts and identifying the character-

istics of the more important job creating firms would significantl contribute toward describing any comparative advantage Maine might posses for promoting future growth of these industries.

Research Hypotheses

Recent studies of high technology industries in New England have underscored the importance which small, developing firms have played in the resurgence of the regional economy (Doody and Munzer, 1981; Hekman, 1980). Given these findings and Maine's location relative to the high technology growth area centered around Boston, Massachusetts, the following hypotheses have been developed concerning high technology industries in Maine:

1. The majority of high technology firms and high technology employment in Maine in 1970, 1976, and 1981 will be geographically located within the area defined as the corridor region.

2. At least fifty percent of all new high technology jobs generated in high technology industries in Maine during the periods 1970-1976, and 1976-1981 will be in independently owned firms.

3. Firms with twenty or fewer employees will generate at least fifty percent of all new jobs created in high technology industries in Maine between 1976 and 1981.

To shed light on the validity of these hypotheses, employment and production data were gathered for 110 firms including 20 three-digit SIC (Standard Industrial Classification) categories. The time periods covered were 1970, 1976, and 1981.[2] This data base was provided by the Bureau of Employment Security and the Bureau of Labor Standards of the Maine Department of Labor. The research was guided by the following questions:

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[2]The high technology industries are individually listed in the appendix.

- How are firms distributed among specific high technology industries and has this distribution changed over time?
- What is the geographic distribution of high technology firms within the state and how is this distribution changing?
- How dynamic have Maine's high technology industries been with respect to plant openings, closings, and acquisitions?
- How is employment generation distributed by size, age, SIC, and type of firm?
- Does Maine show a potential comparative advantage for specific high technology SIC's?
- What implications can be drawn from the Maine data for rural communities seeking high technology development?

Definition of High Technology Industries

The fact that "high technology" has come to be used in a very general way with applicability to almost any recent or emerging innovations that if adopted by a user would provide a range of benefits poses a problematic dilemma for the researcher. Although some general attributes have been suggested in defining high technology, a lack of clarity exists.

In attempting to develop clear criteria for defining high technology, Davis used data from the National Science Foundation (NSF) (Premus, 1982). This work resulted in the development of a measure based on the ratio of industry expenditures for research and development activities versus product sales. Those industries with a larger proportion of investment from sales into R & D were viewed as more representative of high technology. Although his focus was on manufacturing industries, Davis was able to identify ten NSF product classes as having higher R & D expenditure ratios.

Researchers Doody and Munzer (1981) at the Massachusetts Division of Employment Security compared the growth of high technology employment between Massachusetts and other selected states for the years 1975-1979. Included in the study were industries in a group of twenty 3-digit manufacturing SIC categories. These categories had been used during the previous five years by a variety of Massachusetts organizations. Doody and Munzer (1981) found that in general high technology industries produce high value-added products which compete in worldwide markets as contrasted to local or regional markets.

A third important study working toward a definition of high technology involved the types of occupations associated with each industry. Researchers at Northeastern Univeristy developed a set of criteria which included a requirement that to be considered as high technology, an industry must employ a minimum of 8 percent of its workforce as scientists, engineers, or technicians, and at least 5 percent in a more narrowly defined class of scientific and engineering occupations. Including both service and manufacturing industries, this definition encompasses thirty-two 3-digit SIC categories, of which, twenty are strictly manufacturing (Premus, 1982).

General overlap and agreement do appear in the studies cited above. The common characteristics of the industries are outlined by Premus (1982).

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

Using apparently subjective interpretations of these guidelines, Premus (1982) selected five 2-digit SIC categories as definitional

boundaries for including all high technology industries. All of the included industries are in the manufacturing sector.

Furthermore, in the studies of Doody and Munzer (1981) and Premus (1982) the final definition of high technology industries can be found in a list of 3 or 4-digit SIC categories. The SIC categories, because they represent a national standard, allow for comparison of consistent data over time from all states and/or regions. Adjusting only for SIC changes which took place in 1972 permits a valid comparison of data.

The listing of industries included for use in this particular study included the criteria of product innovations as distinguished from process innovations. High technology revolves around the discovery and development of substantially new products or new methods of producing existing products; however, important differences exist between the two. While product innovations involve the manufacture of products essentially new to the market place, process innovations may simply employ new products as inputs to the production process with little or no change in the finished good. In a study of industrial innovation, Abernathy and Utterback (1978) argued that the size of organization, its status in the evolution process, and the type of innovation with which it is most concerned are all necessarily related.

The issue of product versus process innovations takes on an additional meaning in Maine where 16 percent of the manufacturing workers in 1980 were employed in the pulp and paper industry. Although research and development represent a substantial amount of money invested by this industry and generally utilize state of the art equipment in its production process, the end product, paper, would not be considered a high technology product by most measures.

It is apparent that most definitions of high technology are influenced by a certain degree of subjectivity on the part of researchers. This study is no exception. By restricting the definition to those industries exhibiting product innovations, the selection is effectively

narrowed to the manufacturing sector. The decision was made to utilize the list of twenty 3-digit SIC categories as used by the Massachusetts Division of Employment Security. The emerging literature base in high technology indicates considerable agreement with the selected SIC's for this study (Premus, 1982). A complete list of SIC codes and Department of Commerce titles is included in the appendix.

Methodology

The Data Base. Data for this study of the high technology industries in Maine were provided by two bureaus within the Maine Department of Labor, the Bureau of Employment Security, Division of Research and Analysis and the Bureau of Labor Standards. The former maintains records on all private business establishments within the State subject to taxation under Maine unemployment compensation laws.[3] With an agreement of confidentiality, access to these data files was obtained making it possible to identify all firms in Maine which were officially classified under one of the designated 3-digit SIC categories for each of the study years. Information on each firm, obtained from the Bureau of Employment Security, consisted of its name and Maine address, 3-digit SIC classification, annual average employment levels in 1970, 1976, and 1981, liability date, chargeback date, predecessor employer ID (if any), successor employer ID (if any), and current employer ID. Explanation of these terms is provided in the appendix.

The Bureau of Labor Standards has as one of its responsibilities conducting an annual survey of manufacturing establishments within Maine. For the years 1970, 1976, and 1981 (1981 was the latest year for which a complete set of data had been received), additional information was made available under confidentiality restrictions similar to those established with the Bureau of Employment Security.

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[3]Liability under Maine law is established for any firm which (1) employed at least one person who has been paid $1,500 in any calendar quarter, or (2) employed one person for a twenty week period.

The Record of Observations. Data from both information sources were combined to produce a single observation on each firm covering all of the study years in which that firm appeared. These observations were then coded and entered onto computer files using facilities of the Computing and Processing Services Center at the University of Maine at Orono. Each observation is a record of a firm only during those periods when it operated within one of the designated high technology industries.

For purposes of organizing the data base, a distinction stems from differences encountered in the record keeping systems of the two sources of data.[4] Each observation contains information on the operations of separate firms. Should a firm undergo a change in ownership or corporate structure, a separate observation is produced containing the information for the new entity. This is distinct from the record of a single plant which may house several firms over the course of its lifetime. The ability to distinguish between a simple change in ownership which would appear as the death of one firm and the birth of another, and the actual birth or death of a firm is provided through the use of predecessor and successor identification numbers which indicate that an entity change, rather than a birth or death, occurred.

The resulting data base consists of 110 records, each containing information on a single firm covering the years 1970, 1976 and 1981.

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[4]The Bureau of Employment Security uses as its record-keeping basis the legal ownership of the firm. Hence, any change in corporate structure, merger, or sale results in the discontinuation of one identification number and file, and the start of a new identification number and file. The Bureau of Labor Standards, however, uses the existence of physical plant and machinery as its basis for record-keeping, without taking into account any change in the ownership of those facilities. As a result, the combination of these two data sources required an individual examination of each observation from the separate sources and several cross-references using location and predecessor and successor identification numbers prior to establishing a single combined observation for inclusion in the data base for this study.

Distributed over these three study years, information is available on 165 different observations. Obviously, there have been plants which may have operated continuously within a high technology industry over each of the years listed. Others may have changed ownership or SIC classification while still others may have begun or ceased operations during the period studied.

The terms "plant," "firm," and "establishment" are used interchangeably when referring to manufacturing operations. Data pertaining to the number of firms, their locations, and employment levels are complete for all three study years.

Data Limitations. The major limitations associated with utilizing the high technology data currently available were related primarily to the information collected from the Bureau of Labor Standards, referred to here as production data. Most limiting was the extent to which data were unavailable for some firms, particularly in the 1970 study period, and to a lesser extent, the 1976 study year. These missing data were the result of an action by the Bureau of Labor Standards to destroy records on all firms which ceased operation prior to 1976. Of the high technology firms which operated in 1970, production related data were no longer available on 51 per cent of the firms. For firms operating in 1976, the corresponding figure was 20 percent. For 1981, data were currently unavailable on a negligible 4.1 percent of the firms. An initial attempt to compensate for missing data on year to year comparisons used average per firm figures as opposed to raw industry totals. However, a closer examination of the data revealed that the occurrences of missing information were significantly skewed toward the smaller sized firms.

With respect to employment data from the Bureau of Employment Security, information related to annual average employment levels of high technology firms was complete for all firms in all study years. Comparable data were also available for general manufacturing in Maine, high technology, and general manufacturing nationwide.

High Technology Expansion Characteristics and Related Locational Needs

The location needs of high technology firms and the potential for their location in rural areas have produced much discussion but little agreement. Using traditional location theory with its focus on market, labor, and resource requirements has proven problematic when applied to the high technology industry. In fact, these industries are categorized for the most part as "foot loose." For example, transportation loses its importance as a key constraint in location of a plant because the products of many high technology operations are characterized by a very high value to weight ratio. Likewise, energy and natural resource bases are also viewed as non-deterministic inputs to the high technology manufacturing process (Hekman, 1980). In contrast with the market, labor and resource requirements, firms cited quality of life indicators as important to their location decisions. These included attitudes toward business, quality of school systems, cost of property, availability of people-oriented transportation systems, and cultural and recreational amenities.

Location Needs. The resulting profile of location requisites is one which appears surprisingly favorable to the development of rural areas. Offering large pools of trainable labor and the quality of life factors apparently favorable to high technology industries, rural areas in the Northeast stand poised to welcome the growth of high technology in their regions. The recent spread of high technology firms into the Pacific Northwest out of the Silicon Valley region of California is evidence to support this growth potential. Recent data indicate Oregon alone has become the site of over 600 computer and electronics companies (Batt, 1981).

Upon closer examination, the situation involving rural areas becomes obscured with contradictory findings. While high technology firms profess a definite inclination toward quality of life factors found in suburban and rural areas, the Premus (1982) study also revealed a stated preference

for urban settings. Although domestic rural areas may possess the capacity to provide adequate labor skills, particularly in regard to large assembly type operations, this factor immediately places them in direct competition with foreign countries offering considerably lower labor costs (Levin and Rumberger, 1983). Furthermore, studies by Blakely and Bradshaw (1979) have shown that when an industry locates in a rural area there have been few opportunities for local unemployed people, and skilled workers are often attracted from outside the area. Given the conflicting assessments of high technology's potential impacts in rural areas, additional insight and clarification can be gained by examining the expansion process of typical high technology industries and the operating characteristics of these industries as they progress from start-up to maturity.

By distinguishing between product life cycles and process life cycles it can be argued that the required inputs to a manufacturing process play a definitive role in the determination of a firm's location decision. The rationale is useful as a basis for examining the production characteristics of high technology firms as they develop over time, and as a means of assessing the ability of a rural region to foster and sustain high technology industries. Incentives which will attract firms in one evolutionary stage will not necessarily appeal to an enterprise at a different stage (Abernathy and Utterback, 1978; Bollinger, et al., 1983).

Typically, the young start-up firm is very small with only a few professionals and a makeshift factory in which the product is assembled by hand (Hekman, 1978). Production at this stage is restricted primarily to experimental models undergoing continuing development into a viable, marketable product. As discovered in the Premus (1982) survey, the proximity to larger universities, well respected in technological fields, is of major importance to high technology firms, particularly in the early stages of development. Among all high technology firms responding to the Premus survey, over 58 percent indicated that academic institutions played a significant role in their regional location decision. This attribute ranked fourth out of twelve location factors. "The attraction of high

technology companies to university based communities is no accident. Universities contribute significantly to advances in basic science that high technology companies crave" (Premus, 1982). The role of Maine's academic institutions and how they are perceived will be important in the state's ability to attract high technology firms in their early stages of growth.

The second stage of growth involves a rationalization process where developing high technology firms locate around existing establishments. At this stage, the firms benefit from a location which allows them to take advantage of a highly skilled labor force and specialized services. "They are not tempted to move to a region with lower taxes or labor costs because these specialized resources are not as available elsewhere" (Premus, 1982). The result is a continued clustering of high technology firms which in turn further perpetuates the agglomerative benefits provided by the major high technology centers in this country, including a greater access to venture capital.

Finally, the third stage in the production process life cycle is characterized as large scale with an emphasis on mass production of standardized products. The tendency is to suggest that location decisions at this stage shift to a greater reliance on more traditional factors such as water supplies, energy supplies, and unskilled labor. Results of the Premus survey, however, indicate that these factors received relatively lower ratings - particularly water and energy (Premus, 1982). Nevertheless, it is at this stage that the greatest amount of branching occurs, whereby manufacturing and assembly plants are established as entities separate from the corporate headquarters. Previous studies have shown that whether a branch operation is more likely to be located within the same region as the parent offices, or in another region, is a function of the specific industry under study (Hekman, 1980).

For example, Hekman's research has shown that in the case of the computer industry, as production evolves into large scale operations, firms are likely to establish branch manufacturing plants in locations

apart from the corporate headquarter facilities, although these separate plants in many cases are located within the same general geographic region of the country (i.e. New England, Midwest, Pacific, etc.). Also of value to a study of high technology's potential in rural areas is Hekman's finding that by far the greatest percentage of employees in the computer industry are located within multi-plant establishments which in 1979 accounted for over 93 percent of that industry's total nationwide employment. Furthermore, that "employment outside the nation's primary research and development centers should grow more rapidly in the future" (Hekman, 1980).

Based upon previous research on growth patterns and location factors it appears that, for the most part, the role of Maine's rural areas in the continuing development of these industries will be limited to providing potential sites for large, third stage operations (Premus, 1982). Should Maine begin to develop high technology industries at this mature growth level into a significant sector on its economy, a recently voiced concern would need to be addressed concerning the skill level of workers in these industries. Similar to other industries, as the assembly and manufacturing operation becomes more simplified and rationalized in the interest of efficiency, and the degree of mechanization increases, skill requirements of workers decrease sharply. If so, and if it is indeed warrantable that much high technology assembly requires no more than a primary education, then the "...danger from high tech is that it may facilitate the transfer of production overseas" as companies shift their production facilities to countries with considerably lower wage scales (Levin and Rumberger, 1983).

Job Generation

The increased foreign competition, the pace of technological innovation and the disorienting impact of periodic recessions on the labor force, have stimulated interest in the processes of job creation and job elimination. Perhaps the most influential researcher to study this

problem is Professor David Birch of the Massachusetts Institute of Technology. Traditionally, employment research based on the total aggregate number of persons employed and unemployment rates have relied on the changes in newly created and discontinued job opportunities. As input for the design of economic development policy, these data are viewed over time and broken down regionally by size classes, business sectors, and socio-economic characteristics. Birch (1979) has attempted to develop a means of better understanding the dynamics of individual firms as they interact within the overall economy. Birch maintains that individual firms, not some abstraction called "the economy," generate jobs, export products, and utilize natural resources. Through a firm's location decisions, settlement patterns are determined. Extrapolating from the Birch experience, it appears that a detailed examination of individual high technology firms would provide an increased understanding of high technology industry's ability to generate employment in the State of Maine. Moreover, insights would be generated about where high technology employment generation has taken place in the past and where it can reasonably be expected to occur in the future.

The emergence of high technology as a major growth sector in Maine is a relatively new phenomenon. Very little research has focused on the extent to which continued growth is likely to impact the educational, employment, or development policies of the state. Furthermore, little is known about what effect the state's socio-economic characteristics are likely to have on the future expansion of high technology. Much of the literature dedicated to theoretical or empirical research on the process of job generation and the nature and impacts of high technology development quite often deal in general terms with national or regional trends. The appearance of a new growth industry generates a heightened interest in the potential for increased numbers of new jobs. The sudden surge of a new industry can produce dramatic employment growth. For example, in Massachusetts, during a twenty-four month period between 1976 and 1978, the state's engineering and scientific instrument firms generated over 47,000 jobs (Bluestone and Bennett, 1982). Essential to understanding the

nature of such growth is to identify the sources of this job creation a the extent to which it replaces jobs lost during the same period.

Birch has identified six separate processes by which employment changes take place: births, expansions, in-migrations, deaths, contractions, and out-migrations. In his research, Birch (1979) found the birth and expansion of firms to be the principal force affecting the net creation of jobs. The net result upon an area's employment base due to the in-migration and out-migration of firms is virtually negligible. Also, the rate of job loss for any given geographic area appears quite stable over time, and varies little from place to place, generally ranging from 7 to 9 percent annually (Birch, 1979).

Although Birch's study relates to the overall U.S. economy, the methodology, with some refinements, could prove useful to an examination of the high technology industry in Maine. The need for reassessing Birch's work has been pointed out by Haworth (1979). Haworth noted that the data base used by Birch (1979) did not allow tracking the physical assets of a firm. For example, the sale or merger of an existing firm and its related production to another firm erroneously show the death of one firm and the respective loss of jobs, coupled with the birth or expansion of a new firm and its associated job creation. In reality, production and employment levels most likely remain unchanged. Using an improved version of the same Dun and Bradstreet data files used by Birch (1979), findings provided by the Brookings Institute show that small companies of 100 employees or less were responsible for a net creation of 37 percent of new jobs between 1978 and 1980. This finding is at substantial variance to Birch's results which found that small firms were responsible for approximately 66 percent of net new jobs between 1969 and 1976 (Levin and Rumberger, 1983).

Tracking Employment Generation in Maine's High Technology Industries

Accurately tracing the growth of new employment in Maine's high technology industries required addressing problems encountered in earlier studies of the job generation process. Particular attention was given to distinguishing between actual job creation or loss and acquisition and divestiture activity. As previously noted, this was a methodological problem which Birch was unable to resolve.

High technology firms chosen for inclusion in this study were defined by the SIC classification assigned to that operation for the year under study. The assignment of SIC classifications to manufacturing industries is performed by the Bureau of Employment Security and based on information provided by the Bureau of Labor Standards. Over time, firms may elect to change the complete manufacturing operation to the production of a new product. Also, in the case of a plant producing more than one product, the product mix, or volumes at which the various products are manufactured, may also change. In either instance, the product variation over time may be substantial enough to indicate a needed change in the firm's SIC categorization.

As the result of changes in a firm's SIC classification, it is possible for a firm to move in and out of stipulated high technology industries. Unnoted, such occurrences could give the appearance of the birth or death of a firm, similar to the problem produced by acquisition and divestiture activity over the time period involved in the study. Fortunately, the limited size of the high technology sector in Maine made it possible to examine each firm individually to determine whether it operated previously under a non-high technology classification prior to appearing in the study, or if in cases where a firm no longer appears in the study in later years it switched production to a non-high technology area.

By examining thoroughly the characteristics of individual firms throughout the entire data base and determining precisely and accurately

the job generation which had taken place, a framework was designed to conceptualize the information and facilitate analysis. A classification system was developed based on the origination and operation of the first included in the study between the years 1970 to 1976, and 1976 to 1980 The framework was composed of the following five categories.

1. New Plants (NP): These are actual new operations. They have a predecessor number which would indicate previous ownership or change in legal entity. They do not appear in a study yea earlier than the one under consideration, and the chargeback an liability dates (defined in the appendix) occur between th study year under consideration and the previous study year. Also, these firms do not appear previously in a different SIC category.

2. Closed Plants (CP): These are plants which have ceased operating. They do not have a successor ID number which would indicate acquisition by another firm, and do not appear in a subsequent study year under the SIC category under consideration or any other SIC category.

3. Continuous Operations (CO): Firms classified in this category are physical plants which operated continuously under any name or high technology SIC category during any two consecutive study years. Given the nature of the data base, these operations are defined in the following manner: Firms which have employment and an employer ID number under any one of the high technology SIC classifications in any two consecutive study years; or have a predecessor or successor ID number which relates to a firm having employment and an employer ID number under any one of the high technology SIC classifications in an immediately previous or subsequent study year.

4. New Continuous Operations (NC): This category refers to firms which were in operation during a previous study year or have a

predecessor number which shows employment in a previous study year, but not under any of the high technology SIC categories. Hence, the operation is "new" to high technology industries, but is not a newly started manufacturing operation.

5. Closed Continuous Operations (CC): The firms categorized as CC are firms which do not appear in any of the high technology industries in an immediately subsequent study year or have a successor number which relates to a firm with employment in a high technology industry in an immediate subsequent study year. These are firms which are still operating as a non-high technology firm in a subsequent study year or have a successor number which relates to a firm operating in a non-high technology SIC in a subsequent study year.

This classification method provided a balanced accounting of the tabulation procedures while still providing a more detailed analysis of the activity occurring within each SIC category. For example: using the number of high technology firms in 1970 as a base, plus the number of new plants (NP) which began operations between 1970 and 1976, plus the number of previously operating firms which moved into the high technology area between 1970 and 1976 (NC), less the plants which closed between those years (CP) less the plants which continue operating but moved out of high technology production (CC), yields the number of high technology firms operating in 1976. A similar method could be applied to employment figures by taking into account the net change in employment experienced by plants which operated continuously from 1970 to 1976.

PRESENTATION OF HIGH TECHNOLOGY DATA

A description of high technology industries in Maine and the dynamics of the job generation process in these industries since 1970 is the subject matter of this chapter. Guiding the analysis of these industries were the following questions:

- How are firms distributed among specific high technology industries and has this distribution changed over time?
- What is the geographic distribution of high technology firms within the state and how is this distribution changing?
- How dynamic have Maine's high technology industries been with respect to plant openings, closings, and acquisitions?
- How is employment generation distributed by size, age, SIC, and type of firm?
- Does Maine show a potential comparative advantage for specific high technology SIC's?
- What implications can be drawn from the Maine data for rural communities seeking high technology development?

The Growth and Distribution of High Technology in Maine

During the time period covered by this study the number of high technology plants and related employment in Maine experienced a continuous increase. In 1970, 39 plants with a total of 5,379 employees existed. This contrasts with 61 plants and 6,902 employees in 1976 and 65 plants with 10,688 employees in 1981. Over the eleven-year period from 1970 to 1981, the 98.3 percent increase in employment in high technology manufacturing sector compares with a 4.8 percent increase in employment in the general manufacturing sector of the Maine economy. It is notable that this amount of growth in employment was also more than double the growth of total non-farm wage employment in Maine during the period from 1970 to 1981.

With a higher than average amount of growth in employment, it is reasonable to assume that these high technology industries have also become a more important sector of the Maine economy. Relative to the total Maine manufacturing employment, high technology employment has grown

from 5.0 percent in 1970 to 9.4 percent in 1981. This represents 2.4 percent of total Maine employment in 1970 and 3.2 percent in 1981. Of the total U.S. employment in high technology, Maine represented 0.2 percent in 1970 with an increase to 0.3 percent in 1981.

When analyzed by size class the distribution of high technology firms and related employment show marked dissimilarity from the distributions exhibited by all manufacturing firms in Maine. Table 1 presents a comparison of the size distribution of the number of firms in Maine while Table 2 compares a distribution of the number of employees in 1981.

TABLE 1

PERCENT DISTRIBUTION OF ALL MANUFACTURING FIRMS AND HIGH TECHNOLOGY MANUFACTURING FIRMS, BY NUMBER OF EMPLOYEES, MAINE, 1981

Number of Employees	Total Maine Manufacturing	High Tech Manufacturing
0-49	82.1	46.2
50-249	13.0	30.8
250+	4.9	23.0
Total	100.0	100.0

(X^2 = 69.7, 2 d.f., sig. = 0.01)

Source: Maine Department of Employment Security. High Technology Employment in Maine and Selected States. Technical Services Monograph LMEP-10, July, 1981.

TABLE 2

PERCENT DISTRIBUTION OF ALL MANUFACTURING EMPLOYMENT AND HIGH TECHNOLOGY EMPLOYMENT BY NUMBER OF EMPLOYEES, MAINE, 1981

Size Class	Total Maine Manufacturing	High Tech Manufacturing
0-49	14.2	3.8
50-249	28.9	22.1
250+	56.9	74.1
Total	100.0	100.0

X2 = 1538.5, 2 d.f., sig. = 0.01)

Source: Maine Department of Employment Security. High Technology Employment in Maine and Selected States. Technical Services Monograph LMEP-10, July 1981.

The distribution pattern of firms and employment exhibited by the general manufacturing sector of the Maine economy is typical of national trends whereby the majority of firms appear in the smaller size category and diminish in number as firm size increases. Conversely, the greatest percentage of employment is represented by the largest firms while the more numerous, smaller firms are responsible for a decreasing share of total employment.

As seen in Tables 1 and 2, the high technology manufacturing industries in Maine deviated significantly from the general manufacturing sector, particularly in the size distribution of firms. On the employment side, the data appeared to indicate that high technology employment was more heavily weighted toward sizes larger than the norm. In both instances, the tendency for high technology firms to exhibit larger than average size characteristics became even more pronounced when compared to all businesses in Maine, as opposed to the general manufacturing sector alone.

An examination of these size distributions for the years 1970, 1976 and 1981 produced no significant pattern of change over time. The chi-square test of size distribution and time was not significant.

A general overview of the 3-digit SIC categories which make up the high technology industries indicated a lessening of the concentration of firms and employment among a few of the larger SIC's. In 1970, the largest SIC categories in terms of the number of firms in Maine with that classification comprised 56.5 percent of high technology firms that year. This percentage was reduced to 44.6 percent by 1981. Similarly, the 3 largest SIC's for employment in 1970 accounted for 78.4 percent of high technology employment. In 1981, this concentration had fallen to 61.5 percent. Table 3 illustrates this decline in concentration as well as a listing of the top 3 SIC categories in 1970 and 1981.

The rate of growth, in percentage terms, of high technology firms and employment should not be confused with the actual number of jobs produced by this sector of Maine's economy. Between 1970 and 1981 the 98 percent increase in high technology employment in Maine certainly far exceeded the 31 percent increase in similar employment nationwide. However, the actual number of jobs which made up this net increase was merely 5,289, or an average increase of only 480 jobs each year during that 11 year period. Overall, the Maine economy increased by an average of well over 10,000 jobs each year during the same period.

Even under the most optimistic conditions, national high technology employment is not expected to exceed 7 percent of all new job generation by 1990 (Levin and Rumberger, 1983). Currently, Maine's high technology employment stands at roughly 3.2 percent of total employment for the state, but more importantly, it was found that employment in this sector played an increasingly larger role in both manufacturing and total employment in each of the study years. A major question, however, is how much will the New England region differ in high technology employment growth relative to national trends and other regional trends? For example, Massachusetts' percent of high technology to total manufacturing

TABLE 3

THE THREE LARGEST HIGH TECHNOLOGY INDUSTRIES, MEASURED BY NUMBER OF FIRMS AND BY BY NUMBER OF EMPLOYEES AND PERCENT OF ALL SUCH INDUSTRIES, MAINE, 1970 AND 1981

1970				1981			
Number of Firms		Number of Employees		Number of Firms		Number of Employees	
SIC Code	Percent of All Firms	SIC Code	Percent of All Employees	SIC Code	Percent of All Firms	SIC Code	Percent of All Employees
367	30.8	367	57.6	367	27.7	367	41.6
366	15.4	366	11.4	381	9.2	361	12.3
382	10.3	364	9.4	366	7.7	348	7.6
Total	56.5	Total	78.4	Total	44.6	Total	61.5

Source: Maine Department of Employment Security. High Technology Employment in Maine and Selected States. Technical Services Monograph LMEP-10, July, 1981.

is the highest ratio in the nation. Will Maine be able to close this gap and receive a larger proportion of high technology employment in New England?

Regional Growth of High Technology Within Maine

It was anticipated from the literature and previous studies of high technology industry locations that the corridor region along Interstate-95 from Kittery to Bangor would contain the greatest concentration of these firms in the state. If it is indeed warrantable that areas near and around the Rte. 128 high technology center in Boston, Massachusetts can expect increased high technology growth due to a diffusion from the Rte. 128 area as that center begins to approach its holding capacity (Batt, 1981), then it is logical that Maine's share of this diffusion would be greatest in the southern area closest to Boston and diminish as one moved northward along the state's primary transportation route away from Boston. Furthermore, high technology firms responding to the Premus (1982) survey indicated a bias toward locating in urban areas. The data assembled for the present study support these contentions.

Table 4 presents the proportions of the various aspects of high technology industries described by region in 1981. The corridor region accounted for 82.1 percent, 85.2 percent, and 81.5 percent of the state's high technology firms in 1970, 1976, and 1981 respectively. Also, this region accounted for 86.4 percent, 89.2 percent, and 88.3 percent of the state's high technology employment in those same study years.

The regional findings depicted in Table 4 obviously present significant implications concerning the likelihood of high technology industries providing a substantial source of employment and economic growth in rural areas. Although rural regions within the state have experienced some increase in the number of high technology plants and employment, the actual numbers involved are quite small. More importantly, high technology manufacturing employment makes up a much smaller percentage of total manufacturing employment in rural regions than it does in the urban Corridor, as shown in Table 5.

TABLE 4

GEOGRAPHICAL DISTRIBUTION OF HIGH TECHNOLOGY FIRMS AND RELATED VARIABLES, MAINE, 1981

Region	Percent of Total High Technology				
	Firms	Emps.	Value of product	Capital expenditures	Exports
Corridor	81.5	88.3	91.1	92.8	75.7
All Others*	18.5	11.7	8.9	7.2	24.3
Total	100.0	100.0	100.0	100.0	100.0

*Confidentiality restrictions prohibit a further breakdown of these data by region.

Source: Data obtained from the computerized data files of the Maine Department of labor.

TABLE 5

HIGH TECHNOLOGY EMPLOYMENT AS A PERCENT OF ALL MANUFACTURING EMPLOYMENT, BY LOCATION, MAINE, 1970, 1976, 1981

Year	Urban	Rural
1970	6.1	2.0
1976	9.2	2.1
1981	13.3	3.5

Source: Maine Department of Employment Security. High Technology Employment in Maine and Selected States. Technical Services Monograph LMEP-10, July, 1981.

Furthermore, the fact that the Corridor Region maintained its large share of high technology activity since 1970 would seem to indicate that rural areas have yet to exhibit a distinct ability to provide the locational incentives necessary to attract a significant number of high technology firms to the State of Maine.

In discussions concerning Maine's business and economic characteristics the argument has been made that there exist two rather distinct areas within the state: the urbanized, more rapidly expanding corridor region, and the more rural areas throughout the remainder of the state. For reasons cited earlier, an analysis of production related data for the 1970 and 1976 periods would prove misleading due to the extent of missing data. This limitation required that any examination of such variables as value of product, age, multi-plant status, investment in plant and equipment, and import/export data be restricted primarily to the 1981 study year, for which data were complete for both high technology and all manufacturing firms in Maine.

Given this limitation, a comparison of the average value of production per firm between high technology manufacturing firms and all manufacturing firms in the state showed that high technology firms averaged almost three times the value of product as did the general manufacturing firms in Maine: $10,281,700 versus $3,493,800. Upon closer examination it was found that the average value of production per employee was actually greater for the general manufacturing sector than it was for high technology industries. Such a situation could be explained as being due to greater average employment in high technology industries, and in fact it was found that in 1981 high technology firms averaged 164 employess per plant while the general manufacturing firm averaged 47 employees per firm.

As shown in Table 6 high technology plants in urban areas produced at a higher average rate per employee than did plants in rural settings Interestingly, the reverse situation was true for all plants in the general manufacturing sector. Also notable is the fact that in both regional categories and the state as a whole, the general manufacturing

TABLE 6

AVERAGE VALUE OF PRODUCT PER EMPLOYEE, MAINE, 1981

Manufacturing Sector	Rural	Urban
	($000's)	
High technology	47.4	64.7
General	87.6	67.3

Source: Maine State Planning Office. The Economy: A Forecast to 1990.

sector showed greater average rates of production per employee. The data contained in this table may hypothetically indicate several things: First, that from the perspective of the urban/rural interaction, high technology plants have distinctly different production characteristics than manufacturing firms as a whole. Second, given previous studies which have shown an inverse relationship between the labor intensity (versus machine automation) of a production process and the amount of product produced per unit of labor, the data would seem to indicate that high technology plants in rural settings are more labor intensive than those in urban, while the opposite is true for plants in the general manufacturing sector.

Expanding further, specifically in the case of high technology industries, recent theories have suggested various stages of growth involving specific locational and labor needs (Abernathy and Utterback, 1978; Hekman, 1978). The proposed theories have suggested that these firms in their early stages have strong ties to urban areas which provide larger pools of professional research and support services, as well as professional and trained labor. It is only in the later stages when the production process, and the product itself, have been refined and ratio-utilized to the point that it can be instituted on a large scale that the plant becomes more independent of its urban ties and, as a primarily

footloose firm by its nature, is able to locate in less congested areas and be able to take advantage of lesser trained labor pools. Growth theories such as these would explain the higher labor intensity of high technology firms in rural areas, which is further substantiated in Table 7.

Table 7, which presents the average investment in plant and equipment per employee by firms in Maine, is perhaps a better indicator of the labor intensity of the production processes of these firms. The data in this table further support the contention that high technology firms in Maine tend to be more labor intensive in rural settings.

TABLE 7

AVERAGE INVESTMENT IN PLANT AND EQUIPMENT PER EMPLOYEE

Manufacturing Sector	Rural	Urban
	($000's)	
High technology	2.8	4.8
General	11.5	3.0

Source: Maine State Planning Office. The Maine Economy: A Forecast to 1990.

While data in Table 7 are also provided for firms in the general manufacturing sector, it is for informational purposes only and no attempt is made to use it to support similar growth theories, or as the data suggest, an opposing growth theory. This should be evident as the growth theories proposed for high technology industries assume the condition that large-scale manufacturing plants of this category are footloose in their locational needs, while no single locational typology can be assigned to the overall manufacturing sector even as a general statement.

The Dynamics of High Technology Industries in Maine and the Job Generation Process

One of the more important goals of this study was to examine the level of activity in high technology industries, especially in relation to the creation of new jobs and the loss of employment opportunities. Similarly, (Birch, 1979) raised two fundamental questions on job generation in the national economy: First, what type of firm is expanding; and second, what type of firm is associated with the generation of new jobs? Birch's studies found that the answer to both questions was small, independent firms. Specifically, in the Northeast 67 percent of manufacturing jobs created between 1974 and 1976 were in firms 0-4 years old, predominantly independent, and with twenty or fewer employees.

These findings and those of Hekmen (1978) have led to the suggestion that a successful economic development policy for the United States would be targeted to assisting the start-up of small, independently owned, technology oriented firms. These policies must take into account the managerial requisites. This study made no attempt to examine these aspects of promoting high technology firm growth, but instead analyzed the characteristics of the emerging high technology sector in Maine as a means of providing insight into the appropriateness of a policy advocating a concentration of development efforts on small, independent firms.

Employment Changes Between 1970-1976, and 1976-1981

Using the previously defined classification system, Table 8 shows that although there was a greater degree of activity in terms of plant start-ups and plant closings between 1970-1976 than during the 1976-1981 period, the latter time frame was one during which a greater number of jobs was created and fewer jobs were lost. This can be attributed to the fact that during the 1970-1976 period an average of 33.8 jobs was created per high technology business start-up. New high technology enterprises started between 1976 and 1981 employed by contrast an average of 84.4 employees. Likewise, displaced employment due to plant closures decreased

TABLE 8

ACTIVITY LEVELS IN THE HIGH-TECHNOLOGY INDUSTRIES, 1970-1976, AND 1976-1981, TOTAL EMPLOYMENT

Time period	New plants	Employees	Closed plants	Employees	Continued operation	Employees	New continued operation	Employees	Closed continued operation	Employees
1970-1976	32	1,083	11	470	23	+ 100	6	55	5	55
1976-1981	19	1,604	7	280	40	+2,194	6	437	14	189

slightly from an average of 42.7 jobs lost per plant to 40.0 average lost jobs per closed down plant.

The number of plants which operated continuously within the high technology sector between 1976 and 1981 was considerably greater than those which operated continuously during the earlier period. The net increase in employment resulting from these continuous operations was also significantly greater in the later period. From 1970 to 1976 the result of expansion and contraction among these firms produced a net gain of 100 additional jobs. During the later period from 1976 to 1981, the net change in employment increased considerably to a gain of 2,194 new jobs. The specific number of firms and jobs associated with expanded or contracted firms during these two time periods is provided in Table 9.

TABLE 9

EMPLOYMENT CHANGES DUE TO PLANT EXPANSIONS AND CONTRACTIONS IN HIGH TECHNOLOGY INDUSTRIES IN MAINE: 1970-1976 AND 1976-1981*

Time Period	Expansions			Contractions		
	Plants	New Jobs	Average	Plants	Lost Jobs	Average
1970-1976	13	926	71.2	9	826	91.8
1976-1981	29	2,354	172.9	5	160	32.0

*Figures are for plants which operated continuously within any high technology SIC during the time period specified.

As indicated in Table 9 the later period was one during which there were not only many more plants which expanded and fewer contracted, but the employment gain as a result of an expanded work force was larger during the 1976-1981 period. Moreover, the 1976-1981 period averaged almost 173 more employees due to expansion versus an average increase of 71 employees per expanded plant during 1970-1976. Conversely, the number of jobs lost due to reduced operations among high technology plants which operated continuously during the study years was less during the later period in both absolute and average figures.

Six firms moved into or out of the high technology industries during both periods under study. The six firms in the earlier period averaged nearly double the number of employees per firm (144) than did those in the 1976-1981 period (73).

The 1976-1981 period was characterized by larger new firms, smaller closed firms, and more numerous continuously operated firms (which produced a greater net gain in high technology employment) than the 1970-1976 period. These industries are becoming increasingly characterized by larger, more stable firms. Further evidence of this phenomenon and a detailed analysis of the characteristics of these high technology firms in Maine are provided in the next sub-section.

Plant Characteristics and the Job Generation Process

Previous studies of the national economy found that independently owned firms are responsible for the major share of job creation in the U.S. Tables 10 and 11 illustrate a different situation within the high technology industries in Maine. For reasons of confidentiality, it was necessary to combine several more detailed categories within these tables. The non-independent category was originally comprised of three separate columns which classify a plant as the parent headquarters, operating division, or separate subsidiary of a multi-plant corporation.

TABLE 10

HIGH TECHNOLOGY EMPLOYMENT GROWTH BY TYPE OF FIRM AND TYPE OF ACTIVITY, MAINE, 1970-1976
(in percent)

Type of Activity	Total Employment Gain By: Independent	Non-Independent	Row Total
New Plant	13.3	24.4	37.7
New Continued	0.2	29.9	30.1
Continuous Operations	2.1	30.1	32.2
Total	15.5	84.5	100.0

TABLE 11

HIGH TECHNOLOGY EMPLOYMENT GROWTH BY TYPE OF FIRM AND TYPE OF ACTIVITY, MAINE, 1976-1981
(in percent)

Type of Activity	Total Employment Gain By: Independent	Non-Independent	Row Total
New Plant	10.4	26.1	36.5
New Continued	0.8	9.2	9.9
Continuous Operation	3.0	50.6	53.6
Total	14.1	85.9	100.0

As indicated in Tables 10 and 11, approximately 85 percent of all new jobs created during each period was associated with plants which operated as part of a multi-plant corporation. These findings are in direct contrast to those of previous studies of job generation within the national economy which showed that a predominant source of new jobs was provided by independent, free-standing enterprises. Clearly, this information fails to support the hypothesis that over 50 percent of job creation within the high technology industries in Maine during 1970 to 1981 was attributed to activity within independently owned high technology firms.

Table 12 presents the percentage distribution of all new jobs created in the high technology industries in Maine between 1976 and 1981 by size and age of firm. As a precise measure of new jobs only, this table reflects only those new jobs created as the result of a new plant start-up, or the expansion of an existing high technology plant. The inclusion of high technology jobs associated with plants which simply moved into the high technology arena during the study period had no significant effect on these relationships. The findings presented here show a definite trend in favor of the larger sized firms. In fact, while Birch's study of the national economy reported that approximately two-thirds of all new jobs were generated by firms employing less than 20 people, the figures in Table 12 show that firms employing up to 250 workers generated just slightly more than 25 percent of new jobs in these industries. The impact of age, although less clearly evident than size, appears to be in favor of older firms. As the age category increases from 0-5 years, to 6-10 years, to 10 years or older, the distribution of jobs generated changes from 30.9 percent, to 20.8 percent, to 48.3 percent, respectively. These findings fail to provide support for the hypothesis which favored small, independently owned operations.

TABLE 12

PERCENTAGE DISTRIBUTION OF NEW JOBS IN HIGH TECHNOLOGY INDUSTRIES IN MAINE BETWEEN 1976 AND 1981 BY SIZE AND AGE OF FIRM

Size of Firm (Jobs)	Age of Firm (years)			
	0-5	6-10	10+	Total
0-9	0.5	0.2	0.0	0.7
10-49	4.9	1.1	0.0	6.0
40-49	12.0	3.5	4.0	19.5
250+	13.5	15.9	44.3	73.8
Total	30.9	20.8	48.3	100.0

Table 13 shows the relationship between type of operation and the size of the firms in Maine in high technology. As seen in this table multiplant operations were significantly larger than their single plant counterparts. (Additional findings also showed that multi-plant firms in Maine produced a significantly higher value of product (chi-square = 10.4, 2 dif., sig. = 0.01) and exhibited a significantly higher level of capital expenditures (chi-square = 27.0, 2 dif., sig. = 0.01) than single plant manufacturers. Interestingly, the likelihood that manufacturers might utilize export markets as an outlet for their products had no significant relationship to its corporate affiliations.

TABLE 13

FIRM EMPLOYMENT SIZE VERSUS THE OCCURRENCE OF MULTI-PLANT OPERATIONS IN HIGH TECHNOLOGY INDUSTRIES, 64 CASES, MAINE, 1981
(in percent)

	Type of Operation	
Firm Size	Single-Plant	Multi-Plant
0-19	69	6
20-99	21	34
Over 100	10	60
Total	100	100

(chi-square = 29.9, 1 d.f., sig. = 0.01).

POLICY IMPLICATIONS FOR STATE OF MAINE

Some Fundamental Policy Issues

Despite the growing attention and resource commitment given to economic development throughout the United States, there is fundamental disagreement about the efficacy of government's role in this process. The pivotal issue appears to be the extent and nature of involvement. At a national level there are those who argue for a national industrial policy where troubled industries can be rescued and growth industries accelerated. In contrast to government intervention with direct aid to specific industries or regions are "supply-side" policies designed to encourage faster growth through increases in private investment driven by tax cuts and reduced regulation. Many difficult questions remain unanswered: is a market oriented strategy sufficient in the international marketplace? Can government policies identify emerging "winners" targeted as cutting edge

industries? If the pace of innovation is accelerated, how can dislocated workers, caught in the middle, find employment? Debated solutions to date have included some form of "protectionism" and/or quota restrictions, tax and trade initiatives and relaxation of antitrust restrictions with little indication of an emergent industrial policy (Wachter and Wachter, 1981).

A third position has emerged, a kind of middle-ground, that essentially avoids the many difficult political issues associated with specific recommendations and concentrates on points of possible agreement. This includes support for basic research, more spending for science and engineering education and measures designed to allow high technology entrepreneurs to tap new sources of capital through modest changes in current pension fund investment rules (Bluestone and Harrison, 1982).

At a subnational geographic level, state and local governments are searching for some workable combination of labor, tax structure, public infrastructure and venture capital that will distinguish their region as attractive for economic development. But the fundamental question remains: Beyond the creation of a favorable business climate, how active a role can states and localities play in economic development? There are those who argue that even if the difference is marginal - e.g., 1 percent a year in additional growth - the effort is worth it. On the other hand there are those who do not place much faith in state and local development policies - a role limited to facilitation of a limited number of minor events. Within this view, the most significant factors influencing economic activity are broad national economic and demographic trends. Can an industrial policy cushion a region against reversals? Can an industrial policy lift a rural locality or region out of a declining or stagnated environment? Although there is sufficient evidence to suggest that formal policies do make an impact in settings experiencing fundamental structural change in their economies, the question of "the extent of government involvement" is still an unresolved issue (Wachter and Wachter, 1981).

A recent MIT study has noted that there are few common requisites that lead to high technology development when multiple geographic regions

are compared (Bollinger, et al., 1983). Thus there may be many different combinations of prerequisites that lead to high technology growth. It may well be necessary to determine carefully the unique or idiosyncratic factors in a region that lead to a distinctive comparative advantage. Local and state assistance in this process may be their greatest contribution to policy development for a region.

Implications of Study Findings for a High Technology Strategy for Maine

The following policy implications appear to flow from the present study:

1. There appear to be two distinct regions in the State of Maine. One, a rural region with little high technology activity and an "urban" region with virtually 80 percent of the high technology growth. Maine should have a technology strategy with sufficient detail to address the distinct needs of these two regions. Perhaps the distinction between process and product could provide some insight. The rural regions, with more mature industries in food processing and paper, could apply new process technologies to increase productivity and competiveness while the urban areas would continue to expand new high technology products.

2. The finding that large out of state firms account for the majority of employment generation in high technology sectors certainly has implications for state venture capital policies. These firms with ample resources at their own disposal should not require capital inducements from state development agencies. Based on the strength of numerous studies indicating the need for venture capital availability, several states have initiated steps to increase the scope and visibility of publicly operated or publicly subsidized capital financing mechanisms (Maine Development Foundation, 1984). The data presented above clearly show that job creation in high technology industries in Maine is dominated by nonindependent plants. Given the financial resources of multi-plant corporations, (over 90 percent of which have headquarters outside the

State of Maine) it is questionable that the availability of start-up capital within Maine would play a major role in their location and expansion decisions. Conversely, the data can also be used to support the argument that perhaps the low degree of growth and activity within independently owned firms in Maine is an indication of the need for improved financing programs in this state.

It was hypothesized at the outset of this study that, based on the literature associated with technology-related industries and other studies on the job generation process, the majority of new jobs created within the high technology industries in Maine between 1976 and 1981 would be in smaller sized firms employing twenty people or less. Although no specific hypothesis was stated concerning the age of firms as it relates to job generation, many of the prior studies which showed the importance of small, independently owned firms also alluded to the notion that most of the job generation occurred within young firms. The failure to confirm these hypotheses in the present study appears to be sufficient justification to begin a preliminary re-examination of present development policies in the State of Maine.

3. Maine's comparative advantage has yet to be identified. Although this study has isolated SIC 367, electronic components and accessories, as a solidifying area of activity in the state, some major applied economic analysis must be done before conclusions can be reached. A careful analysis of backward and forward linkages of industries in this SIC could very well identify potential inter-industry growth. Estimated impacts of this growth on the Maine economy might be a logical next step.

4. The data presented here show that the prime creators of high technology jobs in Maine in recent years were the larger, older, plants which operated as part of a multi-plant corporation. In light of the finding that most job creation was associated with multi-plant operations it is not surprising that job generation in these industries was also more evident in larger firms. Moreover, multi-plant firms in most cases had higher levels of employment, product, and capital investments than single-

plant firms. In regards to export activity, however, neither single-plant nor multi-plant operations showed a significantly greater tendency to export than the other. Generally, high technology firms with larger employment levels were found to produce a higher volume of product and invest more in plant and equipment. Finally, it is important to note that 54 percent of the firms and 90 percent of the employment in 1981 were part of multi-plant corporations, a point which could be taken to indicate that much of the high technology activity in Maine is of the large scale, mature industry type. If such is the case, then Maine policy makers must be wary of the pitfalls associated with an over emphasis on encouraging or relying upon the development of a mature industry which counts lower wage scales as a major input to its location decision. Maine's past experience with the leather and shoe industry is a prime example of an industry's ability to move production facilities to even lower-wage, overseas locations.

5. An important aspect of this research has been the assessment of high technology industries as providers of future economic growth in rural areas. Arguments which can be put forth that Maine as a whole is rural not-withstanding, it would appear that high technology firms continue to show a definite bias toward locating in the more urbanized southern and corridor regions of the state. If, as has been postulated, (Batt, 1981) the Route 128 area is reaching its high tech holding capacity and such firms are being forced to spread into neighboring states, then Maine can expect continued growth of this kind in the corridor region, but may not experience significant increases in its rural areas.

If the rural areas in Maine are to experience any future increase in high technology employment and activity it would in most probability be of the type associated with large-scale manufacturing facilities involving little research and development activity. Much of the literature and several recent studies of the locational needs of high-tech industries have reported the desirability of locating within a region served by one or more universities with well established research facilities. Such

locational preferences, however, are generally of greater concern for younger, developing industries. Several growth stage theories related to high technology firms have suggested that firms at later stages, when the production process begins to assume greater scales of economy, behave more like traditional footloose industries. It is at these later, labor intensive stages that rural areas may possess the ability to attract high technology firms.

On the basis of a single study it would be presumptious to detail a high technology strategy for the State of Maine; nevertheless, several observations appear warrantable: the State of Maine should consider at the highest priority an effort to articulate the state's unique comparative advantage in high technology in both the short and long run. This review should encompass the fundamental structural differences in the economy between the northern and southern portions of the state and secondly, an estimate of the political resolve necessary to implement a high technology strategy.

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APPENDIX A

DEFINITIONS OF TERMS USED IN THIS REPORT

A. Names and addresses: refers to the business name and Maine address of the high-technology plant in question.

B. 3-digit SIC classification: refers to the 3-digit Standard Industrial Classification codes which have been designated as high-technology industries for purposes of this study. Firms in Maine are classified into one or more 4-digit codes by the Department of Employment Security according to their products or service.

C. Liability date: date on which the firm was found to be liable for unemployment compensation tax. Liability is established for any firm which (1) at least one employee who has been paid $1,500 in any quarter, (2) or one person employed for a 20-week period.

D. Chargeback date: The date which the Maine Bureau of Employment Security records as a firm's initial liability date, irregardless of subsequent changes in the operation's employer ID number.

E. Current employer ID: the State of Maine Bureau of Employment Security ID number assigned to the firm at the time it is being examined.

F. Predecessor ID: the state ID number which the firm had prior to its current one.

G. Successor ID: the new state ID number given to a firm following its current ID for reasons of an acquisition or change in corporate status.

APPENDIX A (continued)

II. ECONOMIC REGIONS

A. Corridor region: York, Cumberland, Androscoggin, Kennebec, Sagadahoc, and Penobscot Counties

B. Eastern region: Lincoln, Knox, Waldo, Hancock, and Washington Counties

C. Western region: Oxford, Franklin, Somerset, and Piscataquis Counties

D. Northern region: Aroostook County

III. THREE-DIGIT HIGH-TECHNOLOGY INDUSTRIES

203 drugs
348 ordinance and accessories, except vehicles and guided missiles
357 office, computing, and accounting machines
361 electric transmission and distribution equipment
362 motors and generators
363 household appliances
364 electric lighting and wiring equipment
365 radio and television receiving equipment, except communication types
366 communication equipment
367 electronic components and accessories
369 miscellaneous electrical machinery, equipment, and supplies
376 guided missiles and space vehicles and parts
379 miscellaneous transportation equipment
381 engineering, laboratory, scientific, and research instruments and associated equipment

APPENDIX B-1

High Technology Employment Loss by Type of Firm and Type of Activity, Maine, 1970-1976
(in percent)

Type of Activity	Independent	Non-Independent	Row Total
Closed Plant	13.5	21.2	34.8
Closed Continued	4.1	--	4.1
Continuous Operation	23.2	38.0	61.1
Total	40.8	59.2	100.0

High Technology Employment Loss by Type of Firm and Type of Activity, Maine, 1976-1981
(in percent)

Type of Activity	Independent	Non-Independent	Row Total
Closed Plant	2.5	42.0	44.6
Closed Continued	14.1	15.9	30.0
Continuous Operation	4.5	21.0	25.4
Total	21.1	78.9	100.0

APPENDIX B-2

Measures of Operating Characteristics of High-Technology Firms by Industry Activity, and by Firm Size (Totals), Maine, 1970, 1976, 1981

Type of Activity	No. of Plants	No. of Employees	Value of Product ($000's)	Equipment Purchases ($000's)	1982 Projected Equipment Purchases ($000's)	1983 Projected Equipment Purchases ($000's)	Imports ($000's)	Exports ($000's)
				- 1970 -				
1970-1976								
CO	23	4,854	93,370	2,535				14,560
CC	5	55	286	3				9
CP	11	470	--	--				--
				- 1976 -				
NP	32	1,083	38,790	710			250	941
NC	6	865	46,567	1,310			1,002	1,041
CO	23	4,954	165,859	4,924			12,360	33,094
1976-1981								
CO	40	6,433	241,672	6,879			12,435	34,674
CC	14	189	2,179	47			227	402
CP	7	280	7,365	18			950	--
				- 1981 -				
NP	19	1,604	98,102	3,826	6,051	6,278	25	595
NC	6	437	20,980	338	730	403	27	1,018
CO	40	8,627	549,227	31,534	34,778	68,096	17,275	82,938

CO (Continuous Operations)
CC (Closed Continuous Operations)
CP (Closed Plants)
NP (New Plants)
NC (New Continuous Operations)

Measures of Operating Characteristics of High Technology Firms by Number of Employees, and by Firm Size (Totals), Maine, 1970, 1976, 1981

Employment Size Category	No. of Plants	No. of Employees	Value of Product ($000's)	Equipment Purchases ($000's)	1982 Projected Equipment Purchases ($000's)	1983 Projected Equipment Purchases ($000's)	Imports ($000's)	Exports ($000's)
				- 1970 -				
0-9	15	55	97	--				--
10-49	5	121	862	31				13
50-250	13	1,787	25,041	338				2,886
Over 250	6	3,416	67,656	2,169				11,670
Total	39	5,379	93,656	2,538				14,569
				- 1976 -				
0-9	26	94	1,278	19			--	18
10-49	9	215	4,791	43			60	1,088
50-250	20	3,057	121,507	4,330			7,121	13,903
Over 250	6	3,536	123,640	2,552			6,431	20,067
Total	61	6,902	251,216	6,944			13,612	35,076
				- 1981 -				
0-9	17	69	2,216	33	9	9	2	78
10-49	13	341	14,469	914	166	112	25	1,228
50-250	20	2,356	104,973	3,531	4,028	4,197	756	6,499
Over 250	15	7,902	546,651	31,220	37,356	70,459	16,544	76,746
Total	65	10,668	668,309	35,698	41,559	74,777	17,327	84,551

APPENDIX B-4

Measures of Operating Characteristics of High-Technology Firms by Industry Activity, and by Firm Size (Averages), Maine, 1970, 1976, 1981

Type of Activity	No. of Plants	No. of Employees	Value of Product ($000's)	Equipment Purchases ($000's)	1982 Projected Equipment Purchases ($000's)	1983 Projected Equipment Purchases ($000's)	Imports ($000's)	Exports ($000's)
				- 1970 -				
1970-1976								
CO	23	211.0	5,187.2	140.8				808.9
CC	5	11.0	286.0	3.0				9.0
CP	11	42.7	--	--				--
				- 1976 -				
NP	32	33.8	1,551.6	28.4			10.0	37.6
NC	6	144.2	9,313.4	262.0			200.4	208.2
CO	23	215.4	8,729.4	259.2			650.5	1,741.8
1976-1981								
CO	40	160.8	6,196.7	176.4			318.8	889.1
CC	14	13.5	272.4	5.9			28.4	50.2
CP	7	40.0	3,682.5	9.0			475.0	--
				- 1981 -				
NP	19	84.4	6,131.4	239.1	378.2	392.4	1.6	37.2
NC	6	72.8	3,496.7	56.3	121.7	67.2	5.4	203.6
CO	40	215.7	13,730.7	788.4	869.4	1,702.4	431.9	2,073.4

CO (Continuous Operations)
CC (Closed Continuous Operations)
CP (Closed Plants)
NP (New Plants)
NC (New Continuous Operations)

APPRENDIX B-5

Measures of Operating Characteristics of High Technology Firms by Number of Employees, and by Firm Size (Averages), Maine, 1970, 1976, 1981

Employment Size Category	No. of Plants	No. of Employees	Value of Product ($000's)	Equipment Purchases ($000's)	1982 Projected Equipment Purchases ($000's)	1983 Projected Equipment Purchases ($000's)	Imports ($000's)	Exports ($000's)
				- 1970 -				
0-9	15	3.7	48.5	--				--
10-49	5	24.2	287.3	10.3				4.3
50-250	13	137.5	2,782.3	37.5				320.7
Over 250	6	569.3	13,531.2	433.8				2,334.0
Total	39	137.9	4,929.3	133.6				766.8
				- 1976 -				
0-9	26	3.6	79.9	1.2			--	1.1
10-49	9	23.9	598.0	5.4			7.5	136.0
50-250	20	152.9	6,075.3	216.5			356.1	695.2
Over 250	6	589.3	24,728.0	510.4			1,286.2	4,013.4
Total	61	113.2	5,126.9	141.7			277.8	715.8
				- 1981 -				
0-9	17	4.1	158.3	2.4	0.6	0.6	0.1	5.6
10-49	13	26.2	1,113.0	70.3	12.8	8.6	1.9	94.5
50-250	20	117.8	5,248.6	176.5	201.4	209.9	37.8	324.9
Over 250	15	526.8	36,443.4	2,081.3	2,490.4	4,697.3	1,181.7	5,481.9
Total	65	164.1	10,779.2	575.8	670.3	1,206.1	284.0	1,386.1