THE METALWORKING MACHINERY INDUSTRY IN NEW ENGLAND:

AN ANALYSIS OF INVESTMENT BEHAVIOR

by

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ABSTRACT

This thesis is a case study of the metalworking machinery industry in the New England region. The major purpose of the analysis is to determine what factors influence the health of firms in this industry, and how firms in New England fare, relative to those in other parts of the country. The thesis is based on information gathered in interviews of a sample of metalworking machinery firms in the region. To the extent possible, secondary data sources were utilized to substantiate the opinions expressed in the interviews.

The thesis is organized into five chapters. The first chapter presents a description of the metalworking machinery industry, the methodology of the analysis, and the organization of the study. Chapter Two is a brief history of the industry. Important characteristics of the metalworking machinery industry are examined in Chapter Three, with emphasis on its cyclical sensitivity and labor problems. An analysis of investment behavior is presented in Chapter Four. Factors which are thought to influence both short and long term investment decisions are discussed, with particular reference to firms in the New England region. The study concludes, in Chapter Five, with a brief review of the principal findings of the analysis. Finally, the implications of these results for the metalworking machinery industry in New England are examined.

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Chapter 1

Introduction

This analysis is a case study of the metalworking machinery industry in the New England region. The major purpose of the analysis is to determine what factors influence the health of firms in this industry, and how firms in the New England region fare, relative to those in other parts of the country. The principal issues of interest concern investment behavior in this industry. An attempt is made to determine what factors influence the investment decisions of metalworking machinery firms, and how these factors influence decision making. Then, by looking at the differential incidence of these factors in New England relative to other concentrations of the industry, it is possible to see if location within New England has a beneficial, detrimental, or neutral impact on metalworking machinery firms. It should be noted at the outset, however, that this study does not presume to provide definitive answers to the question raised above. The study is exploratory in nature and, given the paucity of data available with which to empirically test specific hypotheses, the findings and conclusions of the analysis are somewhat speculative.

This chapter will present a very brief description of the primary products and markets of firms in the metalworking machinery industry and its component sub-industries, followed by a discussion of the methodology of the study. Finally, a brief description of the subsequent chapters will be presented.

Description of the Metalworking Machinery Industry

The metalworking machinery industry, although small in absolute terms,[1] is a very important sector in any industrialized economy. The industry produces the machinery and equipment used by the manufacturers of mass production goods like automobiles, refrigerators, appliances, etc. Metalworking machinery is sold primarily to industrial customers; the equipment is not a consumer (or final demand) product. The metalworking machinery industry (SIC 354) is divided into seven sectors:

SIC 3541 - Metalcutting machine tools;
SIC 3542 - Metalforming machine tools;
SIC 3544 - Special tools and dies, jigs and fixtures;
SIC 3545 - Machine tool accessories;
SIC 3546 - Power driven hand tools;
SIC 3547 - Rolling mill machinery; and
SIC 3549 - Metalworking machinery, not elsewhere classified.

It is difficult to describe the metalworking machinery industry as a whole, because of the very wide diversity of products and types of firms. Therefore, this discussion will divide the industry into its three major sub-sectors: the machine tool industry; the tool and die industry; and the "other" metalworking machinery industry.

The Machine Tool Industry

SICs 3541 (metalcutting machine tools) and 3542 (metalforming machine tools) are the two components of the machine tool industry.

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[1] In 1976, for example, employment in the metalworking machinery industry comprised only .4% of total employment, and 1.5% of manufacturing employment, in the U.S.

[2] Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual, 1972, U.S. Government Printing Office, Washington, D.C., pp. 172-175.

> A machine tool is a power driven machine, not portable by hand, which is used to shape or form metal by cutting, impact, pressure, electrical techniques, or a combination of these processes. It is a complicated, highly-sophisticated device that must be designed and built by skilled engineers and craftsmen to extremely fine tolerances.
>
> Machine tools range in size from the so-called "elephant tools" weighing hundreds of tons to the smaller and more delicate watchmaker's lathe. Prices range from a few hundred dollars for the smaller machines to as much as a half a million dollars for a numerically controlled (highly sophisticated) machining center.3

The Standard Industrial Classification definitions of these two components of the machine tool industry are presented below.[4]

SIC 3541 - Machine tools, metalcutting types: the manufacture of machines, not supported in the hands of an operator, that shape metal by cutting or use of electrical techniques, the rebuilding of these machines, and the manufacture of replacement parts. There are about 50 to 70 separate products included in this 4 digit category, including boring machines, drilling machines, gear cutting and finishing machines, grinding and polishing machines, lathes, milling machines, and other metalcutting machine tools.

SIC 3542 - Machine tools, metalforming types: the manufacture of machines, not supported in the hands of an operator while in use, for pressing, hammering, extruding, shearing, die casting, or otherwise forming metal into shape, the rebuilding of these machines, and the manufacture of replacement parts for them. There are about 50 or so separate products included here.5

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[3] U.S. Congress, House, Subcommittee on Special Investigations of Small Business Problems of the Select Committee on Small Business, Problems of the Tool and Die Industry, and Associated Problems of Manufacturers and Distributors of Machine Tools: Hearings on H.Res. 13, 89th Congress, 2nd session, July 26 and 27, 1966, p. 165.

[4] Please see Appendix for a complete listing of the products of all the four-digit components of metalworking machinery.

[5] Executive Office of the President, Standard Industrial Classification Manual, pp. 172-173.

Although machine tools are crucial for mass production technology, the tools themselves are not mass produced. Machine tools are usually "custom built to meet the end use requirements of the customer; (there are some standard lines of machine tools) but even a standard machine today normally has special-features (designed specifically) for a customer's particular use."[6] There have been some recent developments in machine tool technology that have made the production process somewhat more automated.[7] However, industry spokespersons express the opinion that machine tool production will never be as automated as the production of most other commodities.

The demand for machine tools is a derived demand; it is generated by the demand for other goods. Machine tool companies sell capital goods, almost exclusively to industrial customers, for investment purposes. The following table illustrates the importance of the products of the machine tool industry in industrial investment.

Table 1

Machine Tool Consumption and Capital Investment

	U.S. Machine Tool Consumption (Millions of dollars)	Machine Tool Purchases as a Percentage of	
		Total Industrial Capital Expenditures for Plant and Equipment	Capital Expenditures for Equipment
1960	$655.0	12.3%	16.9%
1970	1,444.8	13.0	17.3
1976	2,135.3	10.9	13.5

Source: 1978-1979 Economic Handbook of the Machine Tool Industry.

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[6] U.S. Congress, Problems of the Tool and Die Industry, 1966, p. 165.

[7] This is discussed in more detail in Chapter Two.

These figures show that machine tool purchases are a fairly substantial, albeit declining, share of capital investment expenditures in the U.S.

The major customers of the machine tool industry include the important manufacturing industries of the nation. Table 2 presents information on those industries with large stocks of machine tools in their plants. It can be seen that the fabricated metals, machinery except electrical, electrical machinery, and transportation equipment industries own the largest shares of machine tools. It is of interest that the metalworking machinery industry itself is an important customer.

> Because the metalworking machinery and equipment industry is a large user of its own output, there is a certain feedback wherein demand for machine tools by other capital-using industries creates a demand for new machine tools to produce the tools initially ordered by the other industries. Several writers have pointed out that machine tools can almost be considered "living things" because they are the only class of machines that can reproduce themselves.8

Firms in the machine tool industry sell their products on a national, and international market. The ties of machine tool firms to local industries, as a source of customers, are rather minimal. The larger machine tool firms use national advertising and national and international trade shows to market their products. The smaller firms in the industry that cannot afford extensive marketing facilities make use of distributors in order to reach this national market. The major geographical markets of the machine tool industry in the U.S. are the principal industrialized regions of the country. Specifically, the following areas had the highest

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[8] James Abert and Clayton McCuiston, The Defense Dependency of the Metalworking Machinery and Equipment Industry and Disarmament Implications, Prepared for the U.S. Arms Control and Disarmament Agency by Resource Management Corporation, Bethesda, Maryland, May 1969, p. 4.

Table 2

Major Customers of the Machine Tool Industry

SIC	Industry	Year[1]	Employees (000)	Machine Tools Owned (000)	Industry Share of Total Machine Tools	Units/ 100 Employees
25	Metal Furnishings, Fixtures	1977	125.7	36.8	1.4%	26.5
33	Primary Metals	1978	1,222.4	117.3	4.5	9.1
34	Fabricated Metal Products	1977	1,549.2	631.6	24.0	37.3
341	Cans and Spray Containers	1977	75.5	20.2	.8	26.2
342	Cutlerly, Hand Tools, Hardware	1977	204.7	63.9	2.4	29.4
343	Heating and Plumbing Fixtures	1977	69.0	22.4	.8	30.8
344	Fabricated Structured Metal Products	1977	413.4	162.5	6.2	34.7
345	Screw Machine Products	1977	105.9	94.3	3.6	79.3
346	Metal Stampings	1977	267.9	113.8	4.3	40.3
347	Coating and Engraving	1977	53.3	13.3	.5	19.1
348	Ordnance and Accessories	1977	118.4	38.8	1.5	32.3
349	Misc. Fabricated Metal Products	1977	240.4	102.4	3.9	38.6
35	Machinery exc. Electrical	1976	2,169.4	961.0	36.5	36.1
351	Engines and Turbines	1976	144.4	41.8	1.6	28.6
352	Farm machinery	1976	140.8	50.5	1.9	33.3
353	Construction, Mining Machinery	1976	343.3	89.1	3.4	24.7
354	Metalworking Machinery	1976	306.7	42.1	9.2	62.6
355	Special-Industrial Machinery	1976	221.5	97.6	3.7	39.8
356	General Industrial Machinery	1976	319.9	133.5	5.1	38.6
357	Office, Computing Machinery	1976	327.1	33.2	1.2	9.8
358	Refrigerator, Service Machinery	1976	188.4	39.9	1.5	20.1
359	Misc. Machinery	1976	177.4	233.3	8.9	76.3
36	Electrical Machinery, Equipment					
361	Trans., Distri. Equipment	1978	1,820.3	339.1	12.9	17.5
362	Electric Industrial Apparatus	1978	147.9	28.3	1.1	18.2
363	Household Appliances	1978	248.2	63.7	2.4	23.9
364	Elec. Lighting and Wiring	1978	183.9	57.8	2.2	28.7
365	Radio, T. V. Equipment	1978	89.6	6.8	.3	7.0
366	Communications Equipment	1978	514.7	62.8	2.4	11.8
367	Electronic Components	1978	310.2	47.9	1.8	14.2
369	Misc. Electric Equipment	1978	167.5	29.6	1.1	7.0
37	Transportation Equipment	1977	1,834.0	361.1	13.7	17.9
371	Motor Vehicles, Equipment	1977	875.5	178.0	6.8	18.6
372	Aircraft and Parts	1977	551.5	139.2	5.3	23.9
373	Ships and Boats	1977	189.5	12.4	.5	4.9
374	Railroad Equipment	1977	58.8	9.0	.3	14.3
375	Motorcycles, Bicycles	1977	17.3	6.5	.2	22.9
376	Guided Missles, Space Vehicles	1977	107.3	7.0	.3	6.4
379	Misc. Trans. Equipment	1977	34.2	9.0	.3	16.1
38	Precision Instruments	1978	546.8	132.5	5.0	22.2
39	Misc. Manufacturing	1978	248.9	51.3	2.0	18.7
	Total		3,516.8	2,630.7	100.0	24.4

[1] Year Surveyed

Source: 12th/ American Machinist Inventory of Metlaworking Equipment, 1976-1978.

percentage of the machine tool stock in the country in 1978: Chicago with 14.4%; Los Angeles with 7.8%; New York/Newark with 7.4%; Detroit with 6.7%; Boston with 5.9%; Philadelphia/Camden with 5.1%; Atlanta/New Orleans with 5.1%; Cleveland with 5.0%; and Bridgeport/Hartford with 4.2%.[9]

Internationally, the major customers of the machine tool industry include: Europe (receiving 36% of 1977 U.S. machine tool export sales), particularly the United Kingdom, Germany, Italy, France and the Soviet Union; North and Central America (receiving 24% of 1977 U.S. machine tool exports), particularly Canada and Mexico; Asia (receiving 19% of 1977 U.S. machine tool exports), particularly Japan and Taiwan; and South America (receiving 16% of 1977 U.S. machine tool exports), particularly Brazil and Venezuela.[10] It should be noted here that, not only is there a large export market for American made machine tools, but there is also a growing American market for foreign made machine tools.[11]

The Tool and Die Industry

The Standard Industrial Classification definition of the tool and die industry (SIC 3544) is presented below, followed by a further explanation of the products of this industry.

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[9] American Machinist, "The 12th American Machinist Inventory of Metalworking Equipment, 1976-1978," December, 1978, pp. 133-148.

[10] National Machine Tool Builders' Association, 1978-1979 Economic Handbook of the Machine Tool Industry, McLean Virginia, National Machine Tool Builders' Association, July, 1978.

[11] The foreign trade situation, and its implications for the metalworking machinery industry, will be discussed further in subsequent chapters.

SIC 3544 - Special dies and tools, die sets, jigs and fixtures, and industrial molds: includes establishments commonly known as contract tool and die shops and primarily engaged in manufacturing special tools and fixtures for use with machine tools, hammers, die casting machines, and presses. Included in this industry are a wide variety of special toolings, such as dies; punches; die sets and components and sub-presses; jigs and fixtures, and special chucking devices.12

Dies - A die set consists of a pair of cutting or shaping tools which, when moved toward each other, produce a certain desired form in, or impress a desired device on, an object or surface by pressure or by sharp force. The term "die" may also refer to one of the basic die set members; the "punch" is the other.

Jigs and Fixtures - Jigs are devices for supporting the workpiece and for guiding the cutting tool of the machine tool during processing. Fixtures are of several types, but the more typical ones support or hold in place a workpiece during its processing; others are used in assembly and checking operations. In general, jigs and fixtures may do all or some of the following operations: locate, clamp or support a workpiece, and guide a tool ....

Mold - A device that forms parts as molten metal, rubber, plastic, or comparable material is fed into it.

Gage - An instrument used to determine whether a given part's dimension is within specified tolerance limits.

Special machines - Nonstandard machine tools, usually used for metalworking operations, and mostly of a metal removal type.13

The tool and die industry is very similar to the machine tool industry in that, while its products are necessary for mass production, the products themselves cannot be mass produced. These products

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[12]Executive Office of the President, Standard Industrial Classification Manual, p. 173.

[13]Harold Arnett and Donald Smith, The Tool and Die Industry - Problems and Prospects, Michigan Business Report (New Series) Number 1, Division of Research, Graduate School of Business Administration, The University of Michigan, Ann Arbor, 1975, pp. 2-3.

> .... are "custom made. Only one die, or set of dies, for example, is needed for the production of many thousands of automobile fenders or hoods of a given design. Dies for such purposes are fashioned at the cost of thousands of highly-skilled man hours in a shop equipped with costly machines, all under the supervision of expert management. In short, the construction of tooling devices contrasts sharply with the ultimate production of goods made possible by the tooling.14

The owner of a tool and die shop further states that:

> We are not production companies in the sense that we produce the same product or the same item over and over. Virtually everything is special and different. The end itself is frequently referred to as the keystone to mass production, without which no civilian or military hard goods could be produced on a quantity basis.15

However, there is an important difference between the two sectors, in that machine tools are considered capital equipment, while tools, dies, jigs, etc., are usually treated as current account, expendable equipment.

The tool and die industry is characterized by relatively small firms. In Connecticut and Massachusetts, for example, the average sized tool and die firm was 13 employees in 1976.[16] Unlike the machine tool industry, these firms are very closely tied to the local economy.

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[14]William A. Paton and Robert L. Dixon, Make-or-Buy Decisions in Tooling for Mass Production, Michigan Business Report Number 35, Bureau of Business Research, School of Business Administration, The University of Michigan, Ann Arbor, 1961, p. 1.

[15]U.S. Congress, Problems of the Tool and Die Industry, p. 20

[16]Bureau of the Census, County Business Patterns, 1976, Washington, D.C., Government Printing Office. Data were not available for other New England states. It should be noted that the average sized firm in New England is less than the national average, due to the existence of larger tool and die firms in the Mid West. These larger firms are closely associated with the automobile industry.

> This is due to the basic nature of the industry. (It) is really a service industry and ... most ... production is done to customer's specifications. This means that there is a need for day to day contact and consultation between the supplier and the customer.17

Therefore, the tool and die industry is very dependent upon the local and regional economy. A survey by the National Tool, Die and Precision Machining Association found that "16% of all companies reported (in 1964) that 100% of their business was within 100 miles of their plant; over half of the companies reported that 75% or more of their business was within 100 miles."[18] The tool and die firms in New England are closely tied to the economic base of the region, particularly the aircraft industry in Connecticut; the tool and die firms in the Mid West are much more dependent upon the automobile industry. The major customers of the industry, based on a survey of 112 companies, are presented below.

Table 3

Major Customers of the Tool and Die Industry

United States

Customer	Percentage of Sales
Automotive industry	27.3%
Business machines and electronics industry	22.3
Appliance industry	9.7
Aircraft industry	6.7
Space-related industries	5.3
Other military-related industries	4.5
Other industries	24.2

Source: National Tool, Die and Precision Machining Association, "Report to the National Commission on Technology, Automation and Economic Progress," in Donald Smith, Technological Change, 1968.

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[17] U.S. Congress, Problems of the Tool and Die Industry, 1966, p. 34.

[18] National Tool, Die and Precision Machining Association Report, Table 10, in Abert and McCuistion, The Defense Dependency of the Metal-working Machinery and Equipment Industry, p. 43.

The tool and die industry is not involved, to any significant degree, in international trade. The same factors that limit sales to the local region (need for contact and consultation with the customer) make it infeasible for the industry to compete internationally. By the same token, the domestic firms do not face much competition from foreign companies. There is, however, foreign competition in the form of what is termed "hidden tooling." That is, for every car or radio imported into the U.S., the American tool and die industry has "lost" the business that would have been generated had the car or radio been produced in this country.

The "Other" Metalworking Machinery Industry

The final component of the metalworking machinery industry has been termed "Other" for lack of a better title. This component consists of SICs 3545 (machine tool accessories), 3546 (power driven hand tools), 3547 (rolling mill machinery) and 3549 (metalworking machinery, not elsewhere classified). These four-digit sectors produce both tools and accessories for, and components of, machine tools, and complete machines that are not classified as machine tools. The Standard Industrial Classification definition of these sectors is presented below.

SIC 3545 - Machine tool accessories and measuring devices: The manufacture of cutting tools, machinists' precision measuring tools, and attachments and accessories for machine tools and for other metalworking machinery, not elsewhere classified. There are about 50 to 70 separate products included here.

SIC 3546 - Power driven hand tools: the manufacture of power driven hand tools, such as drills and drilling tools, pneumatic and snagging grinders, and electric hammers.

SIC 3547 - Rolling mill machinery and equipment: the manufacture of rolling mill machinery and processing equipment for

metal production, such as cold forming mills, structural mills, and finishing equipment.

SIC 3549 - Metalworking machinery, not elsewhere classified: the manufacture of metalworking machinery, not elsewhere classified, such as gas cutting and welding equipment, wire fabricating machinery and equipment and automotive maintainence machinery and equipment.19

The characteristics of this "other" sector of the metalworking machinery industry fall somewhere in between those of the machine tool sector and the tool and die sector. Some firms produce complete machines, such as firms in SICs 3547 and 3549, and have much in common with the machine tool sector. They sell on a national market, their products are usually considered capital equipment, they engage in export trade, and their customers are primarily the same manufacturing industries that buy machine tools. On the other hand, firms in SIC 3545 produce equipment that is usually considered expendable, such as cutting tools that periodically wear out. These firms tend to have more in common with tool and die firms, in that they often serve a local or regional market. However, some firms in this category do sell nationally, and export/import trade is relatively more common among firms in this sector than in the tool and die sector. The customers of firms in this sector are very similar to the customers of the machine tool industry; some of these products are accessories to or attachments for machine tools, and therefore are sold to the same companies that buy machine tools. Since this "other" category of the industry is something of a miscellaneous grouping, and because

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19 Executive Office of the President, Standard Industrial Classification Manual, pp. 173-175.

firms within the group exhibit characteristics similar to both machine tool and tool and die firms, the subsequent discussions in this study will concentrate on either the metalworking machinery industry as a whole, of the two more clearly defined components of the industry -- machine tools and tools and dies.

Methodology of the Study

This analysis is a case study of a particular industry in the New England region. As such, representatives of a number of firms, trade organizations, and unions were interviewed, and it is the data from these interviews that make up an important source of information for the analysis. Eleven firms in the metalworking machinery industry in the region were selected for interviews. It is important to note that the selection of these firms was by no means random. The firms were chosen for a number of reasons, the most important of which was variety.

The sample included one firm with over 1000 employees, two firms with between 500 and 1000 employees, three firms with between 100 and 500 employees, two firms with between 50 and 100 employees, and three firms with less than 10 employees. Four of the firms were owned by corporations or conglomerates; the remainder were independently owned (although in one case, the independent firm owned a number of other firms). Some of the firms had been in existence for over 100 years, while others were relative newcomers to the industry in the region. Three of the firms had moved at least once within the last twenty years (two were independently owned, one was owned by a larger corporation; two were large firms with

more than 500 employees, one had less than 100 employees), all to locations within the region. The employees of five of the firms were represented by collective bargaining units, while the remaining six firms were non-unionized. In terms of geographical representation, two of the firms were located in Massachusetts, one was located in Rhode Island, three were located in Vermont, and five were located in Connecticut.

It is necessary to recognize that, although the sample contained a variety of firm types, this by no means assures that the firms selected are representative of all or most metalworking machinery firms in the region. The problem of being able to generalize from the individual interviews to the industry in the region becomes more clear when it is realized that only eleven firms were included in the sample, while there were over 1200 firms in the industry in New England in 1974.[20] Moreover, as the preceding description of the industry shows (and the information in the Appendix makes even more striking), the industry itself is incredibly diverse in terms of the range of products produced. Therefore, the possibilities of having obtained a very unrepresentative sample are not insignificant. In order to alleviate this problem to some degree, other sources of information were utilized.

In addition to the firm interviews, a number of spokespersons for the metalworking machinery industry were interviewed. These included

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[20] Dun and Bradstreet data, prepared by D. Birch at M.I.T.

representatives of some industry trade associations and unions whose members are employed in the industry. And finally, in an attempt to substantiate the information gathered from these interviews, a fair amount of secondary data was obtained. These data were used both for descriptive purposes, and in order to determine if opinions given in the interviews could be generalized to the metalworking machinery industry, as a whole, in the New England region (and in some cases, the U.S.).

Organization of the Study

The second chapter of the study presents a brief history of the metalworking machinery industry, both nationally and in New England. Since the American metalworking machinery industry originated in this region in the 18th century, its history is both rich and very interesting. However, in order to keep the length of the history manageable, the chapter concentrates on the following topics: the early development of the industry; the industry's historical relationship to the government; and more recent changes in the technology of metalworking machinery.

Chapter Three of the study examines some important characteristics of the metalworking machinery industry, both in the New England region and in the nation as a whole. One of the most important characteristics of this industry is its vulnerability to general business cycles. Chapter Three begins with a discussion of why the industry is so cyclically sensitive, and an examination of which sectors of the industry are most volatile. The chapter then explores the volatility of the industry in the New England region, relative to that in the nation, and

offers some explanations as to why it appears to be more volatile in New England. The ways in which firms attempt to deal with this instability are then explored. These attempts are classified in one of two categories: active responses to unstable demand and reactive, or passive, responses to unstable demand. The active responses consist of attempts by firms or the industry as a whole, to actually modify the character of demand; that is, to smooth out the variations in demand for metalworking machinery. These active responses include attempts to diversify (both products produced and customers), and it is here that the foreign trade activities of the industry are discussed. Specifically, the metalworking machinery industry has attempted, throughout its history, to use the export market as a buffer, to pick up the slack in business that occurs when domestic demand is very low. A number of reasons why the industry has not been entirely successful in pursuing this strategy, including the fact that the American industry may not be competitive on world markets, are discussed. The other active response of the industry has been lobbying to get customers to follow more steady, long range investment programs that are not so susceptible to variation with short term changes in the economy.

Reactive responses consist of the ways in which firms cope with, rather than try to change, the unstable nature of demand for the products they produce. Before discussing these reactive responses, however, an important constraint on the ability of firms to cope with unstable demand is introduced. Specifically, the metalworking machinery industry has been experiencing a very important shortage of skilled labor, both in

the New England region and in the nation as a whole. This shortage has made firms much more reluctant to lay off workers (the way firms would usually deal with declining sales) in business cycle troughs for fear that the firm will never be able to replace these workers on the business cycle upswing. The causes of the labor shortage (long training period necessary to attain competence in these occupations, reluctance of many firms to institute extensive apprenticeship training programs, declining interest in blue collar occupations, etc.) are discussed, along with the effects of this shortage on the management policies of metalworking machinery firms. These firms appear to have become more reluctant to lay off their workers in downturns, even in the face of declining productivity, in recent years than had been the case in the past. Empirical data suggest that this response is not entirely rational (i.e., that workers who are laid off are not irrevocably lost to the industry in periods of expansion), and an attempt is made to reconcile this reluctance to lay off with the empirical data mentioned.

Chapter Four examines investment behavior in the metalworking machinery industry. Investment behavior is looked at from two perspectives -- short term and long term. Short term investment decisions concern annual capital budgeting planning, while long term decisions relate to issues of expansion, contraction, relocation, and decisions to remain in business. Since most investment in the industry is financed out of retained earnings, the cyclical vulnerability of the industry is an important determinant of short term investment decision-making. That is, in business cycle troughs, most firms simply do not have the

resources to invest in new plant and equipment; many firms are actually losing money. Therefore, short term investment behavior is quite cyclically sensitive. However, some firms do pursue steady investment programs, and two factors are investigated (firm size and ownership status of the firm) insofar as they influence the ability to follow stable, as opposed to cyclical, capital investment programs. These two factors are also examined as influences on the character of capital investment in the industry, along with the influences of the labor shortage, and government policies.

The factors influencing long term investment behavior are examined to see how the New England region fares as a site for investment in the metalworking machinery industry. Again, the influences of firm size and ownership status are explored as determinants of decisions to expand, contract, relocate, or go out of business entirely in the New England region. The differential availability of and cost of labor in New England is also discussed. And finally, other factors thought to influence long term investment behavior in the region, including differential costs of doing business in New England, agglomeration economies, and what are termed "idiosyncratic" influences, are discussed.

The study concludes, in Chapter Five, with a brief review of the principal findings of the analysis, and a discussion of the implications of these findings for the metalworking machinery industry in New England.

Chapter 2

History of the Metalworking Machinery Industry

The Development of Metalworking Machinery as an Industry

The New England region was the birthplace of the metalworking machinery industry in the United States, as it was for many other manufacturing industries. In the first half of the 18th century, metalworking in the American colonies was more of a craft than an industry, with a single craftsperson working alone or with a few apprentices. The English government, moreover, tried to maintain this primitive nature of the industry and the colonies' dependence upon England for all manufactured goods by passing a law in 1719 that forbid metalworking in the colonies. Following the American Revolution, the English government prohibited the export of machinery and mechanics to the United States, in the hope of maintaining the dependence of the new nation on England for manufactured goods. It was, however, these conditions that provided the impetus for the development of the American metalworking machinery industry, an industry that would soon overtake its English counterpart.

David Wilkinson, of Pawtucket, Rhode Island, is credited with being the founder of the American machine tool industry.[1] In 1794 he invented a screw cutting lathe with a slide rest that is the first example of an American made and designed machine tool. The early growth of the industry was related to a number of interrelated factors (some of which are still important).

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[1] American Machinist, Metalworking: Yesterday and Tomorrow - The 100th Anniversity of American Machinist, McGraw-Hill Publications Company, New York, 1977, p. 15.

First, the demand for manufactured products was growing rapidly in the new nation, but the means to produce these goods were limited. Further, there was a "continuing critical shortage of labor (in the colonies) that put a premium on labor-saving devices of every sort, establishing an American attitude that would later be crucial."[2] This shortage of labor, which has been a recurring phenomenon throughout the development of the industry, was due not only to the small absolute size of the population in the country, but also to the fact that most colonists were not interested in working in industry; they would work until they had saved enough capital to strike out on their own and buy a farm. Finally, coupled with both these factors was the enormous demand in the new nation for arms, both for national defense purposes and also for the pioneer movement to the west.

In this early period of development, Middletown, Connecticut was the center of arms manufacture in the United States, with other areas in New England such as Hartford, Connecticut; Springfield, Massachusetts; Bridgewater, Massachusetts; New Haven, Connecticut; North Providence, Rhode Island; etc., also becoming very important locations of armament production. In 1794, Springfield, Massachusetts was selected as the site for the first federal armory in the country (perhaps influenced by the fact that then Secretary of War, Henry Knox, was a native of Massachusetts). In 1798, the government needed still more guns, and Congress passed an act to purchase $800,000 of arms and munitions from private sources since government-owned facilities could not meet the needs of the country.[3] These contracts were let to

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[2]Ibid., p. 11.

[3]This act was augumented in 1808.

manufacturers like Eli Whitney in New Haven, Simeon North in Middletown, Robbins and Lawrence in Windsor, Vermont, and other New England entrepreneurs.

The importance of these defense contracts for the metalworking machinery industry became clear in the middle of the 19th century. The manufacturers of armaments were trying to develop a system whereby the parts of the guns they produced were interchangeable, so that the arms could be easily repaired when a part malfunctioned (especially in the more remote areas of the country). The ability to produce interchangeable parts, in turn, depended upon the accuracy of the machine tools used in the production process. The arms manufacturers, then, were inventing and building their own machine tools in order to be able to produce these interchangeable parts demanded by the government. The industry was being transformed from its handicraft tradition, where the accuracy and quality of the product was a result of the craftsperson's skills, to what came to be known as the "American system of manufacture," where the accuracy of production was a result of the machine tools used. By 1850, American manufacturers had succeeded in developing this system of interchangeable manufacturing. Throughout the first half of the 19th century, then, the need for interchangeable parts on guns spurred the development of innovations in machine tool design in the United States, and this development was supported by contracts from the federal government to many arms manufacturers, particularly in the New England region.

It is important to note that the growth of the metalworking machinery industry was also related, as mentioned previously, to the growth of

manufacturing of consumer goods. Again, the design and construction of machine tools was usually done by the manufacturer of the final good. The emergence of metalworking machinery as an industry in its own right appears to have occurred in the mid to late 1800's. In the early part of the 19th century there existed a number of very small machine shops which served the demands of the manufacturing industries of the area.

> Although capitalizing on the system of interchangeable manufacture that the arms makers had created, these new firms did not grow out of arms makers. Rather, they developed out of the unique type of general machine shop that would develop and build any kind of machine that one might wish to order for any purpose. Such shops did not produce standard machines and go out and sell them: they innovated on demand.
>
> These shops were a unique element of the New England scene in the early part of the 19th century and constituted what Monte Calvert has called a "shop culture." It was an elite group in a day when a machinist was "one who invents, or makes, machines." The shops were usually individual or partnership operations, and they rarely grew very large. To sign on as an apprentice in such a shop in those days was the route, and the only route, to becoming a mechanical engineer.[4]

These shops were closely tied to other New England industries, including the textile, hardware, and watchmaking industries. By the mid to late 1850's, however, metalworking machinery had truly emerged as an industry in its own right, with large factories supplementing, but not completely replacing, these smaller shops.

The fact that New England was the center of industrial activity in the nation not only provided an eager market for machinery, but also served quite literally as a "breeding ground" for inventors and skilled labor in the

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[4]American Machinist, Metalworking: Yesterday and Tomorrow, p. 25.

region. There are many examples of cases where, for instance, an individual inventor/designer would take an apprentice, who would in turn marry the boss' daughter, become a partner in the business and go on to develop new machines tools in his own right. The reputation of the region as a source of skilled labor was unparalleled in this period. Roe, in 1916, noted:

> If New England no longer holds all the good mechanics in the United States, there was a time when she came so near it that the term "New England mechanic" had a very definite meaning over the whole country.5

Shifting Customers and Geographical Location of the Industry

By the latter half of the century, a number of firms had emerged which produced machine tools exclusively. New England maintained its position as the major location of the industry through this period, and in 1876, Worcester, Massachusetts was the center of the industry.[6] During the period of the Civil War, there was a greatly expanded demand for the products of the metalworking machinery industry. There was again an enormous demand for arms, and demand for railroad and transportation equipment also boomed. Moreover, because so many men were required to fight the war, there emerged a demand for labor saving machinery in agriculture. After the war, there was a great deal of expansion in the manufacture of civilian goods - railroad

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[5]Joseph Wickham Roe, English and American Tool Builders, Yale University Press, New Haven, 1916, p. 109.

[6]New England had a definite locational advantage in this era, since proximity to water power was a very important factor in machinery manufacturing.

equipment and other consumer goods - and also a growth in the export market[7] of the industry. Another important source of demand for metalworking machinery in this period was the growing bicycle manufacturing industry. Concurrent with the expanding market of the industry was the growth in demand for special, rather than general, purpose machinery.

In this period, the industry began to spread out over a larger geographical area. The Mid Atlantic states of New York, New Jersey and Pennsylvania were becoming more industrialized, and the machine tool industry grew in importance in this region. It was not a case of the firms in New England migrating to this area or going out of business. Rather, the machine tool industry in the Mid Atlantic region, especially in Philadelphia, developed to serve a market that was expanding greatly and hence it also grew.[8] By the late 1800's, Philadelphia had become the dominant center of the industry, largely due to the growth of the railroad and steam engine. At the same time, the industry was also shifting further into the west. The Mid West, particularly, was growing in importance, as the farm machinery industry grew. The industry's development prior to the 20th century was then closely related to the expansion of other industries - textiles and textile machinery, arms and ammunition, and watches and clocks in New England; railroads and steam locomotives in Philadelphia; and farm machinery and bicycles in Chicago,

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[7]Largely to the European market.

[8]It is, however, true that to a large degree, it was entreprenuers and skilled workers trained in the New England metalworking machinery industry that started up and worked in the newer firms in the Mid Atlantic region.

Cinncinnati and the Mid West.

The next industry to exert an influence on both the location and character of the metalworking machinery industry was the automobile industry. By 1900, Cinncinnati was the leading machine tool center in the nation, and in the first two decades of the twentieth century, Michigan and Illinois grew most rapidly due to the expansion of the auto industry in Michigan and the growth of the farm equipment, construction machinery and tractor industries in Illinois. The fact that electricity was coming into use to power machinery was an additional factor that permitted the dispersal of the industry over a wider geographical area. The geographical location of the industry, then, has been closely related to the location of its principal customers. This has been the case throughout most of the 20th century (as it was in the past) with the Mid West still maintaining its dominant position as the automobile industry had become, and still remains, one of the major customers of metalworking machinery. In recent years, the West Coast has grown in importance as a location for the industry, serving the expanding industrial market of the region, particularly the aerospace and defense-related industries. New England is still a very important concentration of the industry, but its relative share of total national production has declined. Additionally, competition from foreign manufacturers in the domestic market has grown, particularly in the last five to ten years, as countries such as West Germany, Japan, Switzerland and others have "caught up" technologically with many manufacturers in the United States. The major customers of the metalworking machinery industry in the 20th century include the automobile industry, the aerospace industry (especially during and after World War II),

durable goods manufacturers, and the producers of consumer goods like refrigerators, electrical appliances, etc.

Relationship to Government

The history of the metalworking machinery industry has been greatly influenced by government policies, and so the development of the industry in the 20th century will be examined in relation to the activities of the federal government.[9] As noted previously, the support of the development of the interchangeable system of manufacturers had a great influence on the growth of the metalworking machinery industry in New England. Moreover, in the Civil War, federal procurement activities had stimulated the growth of the industry.

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[9] In addition to the support of arms manufacture, there are other examples of government (in this case, at the state and local levels) support of the industry in the region. For example, the Robbins and Lawrence firm in Windsor, Vermont, was benefited by the fact that the owner of the company was made the Commissioner of Corrections of the area's prison farm, and was therefore able to use prison labor (at the rate of $.25/day) in his factory (coincidentally, the firm got its real start producing guns for the federal government for the Mexican War in 1838).

Ironically, in the late 1960's, the Cone Automatic Machine Company in Windsor was using the Vermont State Prison Farm as a source of apprentices (in conjuction with a Department of Labor training program). In this later period, however, the prisoners/apprentices were paid regular wages.

There are also examples, from the 19th century, of firms receiving property tax abatements from towns trying to attract new industry.

In the 20th century, the fortunes of the industry were very closely tied to not only the civilian industrial expansion of the nation, but also to the foreign policies of the government, both in war and in peace-time (insofar as the government influenced foreign trade). The machine tool industry began exporting in the mid 1800's, first to England, and then to other European countries. As early as 1900, members of the industry were becoming interested in using foreign trade as a means to protect themselves against the cyclical nature of their sales in the United States. However, in this period, the American manufacturers felt that they were not able to compete effectively on the foreign market for a number of reasons: protective tariffs, they felt, were encouraging retaliation among European countries; they were concerned that they were unable to protect their designs from copying by foreign tool makers; and finally, they felt that transportation costs and wage differentials made it difficult for them to compete effectively in foreign markets. The German industry, particularly, was a threat to the American industry in the early 20th century. A trade association, the National Machine Tool Builders Association, was formed in 1902 as a vehicle through which the manufacturers could lobby for policy changes at the federal level. By 1911, the association was working towards tariff revisions and other areas of interest to the industry. It should be noted that this foreign competition was not really affecting domestic sales - rather, it encroached on the foreign market of the American producers.[10]

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[10]This situation did change later in the century, as foreign machine tool builders have made significant inroads into the U. S. market for machine tools.

In the years preceeding World War I, the export business of the industry was very strong, as European countries tooled up for the war. At the outset of the war, American builders were against the hostilities because they feared that war would hurt their export business. However, the war soon proved to create an enormous demand for the products of the metalworking machinery industry, and these fears were forgotten. The demand for these products was so great that prices began to rise substantially, and in 1917, the War Revenue Act was passed which imposed an excess profits tax on the increased earnings of a company due to the buildup of the war. The industry complained that this act was inequitable for the following reasons:

> .... with the builder of machine tools, business is either feast or famine ....
>
> When times are good, his order books cannot hold all the business offered him. He cannot take the best advantage of his opportunity, for to be able to do so would mean a plant investment out of all proportion to his average needs.
>
> His life is made miserable by dunning customers who insist that they must have the machinery immediately ... Many a buyer would have been willing to pay several times the new prices if the premium would have meant immediate shipment, for the machine would have soon paid for itself ... It is in these periods that the machine tool builder makes his money, if he is to make any at all.
>
> When business is dull, the market dwindles to almost nothing. The machine tool is the basic tool ... when the user finds business falling off, the natural thing is to stop ordering equipment ....
>
> So, one big reason for the higher prices is that in flush years the machine tooler must make a large profit to provide

> for several years for himself and his stockholders ... and to take care of his working force, a handsome reserve fund means everything.11

The tax was nonetheless imposed, and it is difficult to determine whether or not it really was inequitable to this industry. Another important development in the first World War was that of the aerospace industry. Although quite small, it nevertheless represented a new market for the industry, and one that was to grow substantially in the future.

After the war, the industry became concerned that, since they had produced so much during the war, their markets would be saturated. They were also worried that the government would dump their machine tools on the already depressed market. The government, however, did not dump the tools; rather they worked out "an equitable 'service value' pricing formula based on use and 'present market value' of comparable machines."[12] Additionally, in 1919, "Congress passed the Caldwell Act, authorizing the government to sell surplus machine tools to trade, technical, and public schools and universities at 15 percent of cost."[13] This act not only allayed industry's fears that the government would depress the market, but also was important in that it represented a subsidization by the federal government of training programs for skilled labor, an issue of great concern to the industry.

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[11] Iron Trade Review, January 6, 1916, p. 112, in Wayne G. Broehl Jr., Precision Valley: The Machine Tool Companies of Springfield, Vermont, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1959, p. 90.

[12] Wayne Broehl, Precision Valley, p. 103.

[13] Ibid., p. 103.

The industry started to look again to export trade in the post war period. After a short period of poor business immediately following the war, the market again picked up and continued strongly throughout the 1920's. Domestically, the expansion of the automobile industry in this period provided an extremely important market. Moreoever, the 1920's were a boom period for many other American industries; firms were becoming more mechanized and were spending a lot for capital improvements, and so the metalworking machinery industry was quite prosperous. On the foreign side, demand for capital equipment was great, and shipments to countries such as Belgium, Poland, Argentina, Mexico, and China grew.

The great depression did not really affect the metalworking machinery industry until the early 1930's. Again, the industry looked to foreign trade as a means to stabilize business. Russia, which had been a relatively unimportant market previously, "suddenly became far and away the number-one customer" of the industry. The U. S. S. R.'s Five Year Plan for industrializaton created the need for a great deal of capital equipment which the country imported, and this market was especially important to the American industry in the early years of the depression (in 1931, exports to Russia constituted about 23 percent of total domestic output).[14] Sales to the U. S. S. R. dropped off in 1932-1933, and the industry lobbied the government to recognize that nation in order to stimulate sales. Roosevelt recognized the U. S. S. R. in late 1933, but sales to the U. S. S. R. never went as high as they had been in 1931.

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[14] Ibid., p. 127.

By this time, the domestic market had collapsed and industry sales decreased dramatically. However, by 1935 to 1937, domestic sales had picked up to some degree, due in large part to the expansion of the automobile industry. This period "was marked by surprisingly heavy investments in plant improvements. The automakers were determined to get all the work done in a 40-hour week and avoid payment of overtime wages."[15] But, once again, the export market became increasingly important, as other countries began "tooling up" for World War II. In 1938, one half of the industry's sales went to exports, with the Soviet Union and Japan the major customers. The growth of exports to the Allies prior to direct United States involvement in the war was immense. As a result of this, the industry was well prepared, in terms of capacity and employment, to handle the enormous demand generated by American direct involvement in the war.

Nonetheless, the industry was criticized in the beginning of war mobilization efforts. Reminiscent of the experience in World War I, the industry was denounced as;

> The greatest single detriment to the fulfillment of the national defense effort ... refusing to expand and exacting inordinate profits from their privileged position ....

Again, the industry responded:

> .... its economy was really cyclical (and history had time and again shown it was); sizable fat-year profits were needed to pile up a sufficient reserve for the lean years ... Further, if the industry built up its plant and equipment enough to fully satisfy demand when a boom began, it would usually find itself

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[15] American Machinist, Metalworking: Yesterday and Tomorrow, p. 70.

> burdened with an excess capacity that would rapidly eat away the profits of the short high-demand period.16

The industry's complaints appear to have been given consideration, in that during the mobilization for the war, machine tool plant capacity was expanded with new facilities costing $160 million; but of this, $70 million was provided by the Defense Plant Corporation and $91 million was privately financed. A part of this $91 million, moreover, was financed by advances the industry received on pool orders (pool orders were orders placed by the government which advanced up to 30 percent of a contract ahead of the actual production of the product, in order to give the manufacturer working capital to expand facilities if necessary).[17]

The industry had completed most of its war-related production by 1943, and it was about this time that the industry began again to become nervous about prospects in the post-war period. The industry had been subject, again, to an excess profit tax during this period, and in addition, the government had instituted a renegotiation procedure, whereby the government could review the costs of a product after delivery, and renegotiate the cost downward if it was determined that the price was excessive. The industry experienced difficulty after the war, due to both the dumping of about

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[16] Wayne Broehl, Precision Valley, pp. 166-7.

[17] Harless D. Wagoner, The U. S. Machine Tool Industry from 1900 to 1950, The M. I. T. Press, Cambridge, Massachusetts, p. 271.

235,000 surplus machine tools by government,[18] and also the fact that there was excess capacity in the industry due to the war-related expansion. The export market was relatively important in this period until the time when many European countries recovered sufficiently to compete with the American industry again. It was only a short time, moreover, until the beginning of the Korean War, another period of great demand for the industry's products.

At the outset of the Korean War, however, the industry was depressed and hence was somewhat less prepared for the increased production necessitated by the war. Again, the industry was accused of dragging its feet and being a bottleneck in the mobilization effort. Following the Korean War, the industry was, as usual, concerned with post-war adjustment. It appears, however, that the industry was more successful in making the government sympathetic to their demands. For example, in 1954, the government changed the depreciation laws in order to stimulate investment, and hence the sales of the metalworking machinery industry. This change had been advocated by the industry in the 1940's as a means of easing the post-war reconversion efforts of the industry. (The new law enabled investors to use either the declining balance or the sum-of-the-digits methods as an alternative to straightline depreciation).

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[18] Resource Management Corporation, The Defense Dependency of the Metalworking Machinery and Equipment Industry and Disarmament Implications, ACDA/E-130, prepared for The U. S. Arms Control and Disarmament Agency, Bethesda, Maryland, May, 1969, p. 24. The federal government sold off their excess capital equipment at prices as "little as 10 percent of the original cost." It is interesting that, unlike the case after World War I, the government did not turn over this surplus machinery to schools for training purposes.

After the Korean War there was a great deal of expansion in the civilian economy, which, aside from a downturn in 1957-58, provided an ever expanding market for the metalworking machinery industry. This period was also characterized by relatively heavy peace-time defense expenditures (a result of the Cold-War). Moreover, the Vietnam War, combined with the general prosperity of the 1960's, enabled the industry to reach record levels of production in this period.

In addition to government/defense related demand for the industry's output, the industry also received other government support. For example, the Department of Labor, in conjuction with both the National Machine Tool Builders Association and the National Tool and Die and Precision Machining Association, instituted a number of apprenticeship training programs during this period in order to alleviate extreme shortages of skilled labor in the industry. Additionally, Congress, in the mid 1960's, further liberalized depreciation laws and instituted an investment tax credit program which not only greatly expanded the demand for metalworking machinery, but also enabled firms in the industry to update and modernize their own plant and equipment. And finally, the government, beginning in the late 1940's and 1950's became more active in supporting research and development in the machine tool industry, reminiscent of the early history of the industry when the government supported the development of the "American system of manufacture."

Technological Developments in the Metalworking Machinery Industry[19]

Prior to the 20th century, most of the technological developments in the metalworking machinery industry were the product of a single inventor working independently in a machine shop. As noted previously, the small shops of the 19th century, especially in New England, provided an important source of innovation. In addition to government supported developments in arms manufacture and developments that emerged from related industries such as textile manufacturing, these shops were responsible for the major innovations in this period. Typically, an individual machinist would develop a new type of machine, or perhaps an improvement in the design of an existing production procedure. In many cases, this individual would then strike out on his own; since the capital requirements for entry into the business were rather modest this was possible. A large number of the machine tool firms still in business today began in just this way.

As the metalworking macinery industry grew into an independent industry, this trend in innovation appears to have continued; most major inventions

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[19] This is a rather cursory and non-technical review of some principal technological advances in the industry. For a more detailed description of this subject, the following sources are recommended: Joseph Roe, English and American Tool Builders, Yale University Press, New Haven, Connecticut, 1916; Thomas C. Rolt, A Short History of Machine Tools, The M. I. T. Press, Cambridge, Massachusetts, 1965; American Machinist, Metalworking: Yesterday and Tomorrow - The 10th/ Anniversary Issue of American Machinist, McGraw-Hill Publishing Company, New York, 1977; "The Machine Tools That are Building America: A Trilogy on Metalworking in America - Part III," Iron Age, Vol. 28, No. 9, August 30, 1976; and David F. Noble, "Social Choice in Machine Design: The Case of Automatically Controlled Machine Tools," Case Studies in the Labor Process, Monthly Review Press, New York, forthcoming in 1979.

were the product of a single machinist, whether working in his own firm or in the larger companies that had begun to emerge. A very interesting example of this phenomenon is provided in the history of the machine tool companies of Springfield, Vermont. Jones and Lamson had hired, in 1889, a young engineer named Hartness to run their company. He in turn hired a friend named Fellows in 1803 to be his chief machinist. While working at Jones and Lamson, Fellows developed the gear cutting machine in his spare time. Hartness decided to set up Fellows in his own business: he provided Fellows with financing and also helped out the Fellows Company in its early years of operation (with subcontracts when business was poor). Bryant, hired to replace Fellows, invented a grinding machine that was superior to those currently in use.[20] Hartness set up a similar financing arrangement with Bryant, and a new company was formed across the street from Jones and Lamson. And finally, another worker at Jones and Lamson, Fred Lovejoy, developed a new kind of cutting tool, and again Hartness set up Lovejoy in his own business.

It is difficult to isolate exactly when the character of technological development changed. "In the first two decades of the twentieth century, development and improvement of new machine tools and metalworking practices

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[20]The Bryant grinder could do internal, face, and external grinding, making it possible to do all the grinding on a piece without having to move the piece.

continued to be largely dependent on the individual efforts of a relatively small number of engineers, tool designers and skilled mechanics as it had during the nineteenth century."[21] After World War I, however, the use of special purpose machines grew, especially in the automobile industry. There was, concurrent with this trend, a growth in the engineering and development facilities of firms in the industry. The demand for automatic machinery was also growing in this period, and the automobile industry, particularly under the leadership of Henry Ford, was the forerunner of this phenomenon. The drive towards automation continued and intensified throughout the century, necessitating the development of more and more sophisticated types of machinery. The research and development activity in the industry shifted from the individual designer who had very close contact with the actual use of the machine (often as an operator or supervisor of the shop) to the somewhat anonymous engineering department of a firm. At the same time, the actual expense of carrying out research grew as the technology became more sophisticated, and so small firms could not really afford to be actively engaged in the process.[22]

Another aspect of the changing character of the technological development process was the increased involvement, especially after World War II,

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[21] Harless Wagoner, The Machine Tool Industry, p. 28.

[22] The inability of small firms to participate actively in technological development is evident in the tool and die industry, where the average size of firm is very small, and where innovations come either from the suppliers of their capital goods (the machine tool industry) or from their customers research efforts.

of universities and research firms. "By 1950, systematic and cooperative research and development under the control of large corporations, foundations, universities, and the federal government has largely replaced the efforts of individual inventors and engineers."[23] It should be noted, moreover, that these "large corporations" were not necessarily machine tool builders. "Because of the relatively small size of most machine shops, the problem of financing and coordinating research was more difficult than in industries which were dominated by a few large units capable of supporting substantial research programs or of taking the lead in developing cooperative research programs."[24] Rather, firms in the automotive, aerospace, electrical products and other industries (which are often substantially larger than the largest metalworking machinery firm) have become quite involved in developing new technologies that fit their particular needs. These developments are then passed on to the machinery industry, with instructions of "this is what we want, make it." Even in the large firms in the industry, with specialized research and development facilities, much of the research is of a more applied nature, with the "pure" or "basic" work being done in universities, government supported facilities, etc.

The nature of the innovations that have been introduced and accepted can be divided into two categories - materials used and machine design. One of the most important material innovations in the history of the industry was the introduction of high-speed steel. Frederick Taylor's development

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[23] Harless Wagoner, The Machine Tool Industry, p. 33.

[24] Ibid., p. 39.

of high speed steel in 1906 made it possible to increase cutting speeds enormously, to take deeper cuts that were previously feasible, and in general resulted in immense increases in machine productivity. Other advances in materials in the 20th century include the increased use of lubricants to allow faster cutting speeds with less distortion of the piece being machined, the development of better cutting materials such as tungsten-carbide (developed by General Electric under the name Carboloy), ceramic and polycrystalline diamond tipped tools, and the use of new techniques, such as powder metallurgy, electrical discharge and electrochemical machining, etc.[25]

The changes in machine design can be examined in light of the statement made earlier, that the "premium on labor saving devices of every sort established an American attitude that would later be crucial." In addition to this drive to reduce the skilled labor requirements of production, there has been a trend towards taking the "control" over the production process out of the hands of labor by building the skill into the machine. As early as the late 19th century, Frederick Taylor wrote that his "original objective was that of taking the control of the machine shop out of the hands of the workmen and placing it completely in the hands of management, thus superseding 'rule of thumb' by scientific control."[26] This trend had

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[25] Please note, again, that this is certainly not an exhaustive nor inclusive discussion of the significant technological developments in the industry. Please see the references listed in footnote 19 on page especially Iron Age and the American Machinist, for more complete and up to date information.

[26] Iron Age, "The Machine Tools that are Building America," p. 158.

begun even earlier, as in the emergence of the "American system of manufacture," when machines were designed to standardize the work of individual craftspersons.

The emergence of the use of electricity to power machines, however, represents the real beginning of modern control technology. Electrical power, as opposed to earlier power sources such as steam or water power permitted a much greater flexibility in the operation of the machine, and it "also gave birth to various devices for starting and stopping machines which were the predecessors of modern electric and electronic controls."[27] The major manufacturing industries have always been concerned about the "human error" associated with the operators of machine tools, the fact that they may be bored or disinterested in their work, and that too much "judgement" on the part of the operator comes into play when machining. Complaints about the "folklore knowledge that one operator relates to another ... that is more or less intuitive information"[28] have led these manufacturers to demand more and more sophisticated machinery, where the skills needed to operate the machine are lessened and the control over the machining is taken out of the hands of the operator.

The use of electric power on machine tools, replacing the previous system of a series of belts and line shafts, then, was a very important development in this trend to build skills into the machinery. The electric

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[27]Harless Wagoner, The Machine Tool Industry, p. 12.

[28]Iron Age, "The Machine Tools that are Building America," p. 158.

switches which started and stopped the machinery took away some of the "intuitive" aspects of machining. Instead of having the work stop when the operator felt it was time, the electric switches stopped the work automatically. The use of electricity to power machine tools did not become really widespread until the 1920's. At this time, many manufacturers were becoming interested in the scientific management of the production process, and with this trend came the desire on the part of the major customers of the machinery industry for more control over the production process. The major customers of the industry in the first half of the 20th century, industrial giants like the automotive, railroad, and electrical equipment industries, were demanding more automatic machinery, and it was the conditions within these industries that were more important in determining the direction of technological developments that were conditions in the metalworking machinery industry itself.

Further developments in machine design include the use of "tracer technology, perfected during the late 1930's and 40's, which involved the use of patterns or templates; these were traced by an hydraulic or electronic sensing device which in turn conveyed the information to a cutting tool which reproduced the pattern in the workpiece."[29] In the late 1940's and early 1950's, a radically new method of controlling the machining process was developed - numerical control (NC). This process involves the feeding of

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[29]David Noble, "Social Choice in Machine Design: The Case of Automatically Controlled Machine Tools," Case Studies in the Labor Process, Monthly Review Press, New York, forthcoming in 1979, pp. 5-6.

numerical data directly into the machine tool to control the actions of the machinery. This technology, devised by John Parsons and built at the Servomechanisms Laboratory at Massachusetts Institute of Technology, under contract from the Air Force, was especially applicable to the machining of parts for the aircraft industry. The involvement of the government was not limited simply to supporting the research activity (the Air Force spent over $62 million on the research from 1949-59); the Air Force also paid for, and installed, 100 of these numerically controlled milling machines in the plants of prime subcontractors, and paid "the contractors, aircraft manufacturers, and their suppliers .... to learn to use and maintain the new technology."[30]

Numerical control technology has been commerically developed over the last twenty years in a number of ways. Computer numerical control (CNC - where a minicomputer is placed directly on the machine tool to control the production process) has been gaining popularity over tape numerical control (TNC - where mathematical instructions are coded onto a tape which is read by the machine and translated into machine control) due to its greater flexiblity, especially in handling small volume jobs. The first commercial numerical control unit was built by the Bendix Corporation in 1954. The initial period following the introduction of NC machine tools was not characterized by a rapid acceptance of the technology. The industrial use of NC machinery really didn't begin in any significant degree until the mid to late 1960's. Even today, "less than one percent of all machine tools now

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[30] Iron Age, "The Machine Tools that are Building America," p. 158.

in use in the United States are numerically-controlled."[31] Some reasons for this limited acceptance include the fact that the NC machines are extremely expensive relative to conventional ones, the average price of a NC machine being about a quarter of a million dollars in 1977. Since many users of these machines are relatively small metalworking firms, this expense can be overwhelming.[32] Moreover, the complexity of the technology has inhibited its rapid acceptance. And finally, "machine tool and controls experts estimate that NC is applicable to, and economically viable on, only about five to ten percent of the machine tool population."[33]

However, NC machinery has been increasing its share of the machine tool market since 1965, especially the CNC machines, where the overhead of utilizing the technology (that is, the development of software) is considerably less complex and expensive than that associated with the earlier development of numerical control (TNC).[34]

Numerically controlled machining appears, then, to have become increasingly important in recent years, and is still touted, perhaps more so in the last few years, as the major technological development in metalworking

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[31] Iron Age, "The Machine Tools that are Building America," p. 158.

[32] This issue will be discussed in more detail in Chapter Four.

[33] Iron Age, "The Machine Tools that are Building America," p. 158.

[34] See David Noble on reasons why the software of early NC development was so complex and inaccessible.

machinery design. Moreover, the extension of numerical control technology from the early focus on milling machines, jig borers and drilling machines to a broader line of machine tools has occurred. Additional applications of this automatic technology have occurred in areas of materials transfer and multi-function machining centers. One manufacturer has introduced a machining center/transfer line consisting of some 65 machines, close to 60 industrial robots and computer controlled transferring devices. Materials are introduced into the system and the finished product emerges. "There were no machine operators involved. Only machine managers to oversee operations."[35]

Industry spokespersons have heralded these new developments as a means of achieving greater productivity, more accurate production, and also as necessary to survival in a period of extreme shortage of skilled mechanics. David Noble[36] offers another explanation: the desire on the part of management to remove control over the production process from the hands of the operators on the shop floor. As has been discussed, the skills and judgement of machine operators have traditionally been crucial in metalworking manufacture. The operator decided when the specific dimensions of the work have been achieved, when the cutting tools need to be replaced, when the grinding wheel has worn down and needs redressing, etc. Noble notes that

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[35] Iron Age, "The Machine Tools that are Building America," p. 158.

[36] David Noble, "Social Choice in Machine Design."

> .... the very same skills and shopfloor control that made production possible also made 'pacing' possible (and that) pacing was practiced by operators for many reasons: to keep some time for themselves, to exercise authority over their own work, to avoid killing 'gravy' piece-rate jobs by over-producing and risking a rate cut, to stretch available work out for fear of layoffs, to exercise their creativity and ingenuity in order to 'make out' on 'stinkers' (poorly rated jobs), and of course to express hostility to management.37

The concern of management over shop-floor control is illustrated in the following example:

> There was evident prejudice on the part of the operators of the machines in favor of the older type. Apparently, the quality of the Fellows-cut gear was superior to the other and so the operator was stamping the other company's name upon the product from the Gear Shaper and reversing the procedure with respect to the other machine's product. Bill Slomer (Fellows) discovered this and pointed it out to Durham (Buick). So Durham watched and caught the operator red-handed stamping the wrong name upon the Gear Shaper product. Durham swung his right fist from the cellar, so to speak, and caught the operator on the jaw. He went down and out. He nailed the other operator with his left hand and knocked him over a bench. Then he called the foreman over, "Carry this sculch out of here," said Durham, "If it happens again, the same thing will come to you."38

The machine operator, in this case, had enough control over the production process to be able to make the machine he liked appear to be more productive than the machine management might prefer. While this example comes from the early 1900's, other more recent statements from Iron Age further illustrate this point:

> The fundamental advantage of numerical control had been

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[37] Ibid., p. 20.

[38] Wayne Broehl, Precision Valley, p. 64.

clearly spelled out ... It brings production control to the engineering department 39

The computer informs the operator which tools should be changed and when to stop the machine to make tool changes. If the instructions are ignored, the lights flash, and if still ignored, the (production) line is stopped.40 (author's emphasis)

This has created a dilemna for the industry. Man's expertise is desired but the man is not.41

In tool and cutter grinding operations, NC permits complex contours and automatic backoff for clearance operations that can be predicted and controlled rather than reliance on operator's judgement and feel.42

An uninformed or uninterested operator can easily remove excessive amounts of wheel face. When and how much of the wheel to dress is a major productivity decision for management.43

.... using pre-set, quick-change toolholders in conjuction with a tool control board ... removes the responsibility for tool maintainence from the operator.44

An advantage of this new CNC unit is that the user is not required to handle the computational software of the system. Software is stored in programmable read only memories. Control diagnostics, machine logic and control programs are all in non volatile firmware.45 (author's emphasis)

Noble examines the development of numerical control as opposed to a

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[39] Iron Age, "The Machine Tools that are Building America," p. 158.

[40] Ibid., p. 220.

[41] Ibid., p. 226.

[42] Ibid., p. 227.

[43] Ibid., p. 228.

[44] Ibid., p. 281.

[45] Ibid., p. 292.

rival technology with similar capabilities (record-playback), and concludes that NC was "chosen" because it did offer greater opportunities for management to actually control the production process. The few examples presented above suggest that the NC machinery, if not developed specifically for the purpose of removing control from the shopfloor, is nonetheless being promoted for that very reason. A further note concerning this technological development: NC machining does reduce the skill levels required in metalworking manufacturing, as did earlier developments such as tracer technology, electrical, pneumatic and hydraulic controls, etc. However, the degree to which NC has effectively resulted in the transfer of control from the shopfloor to the engineering departments and management offices is not yet clear.[46]

This brief discussion of numerical control technology illustrates a number of aspects of the current trend in research and development in the metalworking machinery industry that have been mentioned above. First, the role of the federal government, in supporting particular research programs, has had a definite impact on the nature of technology developed. Second, the focus of research and machine innovation has shifted from the individual machinist/designer working independently to the large scale research facilities or universities and the major corporate firms of large industries. Third, and closely related to the previous point, is the fact that the machinery builders themselves appear to simply incorporate the technology developed elsewhere (and perhaps do some applied engineering work) to satisfy

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[46] David Noble, "Social Choice in Machine Design."

the needs of their primary customers. And finally, it is these customers, and the conditions existing within these consuming industries, which have shaped the character of recent innovations in machine design. Specifically, the labor problems, especially following World War II, of the automobile, aerospace and other durable goods producers appear to have "encouraged" these industries to demand more and more automated equipment which permits management to exercise greater control over production and decreases the requirements for skilled labor in manufacturing.

Chapter 3

Important Characteristics of the Metalworking Machinery Industry

Cyclical Volatility of the Metalworking Machinery Industry

One of the most distinguishing characteristics of the metalworking machinery industry, both in the United States as a whole and the New England region, is its vulnerability to general business cycles. This cyclical instability is a consequence of the nature of this capital goods producing industry. Since the products of the metalworking machinery industry are sold to industrial customers for capital investment purposes, the industry's health is extremely dependent upon the health of its major customers. These customers are often able to put off their investment expenditures indefinitely during periods of low demand. For example, if the demand for automobiles is depressed, the automotive industry can decide to delay their purchases of new machine tools. The machine tools already in their plants are probably more than adequate for their decreased production requirements. Orders for new machine tools can drop to nothing. On the other side of the business cycle, the demand for new machine tools escalates enormously. Not only are more machines needed to produce the increased volume of automobiles demanded, but the automotive industry needs to replace those older machines whose replacement had been deferred in the downturn.

> (This) durability of machine tools contributes to an "aggravation" of the cyclical demand tendencies for all capital goods to the extent that it may exceed the average durability of such goods. The long life built into machines, and its prolongation through the addition of improvements or by rebuilding means that the purchase of new machine tools can be almost indefinitely postponed when business is poor. When the upturn comes, and increased production plus cost savings is a competitive must, the economic life of the equipment may be seriously curtailed as obsolescence sets in. As a result, a "bunching" of

> orders for new machine tools often occurs and thus the "typical" pattern of cyclical demand for machine tools emerges with its severe fluctuations in amplitude.1

It should be noted here that other segments of the metalworking machinery industry, aside from the machine tool component, are similarly affected by general business conditions. The tool and die industry, for example, experiences similar "bunching of orders" when automobile manufacturers change models and require new dies for body work. Moreover, since a portion of the tool and die industry provides ancillary services such as tooling, jigs and fixtures, to machine tool buyers, their business is very closely tied to machine tool sales. Another factor which intensifies the instability of the tool and die industry is the "make or buy" decision of major customers. Industries such as automobile or aircraft manufacturing usually maintain some in-house capacity for tooling, the so-called "captive" shops. Some industry spokespersons have stated that the growth of the captive shop has increased the vulnerability of small tool and die shops to business cycles. These captive shops, it has been stated, are utilized more intensively during business cycles troughs (so that these industries can stabilize their own employment levels), thereby taking over a part of business that would otherwise go to the independent shops. The degree to which this "make or buy" decision varies over the business cycle will also accentuate the

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[1] Robert S. Himes, A Study of the Machine Tool Industry with Emphasis on the Problem of Stability, Unpublished Ph. D. Dissertation, The American University, Washington, D. C., 1962, in H. Wagoner, The U. S. Machine Tool Industry from 1900 to 1950.

cyclical fluctuations experienced by the tool and die industry.[2]

The "other" segment of the metalworking machinery industry (SICs 3545 - Machine Tool Accessories, 3546 - Rolling Mill Machinery, and 3549 - Metalworking Machinery, not elsewhere classified) is also subject to cyclical instability to some degree. First, some firms in this category also produce machinery (although it is not classified as machine tools). These firms experience problems similar to those of the machine tool industry - durability of product and the relatively minor size of replacement demand in business cycle downturns. Second, other firms which do not produce machine tools may in fact be producing machine tool components, or, like the tool and die industry, products that are required when a new machine tool is purchased or installed. The fortunes of these firms, therefore, are also closely linked to the sales of machine tools. However, this "other" category also includes firms which produce expendable equipment. These are products which are not classified as capital goods; they are used up in the production process and must be periodically replaced. Therefore, to the extent that firms in this category manufacture non-durable or non-capitalized products, they are more insulated from the swings of the business cycle.

The 1967 Bureau of Economic Analysis (BEA) national input-output table (at the 484 industry level of aggregation) was examined in order to determine how much of the output of these component industries was classified

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[2] Most complaints about these captive shops appear to refer to the policies of the automobile industry in the Mid West. Firms in New England seem to feel that the captive shop problem is not a serious one in this region.

as capital purchases (gross private capital formation). The following figures were obtained:

74% of the output of SIC 3541 (metalcutting machine tools) was used in capital formation;

68% of the output of SIC 3542 (metalforming machine tools) was used in capital formation;

18% of the output of SICs 3544 and 3545 (special tools and dies and machine tool accessories[3]) was used in capital formation; and

66% of the output of SICs 3546, 3547 and 3549 (power driven hand tools, rolling mill machinery and equipment, and metalworking machinery, not elsewhere classified) was used in capital formation.

A further look at the BEA input-output table was taken. In the national accounting system used by the BEA in constructing this table, only purchases by private domestic consumers are included in gross private capital formation. This excludes capital purchases by the federal, state and local government, and sales to foreign countries. These categories were added to gross private capital formation to obtain the following figures[4]:

90% of the output of SIC 3541 was used in capital formation;

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[3]Note that this includes both the tool and die industry and part of the "other" portion of the metalworking machinery industry. Unfortunately, this is the way the data were aggregated by the BEA.

[4]Note that these figures are probably overestimates of the degree to which the output of the metalworking machinery industries was used in capital formation, in that they assume that all government purchases and all export sales are for capital equipment. While this assumption is probably relatively realistic, it nevertheless represents an overstatement of the degree to which sales of these component industries are of a capital rather than current or expendable nature.

86% of the output of SIC 3542 was used in capital formation;

24% of the output of SICs 3544 and 3545 was used in capital formation; and

81% of the output of SICs 3546, 3547 and 3549 was used in capital formation.

It is clear from these data that SICs 3544 and 3545 sell a much larger percentage of output to current rather than capital account, and should therefore be theoretically less vulnerable to business cycle fluctuations. Figures 1 and 2 present, respectively, employment and deflated value of shipments (sales) time series for the metalworking machinery industry (SIC 354), the machine tool industry (SIC 3541 and 3542), the tool and die industry (SIC 3544), and the "other" sector of the three-digit industry (SICs 3545, 3546, 3547, and 3549). It can be seen from Figure 1 that employment in the machine tool industry has climbed to higher peaks, and fallen to lower depths than either the tool and die or the "other" metalworking machinery industry. The same pattern can be seen in Figure 2, although here the value of shipments of "other" metalworking machinery reach a higher peak in 1974 than either of the other two subindustries. The coefficients of variation for both employment and sales for these industries are presented below:

Table 4
Variability in the Metalworking Machinery Industry and Its Component Sectors

United States

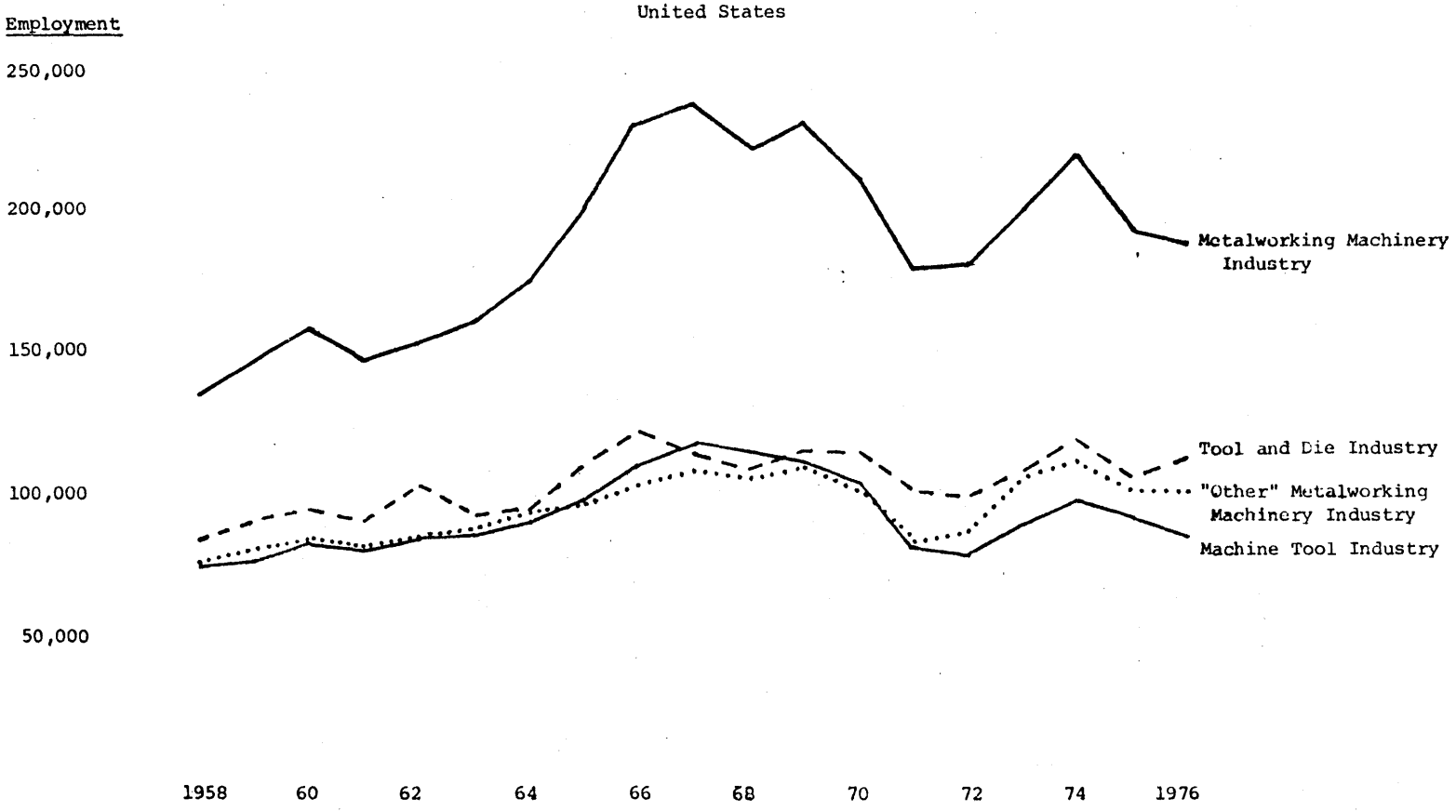
SIC 354	Employment (000)	Value of Shipments (millions of 1972 dollars)
Mean	287.6	7276.1
Standard Deviation	32.8	1810.7

Figure 1

Employment in Metalworking Machinery, Machine Tools,

Tools and Dies and "Other" Metalworking Machinery

United States



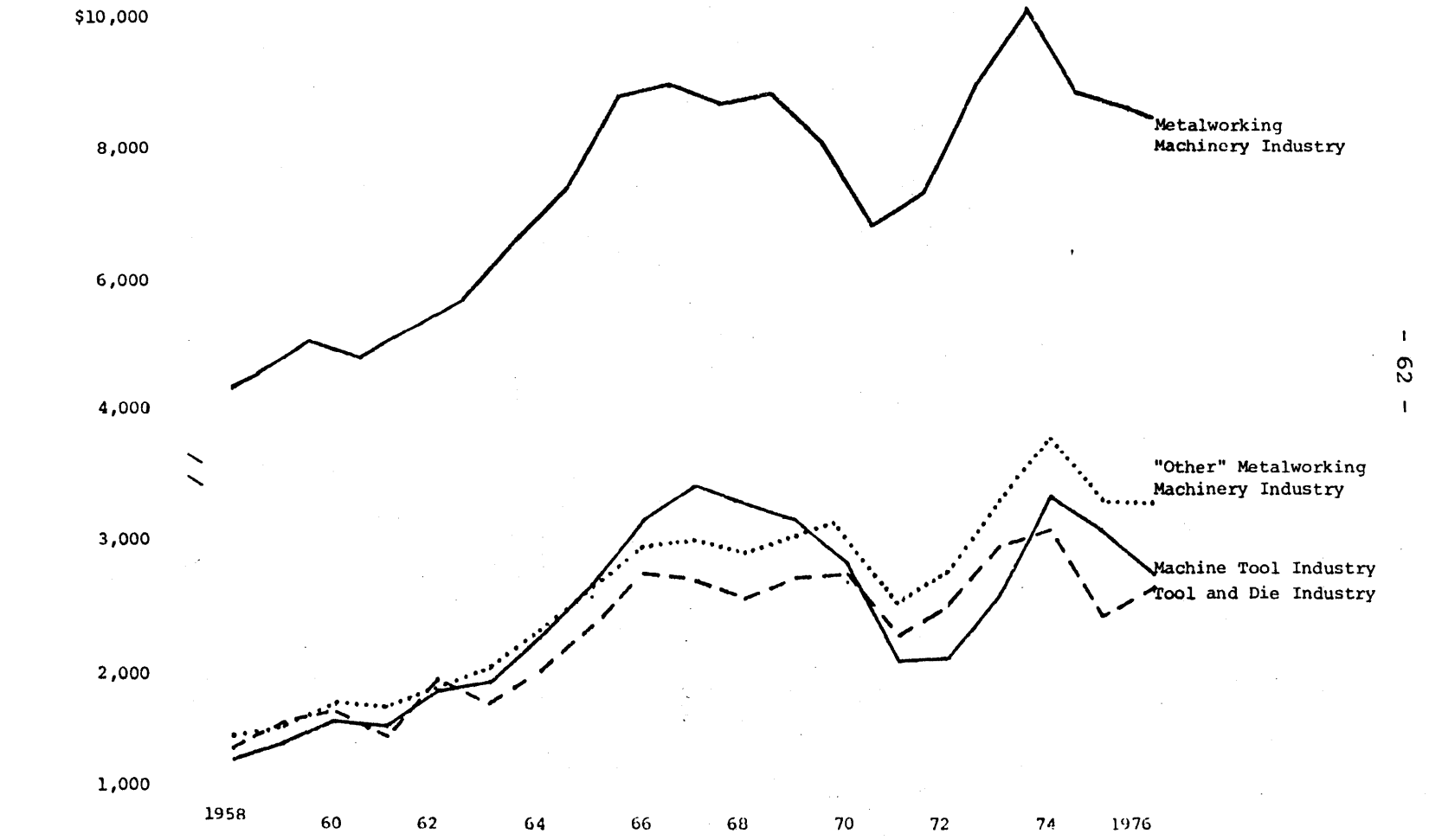
Sources: Annual Survey of Manufactures and Census of Manufactures, 1958-1976.

Figure 2

Value of Shipments in Metalworking Machinery, Machine Tools

Tools and Dies and "Other" Metalworking Machinery

United States



Sources: Annual Survey of Manufactures and Census of Manufactures, 1958-1976.

Coefficient of Variation	11.4%	24.9%
SICs 3541 and 3542		
Mean	90.0	2418.3
Standard Deviation	13.5	688.5
Coefficient of Variation	15.0%	28.5%
SIC 3544		
Mean	102.4	2242.6
Standard Deviation	10.5	503.4
Coefficient of Variation	10.3%	22.4%
SICs 3545, 3546, 3547 and 3549		
Mean	94.6	2564.2
Standard Deviation	10.6	667.3
Coefficient of Variation	11.2%	26.0%

Sources: Annual Survey of Manufacturers and Census of Manufactures, 1958-1976.

These figures support the conclusion that the tool and die industry, and probably part of the "other" metalworking machinery industry experience less violent fluctuations in both employment and sales than does the machine tool industry. This phenomenon, moreover, appears to be a function of the degree to which the industry's products are used in capital formation.

Cyclical Volatilty and the New England Region

Turning to the New England region, the question of whether or not the metalworking machinery industry in this region is more or less stable than its national counterpart arises. There has been a great deal of concern expressed lately as to the differential experiences of regions in business

cycles.[5] The industry mix of a region has been offered as an explanation for these regional differences; that is, regions with a larger portion of their employment in durable goods manufacture are more sensitive to national economic conditions.[6] However, by looking at the cyclical fluctuations of a single industry, the question of industry mix is already accounted for to some degree. Of course, the degree to which the industry is tied to customers in the region will again bring up the question of regional industry mix. However, a comparison of the cyclical instability of the metalworking machinery industry in New England to that in the United States should indicate the degree to which the industry is more or less stable at the two geographical levels, relatively independent of the industry mix of the areas.

Figures 3, 4, 5, 6, 7 and 8 present time series of employment and value of shipments for the United States, New England[7], Connecticut, Massachusetts, Vermont, and Rhode Island (the only states for which time series

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[5]Richard Syron, "Regional Experience During Business Cycles - Are We Becoming More or Less Alike?" New England Economic Review, November/December 1978.

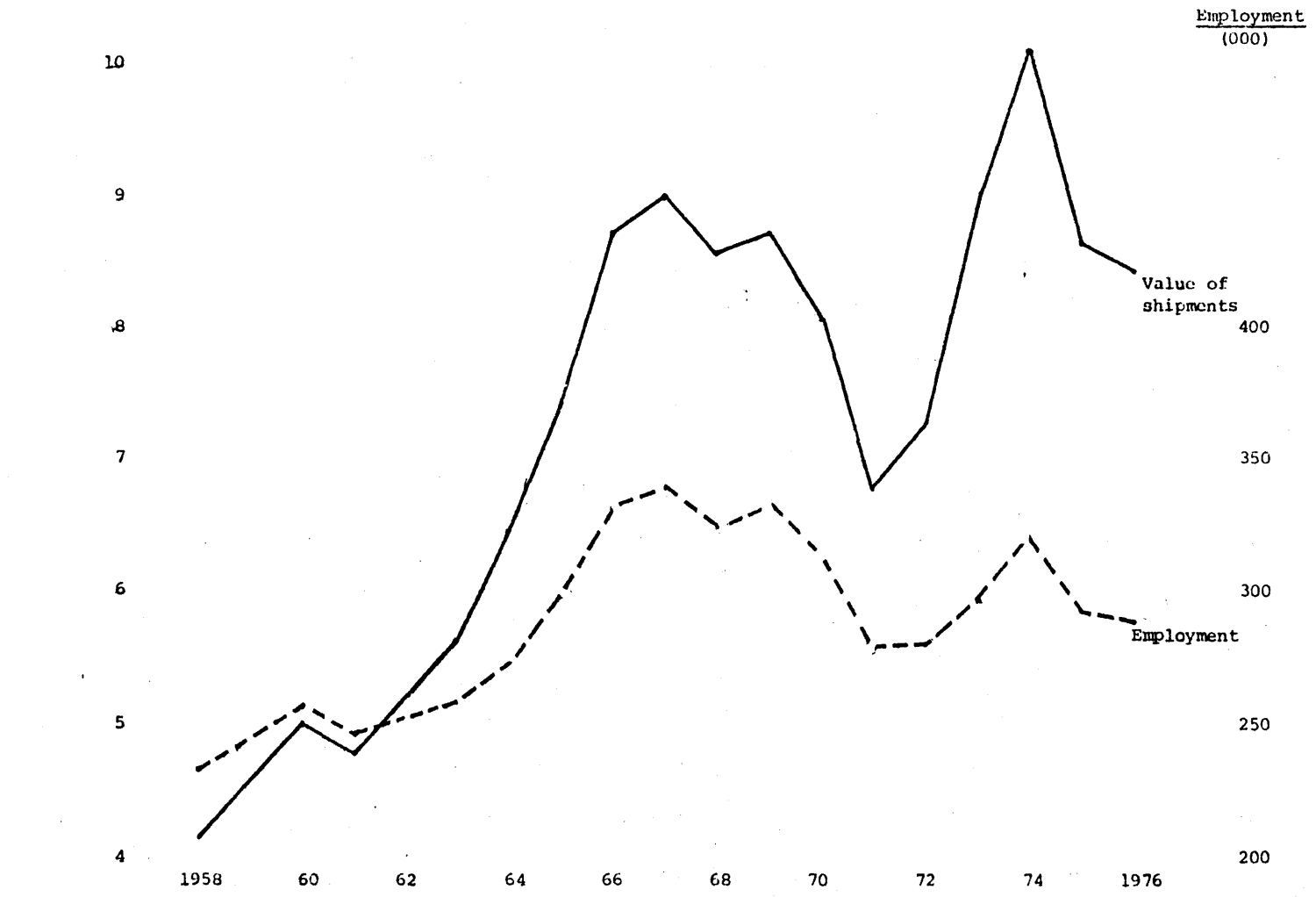
[6]Lynn Browne, "Regional Industry Mix and the Business Cycle," New England Economic Review, November/December 1978.

[7]Please note that the data for New England after 1972 do not include the states of New Hampshire and Maine, as information for these states was not available after 1972.

Figure 3

UNITED STATES

Value of Shipments and Employment

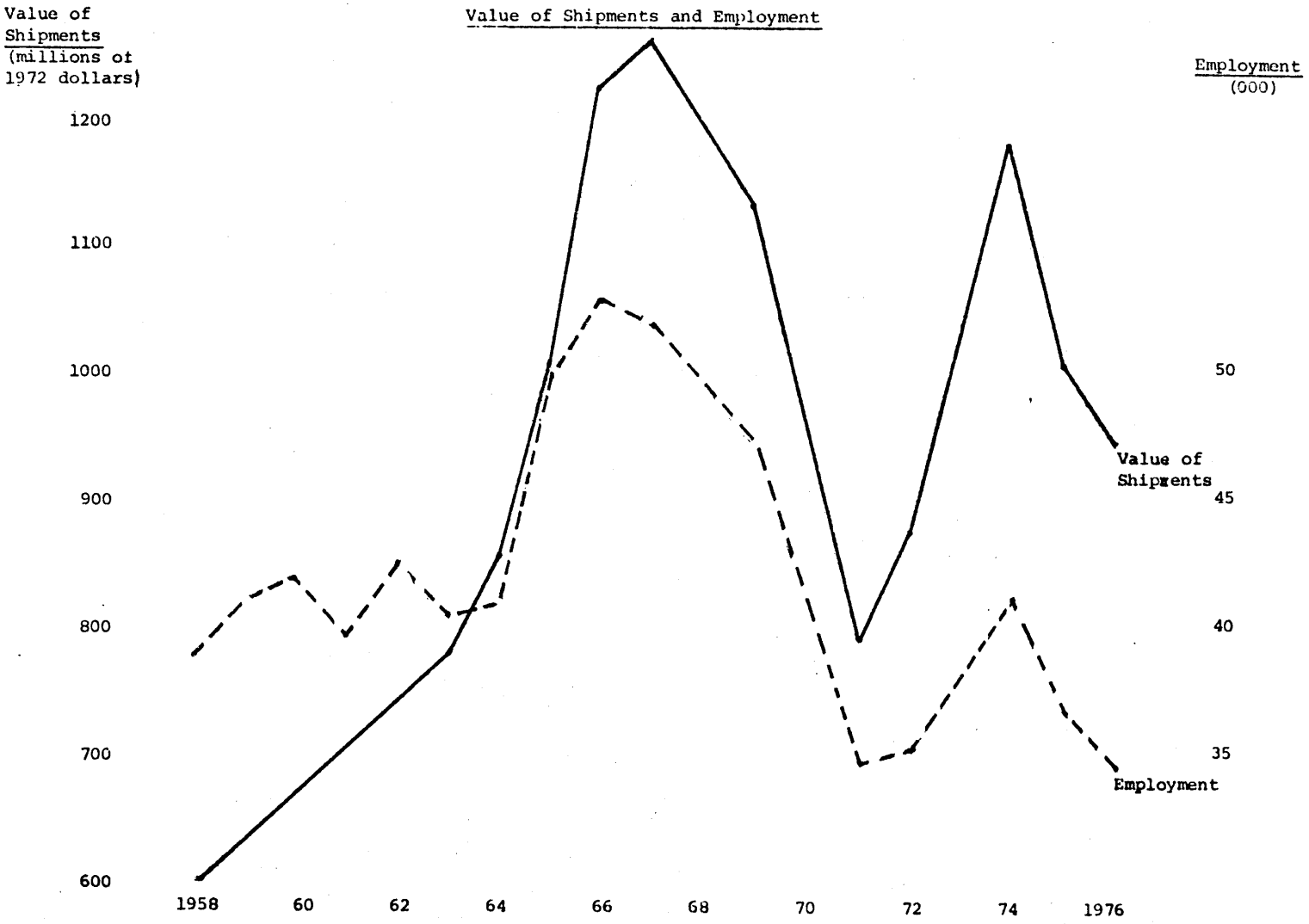


Sources: Annual Survey of Manufactures and Census of Manufactures, 1958-1976.

Figure 4

NEW ENGLAND

Value of Shipments and Employment

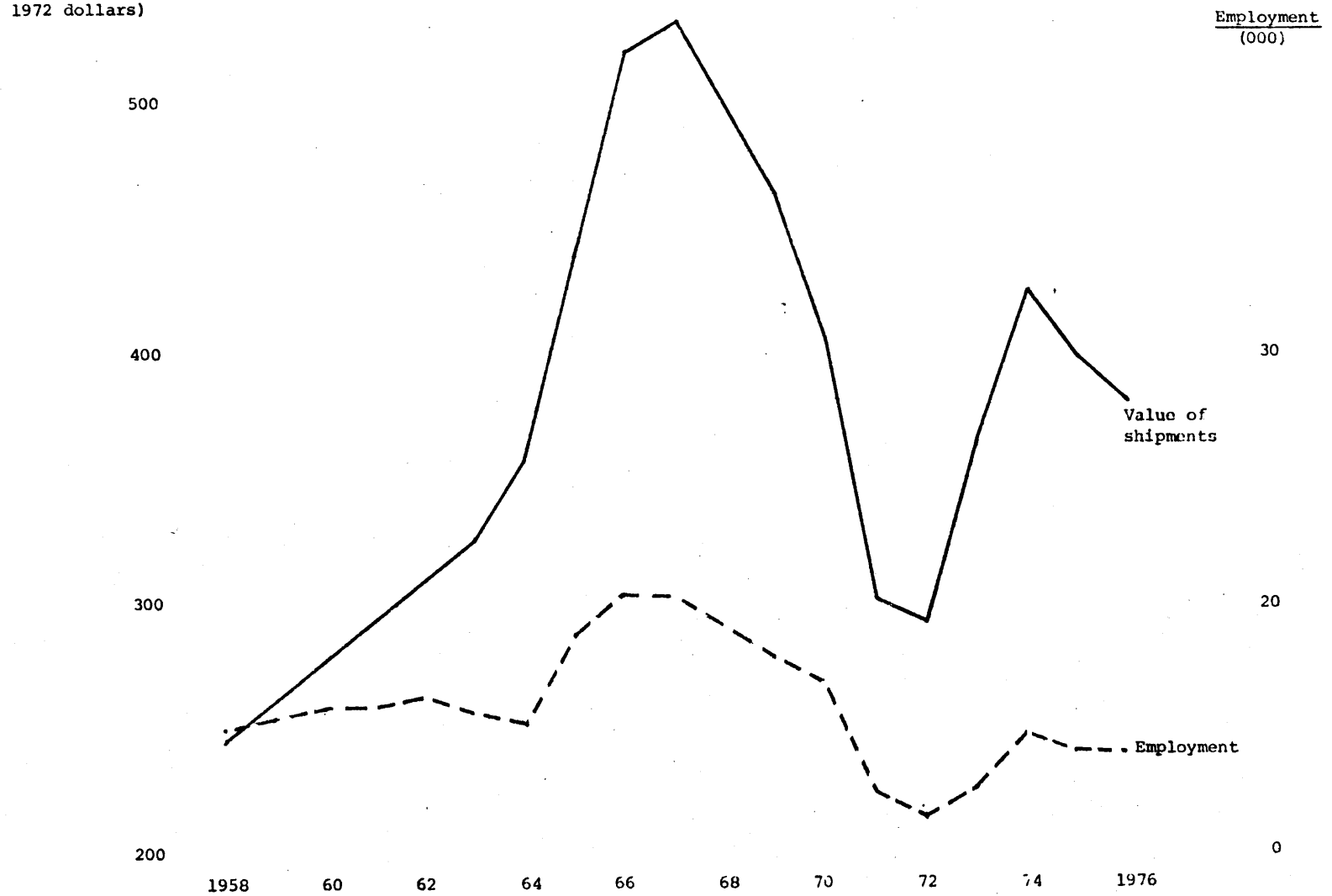


Sources: Annual Survey of Manufactures and Census of Manufactures, 1958-1976.

Figure 5

CONNECTICUT

Value of Shipments and Employment

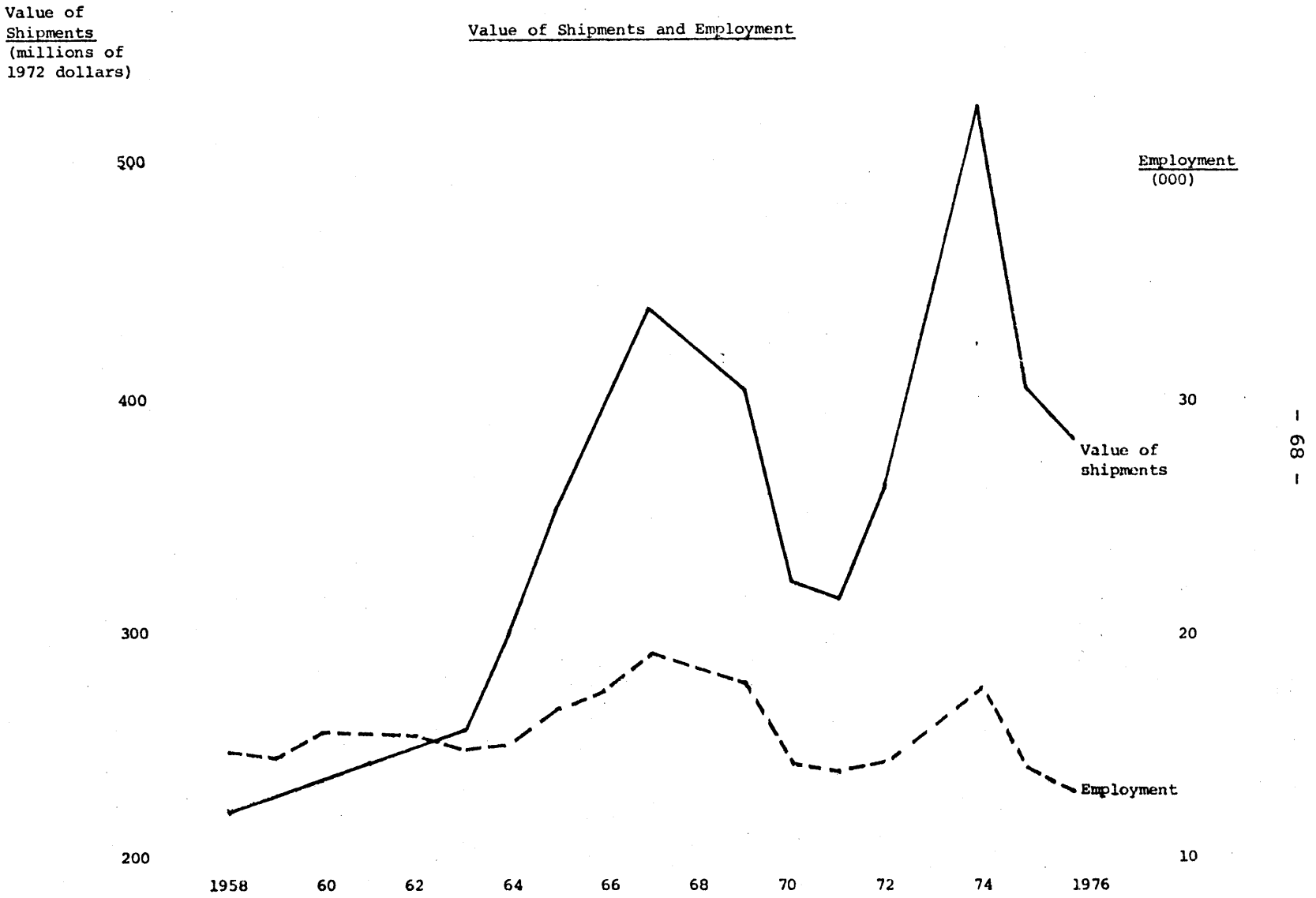


Sources: Annual Survey of Manufactures and Census of Manufactures, 1958-1976.

Figure 6

MASSACHUSETTS

Value of Shipments and Employment

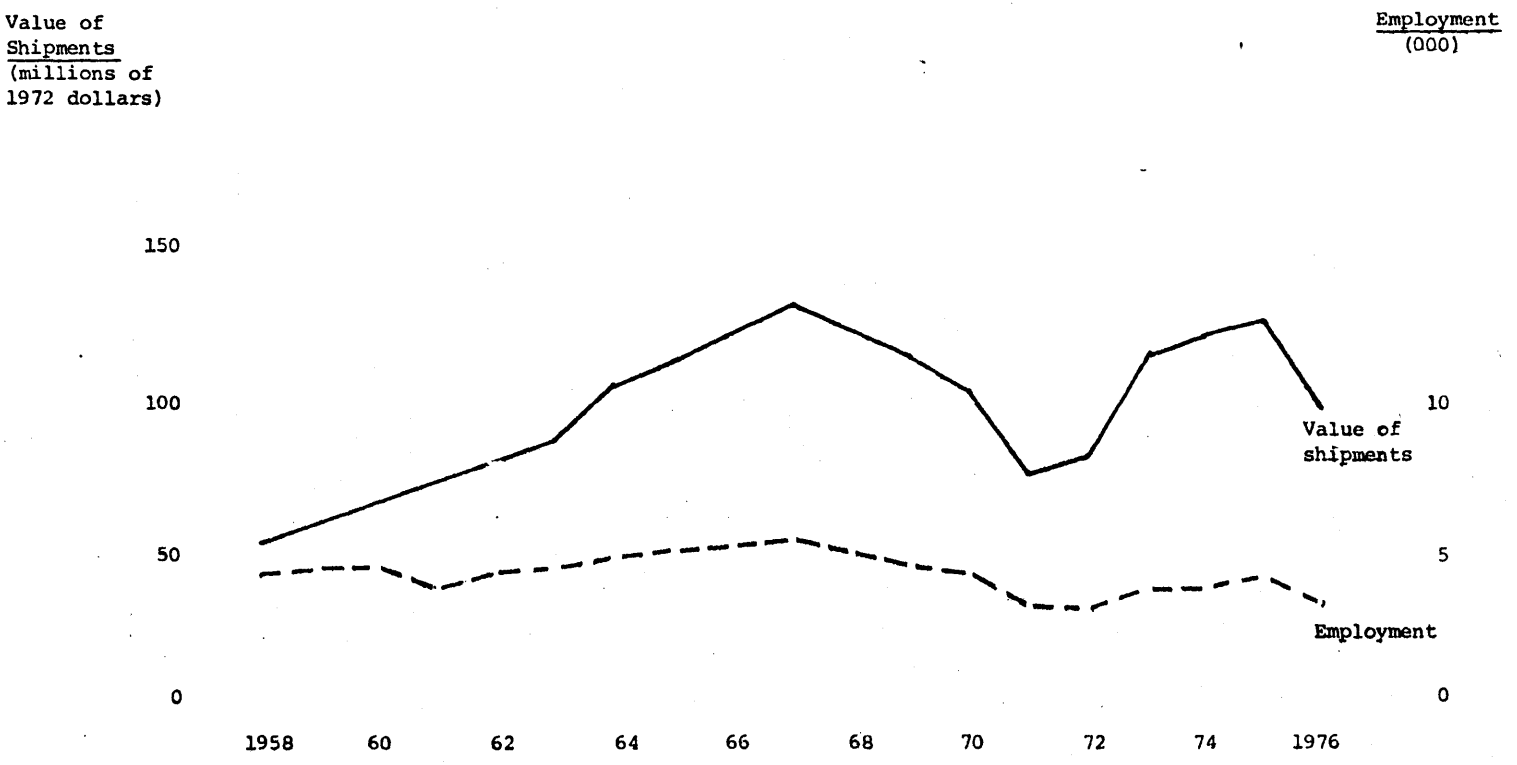


Sources: Annual Survey of Manufactures and Census of Manufactures, 1958-1976.

Figure 7

VERMONT

Value of Shipments and Employment

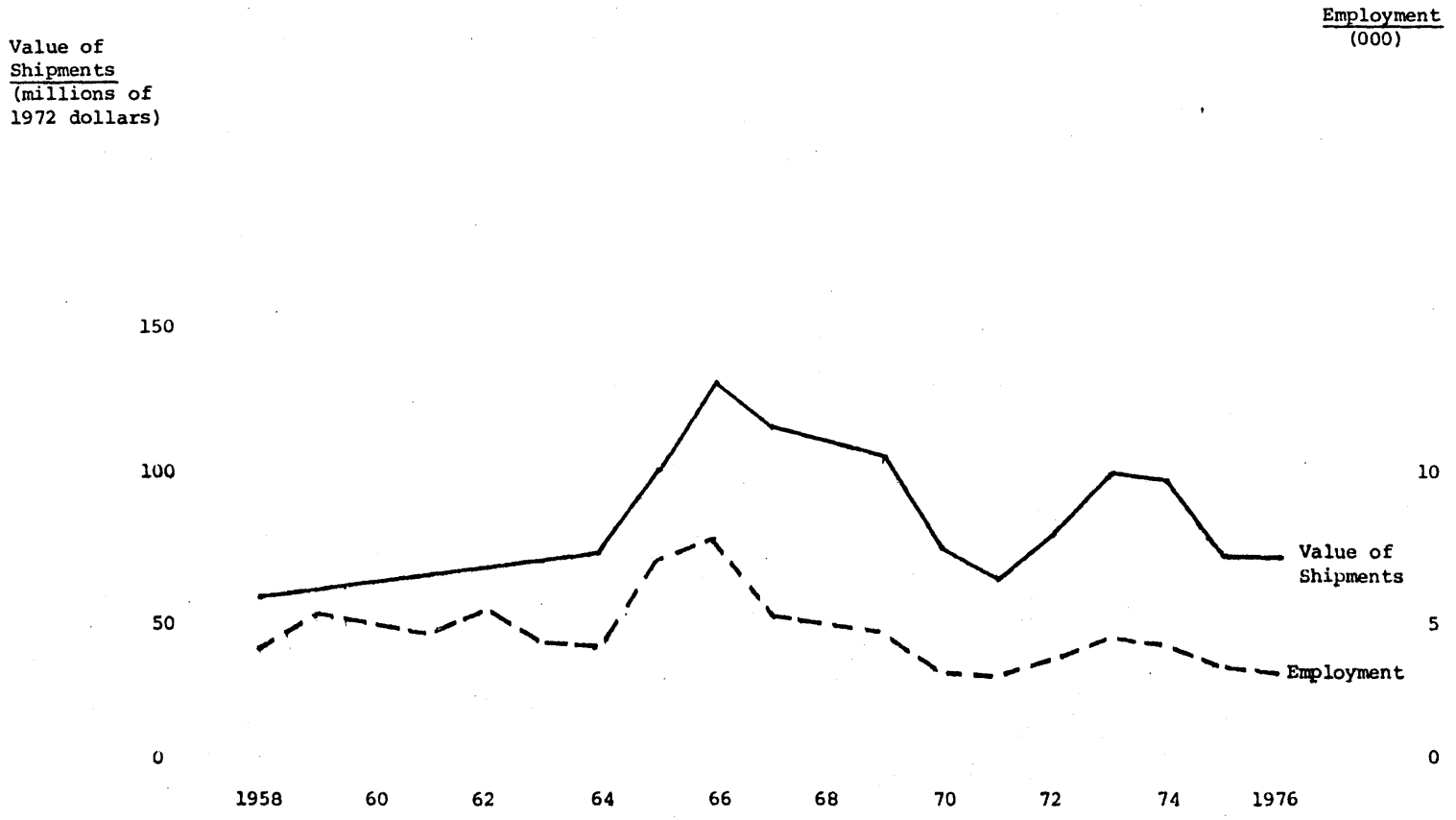


Sources: Annual Survey of Manufactures and Census of Manufactures, 1958-1976.

Figure 8

RHODE ISLAND

Value of Shipments and Employment



Sources: Annual Survey of Manufactures and Census of Manufactures, 1958-1976.

data were available). The differences among the states, the region, and the nation are not immediately apparent in these charts. However, it can be seen that the states and the region follow rather similar cyclical patterns. A series of bivariate regressions were fitted, regressing either employment, the number of production workers, or sales, against time. The standard errors of these equations were then compared to the mean value of the dependent variable to see if, after correcting for the secular trends in the variables, there were discernable differences in stability between the region and states and the nation as a whole. The results are presented below:

Table 5

Variability in the Metalworking Machinery Industry

United States and the New England Region

	Employment	Number of Production Workers	Value of Shipments
United States			
Mean	284.7	213.2	7140.3
Standard Error	29.0	23.4	1053.0
Standard Error/Mean	10.2%	11.0%	14.8%
New England			
Mean	41.8	30.3	921.8
Standard Error	5.6	4.4	173.9
Standard Error/Mean	13.3%	14.5%	18.9%
Connecticut			
Mean	15.9	11.4	328.2
Standard Error	1.7	1.3	74.8
Standard Error/Mean	15.3%	17.3%	21.8%

Massachusetts			
Mean	15.9	11.4	328.2
Standard Error	1.7	1.3	74.8
Standard Error/Mean	10.8%	11.0%	22.8%
Vermont			
Mean	4.3	2.9	97.4
Standard Error	.6	.4	19.7
Standard Error/Mean	14.4%	13.5%	20.2%
Rhode Island			
Mean	4.7	3.4	85.6
Standard Error	1.2	1.0	21.3
Standard Error/Mean	25.1%	28.6%	24.9%

Sources: Annual Survey of Manufacturers and Census of Manufactures, 1958-1976.

In all cases, there is a greater degree of variation in industry sales in the New England states and in the region as a whole than is the case for the U. S. And, with the exception of Massachusetts, there is also a greater degree of variability in both employment and the number of production workers in the New England region.

Two questions immediately come to mind. First, why is the metalworking machinery industry more cyclically sensitive in the New England region? And second, what kind of influence has this instability had on the industry? The former question is difficult to deal with. One possible explanation may be, once again, the industry mix issue. In the first place, the machine tool industry appears to be a substantially larger share of metalworking machinery in this region relative to other areas of the country, and since this component of the three-digit industry is less stable even in the nation,

New England's metalworking machinery industry is more volatile. In the second place, the degree to which the industry is tied to local industries may also offer part of an explanation. The tool and die industry in New England, and particularly in Connecticut, is to some degree a service industry for aircraft firms in the region. The aircraft industry, particularly through the 1960's and early 1970's, experienced enormous growth and decline, presumably causing a "ripple" effect downwards to those firms providing services to the industry. Browne, examining the relationship between industry mix and cyclic vulnerability, notes that:

> New England's industry mix (is) somewhat more procyclical in the sense that the industries followed - in exaggerated fashion - the national cycle more closely. This was particularly so in the late sixties ... New England is much more involved in the manufacture of aircraft and aircraft parts ... In the East North Central division (where the metalworking machinery industry is most concentrated), motor vehicles and primary metals explain why its industry mix does not follow the same pattern as New England ... Both are very volatile - but they do not move exactly in step with the rest of the economy.8

Browne goes on to point out that, in cases where an external factor, such as a decrease in government demand for defense materials, coincides with a general recession, regional responses to the recession may diverge sharply. This, then, appears to have been the case in the late sixties in New England, while in other regions the health of the metalworking machinery industry was tied to other industries not subject to "capricious" changes in government policy.

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[8]Lynn Browne, "Regional Industry Mix and the Business Cycle," p. 44.

It is also of interest to examine the ways in which the industry deals with this problem of instability. This question will be examined from two perspectives: active responses and reactive responses of the industry. The active responses would consist of attempts by the industry to stabilize or smooth out these cycles in product demand. Reactive responses to the instability of demand are of a more passive nature. Specifically, the instability of demand is taken as a given. Firms then are forced to cope with this problem, as opposed to actually alleviating the problem itself.

Active Responses to Instability - Diversification

One way to actively respond to demand instability is to diversify products and/or markets. By diversifying product lines, a firm's fortunes are not tied simply to the sales of one product. This response, however, does not appear to be prevalent among metalworking machinery firms, both in the nation and in the New England region. The probable reason for this is that, given the nature of the production processes of metalworking machinery, any diversification of product would probably be in the direction of other types of capital equipment subject to similar cycles of demand. Moreover, especially for smaller firms, the capital requirements of taking on another, related product line are substantial. Most smaller firms interviewed have expressed the opinion that it is simply not worth the trouble to diversify their product line, since this would entail not only different capital requirements, but also would probably require different labor skills, getting involved in advertising, and other management problems. The Census of Manufacturers publishes "specialization ratios" for manufacturing

industries at the national level. These ratios indicate the extent to which an industry's output is specialized in its primary product -- that is, the degree to which the industry produces secondary products (is diversified). The specialization ratios for the four-digit component industries of SIC 354 reveal that, if anything, the industry has become more specialized in the production of its primary product since 1958, supporting the opinion expressed in the interviews, that product diversification (outside the four-digit product group) is not a widely-used response to cyclical volatility.

Table 6

Specialization Ratios

Sector	1958	1972
SIC 3541 (metalcutting machine tools)	85%	86%
SIC 3542 (metalforming machine tools)	82%	89%
SIC 3544 (special tools and dies)	93%	94%
SIC 3545 (machine tool accessories)	85%	86%
SIC 3546 (power driven hand tools)	n. a.	82%
SIC 3547 (rolling mill machinery and equipment)	n. a.	84%
SIC 3549 (metalworking machinery, not elsewhere classified)	n. a.	86%

Source: Census of Manufactures, 1972.

The other way a firm can diversify is to expand or broaden its market. This response is much more evident among the firms interviewed. Some small firms stated that they did not allow themselves to become too dependent upon any one industry or firm as a major customer. Moreover, those firms,

both large and small, who stated that they made a conscious effort to diversify their customers reported a greater deal of stability in their operations over the business cycle. However, this is by no means a universal practice; there are still a large number of firms completely dependent upon a particular industry, and in some cases a single company, for a substantial portion of their business.

On a more macro level, the metalworking machinery industry, particularly the machine tool industry, has been traditionally interested in the possibility of using the international market as a means of smoothing out the cycles of product demand.[9] During the depression of the 1930's, for example, the export market, especially to countries like the U. S. S. R. and Japan, proved to be extremely important to many firms. The argument of the machine tool industry has been that, in periods of low demand domestically, firms should try to stimulate their foreign export business to pick up the slack in orders. Presumably, in cyclical upswings, when business is booming, firms will then concentrate primarily on the domestic market. Figure 9 presents data on the sales of the machine tool industry and on the percentage of total sales that were exported for the last twenty years. The figure shows that, to some degree, the share of total sales that are foreign moves countercyclically. When the domestic market was expanding enormously in the mid to late 1960's, foreign sales represented a relatively small proportion of total sales. When the domestic market was on the downturn, particularly from 1969 to 1971, foreign sales became a much larger component of total sales. When the

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[9] The tool and die industry, which is much more attached to the local market, is not able to engage in extensive export activities due to the nature of the product and the importance of close contact with customers, as mentioned in Chapter One.

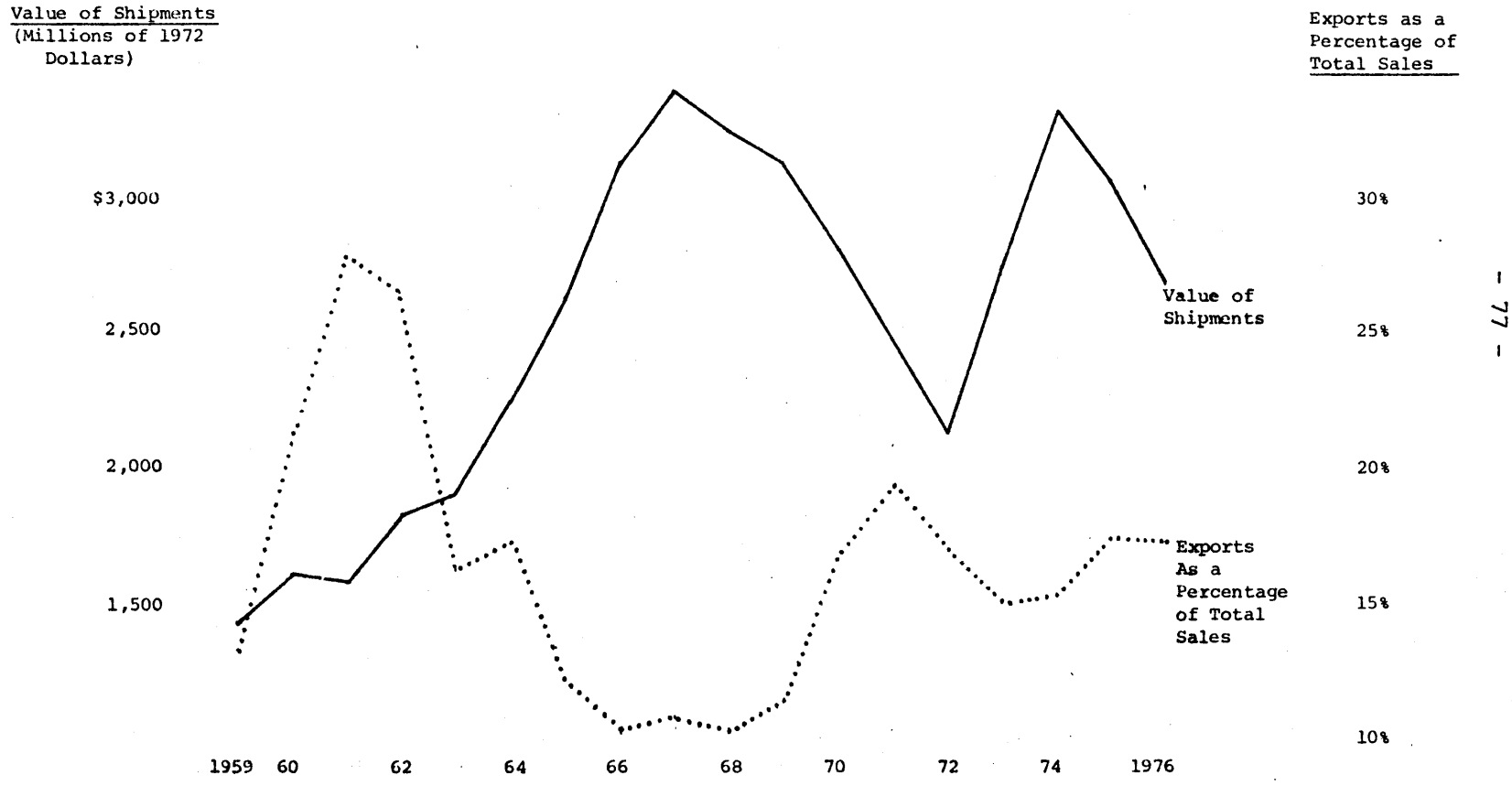
Figure 9

Value of Shipments and

Exports as a Percentage of Total Sales

Machine Tool Industry

United States



Source: 1978-1979 Economic Handbook of the Machine Tool Industry.

domestic market picked up (from 1972 to 1974), exports fell as a share of sales; and in the subsequent downturn of 1974 to 1976, exports again assumed a relatively greater importance. However, these data do not appear to support the hypothesis that firms are completely successful in using the international market as a buffer in periods of low demand, given the fact that the relative importance of exports seems to have declined rather substantially over the last twenty years.

There are a number of reasons why the U. S. machine tool industry has not been able to use export trade to alleviate the cyclical problems of the industry. First, foreign markets are not accessible to all machine tool firms, and, as mentioned above, is not at all relevant to other components of the metalworking machinery industry. Specifically, small firms have a lot of difficulty coordinating an export trade program. Involvement in foreign trade entails a lot of difficult paperwork, extensive advertising and servicing arrangements, and other management problems that most small firms are not prepared to deal with. This is a serious constraint given the fact that a large number of machine tool companies are relatively small. A second limitation on the export programs of the machine tool industry is the fact that business cycles are not exclusively American phenomena. That is, when business is poor in the domestic market, it is likely to be just as bad in the world market, especially in other industrialized nations.

Another very important issue in this regard is the competitiveness of the American machine tool industry. This will generally be influenced by two different sets of factors. First, differential labor and transportation

costs and levels of technological development affect the relative costs of machine tools. As far as labor costs are concerned, the American industry faces relatively similar labor costs as competitors in West Germany and Switzerland, but labor costs are significantly lower in both Japan and the United Kingdom, as Table 7 shows.

Table 7

Average Hourly Earnings and Supplemental Labor Costs in The Machine Tool Industry

United States	$7.58
West Germany	$7.25
Switzerland	$6.87
Japan	$3.62
United Kingdom	$3.16

Source: 1978-1979 Economic Handbook of the Machine Tool Industry.

The United States, then, does experience differentially greater labor costs, although this may not be as great a problem as it appears to be from looking at the data. Specifically, both West Germany and Switzerland have relatively high labor costs, and the machine tool industry in both these countries appears to be doing quite well in the world market.[10]

The problem of differential transportation costs does not appear to present a large problem either. Most firms interviewed expressed the opinion

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[10]It should be noted here that differential unit labor costs would be the more appropriate comparison. Unfortunately, these data were not available.

that, in general, transportation costs were not very important, and didn't appear to damage their competitive position vis a vis the world market.[11]

Finally, the question of technological competitiveness arises. Although the U. S. machine tool industry has enjoyed a position of technological superiority in the world market, probably since the development of interchangeable parts manufacturing, this position has gradually eroded, especially over the last ten to 15 years. Most machine tool builders felt that major international competitors, particularly the German and Japanese machine tool builders, have reached a position of technological parity with the American industry (this is especially evident in the more recent penetration of the American machine tool market by German and Japanese builders). Some industry spokespersons expressed concern that American machine tool builders are less competitive in that their capital stock is older and less productive that that of their major international competitors. While it is not possible to obtain data on the age of the capital stock of the metalworking machinery industry in different countries, data are available on the age of machine tools in use in several countries.[12]

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[11] In fact, at one firm a very large machine was being air freighted to Germany. The machine itself cost about $250,000; the transportation cost would amount to approximately $50,000. It was pointed out, however, that the cost of air freighting the machine was insignificant when compared to the amount of money that would be lost by having to wait for the machine to be shipped and using a less productive machine on the customer's production line in the interim.

[12] The age of the capital stock, then, is not specifically for the machine tool industry alone. The data represent the age of machine tools in use in all industries in each country. However, since most of the machine tool builder's capital stock (equipment) is machine tools, and there does not appear to be any reason to assume that the machine tools owned by the machine tool builders differ in age, across countries, from those held by other industries, these data provide an approximate comparison of the age of the capital stock in the machine tool industry in these countries.

Table 8

Age of Machine Tools in Seven Countries

	Year	Percentage of Machine Tools: Under 10 years old	Over 20 years old
United States	1977	31%	34%
France	1974	34%[1]	33%[3]
West Germany	1977	37%[2]	27%
United Kingdom	1977	39%	24%
Italy	1975	42%[1]	28%[4]
Canada	1978	47%	18%
Japan	1973	60%	n.a.

Notes: [1]Under nine years old.

[2]Under 11 years old.

[3]Over 19 years old.

[4]Over 17 years old.

n. a. - not available

Source: The 12th/ American Machinist Inventory of Metalworking Equipment, 1976-1978.

These data support the contention that the American machine tool industry is at a competitive disadvantage on the world market due to a relatively outdated capital stock. Particularly striking is the fact that Japan has approximately twice the percentage of newer machine tools than the U. S. The U. S. machine tool industry, then, would appear to be less competitive in the world market when considering both factor costs and the quality and age of the capital stock.

There are, moreover, other sets of factors which work against the industry in competing for foreign trade. These factors are basically external to a particular firm. First, international currency exchange rate

fluctuations can have a significant effect on the prices of machine tools. Industry spokespersons say that the devaluation of the dollar has benefitted the export business of American builders.[13] Other external factors, however, have not had such a favorable impact on U. S. machine tool firms. Specifically, international government policies have been cited as a key barrier to foreign trade. For example, NATO countries have agreements on the level of technological sophisitication of products that can be exported to Eastern European countries. The U. S. limits on technological sophistication, however, are more strict than those of other NATO countries, and consequently American machine tool builders cannot compete effectively in this market. Other governmental policies that have been cited as disadvantageous include: the subsidization of credit terms offered by the foreign builder's government in international markets; government financial support for firms exhibiting abroad; and other forms of government support for the machine tool industry (especially in Japan) that enables foreign builders to compete more effectively on the world market. In sum, the machine tool industry has been very interested in using the world market as a kind of cushion in recessionary periods, in order to smooth out the volatile cycles of product demand. However, due to the factors enumerated above, this has not been a particularly successful way of solving the instability problem, particularly in recent years.

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[13]The devaluation of the dollar has also been cited as an important factor in curbing American machine tool imports in recent years.

Active Responses to Instability - Lobbying

The other major attempts of the metalworking machinery industry to stabilize demand center on lobbying activities. The industry, through the major trade associations such as the National Machine Tool Builders Association (NMTBA), the National Tool, Die and Precision Machining Association (NTDPMA), and the American Machine Tool Distributors Association (AMTDA) have lobbied for greater government support of capital investment for many years. In particular, these associations have been active supporters of government policies such as liberalized depreciation allowances, investment tax credits, and other policies which would stimulate industrial investment activity. Moreover, the NMTBA also lobbies extensively on foreign trade issues. Specifically, the industry has been interested in getting most favored national status conferred on Eastern European countries so that, through the Export-Import Bank, they can provide financing arrangements that are more competitive with those offered by other countries.

It is a mistake, however, to classify these lobbying efforts as attempts to stabilize demand over the business cycle. With the exception of the foreign trade lobbying, these activities are not really directed at smoothing out demand. Rather, they attempt to stimulate total demand but do not really address the timing problem. A different type of lobbying activity, directed at private firms rather than public policy, is actually concerned with the timing of investment. This effort consists of convincing industry to follow more "rational" investment and replacement policies, to develop long range goals and capital budgeting programs. The Machinery and Allied Products Institute (MAPI) represents the interests of the producers of capital

equipment (not just the metalworking machinery industry) and has been quite active in trying to get industry to follow more "rational" (that is, steady, less lumpy) investment programs. They have produced a number of management handbooks on the subject[14] and would appear to represent the most significant attempt, on the part of the metalworking machinery industry, to actively work towards stabilizing demand.[15]

The extent to which these active attempts do in fact smooth out the bunchiness of demand appears to be rather limited. A quick look at Figures 1 and 2 immediately reveals that demand is extremely unstable and there are no real indications that it is becoming less so. The reasons why these active responses have met with relatively little success are rather straightforward. Primarily, it would appear that the problem is one of scale. The metalworking machinery industry is relatively small when compared to other industries. In 1976, the sales of the metalworking machinery industry represented less than one percent of the sales of all manufacturing industries. Moreover, in

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[14] See, for example, George Terborgh, Business Investment Management, The Machinery and Allied Products Institute and the Council For Technological Advancement, Washington, D. C., 1967.

[15] Some of the firms interviewed do in fact follow the MAPI guidelines on investment policy.

terms of the actual size of firms in the metalworking machinery industry, it can be seen that this industry is characterized by much smaller firms than other industries. In 1972, the average size of firm in the metalworking machinery industry was 28 employees; the average size of firm in all manufacturing was 59 employees. Therefore, it is not surprising that lobbying efforts by this industry appear to meet with less success than the efforts of other more powerful industries (such as the automotive, petroleum, aerospace industries).

Reactive Responses to Instability

As described below, reactive responses represent those attempts by the metalworking machinery industry to cope with cyclical instability. They reflect an acceptance of unstable demand as a fact of life. These reactive responses center around labor policies vis a vis the business cycle.[16] At this point, it is necessary to introduce an important constraint on management's labor policies - a significant shortage of skilled labor. The metalworking machinery firms in New England have complained, unanimously, about

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[16] It should be noted here that, to the extent possible, firms also try to accumulate back orders in order to provide a cushion in periods of low demand. However, it might be argued that this is more of an active response (that is, changing the stability of production), particularly at the firm level.

the serious shortage of skilled labor in the region. This is not a new phenomenon. The industry has voiced this complaint throughout the twentieth century. Nor is this phenomenon limited to New England. The shortage of labor has been felt in all major centers of the industry. This limited availability of skilled labor appears to have had a definite influence on the management policies of firms in this region. The influence of the shortage on management policies, particularly with reference to business cycle fluctuations, will be discussed below.[17] But first, it is necessary to examine the causes of this shortage.

Causes of Labor Shortages

One factor which seems to have exacerbated the shortage of workers is the fact that the skill levels required in this industry are extremely high. Tool and die makers, particularly, are considered to be "at the top of the occupational ladder among skilled craftsmen."[18] These workers must complete a very long training period to become fully qualified. Horowitz and Herrnstadt, in a study of skills acquisition of tool and die makers, found that, in order to become "all around craftsmen" the following time was required:

> 6.5 years for individuals who combined vocational high school education with an apprenticeship program, to become competent, all around tool makers and 8.0 years to become competent, all around diemakers;
>
> 7.0 years for individuals in apprenticeship programs (with no vocational education) to become competent all around tool makers, and 10.0 years to become competent, all around diemakers;

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[17] The shortage has also influenced investment behavior in the industry. This will be examined in Chapter Four.

[18] Morris A. Horowitz and Irwin L. Herrnstadt, The Training of Tool and Die Makers, Department of Economics, Northeastern University, Boston, Mass., September 1969, p. 15.

> between 10 and 12 years for individuals either having vocational education, by itself, or who "picked up the trade" to become proficient toolmakers or diemakers.[19]

The accepted apprenticeship period for tool and die makers and machinists is four years,[20] but Horowitz and Herrnstadt point out that, at least for tool and die makers, a longer period is necessary before the workers become competent craftspersons. There are a wide range of skills required in the metalworking machinery industry, with corresponding differences in training requirements. At one end, the training time necessary to become a skilled machine operator can range from six months to a year.[21] At the other end, there are certain jobs within the industry which require years and years of experience. On a plant tour of one firm in the interview sample, a man was pointed out doing a very delicate adjustment and measuring operation on a small part. He explained that it took him at least twenty years or more to master the critical skills necessary for his job; he had to be able to "feel" that the piece was of the proper dimensions and it took many years of experience to develop this "feel."

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[19] Ibid., p. 7.

[20] U. S. Congress, House Subcommittee on Special Investigations of Small Business Problems of the Select Committee on Small Business, Problems of the Tool and Die Industry and Associated Problems of Manufacturers and Distributors of Machine Tools: Hearings on H. Res. 13, 89th/ Congress, 2nd/ session, 26 and 27 July, 1966, p. 85.

[21] Ibid., p. 85.

The high level of skills required, with the consequent long periods of training, is probably responsible for short-run shortages of skilled labor. Specifically, in a business cycle upswing, labor is in very great demand, but there is a substantial lag between the supply of new labor and its demand, given the extensive amount of time it takes to adequately train the new entrants to the labor force. However, the shortage of labor is not simply a short-run adjustment problem.

There has been, in recent years, a shift in attitudes in this country. There has been a shift in emphasis away from blue collar careers and vocational education in favor of white collar occupations and college education. Many firms in the region have stated that area vocational high schools, with some notables exceptions, are woefully inadequate. The machinery used in these schools is often outdated, and the skills taught are not always those most needed in local shops. Moreover, there is the feeling in many firms that young people are not interested in this trade. More high school students are interested in college education at the present time than has been the case in the past. Additionally, the aptitude and skills required for these occupations are very similar to those of an engineer, and so many young people with this aptitude are turning to an engineering career rather than working in blue collar jobs.

Aside from the competition from college, firms have also cited competition from other industries for entrants into the labor pool as a major problem. A small tool and die shop, for example, might offer a vocational high school graduate an apprenticeship, with a starting pay of, say $3.50 to $4.00 per hour. In five or ten years that individual would be earning

about $25,000 per year (these figures were supplied by the owner of a small shop). However, this graduate might also be offered a job on the production line of an aircraft plant, say at $5.00 to $6.00 per hour. While the overall earning potential in the tool and die business may be superior in the long run, the owner said that it is nonetheless quite difficult to attract new entrants when the immediate rewards in another industry are so much higher.[22] An additional factor that was mentioned in connection with this difficulty in attracting new workers was that, at least for one owner, the occupation itself had "a bad reputation." People think its a dirty job,[23] it's not very glamorous.

The industry has taken some steps to alleviate this labor shortage. First, the industry has historically been involved with eduational institutions. In 1868, a group of machine tool builders started the Worcester Free Institute of Industrial Science (later to become Worcester Polytechnical Institute) to train machinists. Individual firms have set up cooperative training programs with local high schools (such as the Springfield Cooperative Training Course, set up in 1916 and still active today in Springfield, Vermont) to provide preliminary training and shop experience for students.

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[22]This difficulty of attracting apprentices due to low entry wages is not a new problem. In the early 1900's, for example, "the apprentice was supposed to receive valuable instruction for which he paid his employer a part of the value of his work ... the apprentice was also usually required to post a bond upon entering his apprenticeship ... to ensure his employer that he would not leave before completing his apprenticeship and would make a conscious effort to complete it successfully." H. Wagoner, The Machine Tool Industry, pp. 87-88.

[23]This owner, however, pointed out how clean his shop and workers were to dispel this myth.

Additionally, both the National Machine Tool Builders Association and the National Tool and Die and Precision Machining Association have set up apprenticeship programs, with the support of the Deparmtent of Labor (which pays for the costs of instruction while the trade associations handle the paperwork and administration of the program). And finally, CETA money is often available to help defray the training costs incurred by firms. While all firms interviewed have said that programs of this kind are extremely important, the magnitude of these efforts is not great enough to meet their needs. It appears that, at best, perhaps ten percent of a firm's new recruits are connected with any of these programs.

There are a few reasons why these programs are not able to supply a sufficient number of workers, however. Many firms are very reluctant to institute extensive apprenticeship programs due to the expense of doing so. Again, the cyclical nature of the industry is important, in that firms don't want to train workers, only to lay them off when business is slow. Additionally, many smaller firms are at a distinct disadvantage in that it is necessary to maintain a certain ratio of journeymen to apprentices. The small shops interviewed seem to feel that eight or nine journeymen are required to adequately train one apprentice in the shop. Since many firms, especially in the tool and die industry, are quite small, the potential for large scale apprenticeship programs are limited. And finally, what appears to be the biggest perceived disincentive to in-house training is the fear of "pirating."

This fear has been around for most of the twentieth century, beginning with the advent of automobile manufacturing at the start of the century and continuing to the present day. Since machinists and tool and die makers are needed in almost every manufacturing industry, firms in the metalworking

machinery industry are always fearful that skilled workers, especially those the firm itself has trained, might leave for greener pastures in other industries. These pastures, moreover, do appear to be greener as the following figures illustrate:

Table 9

Average Hourly Wages of Production Workers

Year	Motor Vehicles and Equipment Industry	Aircraft and Parts Industry	Metalworking Machinery Industry
1971	$4.74	$4.32	$4.28
1972	$5.11	$4.65	$4.59
1973	$5.45	$5.00	$4.84
1974	$5.90	$5.40	$5.18
1975	$6.47	$5.99	$5.51
1976	$7.10	$6.45	$5.94
1977	$7.90	$6.91	$6.44

The hourly wage in the automotive and aircraft industries has been consistently higher than those in the metalworking machinery industry. In addition to the wage differential, the fact that both the automobile and aircraft (and many other durable goods) industries are much larger and more concentrated also influences the situation. The larger firms are able to engage in much more extensive recruiting operations. And since, on average, these industries are more unionized than metalworking machinery (from 1973 to 1975, 36% of production workers in metalworking machinery were union members; 82% of production workers in motor vehicles and equipment were union members; and 60% of production workers in aircraft and parts were union members)[24], it is quite probable that fringe benefits and security are greater in these other

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[24] R. B. Freeman and J. L. Medoff, New Estimates of the Industrial Locus of Unionism in the U. S., Discussion Paper Number 636, Harvard Institute of Economic Research, Harvard University, Cambridge, MA, July 1978, pp. 17-18.

industries, offering further inducements to labor than are apparent by looking only at hourly wage data.

This problem was aggravated during the Vietnam War (before the downturn of the late sixties) by government policies. Certain defense industries were classified as "essential activities," particularly aircraft and ordnance industries. This classification, in many cases, carried with it a draft deferrment status for workers. While draft deferrment was not guaranteed to workers in these industries, local draft boards would nonetheless be more inclined to draft a machinist or tool and die maker working in the machine tool industry than one aircraft.[25] A National Machine Tool Builders Association survey of 22 major machine tool firms in 1966 found that "a number equivalent to more than one out of every three skilled workers hired by these companies since July 1, 1965, has been lost in this period to non-machine tool defense industries alone."[26]

The degree to which workers shift among comparable industries has been investigated with mobility data from the Longitudinal Employer Employee Data (LEEDs) file. This analysis will be discussed in more detail below. However, insofar as "pirating"[27] among industries does take place, it appears that this is a two-way street. The number of employees leaving the

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[25]The machine tool industry petitioned the Interagency Advisory Committee on Essential Activities and Critical Occupations, Bureau of Employment Security, Department of Labor, for essential industry status in 1966, but this petition was denied.

[26]U. S. Congress, Problems of the Tool and Die Industry: Hearings on H. Res. 13, 1966, p. 169.

[27]Wagoner, The Machine Tool Industry, notes that "the term (pirating) hardly seems appropriate since the only force used (is) that of persuasion, the promise of better pay in expanding industries, more rapid upgrading, and steadier employment." (p. 347).

metalworking machinery industry for jobs in "competing" industries[28] appears to be almost equally balanced by the number of employees leaving competing industries for jobs in metalworking machinery. Some firms interviewed have expressed the opinion that, while larger firms in other industries may be at an advantage in recruiting workers, the smaller firms offer "better working conditions" -- more flexibility, more informality, less of an assembly line atmosphere, etc. The owner of one small firm (eight employees) said that, in the last five years, three of his employees had left for jobs in "competing" industries, and all three have since returned to his shop.

In conclusion, the degree to which firms in the metalworking machinery industry are at a disadvantage in competing for a given labor pool is unclear, at best. What is clear is that skilled machinists and tool and die makers are in great demand, both in New England and other regions of industrial concentration. The following section will examine the ways in which this labor shortage has affected management decisions, particularly as a constraint on the ability of firms to cope with business cycle fluctuations.

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[28]The following industries were considered to be competitors for the supply of skilled machinists and tool and die makers:

SIC 33 (primary metal industries);
SIC 34 (fabricated metas products, except machinery products and transportation equipment);
SIC 35 (machinery except electrical, excluding metalworking machinery);
SIC 36 (electrical and electronic machinery, equipment and supplies); and
SIC 37 (transportation equipment).

Responses to Unstable Demand under the Constraint of Labor Shortage

The shortage of labor, combined with the extreme instability of product demand, has created problems for firms in the metalworking machinery industry. On the one hand, when product demand is very low, there is very little demand for skilled labor. On the other hand, many firms try to avoid laying off their workers for fear that they will never be able to replace them when product demand picks up again. Companies first respond to changes in product demand by changing the number of hours worked by production workers. As Table 10 shows, in peak periods, there is a great deal of overtime work.

Table 10

Weekly Overtime Hours of Production Workers

Year	All manufacturing	Durable Goods Industries	Metalworking Machinery Industry
1958	2.0	1.9	2.5
1959	2.7	2.7	4.0
1960	2.4	2.4	4.3
1961	2.4	2.3	3.4
1962	2.8	2.8	4.7
1963	2.8	2.9	4.8
1964	3.1	3.3	5.9
1965	3.6	3.9	6.7
1966	3.9	4.3	7.8
1967	3.4	3.5	6.5
1968	3.6	3.8	5.4
1969	3.6	3.8	6.0
1970	3.0	2.9	4.3
1971	2.9	2.9	2.8
1972	3.5	3.6	4.9
1973	3.8	4.1	6.4
1974	3.2	3.4	5.8
1975	2.6	2.5	3.3
1976	3.1	3.1	4.0
1977	3.4	3.6	5.4

Source: 1978-1979 Economic Handbook of the Machine Tool Industry.

In slack periods, hours are decreased but the number of workers remains constant, thereby keeping the existing labor force intact. However, there are periods when business is so poor that shortening the number of hours worked is simply not enough. Specifically, from 1967 to 1971, and from 1974 to 1976, the demand for metalworking machinery decreased dramatically, and large scale lay offs occurred.

The owners/managers of most firms interviewed have said that, in recent years, they have attempted to retain as many workers as possible during these slack periods. They have expressed the fear that, if they lay off a skilled worker, he/she may either migrate to another state or region in search of more stable employment, or take a job in a different industry and be unwilling to return to the firm when business is on the upswing. In order to examine these issues, data were obtained to investigate the following questions:

(1) Have firms become more reluctant to lay off workers in cyclical downturns?

(2) When layoffs do occur, who gets laid off? Where do these workers go?

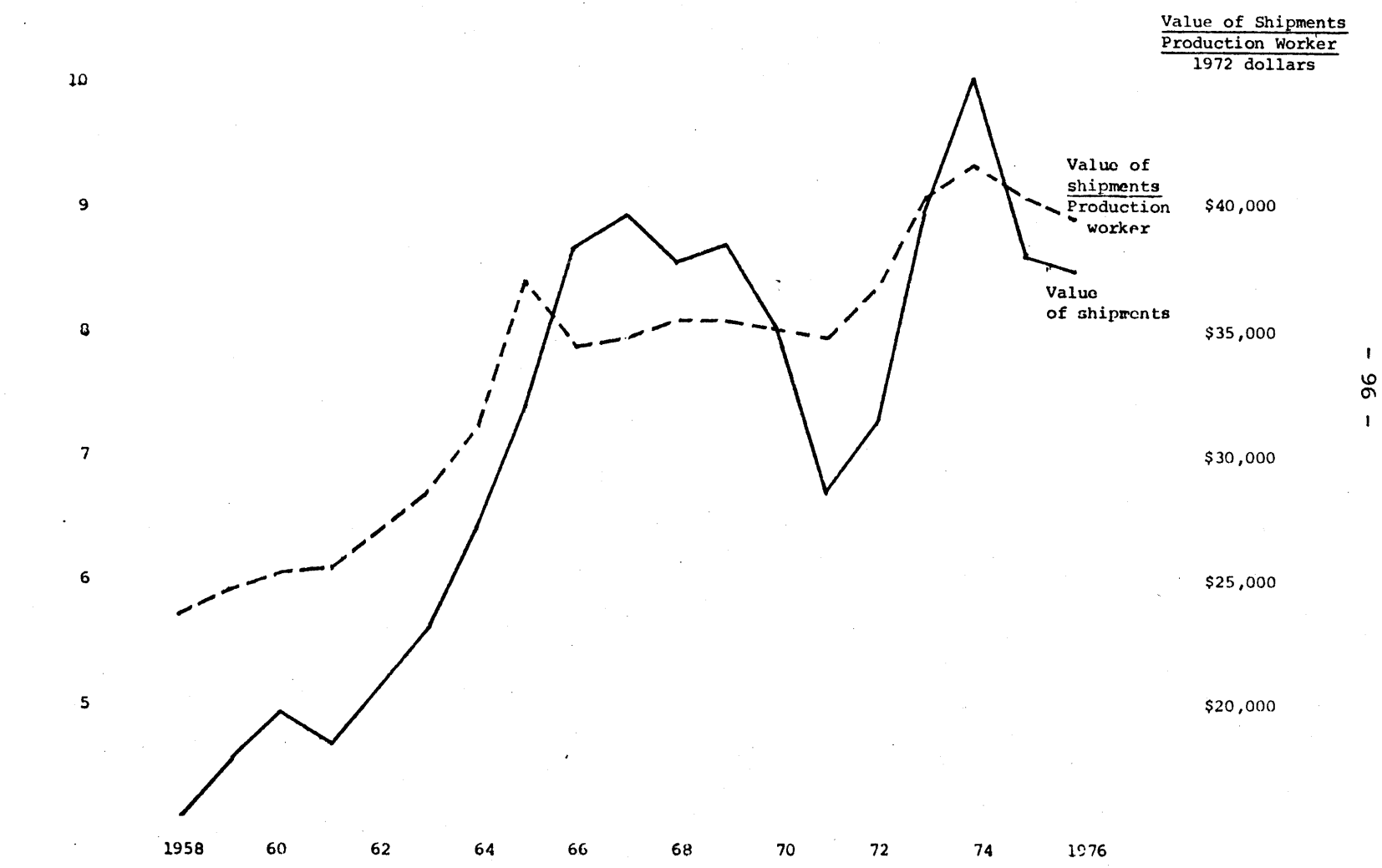
(3) When product demand is on a cyclical upswing, where do the new employees come from?

The first question was addressed by looking at data from the Census of Manufactures and the Annual Survey of Manufacturers. It is hypothesized that, if firms are laying off workers in periods of low demand, then output per worker will remain relatively constant over the business cycle. However, if firms are afraid to lay off workers, then the output per worker will actually decline in downturns; that is, sales would decrease at a faster rate than employment. Figures 10 and 11 present the sales or output (value of shipments) of the metalworking machinery industry from 1958 to 1976,

Figure 10

UNITED STATES

Value of Shipments and Value of Shipments per Production Worker

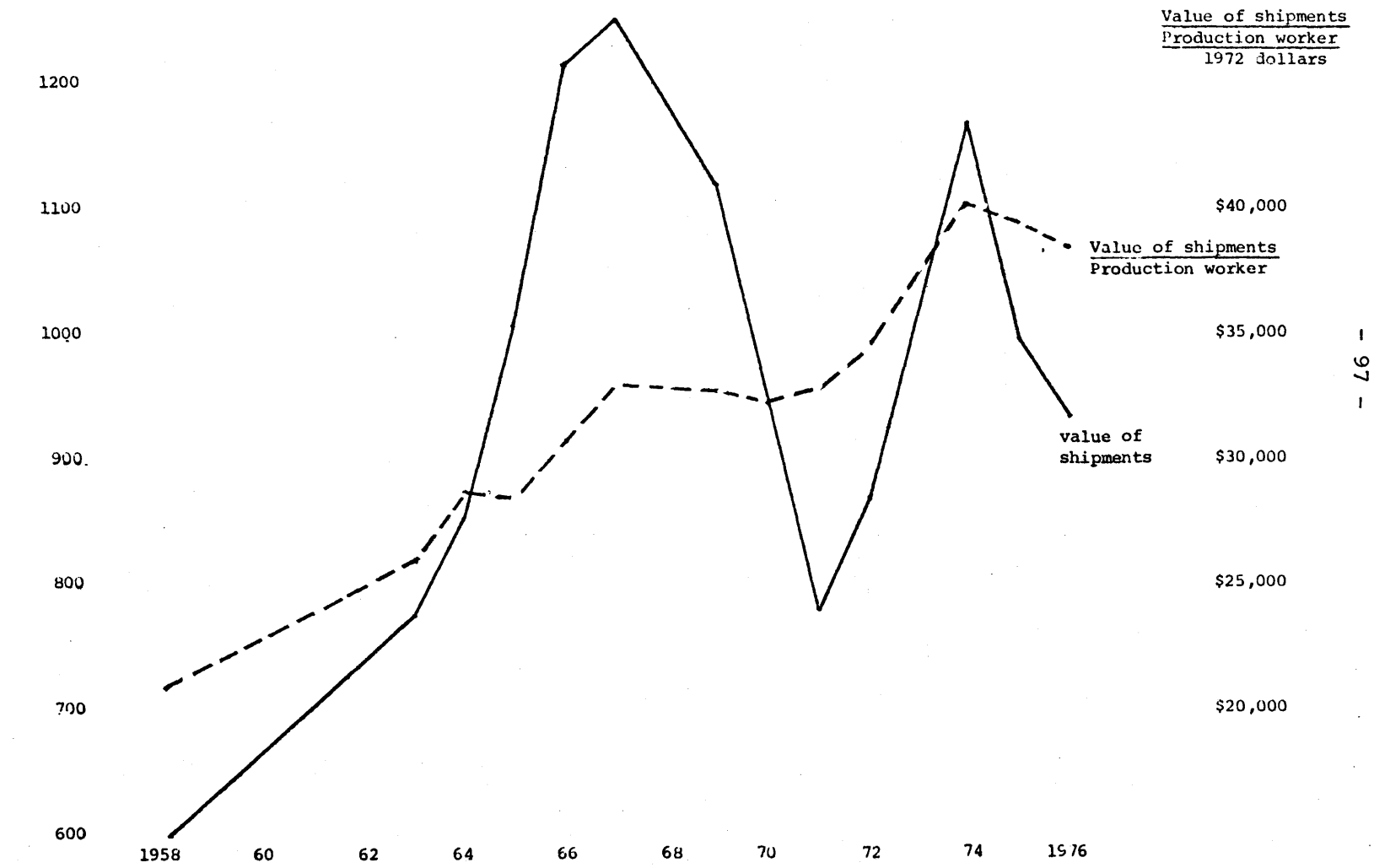


Sources: Annual Survey of Manufactures and Census of Manufactures, 1958-1976.

Figure 11

New England

Value of Shipments and Value of Shipments per Production Worker



Sources: Annual Survey of Manufactures and Census of Manufactures, 1958-1976.

along with the output per production worker (value of shipments per production worker), for both the United States and the New England region. Output per production worker has clearly increased substantially over this period (all figures are in constant dollars) reflecting increases in productivity associated with the use of more labor saving equipment. The interesting thing to note, however, is the different pattern of the output per worker line in the two recessionary periods in this time interval.

From the U. S. figure, it can be seen that, from the peak of 1967 to the trough of 1971, industry sales decreased dramatically. Output per worker, however, remained constant, indicating that decreases in employment kept up with decreases in sales. The same pattern can be seen on the New England figure. In fact, from 1967 to 1971, U. S. sales decreased by 25%, and the number of production workers also decreased by 25%. In New England, industry sales fell off by 37% and the number of production workers diminished by 37% for the same period. From the peak of 1974 to the trough of 1976, however, a different picture is visible. Again, in both the U. S. and the New England region, sales of metalworking machinery declined. But in this downturn, output per production worker also declines, indicating that employment is declining less rapidly than sales. In the U. S., sales decreased by 16%, the number of production workers by 11%; in New England, sales declined by 20%, the number of production workers by 16%.

These data support the claims made by representatives of the firms interviewed: namely that, especially after the 1971 recession, they have been less inclined to lay off workers than had been the case in the past. Apparently, after the massive layoffs during the 1967 to 1971 cycle, many firms found it difficult to obtain sufficient labor needed for the subsequent business cycle

upturn and so have modified their management policies in an attempt to alleviate this problem. The data presented above appear to support this hypothesis; that metalworking machinery firms have become more concerned with stabilizing their employment levels perhaps at the expense of productivity (output per worker). It is interesting to note that this phenomenon is not limited to the New England region. Rather, the data for the U. S. as a whole suggest that the same thing is happening at the national level, again supporting the assertion that the shortage of skilled labor is not a uniquely New England experience.

The latter two questions address the issue of worker mobility. When workers are laid off, what happens to them, and when metalworking machinery firms are hiring on the busness cycle upturn, where do they get their expanded work force? These questions attempt to determine if management's perception of worker mobility is consistent with reality. Specifically, if management is acting under the impression that workers who are laid off are leaving the region or taking jobs in other industries and are unwilling to return to the metalworking machinery industry, then it is interesting to discover if in fact workers do not return to the industry in business cycle upswings. The Longitudinal Employer Employee Data (LEEDs) file was utilized in order to examine these questions.

The LEEDs file is a one percent sample of all workers covered by Social Security for the period 1957 to 1975.[29] It is possible, with the LEEDs file, to see where workers go from the peak to trough of a business cycle, and

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[29]Please see Barry Bluestone, Alan Matthews and Lynn Ware, "Worker Mobility in the New England Region (LEED Analysis)," New England Economy Project Working Paper No. 3, Joint Center for Urban Studies of MIT and Harvard Univ., Dec., 1978, for a more complete description of this data source.

conversely, to see where workers employed in a peak period were employed in the preceding trough. Tables 11, 12, 13, and 14 present this information for two business cycles in this twenty year period for the New England region, and the states of Connecticut, Massachusetts, and Vermont. The cycles under consideration are the expansionary periods of 1964 to 1967 and 1971 to 1974; the recessionary periods of 1967 to 1971 and 1974 to 1975 (although the actual trough in this latter recession was 1976, unfortunately data were not available for this year).

The most striking feature of these tables is the cyclical instability of employment in this industry. Only 44% of those employed in the industry in New England in 1967 had been employed in the industry in 1964; only 40% of those employed in the industry in 1967 were still employed in the industry in 1971; only 39% of those employed in 1974 had been employed in the industry in 1971; and 74% of those employed in 1974 were still employed in the industry in 1975.[30] The mobility of workers in the individual states appear to be relatively consistent with that of workers in the whole region, with the possible exception of Vermont.[31] Therefore, for the sake of clarity and ease of understanding, these tables will be discussed with reference to the New England region as a whole, and not to each individual state.

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[30] This last percentage is substantially greater than the previous ones since the real trough occurred in 1976, and this was a less severe recession than that of 1971.

[31] The small absolute number of workers included in the Vermont sample appear to render this data less reliable than those for the other states and the region as a whole. Additionally, there appear to be some data problems, particularly for the period 1974 to 1975 (where the "unknown" category is so large), with the Vermont sample.

Table 11

Source of New Entrants to Metalworking Machinery Industry

New England, Connecticut, Massachusetts and Vermont

1964 to 1967

	New England	Connecticut	Massachusetts	Vermont
Employment in Metal-working Machinery in 1967	659	281	217	65
Percent of workers employed in Metal-working Machinery in the region (state) in 1964	44%	38%	48%	66%
Of those workers not employed in Metal-working Machinery in the region (state) in 1964, the percent-age who were:				
Retired in 1964	0%	0%	0%	0%
Not in covered employ-ment 1964	27	34	16	24
Employed in:				
Metalworking Machinery outside the region in 1964	0	2	0	0
Metalworking Machinery in another state in New England in 1964	n. a.	0	0	0
Other Metalworking manufacturing in 1964 [1]	24	23	32	22
Non-Metalworking manufacturing in 1964 [2]	16	10	24	22
Trade and services in 1964 [3]	18	10	18	16
Other industries in 1964 [4]	15	13	10	16

n. a.: not applicable

Source: LEEDs data, prepared by Alan Matthews and Barry Bluestone

notes to Table 11

[1]Employed in SICs 33 (Primary metal industries), 34 (Fabricated metal products except machinery and transportation equipment), 35 (Machinery, except electrical and metalworking machinery), 36 (Electrical and electronic machinery, equipment, and supplies), and 37 (Transporation equipment).

[2]Employed in SICs 20 (Food and kindred products), 21 (Tobacco manufactures), 22 (Textile mill products), 23 (apparel and other finished products, except furniture), 25 (Furniture and fixtures), 26 (Paper and allied products), 27 (Printing, publishing, and allied industries), 28 (Chemicals and allied products), 29 (Petroleum refining and related industries), 30 (Rubber and miscellaneous plastics products), 31 (Leather and leather products), 32 (Stone, clay, glass, and concrete products), 38 (Measuring, analyzing, and controlling instruments; photographic, metal and optical goods; watches and clocks), and 39 (Miscellaneous manufacturing industries).

[3]Employed in SICs 50 (Wholesale trade - durable goods), 51 (Wholesale trade - nondurable goods), 52 (Retail trade - building materials, hardware, garden supply, and mobile home dealers), 53 (Retail trade - general merchandise stores), 54 (Retail trade - food stores), 55 (Retail trade - automotive dealers and gasoline service stations), 56 (Retail trade - apparel and accessory stores), 57 (Retail trade - furniture, home furnishings, and equipment stores), 58 (Retail trade - eating and drinking places), 59 (Miscellaneous retail trade), 70 (Hotels, rooming houses, camps, and other lodging places), 72 (personal services), 73 (Business services), 74 (Automotive repair, services, and garages), 76 (Miscellaneous repair services), 78 (Motion pictures), 79 (Amusement and recreation services, except motion pictures), 80 (Health services), 81 (Legal services), 82 (Educational services), 83 (Social services), 84 (Museums, art galleries, botanical and zoological gardens), 86 (Membership organizations), 87 (Private households), and 89 (Miscellaneous services).

[4]Employed in SICs 01 (Agricultural production - crops), 02 (Agricultural production - livestock), 07 (Agricultural services), 08 (Forestry), 09 (Fishing, hunting, and trapping), 15 (Building construction - general contractors and operative builders), 16 (Construction other than building construction - general contractors), 17 (Construction - special trade contractors), 40 (Railroad transporation), 41 (Local and suburban transit and interurban highway passenger transportation), 42 (Motor freight transportation and warehousing), 43 (U. S. Postal Service), 44 (Water transportation), 45 (Transportation by air), 46 (Pipe lines, except natural gas), 47 (Transporation services), 48 (Communication), 49 (Electric, gas and sanitary services), 60 (Banking), 61 (Credit agencies other than banks), 62 (Security and commodity brokers, dealers, exchanges, and services), 63 (Insurance), 64 (Insurance agents, brokers, and service), 65 (Real Estate), 66 (Combinations of real estate, insurance, loans, law offices), 67 (Holding and other investment offices), 91 (Executive, legislative, and general government, except finance),

92 (Justice, public order, and safety), 93 (Public finance, taxation, and monetary policy), 94 (Administration of human resources programs), 95 (Administration of environmental quality and housing programs), 96 (Administration of economic programs), and 97 (National Security and international affairs) -- but only workers in these SICs who are covered by Social Security.

Table 12

Destination of Workers Displaced from Metalworking Machinery Industry

New England, Connecticut, Massachusetts and Vermont

1967 to 1971

	New England	Connecticut	Massachusetts	Vermont
Employment in Metalworking machinery in the region (state) in 1967	65,900	28,100	21,700	6,500
Percentage of workers employed in Metalworking Machinery in the region (state) in 1971	40%	37%	45%	52%
Of those workers not employed in Metalworking Machinery in the region (state) in 1971, the percentage who were:				
Retired (dead or disabled)	12%	10%	13%	25%
Not in covered employment	15%	15%	20%	12%
Employed in:				
Metalworking Machinery outside the region in 1971	1%	1%	1%	4%
Metalworking Machinery in another state in New England in 1971	n.a.	0%	0%	4%
Other Metalworking manufacturing in 1971	22%	25%	28%	4%
Non-Metalworking manufacturing in 1971	10%	8%	13%	10%
Trade and services in 1971	21%	21%	13%	20%
Other industries in 1971	19%	20%	13%	22%

n. a.: not applicable

Source: LEED's data, prepared by Alan Matthews and Barry Bluestone

Table 13

Source of New Entrants to Metalworking Machinery Industry

New England, Connecticut, Massachusetts and Vermont

1971 to 1974

	New England	Connecticut	Massachusetts	Vermont
Employment in Metal-working Machinery in 1974	54,500	22,000	20,400	3,600
Percentage of workers employed in Metal-working Machinery in the region (state) in 1971	39%	39%	38%	56%
Of those workers not employed in Metal-working Machinery in the region (state) in 1971, the percent-age who were:				
Retired in 1971	2%	2%	0%	0%
Not in covered employment in 1971	19%	25%	18%	18%
Employed in:				
Metalworking machinery outside the region in 1971	5%	5%	7%	0%
Metalworking machinery in another state in New England in 1971	n.a.	0%	0%	0%
Other Metalworking manufacturing in 1971	21%	22%	22%	18%
Non-Metalworking manufacturing in 1971	13%	10%	18%	0%
Trade and services in 1971	24%	19%	27%	31%
Other industries in 1971	16%	17%	8%	3%

n. a.: not applicable

Source: LEED's data, prepared by Alan Matthews and Barry Bluestone

Table 14

Destination of Workers Displaced from Metalworking Machinery Industry

New England, Connecticut, Massachusetts and Vermont

1974 to 1975

	New England	Connecticut	Massachusetts	Vermont
Employment in Metalworking Machinery in 1974	54,500	22,000	20,400	3,600
Percentage of workers employed in Metalworking Machinery in the region (state) in 1975	74%	74%	78%	58%
Of those workers not employed in Metalworking Machinery in the region (state) in 1975, the percentage who were:				
Retired (dead or disabled)	4%	4%	17%	0%
Not in covered employment in 1975	19%	23%	16%	13%
Employed in:				
Metalworking machinery outside the region in 1975	0%	4%	0%	0%
Metalworking machinery in another state in New England in 1975	n.a.	0%	0%	0%
Other Metalworking manufacturing in 1975	19%	12%	32%	7%
Non-Metalworking manufacturing in 1975	12%	8%	21%	0%
Trade and services in 1975	23%	35%	5%	0%
Other industries in 1975	19%	15%	16%	13%
SIC unknown in 1975	4%	0%	0%	67%

n. a.: not applicable

Source: LEEDs data, prepared by Alan Matthews and Barry Bluestone

By examining the peak to trough tables, it is possible to see how workers dealt with the rapid decline of the metalworking machinery industry in business cycle downturns. Unfortunately, it is not possible to determine from these data whether workers leaving the industry in a cyclical downturn have done so voluntarily or involuntaryily. However, it appears reasonable to assume that the majority of these workers have been involuntarily displaced (laid off) in these periods of substantial industry contraction. Tables 12 and 14 show that, for the two recessionary periods under consideration, about 20% of those workers displaced from the peak year to the trough year end up employed in what has been classified as "competing" industries,[32] where, presumably, wages and benefits are relatively comparable with (if not greater than) those in the metalworking machinery industry. Another 10% or so of those workers displaced in the downturn are employed in other manufacturing industries where, again, wages are assumed to be relatively comparable. A rather large number of displaced workers are employed in what are usually considered low-wage industries (trade and services) or are not in covered employment in the trough year.[33]

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[32]The following industries were considered to be competitors for the supply of skilled machinists and tool and die makers:

SIC 33 (primary metal industries);
SIC 34 (fabricated metal products, except machinery products and transportation equipment);
SIC 35 (machinery except electrical, excluding metalworking machinery);
SIC 36 (electrical and electronic machinery, equipment and supplies); and
SIC 37 (transporation equipment)

[33]The percentage of workers not in covered employment in the trough year is an upper limit on the unemployment rate of workers displaced from the industry in that it includes both unemployed workers and those workers employed in non-covered public or private sector jobs, and workers who have dropped out of the labor force.

The interpretation of these data should not, however, necessarily be that it is the skilled workers who are laid off and forced to accept much lower paying, less skilled jobs or go on unemployment. If the age structure of the displaced worker is taken into account, it can be seen that it is the younger and presumably less skilled workers who are not in covered employment or are employed in low wage industries. The following table[34] illustrates this point.

Table 15

Age Distribution of Displaced Workers

New England

Percent of 1967 workers:	less than 25 years old	25-34	35-54	over 55 years old
Employed in SIC 354 in 1971	18%	37%	52%	46%
Employed in SIC 354 retired, dead, or disabled in 1971	20	38	56	77
Not in covered employment in 1971	13	12	7	5
Employed in trade and service in 1971	22	14	9	6

It can be seen that the younger workers are much more likely to be laid

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[34] Table 15 presents age breakdowns for all workers in the New England region for the downturn of 1967 to 1971. These figures are comparable, in terms of age/destination characteristics, to the downturn of 1974 to 1975. Additionally, the data are representative of the age/destination characteristics of the individual states in the region in both downturns.

off in cyclical downturns, and additionally, are more likely to be employed in lower-wage industries. This result is certainly reasonable, given the fact that it takes many years to acquire the skills needed in this industry and, when business is poor, management tries to hold onto its most skilled, older employees. The important conclusion to be reached from these data is that, although employment in the metalworking machinery industry is extremely unstable over business cycles, it is the younger and less skilled component of the labor force that bears the brunt of this instability. The older, skilled workers are both less likely to be laid off, and when they are displaced, they experience greater job mobility among comparable industrial sectors.

The next question to be examined with the LEEDs file is what happens in business cycle upswings? When business is growing, from what sources do firms get their expanded labor force. Tables 11 and 13 present this information for the two expansionary periods under consideration, 1964 to 1967 and 1971 to 1974. In both periods, the largest source of new employees is the "not in covered employment" category. This category is a particularly important source of young workers, as would be expected. The trade and service sector has increased in importance as a source of new employees. Again, this is not a surprising finding given the fact that this sector has grown in size in the New England region in the recent past, relative to the manufacturing sector. The workers drawn from the services and trade sector tend to be younger than those drawn from both the metalworking manufacturing sector and other manufacturing sector. This suggests that the metalworking machinery industry is able to attract older, skilled workers from the "competing" industries in periods of substantial expansion.

The mobility of workers across industries is of interest insofar as it relates to both the "pirating" issue raised previously, and the apparent belief of management that, once workers have been laid off from the industry, they are irrevocably lost as a future source of labor. Table 16 shows the mobility pattern of workers among industries for the two expansionary and recessionary periods under study for the New England region. These data present information on the destination of workers displaced from the metalworking machinery in recessionary periods, and the source of new workers added to the industry's labor force in expansionary periods. These data would seem to discredit the industry's contention that workers laid off are workers gone forever. For example, 23% of those workers displaced in the 1967 to 1971 recession were employed in the other metalworking manufacturing sector in 1971; in the subsequent upturn of 1971 to 1974, 23% of the new workers in SIC 354 had been employed in the other metalworking manufacturing sectors in 1971. The mobility of workers among other industries in these business cycles exhibits a similar, balanced pattern.

This is not to say, however, that it is the same workers bouncing back and forth between the metalworking machinery industry and another specific industry. The data only say that the flows of workers among those industries across the business cycle appear to be quite stable -- the metalworking machinery industry may lose workers displaced in downturns to other industries, but these other industries also appear to represent important sources of new labor when metalworking machinery is on the upswing. Moreover, to the extent that age is correlated with skills, the metalworking machinery industry appears to be holding its own in comparison to the "competing" industries. That is,

Table 16

Inter-Industry Mobility Over the Business Cycle

New England

	Origin of workers Entering SIC 354 from 1964-1967		Destination of Workers Leaving SIC 354 from 1967-1971		Origin of Workers Entering SIC 354 from 1971-1974		Destination of Workers Leaving SIC 354 from 1974-1975	
	Number	%	Number	%	Number	%	Number	%
Total	36,700	100%	39,000	100%	31,500	100%	14,100	100%
Retired	0	0%	4,700	12%	300	1%	700	5%
Not in Covered Employment	10,100	28%	6,200	16%	6,800	22%	2,700	19%
Employed in:								
Other metal-working manufacturing	8,600	23%	8,800	23%	7,100	23%	2,600	18%
Non-metal-working manufacturing	6,000	16%	4,200	11%	4,400	14%	1,600	11%
Trade and services	6,800	19%	7,900	20%	6,600	21%	3,100	22%
Other Industries	5,200	14%	6,800	17%	6,000	19%	2,200	16%
Unknown Industry	0	0%	400	1%	300	1%	1,200	9%

Source: LEEDs data, prepared by Alan Matthews and Barry Bluestone.

although a substantial proportion of older workers take jobs in the other metalworking manufacturing sector in a recession, it is also true that a large number of the workers drawn from the other metalworking manufacturing sector in an expansionary period are in the older age groups. These figures belie the industry's contention that other sectors have been capturing a portion of their skilled labor force over successive business cycle fluctuations.[35]

The other concern expressed by many firms is that, after being laid off by the metalworking machinery industry in the New England region, many workers leave the region and thereby, again, deplete the labor force available to the industry in subsequent expansionary periods. Table 17 examines this issue of geographical mobility. It appears that, as in the case of inter-industry mobility, there is a degree of stability in the outflow of workers in downturns and the inflow of workers in upturns.[36] For example, in the New England region, 5300 employees, or 13% of the workers displaced in the 1967 to 1971

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[35]There is an important qualification to this conclusion. These data represent only the percentage distribution of origins and destinations of the expanded and displaced work force, respectively. To the extent that the metalworking machinery industry is experiencing an absolute shortage of labor, the fact that an equivalent percentage of workers return from a given industry as leave metalworking machinery for that industry may not be adequate from the persepective of the metalworking machinery industry. The issue of an absolute, as opposed to relative, shortage of skilled labor will be discussed in more detail below.

[36]Please note that the number of workers leaving the region in a downturn and returning to the region in an upturn may be underestimates. This is due to the fact that the LEEDs data do not contain information on the geographical location of unemployed workers, retired workers, workers in uncovered employment, and workers not in the labor force. Therefore, workers who are unemployed, for example, in a recession year are assumed to be located in the New England region although they may have moved to another region. Similarly, the geographical location of workers added to the labor force in an expansionary period who were not in covered employment at the beginning of the period is assumed to be the New England region, although these workers may have been located outside the region at the time.

Table 17

Inter-Regional Mobility Over the Business Cycle

New England

Workers Entering Metalworking Machinery Industry in New England from 1964 to 1971	36,700
Number employed outside the region in 1964	1,900
Percentage of new entrants from 1964 to 1967 from outside the region	5%
Workers Leaving Metalworking Machinery Industry in New England from 1964 to 1971	39,300
Number employed outside region in 1971	5,300
Percentage of displaced workers leaving the region from 1967 to 1971	13%
Workers Entering Metalworking Machinery Industry in New England from 1971 to 1974	33,000
Number employed outside the region in 1971	6,000
Percentage of new entrants from 1971 to 1975 from outside the region	18%
Workers Leaving Metalworking Machinery Industry in New England from 1974 to 1975	14,100
Number employed outside the region in 1975	2,300
Percentage of displaced workers leaving the region from 1974 to 1975	16%

Source: LEEDs data, prepared by Alan Matthews and Barry Bluestone

recession, left the region; however, 6000 employees, or 18% of the expanded 1974 labor force, consisted of workers employed outside of the region in 1971. Summing over the two complete business cycles under consideration, it can be seen that 7,900 (1,900 from 1965-1967 plus 6,000 from 1971-1974) of the new entrants to New England's metalworking machinery industry during these two upswings came from outside the region. 7,600 employees (5,300 from 1971-1974 plus 2,300 from 1974-1975) displaced from the industry in the two downturns took jobs in other areas of the country. These data do not support industry claims that the New England region has experienced a net loss in metalworking machinery workers, relative to other regions, over the last two business cycles.

Why, then, are firms apparently more reluctant to lay off workers in recessions? The LEEDs data suggest that while there is a great deal of both inter-industry and inter-regional mobility among workers displaced in downturns, the flow of workers to other industries and regions is not uni-directional. Therefore, the fears that workers laid off are workers gone forever do not appear to be substantiated by these data. A few factors will be discussed that will attempt to reconcile the contradiction between this mobility data and the expressed reluctance of management to lay off employees.[37] First, there is the problem that, as metioned above, while

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[37]Remember that the data on output per worker presented previously appear to support the fact that, at least in the 1974 to 1976 recession, fewer workers were laid off than would have been expected given the decline in industry sales.

the flows across industries and regions are relatively equivalent, there is no indication that these are the same people entering and leaving the industry. There is the possibility that the workers leaving the industry in downturns are more highly skilled than those entering the industry on the upswing. Unfortunately, there are not data available which would permit an analysis of inter-industry or inter-regional mobility by different skill levels. With the data available, it would seem that this is a distinct possibility, in light of the fact that firms have stated that they are increasingly reluctant to lay off workers.

A second possible explanation is related to the problem of an absolute, rather than relative, shortage of labor. Firms may be getting an equivalent percentage or number of returning workers but, as mentioned previously, this may not be a sufficient supply of labor in expansionary periods. Every firm interviewed stated that they could expand their production if only they had more skilled workers. This absolute shortage of employees may be conditioning management's perceptions of the mobility of workers. If a firm has difficulty obtaining an adequate number of employees, it is probably more likely to be reluctant to lay off workers, regardless of whether or not workers who are laid off return to the firm (or industry) in later periods. So, it would appear that, since the absolute shortage of labor looms so large in the eyes of management, firms may not be distinguishing between this absolute shortage and the shortage relative to other industries or regions.

The empirical results presented in this chapter have established the two major problems of the metalworking machinery industry in both New England and the United States: the extreme volatility of product demand and the

shortage of skilled labor. These two problems, both separately and in combination, are important factors influencing investment behavior in the industry. These influences on investment behavior, along with a consideration of how other factors such as ownership and size characteristics influence investment, will be the subject of Chapter Four.

Chapter 4

Investment Behavior

This chapter will examine the investment behavior of firms in the metalworking machinery industry; what factors appear to have an important influence on investment behavior, and particularly, are there influences on investment that differentially affect the metalworking machinery industry in the New England region. First, it is necessary to distinguish between short term and long term investment decisions. Short term investment decisions concern the annual capital budgeting activities of firms, while long term investment decisions concern such issues as whether firms will expand their plant, move to another site, or close down operations entirely. This analysis will look at these two types of behavior separately, in that different factors are more or less important depending upon the time frame under consideration.

Short Term Investment Behavior

In order to examine short term behavior, it is necessary to understand how investment is financed in this industry. The large majority of metalworking machinery firms finance their capital expenditures out of retained earnings. There is very little interaction with capital markets, as firms usually do not seek to finance investment by borrowing. In the cases where borrowing does occur, it is usually because the firm does not have the necessary resources at hand. Metalworking machinery firms get most of their outside financing from local banks, and loans are usually made on a short term basis. In some instances, notably with the larger firms in the industry,

long term loans are obtained from insurance companies. However, as mentioned, the magnitude of borrowing from sources such as banks or insurance companies is relatively insignificant when compared to the amount of financing obtained from internal sources. The use of stock issuance as a means of obtaining financing is extremely limited in this industry. Industry spokespersons have stated that this is the case due to the fact that the industry is not particularly glamorous, it is relatively high risk and there is very little product identification. As a result, it is not easy to interest this investing public in the metalworking machinery industry.

Cyclical Behavior

The fact that most investment is financed out of retained earnings is very important when looking at short term investment behavior. Specifically, since the industry experiences such extreme volatility over the business cycle, retained earnings are also subject to such instability. The following table illustrates, for example, the net income or rate of profit in the machine tool industry compared to that of all manufacturing industries from 1965 to 1976.

Table 18

Net Income After Taxes

Year	As Percent of Sales		As Percent of Assets	
	Machine Tool Industry	All Other Manufacturing Industries	Machine Tool Industry	All Other Manufacturing Industries
1965	6.0%	5.6%	7.7%	7.7%
1966	6.5	5.6	8.8	7.7
1967	6.4	5.0	8.8	6.6
1968	5.6	5.1	7.3	6.6
1969	4.3	4.8	5.1	6.1
1970	1.5	4.0	1.9	4.9
1971	(1.7)	4.1	(1.7)	5.1
1972	(1.1)	4.3	(1.2)	5.5
1973	2.4	4.7	2.7	6.5
1974	3.2	5.5	4.1	7.6
1975	4.0	4.6	7.0	6.0
1976	4.9	5.4	6.5	7.3
1977	4.8	5.3	7.4	7.6

Numbers in parentheses indicate losses.

Source: 1978-1979 Economic Handbook of the Machine Tool Industry.

It can be seen that, in recessionary periods, the income of the machine tool industry is significantly less than that of other manufacturing industries. Only during the peak periods of the late 1960's was the income of the machine tool industry significantly greater than that of other manufacturing industries. For example, in 1971, the machine tool industry experienced a net loss of 1.7% of sales, while other manufacturing industries had income of 4.1% of sales. It is quickly apparent that, if the metalworking machinery industry depends upon retained earnings to finance investment expenditures, then firms in the industry will not be able to pursue very extensive investment policies in periods of low demand unless they have accumulated a fair

amount of savings when business was good.

Figures 12 and 13 present data on gross investment expenditures for the metalworking machinery industry in the United States and the New England region, along with data on sales and employment for the period 1958 to 1976. Before examining these data, however, it is necessary to discuss the source of this information. These data were obtained from the Annual Survey of Manufacturers and the Census of Manufacturers, and represent the annual expenditures of the industry for new capital equipment. Since these data are for gross expenditures, they include both net new investment and expenditures for replacement. Data were obtained from the Office of Economic Growth (OEG) of the Bureau of Labor Statistics that compare gross and net investment expenditures for the metalworking machinery industry at the national level for the period under consideration.[1] Figure 14 presents both the gross and net capital expenditures of the industry, along with the net stock of capital assets for the period of 1959 to 1974. This figure shows that, although there is a large difference between gross and net expenditures -- for example, in 1971 gross expenditures amounted to $143 million while net expenditures were minus $21 million -- the two lines follow

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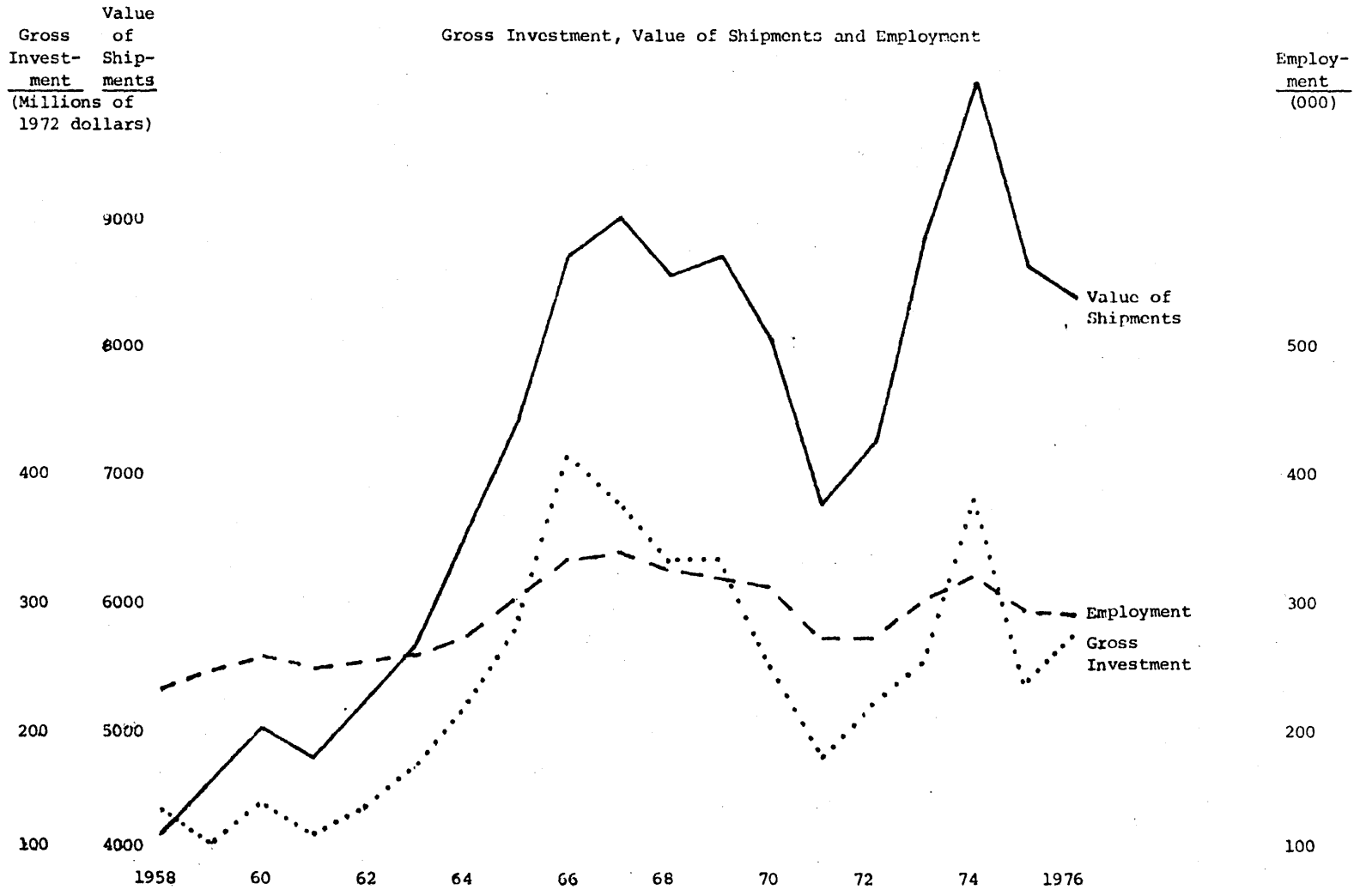
[1]These data are based on the Annual Survey of Manufacturers figures, but have been adjusted to take into account both the discards of worn out assets and the decline in productivity of the assets over the service life of the equipment.

Figure 12

UNITED STATES

Gross Investment, Value of Shipments and Employment

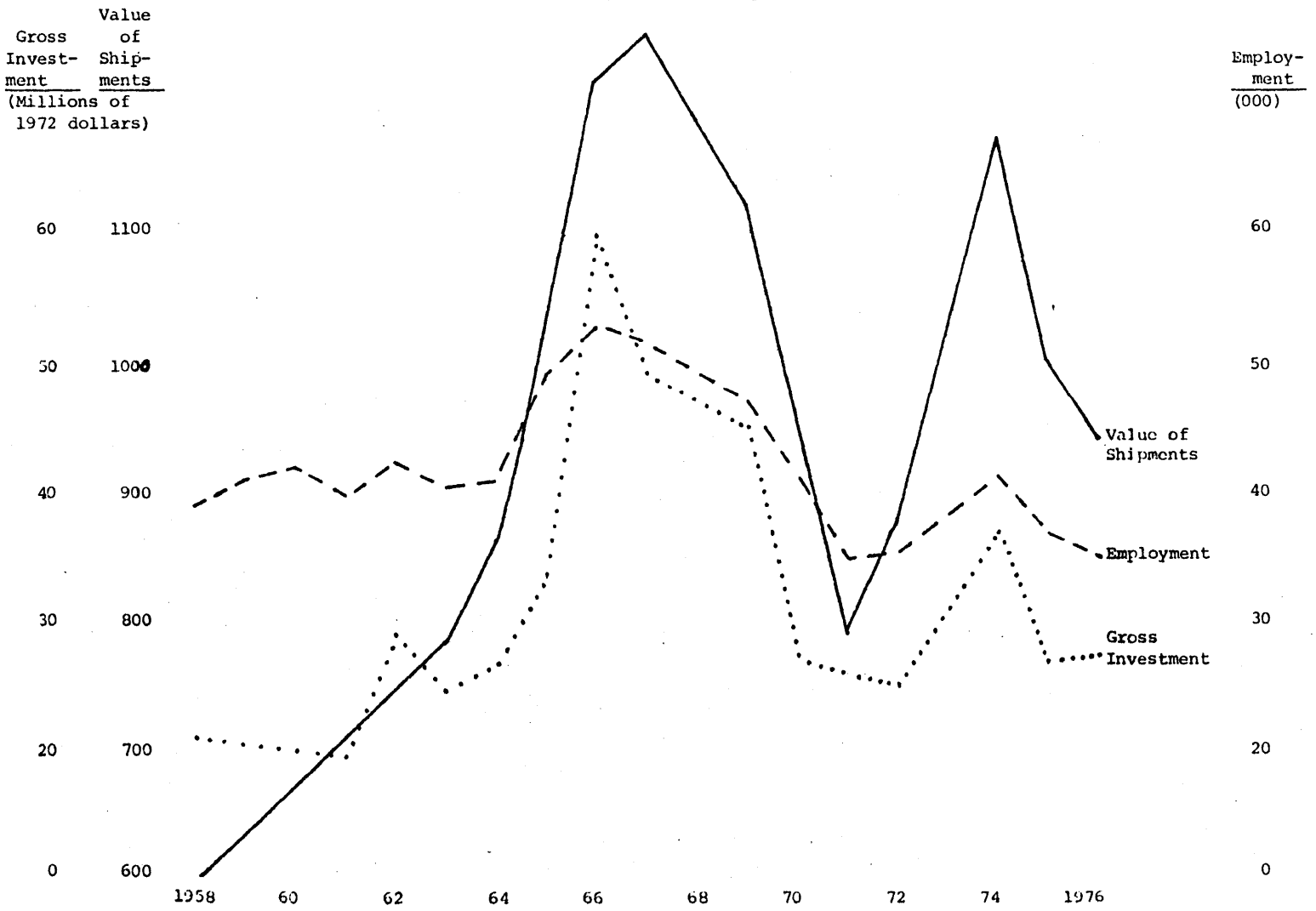


Sources: Annual Survey of Manufactures and Census of Manufactures, 1958-1976.

Figure 13

NEW ENGLAND

Gross Investment, Value of Shipments and Employment



Sources: Annual Survey of Manufactures and Census of Manufactures, 1958-1976.

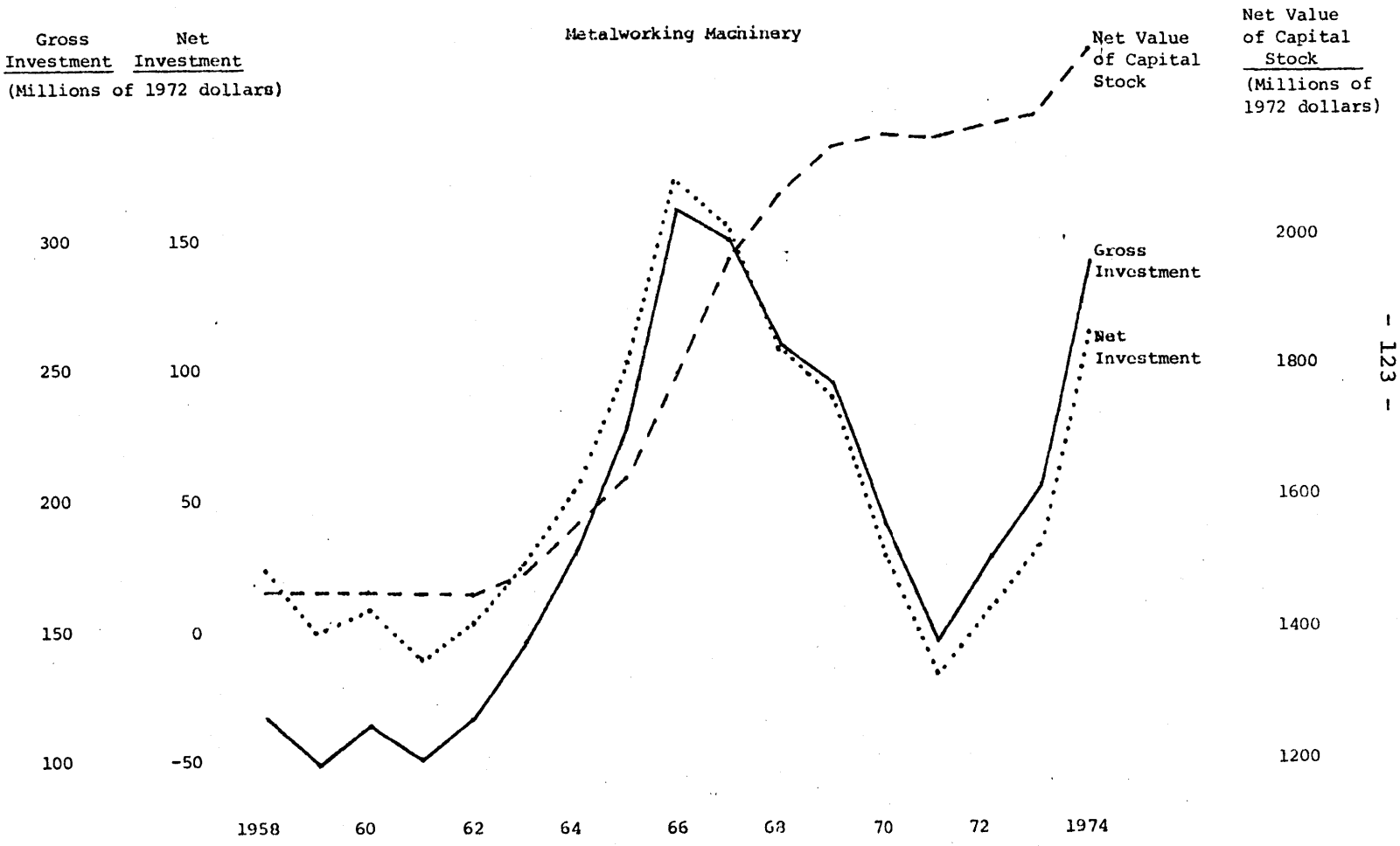
Figure 14

UNITED STATES

Gross Investment, Net Investment And

Net Value of Capital Stock

Metalworking Machinery



Source: U.S. Bureau of Labor Statistics - Office of Economic Growth, March, 1978.

the same pattern. The data from the Office of Economic Growth on gross investment were then compared to those from the Annual Survey of Manufacturers for both the U. S. as a whole and the New England region, and are presented in Figure 15. It can be seen, for the U. S., that although the gross investment reported by the Annual Survey of Manufacturers is quite a bit larger than that calculated by the Office of Economic Growth, again the pattern is quite similar. The purpose of this discussion is simply to show that, while data on net investment are not available for the New England region, the gross investment data reported in the Annual Survey of Manufacturers is probably representative of the relative, but not absolute, magnitude of net new investment in the region.

Returning to Figures 12 and 13, and assuming that gross and net investment move in very similar patterns, it can be seen that investment in the industry is quite cyclical, both in the New Enland region and the nation as a whole. As discussed above, this is partially a function of the usual means of financing new investment. Moreover, the metalworking machinery industry is, like many of its customers, likely to follow somewhat "lumpy" investment programs. Specifically, since much of the capital equipment purchased by the industry is also produced by the industry (particularly machine tools), the durability of the capital equipment accentuates the cyclical instability of investment behavior.[2] These two factors (the dependence on retained earnings as the source of investment finance and

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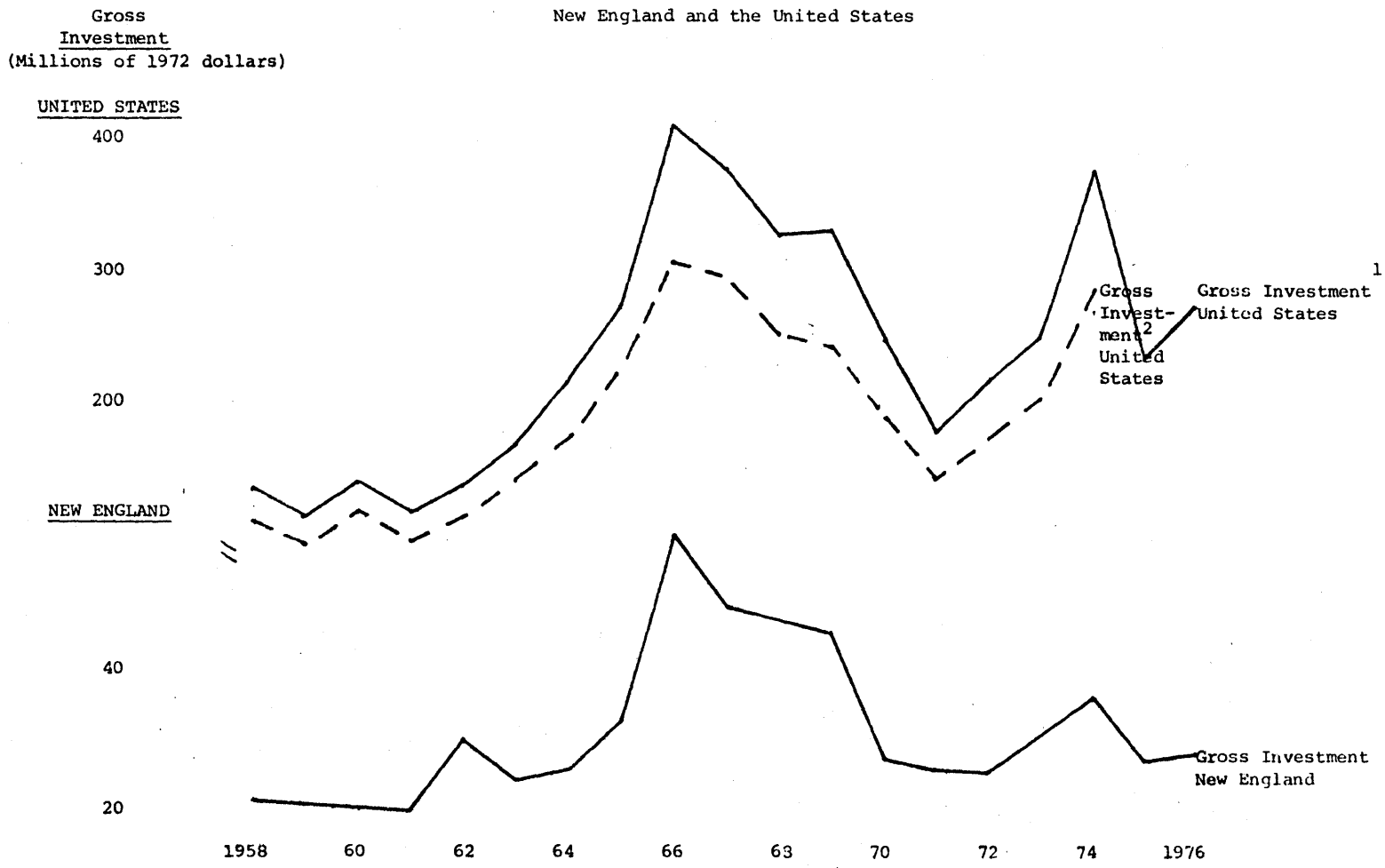
[2] Recall that, since machine tools are extremely durable, their replacement can be deferred almost indefinitely in recessionary periods, but on the business cycle upswing replacement and updating becomings essential to satisfy greatly increased demand, especially given the greatly increased productivity of the newer machine tools.

Figure 15

GROSS INVESTMENT

New England and the United States



[1]Data from the Annual Survey of Manufactures and the Census of Manufactures.

[2]Data from the Office of Economic Growth, Bureau of Labor Statistics.

the ability to defer replacement of capital equipment in recessionary periods) combine to produce a very cyclical pattern of investment expenditures in the metalworking machinery industry.

Ownership Status

At this point, it is interesting to ask if there are differences in short-term investment behavior among different types of firms. Specifically, are certain types of firms better able to pursue more long term, steady investment strategies that are not so sensitive to business cycle fluctuations. Representatives of some firms interviewed have expressed the opinion that corporate or conglomerate ownership of a metalworking machinery firm may confer advantages in this regard. That is, the parent firm can supply investment financing in periods when a particular firm is experiencing short-term net losses of income. A number of firms interviewed have said that this has been, in fact, the case for them. Unfortunately, data are not available with which to test the hypothesis that corporate or conglomerate ownership of metalworking machinery firms results in more even, less cyclically unstable investment behavior. All that can be said definitively is that the managers of the corporate and conglomerate owned firms interviewed seem to feel that this is the case.

Firm Size

However, there is another important factor which needs to be examined when discussing the stability of investment expenditures over the business cycle. This factor is firm size. It must be remembered that, on the average, it is the largest metalworking machinery firms that are owned by corporations or conglomerates. It is possible, then, that it is really the size of the

firm, and not the ownership status of that firm, that permits the owner/manager to pursue a stable investment program. For example, a small firm in the industry may very well be unable to generate the savings needed to finance capital improvements over downturns in the business cycle. The larger, independent firms, on the other hand, are better able to accumulate this cash reserve and therefore will be relatively less dependent on general economic conditions when planning their capital expenditures. Moreover, industry spokespersons have stated that the larger independent firms are likely to have greater management expertise and more concern for long-range planning than are the smaller independent companies. This difference in management sophisitication and length of planning horizon is apt to result in greater instability in investment expenditures among small, relative to large (either corporate or conglomerate owned or independent) firms. For example, the owner of one relatively large, independent, machine tool company stated that his capital expenditures remain quite constant over the business cycle. Another very large independent firm engaged in rather substantial capital investment spending in a period when the company was experiencing losses. The controller of this firm stated that the management of the firm was being reorganized, and that, although they experienced significant losses in the short run, the company was more concerned with the long run growth potential of the business.

Again, it is unfortunate that data on the investment policy of firms, by size and ownership status, are not available. Interviews with representative firms in the region, however, appear to suggest that it is more likely that the size of a particular firm, rather than its ownership status, enables the firm to follow a steady investment program in the face of unstable

product demand.

The size of the firm may have other influences on short term investment behavior. First, to the extent that borrowing is an important source of finance, it might be expected that smaller firms would have more difficulty obtaining funds than larger firms. Reasons for this might include factors such as reluctance on the part of banks to deal with the smaller firms (due to a higher perceived risk), unfamiliarity of owners of firms with the banks and financing arrangements, and other miscellaneous factors that might limit the access of small firms to capital markets.[3] Among the small and medium sized firms interviewed, however, the ability to obtain adequate outside financing was cited as a problem only once. This firm experienced difficulty in obtaining funds from a commercial bank five years ago due to the fact that the firm was undercapitalized. The treasurer of this firm, however, stated that this has not been a problem since that time. Moreover, it should be recalled that the importance of borrowing, relative to retained earnings, as a source of investment finance is minimal. There also appears to be some more idiosyncratic approaches to financing among smaller firms in this industry. One firm, for example, was advanced money from its customers to buy the machinery necessary to start the

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[3] See U.S. Congress, Problems of the Tool and Die Industry, 1966, for a description of problems small metalworking machinery firms face in financing their capital expenditures through borrowing. One factor cited was the lack of familiarity of bankers with the metalworking machinery industry. Spokespersons stated that banks were reluctant to finance the machinery purchases of small firms because "of their inability to handle the reclaimed machinery in case of default. They knew nothing about the machinery business and did not want to get into it." p. 61.

business.[4] On the whole, then, it would appear that the size of firm does not adversely affect ability to obtain external financing for capital expenditures.

The second way in which size may affect investment practices concerns the types of equipment that can be purchased. In the last ten years, the complexity, sophistication, and particularly the cost of modern machinery has increased enormously. The degree to which small firms can utilize these technological developments is related to three issues: cost; applicability; and accessibility. The cost of numerically controlled machine tools is substantially greater than the cost of the more conventional machine tools they replace. The following table shows how the average price of complete machine tools (the value of shipments divided by the total number of units shipped) has grown,[5] and how it compares with the average price of numerically controlled machine tools.

Table 19

Average Costs of Machine Tools

	Average Cost of Complete Machine Tools	Average Cost of Numerically Controlled Machine Tools
1960	$4,244	n.a.
1965	$5,819	n.a.
1970	$6,147	$109,942
1975	$8,583	$122,026
1977	$8,907	$116,228

Source: 1978-1979 Economic Handbook of the Machine Tool Industry

[4]The larger machine tool companies sometimes provide financing services for their customers.

[5]These data are in current dollars, and therefore don't control for inflation.

It is quite clear that numerically controlled machine tools are very expensive, costing on the average about a quarter of a million dollars. The question is, can a small metalworking machinery shop afford such expensive equipment? The answer appears to be equivocal. Of the small firms interviewed, one (nine employees) had just purcahsed a $125,000 computer numerically controlled EDM (electrical discharge machinery) wire cutting machine, and has plans to purchase another next year.[6] However, two other small firms (both under ten employees) reported that they use only conventional machine tools -- they can't afford the expensive numerical control equipment, and they don't do any capital spending other than for replacement and maintainence. It is difficult to draw a firm conclusion as to whether or not small firms can afford to utilize these new technological developments. At least one small firm can and does, which would suggest that it is feasible. Is this firm an aberration or is it typical of other small metalworking machinery companies? The owner feels that he is somewhat more aggressive than other small shops in the region, but not in comparison to small firms in the Mid West. He feels that it is indeed financially feasibly for small shops to take advantage of numerical control technology, but that the owners of other small firms in the area are too cautious[7] and aren't willing to pursue aggressive investment programs.

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[6]The purchase of the first EDM machine is financed out of retained earnings. The owner plans to borrow part of the cost of the second machine, and doesn't foresee any problems obtaining this financing from a local bank.

[7]He attributes this cautiousness to what he calls "an Old Yankee mentality," and says that small firms in the Mid West and West aren't afflicted with this shortcoming.

The applicability of and accessibility to numerical control technology by small firms is also of interest. Small firms in the metalworking machinery industry tend to do low volume[8] and often very customized work. In the earlier stages of numerical control development, the technology was really only economically justified for very large volume jobs, and was therefore not applicable to the work of smaller (and many larger) shops. However, in recent years, and particularly with the development of computer numerical control (CNC) rather than tape numerical control (TNC), this has changed to some degree. As discussed in the history of technology in metalworking machinery (Chapter 2), CNC is much more flexible than TNC and more readily applicable to small volume work. Therefore, although it hasn't been the case in the past, it does appear that numerical control technology is becoming more relevant to the operations of small, low volume shops.[9] And finally, the issue of accessibility of small shops to the new technology arises. This discussion is similar to that concerning applicability. Specifically, in the early days of numerical control, the complexity of the soft-ware associated with its use was overwhelming.[10] Again, however, in more recent years

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[8] It has been said that over 70% of all metalworking jobs are small volume jobs. U. S. Congress, House Subcommittee on Special Investigations of Small Business Problems, Hearings on Problems of the Tool and Die Industry, 1966, p. 60.

[9] Recall that, as discussed in Chapter 2, numerical control technology is by no means applicable to all jobs, of either large or small firms.

[10] Please see David Noble for a discussion of why small firms couldn't easily get into using numerical control because of complicated programming requirements.

the soft-ware has become less complicated, and the newer machines can be utilized by persons having relatively minimal training in computer programming.

This discussion of firm size and investment policy began by examining the stability of investment expenditures over business cycle fluctuations and continued by looking at the ability of small firms to invest in modern equipment. While it appears that there are some reasons to believe that larger or corporate/conglomerate owned firms may be in a better position to follow stable investment programs, there does not seem to be any major constraints on the ability of smaller firms to purchase modern equipment. Data from the 12th/ American Machinist Inventory of Metalworking Equipment 1976-1978 strongly support this notion, as the following table shows.

Table 20

Age of Machine Tools Owned by Firm Size

	Firms w/20-49 employees	Firms w/50-99 employees	Firms w/100 or more employees
Total Units	306,593	234,002	1,197,687
Percentage 0-4 years old	12%	12%	10%
Percentage 5-9 years old	25%	25%	19%
Percentage 10-19 years old	36%	38%	34%
Percentage over 20 years old	27%	25%	37%
Percentage of units that are numerically controlled	1.3%	1.8%	2.7%

Source: 12th/ American Machinist Inventory of Metalworking Equipment 1976-1978.

Before interpreting these figures, it should be noted that they represent the age of machine tools in all industries. That is, they include machine tools in automotive, appliance, construction machinery firms, etc. Moreover, they do not include firms with less than 20 employees due to data problems with that subsample.

However, to the extent that these figures are representative of firms, by size class, in the metalworking machinery industry, the numbers are very interesting. First, as would be expected given the considerations raised above (cost, applicability and accessibility), the percentage of numerically controlled machines is much lower in the smaller plants. However, the smaller and medium sized firms have both a greater percentage of new machine tools, and a much smaller percentage of old machine tools than do the larger firms. These data suggest that the two small firms interviewed that did no updating of their capital stock are not typical of other small and medium sized firms. Rather, the smaller firms in this sample appear to be keeping up with larger firms in purchasing new equipment and are probably ahead of the larger firms in retiring older, less productive equipment. These figures appear to support the hypothesis that, at least in terms of the purchase of conventional machine tools, smaller and medium sized firms do at least as much updating of capital stock as do larger firms.

The question of whether or not small firms pursue less steady investment programs, however, is not addressed by these data. It is interesting to note that the survey from which these data were obtained was performed in 1978, an expansionary period for the metalworking machinery industry. If smaller firms are more likely to purchase new capital equipment only in periods when business is quite good, then these figures are reasonable. The smaller

firms will have been purchasing new machinery and getting rid of older, less productive machinery on this upswing, and so it is natural that the age of the capital stock in these firms is relatively new. Presumably, in a recessionary period, such as that experienced from 1969 to 1971 or 1974 to 1976, the age of the capital stock would be older. Unfortunately, data are not available with which to investigate this question.[11]

Labor

The next factor to be examined as an influence on short term investment behavior is labor. Specifically, the availability of labor is hypothesized to have an important effect on both the type and level of investment undertaken by metalworking machinery firms. As discussed in some detail in Chapter Three, the industry is experiencing severe shortages of skilled labor, both in the New England region and in the nation as a whole. One response to this labor shortage might be to purchase more capital intensive, labor saving equipment. It has been noted that, over the history of this industry, the trends in technological development have been in the direction of building the skills of the machinists into the machine itself and thereby decreasing the skill requirements of workers in the industry. It is very difficult, however, to quantitatively prove that the metalworking machinery industry has become more capital intensive over time due to the paucity of capital stock data available. Qualitatively, this assertion would seem to be true.

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[11] For example, the last American Machinist Inventory was taken in 1973, another expansionary period for the industry and again, the smaller firms had more newer and less older machine tools in their capital stock.

The representative of most firms interviewed seemed to feel that this was, in fact, the case. Trade journals advertise the newer, more sophisticated and labor-saving machinery extensively as a way to decrease the labor and skill requirements of production. The 12th/ American Machinists Inventory of Metalworking Equipment 1976-1978 states that the productivity[12] of machine tools has increased dramatically over the last 20 years. The 12th/ American Machinists Inventory of Metalworking Equipment 1976-1978 index of productivity increased by approximately 70% from 1945 to 1960; by approximately 110% from 1960 to 1975; and for the 20 year period of 1958 to 1978, the index increased by about 145%. These figures, however, refer to the productivity of machine tools in all users industries.

In order to see if the metalworking machinery industry itself has become more capital intensive, the data from Office of Economic Growth were examined. Recall that this source contains data on both gross and net investment expenditures, and net capital stock for the industry at the national level. (See Figure 14). It is hypothesized that, if the industry has become more capital intensive, the net value of capital stock per production worker will increase. Data on the value of capital stock per production worker for the period 1958 to 1974 are presented below.

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[12] Productivity is measured by the output of and number of machine tools in user industries.

Table 21

Net Value of Capital Stock per Production Worker

Year	(1972 dollars) Net Stock/Production Worker
1974	$ 9,446
1973	9,816
1972	10,866
1971	11,069
1970	9,476
1969	8,635
1968	8.463
1967	7,572
1966	7,080
1965	7,102
1964	7,359
1963	7,496
1962	n.a.
1961	7,787
1960	7,481
1959	7,779
1958	8,296

n.a.: not available.

Source: Office of Economic Growth, Bureau of Labor Statistics.

The net value of capital stock per production worker has varied considerably over the business cycle. As would be expected, the value is greater in downturns (where there are less workers) such as 1971, and relatively low in peak periods (where the work force is enlarged) such as 1957 and 1974. It is interesting to note, however, that, over this period, the value of stock per production worker does not really appear to have increased dramatically. In fact, on average over this period, the value of net capital stock per production worker increased only about $200 per year.[13]

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[13] A bivariate regression of value of stock per production worker against time produced a regression coefficient of 199.

The figures presented in Table 21 do not appear to strongly support an hypothesis of increasing capital intensity in the metalworking machinery industry. However, this is not a definitive answer to this question of capital intensity. It should be recognized that the quality of the data on capital stocks may be suspect. It is very difficult to obtain accurate data in this area, and the Office of Economic Growth developed a capital stocks model to derive these figures. This model may contain various specification errors and moreover, some assumptions made in developing the model are questionable.[14] Therefore, it is possible that these figures are inaccurate.

In conclusion, it is difficult to document how the labor shortage has affected the type of equipment purchased by metalworking machinery firms. On the one hand, firm representatives interviewed have usually stated that they are taking advantage of more automated machinery as a means of dealing with the shortage of skilled labor. However, they have also stated that much of their work is not amenable to automatic or numerically controlled machinery. Unlike other metalworking industries, the work done by metalworking machinery firms is more likely to be specialized or prototypical and

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[14]For example, 1958 and 1963 capital investment flow matrices were used to derive the investment "bundles" of particular industries. These bundles are assumed to remain constant over time. Additionally, the replacement and decay functions derived in the model contain unrealistic assumptions, such as assuming the service life of certain assets are the same in all industries, that the asset does not depreciate over its service life, etc. This is not intended as a criticism of the Office of Economic Growth model. The model attempts to deal with difficult data problems by making the most realistic assumptions possible. This discussion of the capital stock model is only intended to point up problems associated with using the data from the model and to emphasize the fact that these data may be biased or incorrect and should be interpreted with caution.

therefore less conducive to automation. For example, comparing the purchases of numerically controlled machinery across different industries, it can be seen below that the metalworking machinery industry is relatively less advanced than other industries.

Table 22

Percentage of New Machine Tool Purchases that are for Numerically Controlled Machine Tools

Purchasing Industry	Metal Cutting Machine Tools	Metal forming Machine Tools
Metalworking machinery (SIC 354)	8.1%	.3%
Railroad equipment (SIC 374)	10.1%	2.4%
Construction and mining machinery (SIC 353)	15.3%	3.0%
Ordnance and accessories (SIC 348)	15.5%	1.2%
Guided missles, space vehicles (SIC 376)	18.0%	2.7%
Aircraft and parts (SIC 372)	23.4%	2.2%

Source: 12th/ American Machinist Inventory of Metalworking Equipment 1976-1978.

To some extent, the metalworking machinery industry is limited by the nature of its production processes from utilizing more capital intensive equipment. The data on the value of stock per production worker also suggest that, while the newer and more automatic machinery generates a lot of attention among firms in this industry, the degree to which it has been used to substitute capital for labor does not appear to be substantial.

Another way in which the limited availability of labor has affected investment has been suggested by some industry spokespersons. Specifically, it has been stated that, contrary to conventional micro-economic theory, firms do not treat labor as a variable cost. Fearing that workers who are laid off are lost forever as a source of new labor, the owners/managers of metalworking machinery firms do not lay off workers in downturns, thereby effectively treating labor as a fixed cost. This issue has been discussed in detail in Chapter Three. Recall that the data on the value of shipments per production worker (see Figures 10 and 11 in Chapter 3) over recent business cycles support the contention that firms have become more reluctant to lay off workers in recessions.[15] It is this combination of cyclical instability and severe scarcity of skilled labor that has induced firms to treat labor costs as fixed. The argument continues, moreover, that since labor is a fixed cost that is underutilized in recessions, firms are afraid to overextend themselves in terms of capital investment. The firm is forced to pay for one underutilized factor of production in periods of low demand, and it simply cannot afford to pay the cost of also having idle capital at the same time. Therefore, it is claimed that this scarcity of labor has resulted in underinvestment in the industry as a whole.

While this is certainly a very interesting argument, it is quite difficult to document empirically. It is probably impossible to determine whether or not the American metalworking machinery industry is undercapitalized,

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[15] Also recall that the data from the LEED file (see Tables 15 and 16 in Chapter 3) suggest that management's fears are unfounded.

particularly as a result of labor shortages. It is infeasible to try to compare investment behavior in the metalworking machinery industry with that of other industries which do not experience such cyclical volatility or extreme labor shortages, since there are such enormous differences in production processes across industries. It might be interesting to compare the metalworking machinery industry in the U. S. to that in other countries (again with less severe instability and/or labor scarcity problems) but again the comparison is complicated by many exogenous factors (i.e., differences in depreciation laws, different levels of government support for capital investment, etc.). Therefore, while the argument that the combination of cyclical instability and labor shortages has resulted in underinvestment in the metalworking machinery industry appears plausible, it is beyond the scope of this study to do more than present the discussion as an interesting idea.

Government

Governemnt policies have influenced short run investment behavior in the metalworking machinery industry. These influences can be categorized as either direct or indirect. The direct influences include those that have an immediate effect on a metalworking machinery firm's investment decisions. The indirect influences include various government policies that affect the metalworking machinery industry's customers, and thereby the industry itself. While it could be argued that these latter policies really influence the demand for metalworking machinery, in some cases this demand actually changes the way in which the metalworking machinery industry makes investment decisions.

Government policies that directly influence investment behavior are investment tax credit and depreciation allowance laws. Some firms interviewed felt that more liberalized depreciation and investment tax credits were extremely important in enabling them to engage in capital investment, while others stated that these regulations had not significantly influenced their decision-making. All firms, however, were very much in support of any further liberalization of these laws.[16] The industry has also complained that depreciation laws are much more liberal in other countries, and that this has resulted in a rather undercapitalized metalworking machinery industry in the U. S. relative to its major competitors. The following data gives some, but not overwhelming, support to this contention, although not with respect to West Germany and France.

Table 23

Cost Recovery Allowable for Tax Purposes on Machinery and Equipment

(% of original cost)

	First Year	Third Year	Seventh Year
U. S.	41.1%	70.8%	103.0%
U. K.	100.0%	100.0%	100.0%
Japan	61.9%	82.0%	102.7%
West Germany	25.0%	57.8%	86.7%
France	31.3%	67.5%	94.9%

Source: 1978-1979 Economic Handbook of the Machine Tool Industry.

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[16] It should be rememberd that this support may be due to the fact that a liberalization of depreication laws, for example, would stimulate demand for the output of the metalworking machinery industry substantially, rather than due to the fact that it would enable these firms to engage in greater investment activity in their own plants.

The extent to which the U. S. metalworking machinery industry is undercapitalized and hence less competitive with the world industry is not known (although the data in Table 8, Chapter 3, suggest that the capital stock in the U. S. is quite older than in other countries).

Another government policy that directly affects investment is the provision of Small Business Association financing to the industry. There was some interest in this in the late 1960's,[17] although no firm interviewed mentioned the Small Business Association as a source of financial capital. This is not surprising given the fact, discussed previously, that most firms finance investment out of retained earnings and usually do not borrow.

A final government policy that is seen as directly influencing the character of investment is product liability legislation. This has become an extremely important issue to the industry in the last few years, and is the object of some very intense lobbying efforts on the part of the metalworking machinery industry. What has happened is that the builders of machine tools have been held liable for injuries of workers using the machine. Industry complaints center on the unlimited liability born by the machine tool builder[18] and the fact that the costs of product liability insurance

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[17] See U. S. Congress, House Subcommittee on Special Investigations of Small Business Problems, Hearings on Problems of the Tool and Die Industry, 1966.

[18] The builder is liable even if the fault lies with the owner of the plant in which the machinery was being used. That is, the owner may have removed a protective guard, or may be running a shop that is very unsafe, but the liability for injury is born by the original builder of the equipment. See American Machine Tool Distributors, A State Legislator's Guide to Product Liability Problems, Washington, D. C., 1977.

have skyrocketed in recent years.[19] This issue of escalating product liability insurance costs may be influencing the character of investment in the following way. Firms are very anxious to be able to "prove" that their product was not defective leaving the factory door. This appears to have spurred demand for automated product inspection equipment. Some equipment is advertised as being able to reduce the risk of human error associated with manual or visual inspection techniques. The new equipment, through the use of advanced technologies like lasers, can determine if the work is accurately dimensioned, constructed, etc. Moreover, the equipment can produce computer printouts detailing the quality of the work, and this material would presumably be very useful in proving innocence in court. While many of the firms interviewed have not yet begun to explore these new product inspection techniques, other firms (and trade journals) seem to feel that this is an important development and will become more widespread, particularly in the face of increasing insurance costs.

The government indirectly influences short term investment behavior in the metalworking machinery industry in two ways. First, various government policies and/or regulations may stimulate demand for the products of the metalworking machinery industry. Specifically, policies such as the investment tax credit or the liberalization of depreciation allowances influences the industry in that they stimulate demand for investment goods in general, and metalworking machinery in particular. Moreover, government defense

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[19]Firms interviewed, even those who had had no claim against them, reported increases of greater than 1000% in their product liability insurance premiums.

expenditures also stimulate the demand for metalworking machinery. Government contracts for airplanes or armaments, for example, necessitate the purchase, on the part of the prime contractors, of machine tools, tools and dies, etc. In some cases, the government itself purchases the machine tools (when the prime contractor does not have the types of machinery required and is unwilling and/or unable to purchase them on its own)[20] and places the machinery in the plant of the prime contractor.[21] This increased demand

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[20] "The justification for the Government providing such equipment is supposedly that the capacity to do this work is not otherwise available and that the prime contractors are not able to purchase this expensive equipment for what might be short-term use on Government contracts." U. S. Congress, House Subcommittee on Special Small Business Problems of the Select Committee on Small Business, Problems Facing the Tool and Die Industry: Hearings on H. Res. 66, 91st Congress, 1st session, June 3 and 4 and July 5, 1969, p. 9.

[21] Some concern has been expressed, on the part of smaller firms in the metalworking machinery industry, that this practice of placing machine tools in the hands of prime contractors is detrimental to the industry (Ibid.). Specifically, it has been alleged that the prime contractors use these government owned machines on commercial contracts (there is an arrangement whereby the prime pays a "rent" to the federal government for the amount of time the machine is used for commercial purposes, but the extent to which this arrangement is enforced, and the reasonableness of the rental schedules, are not clear -- again, see Ibid.). They are thereby able to get more business because they don't have to pay the cost of machine purchase and can therefore bid less than a smaller firm for a comparable job. Moreover, it has been alleged that prime contractors with government owned machine tools in their plants have a competitive advantage in bidding for other government contracts, relative to firms who are not prime contractors, again, because they either are not paying the full purchase cost of the machine, or because the machine performs specialized functions and the other firms cannot afford to purchase the machinery necessary to perform similar work. Therefore, the extent to which the practice of the federal government purchasing machine tools to place in the plants of prime contractors actually benefits firms in the metalworking machinery industry is questionable. The 12th American Machinist Inventory of Metalworking Equipment, 1976-1978 finds that there are approximately 28,000 machine tools owned by the Department of Defense and located in the plants of contractors (no estimate is made of the value of these machine tools, but it is probably reasonable to assume that these machines are relatively sophisticated - such as numerically controlled machine tools in the plants of contractors in the aerospace industry).

generates the need, within the metalworking machinery industry, for increased productive capacity, and hence greater capital investment.

The second way in which government policies, and particularly regulatory policies, influence investment behavior in the metalworking machinery is rather interesting. In recent years, the federal government (and some state governments) have instituted a number of laws regulating, for instance, safety in the work place, the level of pollution that industries can emit, the level of gas mileage required on new cars, etc. All of these regulations require some capital investment on the part of the regulated industries. Utilities must install air scrubbers to cut down on the level of pollution emitted from their smokestacks, factories must update their machinery to get rid of equipment that may be unsafe to operate, automobile companies must design new models that are more fuel efficient, etc. While industry in general usually resents this type of government intrusion in the "free market," the metalworking machinery industry, and to some extent many other capital goods producing industries, are in a somewhat different position. The representatives of most of the firms interviewed expressed some resentment of government encroachment in their domain, the pervasive influence of "big brother" in our society.[22] However, these firms may in fact be benefitting from this "excessive regulation." Specifically, most of these government regulations require investment in newer, safer, less polluting, etc., capital equipment, and to a greater or lesser degree, the demand for metalworking machinery is thereby stimulated.

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[22] There is one exception to this statement. All metalworking machinery industry firms interviewed expressed the opinion that they were in favor of recent Occupational Health and Safety (OSHA) regulations, although a few firms felt that either the timetables for compliance were unreasonable, or that the regulations were to some extent picky.

These regulations are interesting, not only because they may stimulate the demand for metalworking machinery, but also because they may affect the character of that demand. That is, when an industry is forced to comply with a particular regulation, it is usually given a certain amount of time to demonstrate compliance. For example, the automotive industry has been given between about five and ten years (depending upon how successful the automotive lobby is in Congress) to meet federal miles per gallon standards on new cars. Similarly, there are timetables for compliance with Environmental Protection Agency and Occupational Health and Safety Administration standards. This is extremely important for the metalworking machinery industry. The regulated industries know when they have to meet a particular standard, and can plan the necessary conversion of their capital stock well in advance. In turn, the metalworking machinery industry, with orders placed up to five to eight years ahead, is no longer facing the uncertain, unstable product demand picture to which it is accustomed. This reduces the risk associated with investment in the metalworking machinery industry, and therefore enables firms in the industry to pursue more long term, steadier, investment programs. Representatives of a few firms in the interview sample have stated that the retooling going on in Detroit associated with the construction of smaller, more fuel efficient cars has given them a much less uncertain picture of their future business. They say that they now have enough orders to keep them busy through 1985. These firms have also stated that they are much better able to plan their capital investment needs for the future.

Long Term Investment Behavior

As mentioned breifly above, long term investment decisions concern such management decisions as: do we expand, do we contract, should we move to another location, either in the New England region or elsewhere, should we close down altogether? It is very difficult to really address these questions, either with published data or with information gathered in the interviews. Therefore, the discussion of long term investment behavior will be somewhat more tentative than that concerning short term behavior. Factors will be examined which do have an influence on these types of decisions, but only in a rather speculative manner. The factors to be discussed are of particular interest insofar as they influence the competitive position of the New England region as an attractive site for future continued or expanded investment activity in the metalworking machinery industry. Therefore, where applicable and possible, an attempt will be made to compare the interregional and/or international differences in the factors under consideration.

Labor Situation

It has been made clear earlier that the metalworking machinery industry is, in general, experiencing a significant shortage of skilled labor. This shortage has influenced the long run investment behavior of almost every firm in the interview sample. Specifically, the owners and managers of these firms have stated that they would really like to expand their physical capacity, if only there were enough employees available to work in these plants. The labor shortage, then, has acted as a constraint on the expansionary plans of the firms interviewed. It is important to recognize that

this labor shortage does not appear to be adversely affecting the potential for expansion in the New England region vis a vis other areas of the country. Industry spokespersons have stated that the same problem exists and probably of a more severe nature in the other industrialized areas of the country. Moreover, most firms didn't feel that, for example, the Sunbelt region represents a superior location for expansion in terms of labor availability. While wages may be somewhat less, most owners and managers felt that the skill levels of the work force in that region are not up to par with those of New England workers. This same feeling appears to extend to prospects of expanding the industry internationally.[23] Again, it is felt that skill levels in places such as Southeast Asia or South America are suitable only for the production of relatively unsophisiticated, lower tolerance work (of course with the notable exception of Japan).

However, this is not a static phenomenon. After World War II, Japan produced only rather "simple-minded" machine tools, where the required skills were minimal. Today, however, the Japanese machine tool industry is recognized to be on equal terms with the American industry, in terms of the quality and sophistication of its products (and by implication, the skills of its work force). Therefore, although at the present time other areas are not suitable locations for the industry due to an inadequate supply of skilled labor, there is no reason to believe that this will always be the case. A contributing factor here concerns the "deskilling" of occupations in the metalworking machinery industry. It has already been noted that, although

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23 A more detailed description of foreign investment by American machine tool builders is presented below.

the metalworking machinery industry is probably less amenable to automation and mass production technology, it is true that the use of numerically controlled machine tools does result in the need for less skilled machinists and machine operators. It takes much less time and energy to train a qualified button pusher than it does a tool and die maker or machinist. Therefore, it is possible that, in the future, the metalworking machinery industry may become less tied to its present locations in industrialized areas (where a large, albeit insufficient, pool of skilled labor resides) as the skill levels required in production diminish or change.[24] It must be pointed out, again, that these changes in labor requirements have not really been substantial up till now, and it is necessary to recall that it is very unlikely that all of the metalworking machinery industry has the potential to become relatively deskilled.

A second factor concerning the labor situation that is often mentioned in discussions of industrial location/relocation is the extent of unionization and the militancy of the labor force. It is generally assumed that the more extensive the unionization or the greater the militancy, the less desirable is a particular location for economic development. As mentioned earlier, about 40% of the production workers in the metalworking machinery industry are unionized (the unions include, but are not limited to, the International Association of Machinists (IAM), the United Auto Workers (UAW), the United

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[24] It should be noted that required skills are changing with technology. Demand is particularly high for engineers, computer programmers and operators, and electricians. To the extent that the amenities of the New England region continue to be attractive to these labor groups, the region is probably in a better position in the long run, compared, for example, to some industrialized areas in the Mid West.

Electrical, Radio and Machine Workers of America (UE), and the United Steel Workers of America). Unfortunately, it was not possible to obtain regional breakdowns on the extent of unionization in the metalworking machinery industry. However, with the exception of one firm, the unionization and/or militancy of the work force was not cited as a problem in the New England region. It may, in fact, represent a competitive advantage for firms in this region relative to other major concentrations of the industry. That is, it is probably reasonable to assume (and representatives of a number of firms interviewed suggested) that the metalworking machinery industry is less unionized in New England than in its major center - the Mid West. Certainly, the hourly wages of production workers in New England region are, and have been, lower than the national average, as the following table documents.

Table 24

Wages per Hour of Production Workers

Metalworking Machinery Industry

(Current Dollars)

Year	New England[1]	United States
1976	$5.77	$6.22
1975	5.41	5.72
1974	5.08	5.29
1973	4.70	4.93
1972	4.38	4.65
1971	4.09	4.38
1970	3.98	4.21
1969	3.72	4.21
1968	n.a.	3.76
1967	3.35	3.54
1966	3.13	3.35
1965	2.93	3.21
1964	2.96	3.13
1963	n.a.	3.08
1962	2.66	3.08
1961	2.56	2.83
1960	2.54	2.82

n. a.: not available

[1] Data for New England after 1972 are weighted averages of hourly wages in Connecticut, Massachusetts, Vermont and Rhode Island since data were not available for New Hampshire and Maine after 1972.

Source: Annual Survey of Manufacturers and Census of Manufacturers.

Therefore, the issues of relative degree of unionization and the relative wages paid to production workers would seem to suggest that the New England region is not at a disadvantage, and may in fact be in an advantageous position, as a site for capital investment in the metalworking machinery industry.

Firm Size

The long term investment behavior of firms, by size class, is of interest insofar as different sized firms are more or less likely to expand, contract, or go out of business entirely. This issue will be examined with respect to business cycle fluctuations. It is hypothesized that the larger firms in the industry are better able to withstand business cycle fluctuations, while smaller firms are more likely to be "shaken out" in periods of low demand. Over a series of cycles, presumably, the larger firms will be able to capture a greater share of the market, resulting in greater concentration in the industry as a whole. At the national level, concentration ratios for the seven four-digit SIC components of metalworking machinery were examined to determine if these industries have become more concentrated over the last twenty years. While SICs 3541, 3544 and 3545 have become slightly more concentrated in this period, SIC 3542 has become noticeably less concentrated. Unfortunately, data are not available to determine whether SICs 3546, 3547 or 3549 are more or less concentrated, since prior to 1972, these SICs were

Table 25

Concentration Ratios - United States

	Percentage of Value of Shipments Accounted for by:				
	4 largest companies	8 largest companies	20 largest companies	50 largest companies	Total Number of Companies
SIC 3541 - Metal cutting machine tools					
1972	22%	33%	55%	75%	857
1963	20	32	52	74	784
1958	21	32	52	74	608
SIC 3542 - Metal forming machine tools					
1972	18	33	54	75	375
1963	22	39	61	80	362
SIC 3544 - Special tools and dies, jigs, fixtures and molds					
1972	7	10	14	21	6513
1963	6	9	14	21	5850
SIC 3545 - Machine tool accessories					
1972	19	30	47	63	1113
1963	17	29	46	63	983
SIC 3546 - Power driven hand tools					
1972	48	70	93	99	71
SIC 3547 - Rolling mill machinery					
1972	69	88	96	100	40
SIC 3549 - Metalworking machinery, not elsewhere classified					
1972	15	27	50	72	384
SIC 3548 - Consisted of SICs 3546, 3547, 3549 in earlier census years					
1963	25	40	64	85	420

Source: Census of Manufactures, 1972.

combined into one category, SIC 3548. These figures suggest that, not only is the metalworking machinery industry as a whole not extremely concentrated, but also that the industry does not appear to be moving toward greater concentration. Concentration data are not available at the regional level, and, if available, it is likely that New England would be even less concentrated than the nation as a whole, since most of the really large machine tool and tool and die companies are located in the Mid West.

While these data do not support the contention of increased concentration, they really do not address the issue of the survival of small versus large firms over the business cycle. The distribution of firms by size class may be becoming more skewed towards larger firms over time, or this pattern may show up to a greater degree in recessionary relative to peak periods. These phenomena would not necessarily be apparent in the concentration data, for selected years, presented above. Two data sources were utilized in order to investigate this question of survival. First, information on the number of firms, by size class, was obtained from the County Business Patterns for the period 1959 to 1976. These data were examined in order to determine if, in fact, the distribution of firms by size class had changed in the last twenty years, and if the distibution varied with changes in the business cycle.

A series of cross-section regressions of the following form were performed on the distribution of firms, by size class, for each year in the period 1959 to 1976 for the New England region.

$$X = \alpha + \beta Y + \varepsilon$$

where: X = the log of the number of firms in each size class; and

Y = 1-6, depending on size class.

1 = less than 20 employees,
2 = 20-49 employees,
3 = 50-99 employees,
4 = 100-249 employees,
5 = 250-499 employees, and
6 = more than 500 employees.

The smaller the coefficient of the equation ( ), the steeper the slope of the line (the coefficient is always negative), and hence the greater importance of smaller, relative to larger firms. Conversely, the larger the coefficient, the flatter the line and hence the relatively greater importance of larger sized firms. The value of the coefficient in 1958 (a recessionary year) is -1.212; the value of the coefficient in 1976 (also a recessionary year) is -1.076. The shape of the distribution, then has flattened over this period, implying a relatively greater share of larger versus smaller firms. It must be kept in mind that this is not the same thing as concentration. Larger and medium sized firms may have become more important, but this does not mean that only a <u>few</u> large firms have gained an increasing share of the market.

A comparison of this slope over recent business cycle peaks and troughs is also of interest. The figures shown in Table 26 would appear to support the hypothesis that the larger firms (or the right hand side of the distribution) are probably more successful in weathering the ups and downs of recent business cycles.

Table 26

Changes in the Distribution of Firms by

Size Class over Business Cycles

New England

1967 peak year	b = -1.180
1971 trough year	b = -1.134
1974 peak year	b = -1.143
1976 trough year	b = -1.076

Source: County Business Patterns, 1959-1976.

While the differences among the beta coefficients may not be statistically significant, it is quite interesting to note that the slope flattened from the peak to trough in both cases, and, in the only example of trough to peak movement, the slope then steepened (but not to its previous high).

Dun and Bradstreet data were then obtained to further examine this question. Table 27 presents data on the net change in the number of metal-working machinery establishments in New England for three time periods.[25] It is clear that smaller firms experience greater losses in the number of establishments over recessionary periods than do larger ones. For example, from 1969 to 1972, there was a 6.9% decrease in the number of firms with less than 20 employees, but only a 3.0% decrease in the number of firms

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[25]These periods roughly correspond to recent cyclical fluctuations: 1969 to 1972 compare with the metalworking machinery downturn of 1967 to 1971; 1972 to 1974 compares with the upswing of 1971 to 1974; and 1974 to 1976 exactly corresponds to the most recent downturn in the metalworking machinery industry in New England.

Table 27

Components of Change in the Number of Firms by Size Class

New England

Size of firm (# of employees)	Total Number of Firms at Beginning of the Period [1]	Net Change in Number of Firms		Net Change Due to: Openings of New Firms	Net Change Due to: Closings of Existing Firms
		Number	%		
1969-1972					
less than 20 employees	1,018	-70	-6.9%	11.5%	-18.3%
21-100 employees	254	-23	-9.1%	5.5%	-15.0%
greater than 100 employees	67	- 2	-3.0%	10.4%	-13.4%
Total	1,339	-95	-7.1%	10.3%	-17.4%
1972-1974					
less than 20 employees	1,047	-16	-1.5%	7.4%	- 8.8%
21-100 employees	217	- 8	-3.7%	4.1%	- 7.8%
greater than 100 employees	58	- 1	-1.7%	10.3%	-13.8%
Total	1,322	-25	-1.9%	7.0%	- 8.9%
1972-1974					
less than 20 employees	1,088	-75	-6.9%	5.5%	-12.3%
21-100 employees	238	-14	-5.9%	1.7%	- 7.6%
greater than 100 employees	64	- 2	-3.1%	4.7%	- 7.8%
Total	1,390	-91	- 6.5%	4.7%	-11.3%

[1] These data represent three different samples, hence the number of establishments, for example, for the base year 1972, is not equal to the number of establishments in 1969 plus the net change from 1969 to 1972.

Source: Dun and Bradstreet data prepared by David Birch, M. I. T.

with more than 100 employees. The relationship is almost exactly the same in the 1974 to 1976 downturn. It is interesting to note that the number of firms decreased even in the expansionary period of 1972 to 1974, particularly among firms with between 21 and 100 employees.[26] The loss in the number of firms in this period was approximately the same for both the smaller and larger sized establishments.

Although there appears to be a higher mortality rate among the smaller and medium sized firms in the industry in New England during recessionary periods, this is not to say that employment in the larger establishments is any more stable in recessionary periods. Table 28 presents information on employment changes by size class of establishments. In the 1969 to 1972 downturn, particularly, the larger and medium sized firms experienced a much

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[26] A possible explanation for this occurrence is that, if it is at all possible, firms would much prefer to liquidate their assets on a business cycle upswing. At the start of an upturn, prices for capital equipment tend to be much higher. Consuming industries are demanding new machinery, and the metalworking machinery industry itself needs to expand it capacity in order to satisfy this increased demand. Coupled with this is the fact that the lead time on new machinery tends to be long, particularly in expansionary periods. Therefore, the market for used machinery is very strong on the upswing. The metalworking machinery firm that has to go out of business, then, will try to remain open (even if business is extremely poor) until the upswing, when it can obtain top prices when liquidating its capital stock. This explanation appears to be reasonable, given the data on closings in the 1972 to 1974 period. Specifically, there is a greater incidence of closings among the larger firms in this expansionary period. Presumably, these larger firms have a greater ability to remain in business during the period of low demand in order to liquidate in a period when the price of used capital equipment is substantially greater.

Table 28

Components of Employment Change by Size Class of Firm

New England

Size of firm (# of employees)	Total Employment of Beginning of Period 1	Net Change in Employment	Net Employment Change Due to: Openings of New Firms	Closings of Existing Firms	Expansion of Existing Firms	Contraction of Existing Firms
1969-1972						
less than 20 employees	7,052	- 5.7%	9.0%	-16.7%	14.4%	-12.5%
21-100 employees	11,072	-16.7%	5.1%	-14.1%	4.3%	-12.3%
greater than 100 employees	31,724	-22.6%	9.6%	- 7.6%	1.7%	-17.2%
Total	49,848	-18.9%	8.5%	-16.2%	4.1%	-15.4%
1972-1974						
less than 20 employees	7,059	11.8%	5.7%	- 7.6%	19.9%	- 6.1%
21-100 employees	9,518	3.2%	4.2%	- 8.2%	11.8%	- 4.7%
greater than 100 employees	23,915	4.0%	8.8%	-14.8%	8.6%	- 0.6%
Total	40,492	5.2%	7.1%	-12.0%	11.3%	- 2.6%
1974-1976						
less than 20 employees	7,514	- 1.5%	2.9%	- 9.0%	12.9%	- 8.6%
21-100 employees	10,548	- 9.7%	1.4%	- 8.0%	5.6%	- 8.7%
greater than 100 employees	27,100	- 7.9%	5.2%	- 3.5%	3.6%	-11.1%
Total	45,172	- 7.3%	3.9%	- 5.4%	4.3%	-10.1

[1] See note 1, Table 27.

Source: Dun and Bradstreet data prepared by David Birch, M. I. T.

greater loss of employment than did the smaller ones. Moreover, smaller firms experienced much greater employment growth in the subsequent upturn of 1972 to 1974. The major source of this growth was through the expansion of existing firms, rather than through the openings of new firms. This finding is interesting in that it is often assumed that, in expansionary periods in this industry, a large number of small firms enter the industry. However, these data show that, in fact, there was a net loss in the number of small firms (and also medium and large firms) in this recent growth period.

Another interesting difference between small and large establishments can be seen in this data. Both small and large firms experienced large employment losses in the two recessionary periods under consideration (although the larger firms had much greater losses). However, the sources of this employment loss is very different between the two size classes). In the 1969 to 1972 recession, small firms experienced an employment loss of about 17% due to the closings of existing firms, while small firms experienced a net growth in employment of about 2% due to the expansion of existing firms (14.4% expansion - 12.5% contraction). In this same period, large firms experienced an employment loss of about 8% due to the closings of existing firms, while the employment loss due to the net contraction of existing firms was over 15% (1.7% expansion - 17.2% contraction). The differences are even more striking in the 1974 to 1976 recession. Here, small firms lost about 9% of their employment due to closings of existing firms, but gained about 4% of their employment as a result of net expansions (12.9% expansions - 8.6% contractions). The larger firms lost only about 3.5% employment as a result of the closings of existing firms, but had a net

loss of about 8% (3.6% expansion - 11.1% contraction) due to the contraction of existing firms.

It is clear that, in recessionary periods, larger firms accomplish reductions in employment by contracting in size, while smaller firms are more likely to go out of business entirely. Additionally, those small firms that do not go out of business appear to be able to expand, even over downturns. This implies that those small firms that survive recessions are quite successful, and it is likely that it is the more marginal smaller firms that are shaken out of the industry.[27] These data suggest that larger firms are not more insulated from business cycle fluctuations (in fact, the opposite appears to be the case, in terms of employment loss). Rather, it appears that the larger firms are more likely (or better able) to deal with this volatility of demand by the expansion and contraction of employment within existing firms, while smaller firms are more likely (or forced) to deal with decreased product demand by going out of business.

Ownership Status

The influence of ownership status on long term investment behavior has been the subject of much interest among researchers of industrial location/relocation decisions. It is sometimes argued that independently owned firms are likely to have a greater attachment to the local area, while firms owned by corporations or conglomerates are more likely to pick up stakes and move to another area if the going gets tough. On the other hand, it can be

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[27] An industry representative concurs with this assertion, saying that it is the undercapitalized, under-financed small firms with limited management skills that go under in recessions.

be argued that corporate or conglomerate ownership confers some benefits on a particular firm. Specifically, a metalworking machinery firm may be better able to last out periods of very low demand if it is owned by a corporation/conglomerate, in that the parent firm may provide a cushion (in terms of cash flow) to the firm in these periods, while an independent firm might be driven out of business. This argument is reminiscent of the discussion of ownership and short term investment behavior presented previously.

The information gathered from firms in the interview sample are somewhat equivocal. Most representatives of corporate or conglomerate owned firms felt that, at least to some degree, the parent firm was helpful in providing funds, particularly investment funds, in recessionary periods.[28] However, the general feeling was that this was not a major consideration,[29] and that corporate/conglomerate ownership had not greatly altered their operations. The issue of attachment to the region among corporate/conglomerate owned firms is also difficult to examine. Again, the interview data are somewhat ambiguous. The managers of a number of corporate/conglomerate owned firms felt that this was not the case for their firms. However, a few

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[28] Other cited advantages of corporate/conglomerate ownership include the accessibility to greater management training and expertise, national advertising outlets, and accessibility to more advanced research and development facilities.

[29] The corporate/conglomerate firms visited tended to be rather large and very well established firms (in the area for 50 to 150 years). Therefore, these firms are undoubtedly very used to dealing with cyclical volatility, and so it is not too surprising to find out that these firms did not seriously consider outside ownership to be an important factor influencing their ability to survive in business cycle downturns.

others expressed the opinion that firms owned by corporations or conglomerates might be in a somewhat more vulnerable position relative to independently owned firms. Specifically, one manager said that many corporations/conglomerates follow certain rules of thumb in assessing the performance of a particular division or subsidiary. For example, the corporation in which he had previously been employed (incidentally, this was not a metalworking machinery corporation nor one that has extensive holdings in the metalworking machinery industry) had a rule that if a particular plant experienced a strike of longer than a specified duration, the parent would close that division, regardless of the long run health of that firm. He mentioned that another conglomerate owned machine tool company in the area began to talk about moving out of the area when it experienced an extended strike in the late 1960's. This manager did state that the corporation that owns the firm he presently works for does not follow such arbitrary rules of thumb; he cited this example as a possible disadvantage of outside ownership. The representatives of a few other firms have also discussed this type of problem, but always in a rather unspecific manner, never mentioning it as something that they would have to deal with in their own operations.[30]

There is, however, one example from the interview sample where corporate ownership appears to have distinctly lessened attachment to the New England region. The corporation under consideration purchased a machine tool plant in the region quite a number of years ago. The corporate representative said that labor costs were higher, unionization stronger, and productivity

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[30] One possible reason for this phenomenon is that, from the interviews and secondary data sources examined, it does not appear that New England is a particularly disadvantageous location for the metalworking machinery industry. This assertion will be discussed further in the concluding chapter.

lower in this plant than in most of the other holdings of the corporation.[31] The corporation has intentionally disinvested in this plant over this period, paring down product lines (to those which are most profitable, not necessarily the same as those with the greatest sales), stabilizing employment (it has remained constant over the last ten years), and not doing any capital investment (other than maintainence and limited replacement) in the plant's facilities.[32] The corporate ownership of this firm, apparently, has resulted in a much lower attachment to the New England region than might be the case otherwise, as the corporation has chosen to invest in other regions (in the same product line) and disinvest in the New England plant.

In order to more fully examine the role of ownership in long term investment behavior, data were obtained on employment and establishment change by ownership status. Table 29 presents information on the change in the number of establishments, by ownership status, for the New England region, for the periods 1969 to 1972, 1972 to 1974, and 1974 to 1976. In every period under consideration, non- independent firms experienced greater mortality (closings) than did the independent firms. However, the data on

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[31] Please note that these complaints do not appear to be substantiated by the wage data presented above, or by the opinion (of every other owner/manager interviewed) that unionization was a "neutral" factor affecting the competitive position of the New England region relative to other areas of the country.

[32] The corporation has not completely divested of this plant for somewhat idiosyncratic reasons. The plant is a very old and very distinguished name in the metalworking machinery industry, and the corporation keeps it operating, in this diminished capacity, for "traditional" reasons.

Table 29

Components of Change in Number of Firms by Ownership Status

New England

Ownership Status	Total Number of Firms at Beginning of Period	Net Change in Number of Firms		Net Change Due to Openings of New Firms	Net Change Due to Closings of Existing Firms
		Number	%		
1969-1972					
Independent	1,190	-82	- 6.9%	9.0%	-15.8%
Non-Independent[2]	179	-10	- 5.6%	19.0%	-25.1%
Total	1,369	-92	- 6.7%	10.3%	-17.0%
1972-1974					
Independent	1,172	-29	- 2.5%	6.1%	- 8.4%
Non-Independent	180	+ 7	+ 3.9%	13.3%	-10.0%
Total	1,352	-22	- 1.6%	7.0%	- 8.7%
1974-1976					
Independent	1,222	-70	- 5.7%	3.7%	- 9.6%
Non-Independent	201	-21	-10.4%	10.0%	-19.9%
Total	1,423	-91	- 6.4%	4.6%	-11.0%

[1]These data represent three different samples, hence the number of establishments, for example, for the base year 1972, is not equal to the number of establishments in 1969 plus the net change from 1969 to 1972.

[2]Non-Independent includes the headquarters or branch plant head/office of a multi-unit corporation and the parent or subsidiary of a conglomerate.

Source: Dun and Bradstreet data prepared by David Birch at M. I. T.

net change in the number of establishments show that, at least for the periods 1969 to 1972 and 1972 to 1974, the non-independent firms had a smaller loss in the number of establishments than did independent firms (that is, there were more openings, relative to closings, of non-independent firms that independent firms).

Table 30 presents information of the components of employment change by the ownership status of the firm. As was the case with the data on employment change by size class, the non-independent firms experienced greater employment losses in downturns and smaller gains in upturns than the independent firms. This is not at all surprising given the fact that the independent firms tend to be much smaller than the corporate/conglomerate owned firms, as the following tables shows.

Table 31

Average Firm Size

New England

Year	Independent Firms	Non-Independent Firms
1969	16 employees	174 employees
1972	14 employees	137 employees
1974	15 employees	137 employees

Source: Dun and Bradstreet data.

In every case, the non-independent firms experienced a greater percentage employment loss due to closings than did the independent firms, and, in both recessionary periods, the non-independent firms also had greater employment losses due to net contraction of existing firms (expansions - contractions). When looking at the net changes in employment due to openings and closings

Table 30

Components of Employment Change by Ownership Status of Firms

New England

Ownership Status	Total Employment at Beginning of Period 1	Net Change in Employment	Net Employment Change Due to: Openings of New Firms	Closing of Existing Firms	Expansion of Existing Firms	Contraction of Existing Firms
1969-1972						
Independent	18,652	-13.0%	4.1%	- 9.6%	6.4%	-13.9%
Non-Independent[2]	31,196	-22.5%	11.1%	-20.1%	2.8%	-16.3%
Total	49,848	-18.9%	8.5%	-16.2%	4.1%	-15.4%
1972-1974						
Independent	15,920	6.0%	2.5%	- 7.7%	17.2%	- 6.0%
Non-Independent	24,572	4.7%	10.2%	-14.7%	7.5%	- 0.3%
Total	40,492	5.2%	7.1%	-12.0%	11.3%	- 2.6%
1974-1976						
Independent	17,661	- 4.7%	1.2%	- 3.9%	6.9%	- 9.1%
Non-Independent	27,511	- 9.0%	5.7%	- 6.4%	2.7%	-10.8%
Total	45,172	- 7.3%	3.9%	- 5.4%	4.3%	-10.1%

[1] See note 1, Table 27.

[2] See note 2, Table 30.

Source: Dun and Bradstreet data prepared by David Birch, M. I. T.

and expansions and contractions in the 1969 to 1972 recession, it can be seen from Table 32 that there is not a significant difference between the way independent and non-independent firms effect employment decreases.

Table 32

Net Changes in Employment in Recessionary Periods

	Percentage of Net Employment Loss Due to	
	Openings and Closings of Firms	Expansions and Contractions of Existing Firms
1969 to 1972		
Independent Firms	42%	58%
Non-Independent Firms	40%	60%
1974 to 1976		
Independent Firms	53%	47%
Non-Independent Firms	8%	92%

Source: Dun and Bradstreet data prepared by D. Birch.

However, in the 1974 to 1976 recession, it can be seen that the non-independent firms accomplished employment decreases almost exclusively through the contraction of existing firms, while the independent firms experienced a greater net loss of employment due to the closings of existing firms. It is difficult to draw conclusions from these data. It is clear that the non-independent firms experience greater employment losses than do the independent firms, but only in the case of the 1974 to 1976 recession does there appear to be a significant difference between these two types of firms in the way they effect these employment changes.

In conclusion, the issue of ownership status and long term investment behavior is not definitively resolved. Insofar as being able to weather business

cycle fluctuations, it would appear that the size of the firm is at least as an important consideration (and probably even more so) than the ownership status of the firm. This conclusion is consonant with the assertion made earlier that size, rather than corporate/conglomerate ownership, is probably the determining factor in enabling a firm to pursue a steady short term investment program in the face of volatile product demand. The other quesiton raised -- the relationship between ownership and attachment to the region (or, perhaps, propensity to close) -- has certainly not been adequately settled. There is some evidence from the interview sample that corporate/conglomerate ownership may reduce such an attachment, but it is quite possible that this finding is not generalizable to all metalworking machinery firms in the region. Moreover, there are no secondary data available that are really capable of answering this question. The Dun and Bradstreet data would appear to suggest that there is a higher frequency of closing among corporate/conglomerate owned firms, but it is also true that there is a higher frequency of openings among this class of firms in the New England region in the period under study. The Dun and Bradstreet data also suggest that, in the more recent recession in the region, corporate or conglomerate owned firms are more likely to accomplish employment decreases through contraction as opposed to closing than are the independent firms.

It must also be remembered that the analysis of these data are using employment changes as a proxy for changes in capital investment (for lack of any investment data), and it is possible that there are differences in investment per employee between independent and non-independent firms. Specifically, a corpoate owned firm may experience employment declines but may be investing more capital in its plant (becoming more automated or

capital intensive) than an independent firm experiencing employment increases. The reverse of this situation is clearly the case with the corporate owned firm mentioned above, where employment was quite stable, but the corporation was intentionally disinvesting in the physical plant. And finally, this discussion of ownership has not addressed the New England question at all. Unfortunately, it has not been possible to determine if there is a greater or lesser degree of corporate/conglomerate ownership of metalworking machinery firms in this region, and/or if corporate/conglomerate investment policies adversely affect this region relative to the rest of the nation. It would be possible, given data for another region (such as the Mid West or the West), to see if corporate/conglomerate ownership is differentially affecting the long term investment picture in the New Englnad region, relative to investment in other areas. However, although it is unsatisfying, the limitations of this analysis and discussion make it impossible to answer these latter questions.

Other Factors

This final section on long term investment behavior will discuss a number of factors, including government policies, the costs of doing business, agglomeration economies, and finally, idiosyncratic factors which influence long term investment. These issues will be examined, with particular attention given to the influence of these factors in the New England region relative to other locations.

Government policies: Government policies will be divided into two parts; domestic and inter-national government activities. Since the object of this discussion is to determine if government policies (domestic) adversely affect the metalworking machinery industry in New England, the focus here will be on

state and local policies. Specifically, the New England region has often been assailed as a high tax region, and it has sometimes been alleged that the high taxes are a deterrent to capital investment in the region. Representatives of all firms in the interview sample have complained about the high taxes in the region, but these complaints seem to be pro forma. That is, no firm felt that the relatively higher taxes were a sufficient reason to relocate out of the region, or to reduce their investment expenditures here. In fact, even the corporation, mentioned earlier, that is disinvesting in its New England plant said that taxes in the region, relative to other regions, were not any problem. A number of firms said that, while state and local taxes may be higher here, this does not affect the competitive position of metalworking machinery firms in the region. Among the firms in the interview sample that have relocaed in the last twenty years (all relocations were within the region)[33], a number have said that they received tax concessions (in the form of property tax abatements) from the community to which they had moved. However, all of these firms said that the receipt of tax rebates was not at all a determining factor in their choice of location.[34] Rather, it was considered "gravy" or "icing on the cake," after the new location was chosen.

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[33] An expanded discussion of relocation is presented below.

[34] This finding is consistent with other empirical studies of industrial location decisions, such as Dennis Carlton, "Models of New Business Location, University of Chicago, CMSBE Report number 7756, Nov. 1977; Roger Schmenner, Manufacturing Location Decisions: Evidence from Cinncinnati and New England, Report to the Economic Development Administration, Department of Commerce, March, 1978; and Due, "Studies of Local Tax Influences on Location of Industry," National Tax Journal, 1961.

The consideration of international governmental activities concerns the attempts of American metalworking machinery firms to gain larger shares of the international market. As was discussed in Chapter 3, metalworking machinery firms have had some difficulty competing in foreign markets, partially as a result of policies that limit imports of machinery in some countries. A number of firms, particuarly larger firms, have set up plants in these countries in order to circumvent these import restrictions. The magnitude of this phenomenon is rather substantial, as the data in Table 33 document.

Table 33

Capital Expenditures by Majority Owned Foreign Affiliates of U. S. Companies and all U. S. Companies

Captial Expenditures by Majority Owned Foreign Affiliates of U. S. Companies	1971	1973	1975	1977
	(Millions of Dollars)			
All manufacturing firms	$ 7,046	$ 9,247	$11,242	$12,285
Machinery (except electrical) firms	1,787	2,602	2,798	3,360
Capital Expenditures by U. S. Companies				
All manufacturing firms	$29,990	$38,010	$47,950	$60,160
Machinery (except electrical) firms	2,800	3,420	4,500	5,760

Table 33, continued

	1971	1973	1975	1977
	(Millions of Dollars)			
Ratio of Capital Expenditures by Majority Owned Foreign Affiliates of U. S. Companies to Capital Expenditures of U. S. Companies				
All manufacturing firms	.23	.24	.23	.20
Machinery (except electrical) firms	.64	.76	.62	.58

Source: 1978-1979 Economic Handbook of the Machine Tool Industry.

The capital expenditures by majority owned affiliates of U. S. companies are very significant, especially for firms in the machinery industry,[35] where the foreign affiliates invest, on average, almost two thirds the amount invested by domestic companies. Table 34 presents data on the geographical location of this foreign investment, and it is clear that Europe, particularly West Germany and the United Kingdom, are very important locations. These data suggest that, to some extent, capital investment projects in metalworking machinery in the U. S. and New England must compete with those in other areas of the world, especially Europe. To the extent that the policies of other countries inhibit the ability of the U. S. metalworking machinery industry to do business there, and to the extent that the U. S. industry decides to actively compete in these markets, then the prospects for

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[35] It is probable that data for the machinery, except electrical, industry (SIC 35) are upper limits on foreign investments by the metalworking machinery industry SIC 354), because SIC 35 includes such industries as construction, mining, and other machinery, whose foreign holdings are thought, by metalworking machinery spokespersons, to be more extensive than those of SIC 354.

Table 34

Estimates of Capital Expenditures by Majority Owned Foreign Affiliates of U. S. Companies in Selected Areas

Capital Expenditures by Majority Owned Foreign Affiliates of U. S. Companies	1971	1973	1975	1977
	(Millions of Dollars)			
All manufacturing firms	$7,046	$9,247	$11,242	$12,285
Machinery (except electrical) firms	1,787	2,602	2,798	3,360
Percentage of these expenditures in:				
Canada				
All manufacturing	18%	20%	19%	22%
Machinery (except electrical)	11	8	12	11
Latin America				
All manufacturing	9	11	12	12
Machinery (except electrical)	6	6	6	7
Europe				
All manufacturing	62	58	58	55
Machinery (except electrical)	69	74	69	69
West Germany				
All manufacturing	18	15	13	13
Machinery (except electrical)	n.a.	17	16	16
United Kingdom				
All manufacturing	15	17	14	15
Machinery (except electrical)	18	n.a.	21	21
Asia and the Pacific				
All manufacturing	7	7	7	8
Machinery (except electrical)	n.a.	n.a.	n.a.	12

n.a. - not available

Source: 1978-1979 Economic Handbook of the Machine Tool Industry

long term investment in the U. S. and the New England region are somewhat diminished.

Costs of Doing Business: The factors to be discussed here include various costs that may affect New England, vis a vis other regions, as a place to do business. Representatives of most firms interviewed felt that energy, transportation, and environmental (that is, the cost of compliance with environmental regulations) costs are higher in New England than elsewhere in the country. However, these representatives did not feel that these cost differentials seriously affected their competitive position, probably because these factors costs are not an enormous share of total costs. Additionally, it must be remembered that hourly wages of metalworking machinery production workers are lower than the national average, and therefore these cost advantages/disadvantages may offset one another.

Agglomeration Economies: The importance of agglomeration economies in the metalworking machinery industry is also of interest. Representatives of some firms in the interview sample have stated that they sometimes share or trade special machinery. In this way, a firm does not have to incur the large capital costs of an expensive heat treatment facility, for example, that it needs only a few times a year. The firms that share or trade machinery have usually stated that this is a very informal, unstructured process. Moreover, managers seem to feel that this type of activity is really a convenience, not a necessity, and that it does not really influence their locational preferences. On the other hand, access to a skilled labor pool (for which a large industrial base is often crucial) is extremely important to firms, and may therefore represent a type of agglomeration

economy.[36] And finally, especially for the small tool and die shops, close contact with customers is very important (urbanization economies). This latter fact may present something of a problem for tool and die firms in the region. That is, if other industries move out of the region, tool and die firms, which are essentially service providers to these firms, will lose their business. The locational decisions of these tool and die companies (and their decisions to expand, contract, or go out of business) are of necessity tied to the locational decisions of their major customers.

Idiosyncratic Factors: The last influence on long term investment behavior to be discussed here has been termed "idiosyncratic." This idiosyncratic behavior is difficult to analyze empirically, but this is not to say that it is an insignificant influence on investment behavior. As Chapter 2 documents, the metalworking machinery industry has had a long history in the New England region. Some firms are still run by direct descendents of the original founders of the 19th century. From the interviews conducted, it appears that there is a very strong attachment, even among some newer firms, to the region for traditional/historical reasons. The fact that many firms are family owned and run also contributes to the importance of such "idiosyncratic" investment behavior. For example, the owner of one firm said that, if his oldest son remained in the business, he would expand. If the son returned to his previous job as a teacher,

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[36] This large industrial base may also represent a disagglomeration economy, in that a large number of firms are competing for a limited labor supply. It is also of interest that some firms, apparently, prefer being the big fish in a little pond. That is, rather than being in urban areas, these firms are in somewhat isolated areas, but are able to attract labor, by, say, paying the highest wages in the county.

however, the owner would close the plant down. Other large old firms are closely held corporations, with the major stockholders (aside from family members) being members of nearby communities. The owners of these firms feel that, although the plant might be moved to another location, it would be to a location in the same general vicinity. Even among firms owned by large corporations or conglomerates, attachment to the region appears to be quite strong. The manager of one of these firms said that it would take a really extreme situation, such as no energy or no labor, to get the firm to move out of New England.

It must be recognized that this professed attachment to New England may be masking another important issue - the extremely high cost of moving. Firms in the metalworking machinery industry have a great deal of capital equipment, and hence their mobility is somewhat constrained by the costs of moving this equipment. It took one firm, which moved to its present location in the early 1960's, about two and a half years to complete its move of about 20 miles. However, a number of firms who had moved over the study period were interviewed. In all cases (three), the firm moved to a location within 20 to 30 miles of the original site. The reason for the move was always to expand/update the companies' physical capacity. Two firms had been operating in multi-storied plants built between 1850 and 1900 which were clearly inadequate for modern production processes. The third had moved when it outgrew its previous plant (and is planning to move in a year or two as it has again outgrown its present space). What is important is that each firm (one large, independent; one large corporate owned; and one smaller independent) moved a very short distance. In all cases, the selection of the site was for somewhat idiosyncratic reasons

(the owners had bought the land earlier for speculative purposes, and when the decision to move was made, that land seemed an appropriate location), and one of the prime considerations in the move was keeping the existing labor force intact.

In conclusion, it appears that the New England region, at the least, is not in a particularly disadvantageous position as a site for long term investment in the metalworking machinery industry. Firms in the region appear to be attached to the area - the manager (who hails from the Mid West) of one large corporate owned firm in western Massachusetts "loves" the quality of life in New England, and feels that there is an excellent "work ethic" and a lot of "Yankee ingenuity" in the work force. There do not appear to be any overwhelming cost disadvantages to doing business in the region. And finally, although every firm complains about the labor shortage, there seems to be a feeling that the labor force in New England is at least a known quantity and quality. Managers and owners, when asked about the labor situation in the South or Mid West, seemed to feel that the quality of skilled labor in the South was questionable, and that the availability of skilled labor might be even less certain in the Mid West than in New England.

Chapter 5

Conclusions

This chapter will review some of the principal findings of this study, and briefly discuss the implications of these results for firms in the metalworking machinery industry in New England.

Principal Findings

Volatility

It has been shown, in Chapter Three, that the metalworking machinery industry is extremely sensitive to business cycle fluctuations. Moreover, the industry in New England appears to be more volatile than its national counterpart. This is probably because metalworking machinery firms in New England are more closely related to the defense industries in the region and, particularly in the recession of 1967 to 1971, decreases in demand for defense-related products coincided with a general decline in economic activity. It would appear that firms in this region are probably more dependent upon federal government procurement policies than are firms in other areas of the country. However, it is beyond the scope of this analysis to try to predict future federal government policies and thereby determine if this dependence will have a beneficial or detrimental impact on metalworking machinery firms in New England.

Labor

The existence of a skilled labor shortage was first discussed in Chapter Three. However, this problem does not appear to be differentially

affecting metalworking machinery firms in New England. The representatives of most firms in the interview sample expressed the opinion that the labor shortage problem is at least as bad, if not worse, in other parts of the country, particularly the Mid West. Also, the labor shortage problem may be alleviated, to some degree, by the fact that attitudes towards work and college among young people in this country may be shifting. That is, with many college graduates unable to find suitable employment after graduation, there appears to be more interest in recent years in blue-collar work than had previously been the case. Although this is difficult to empirically document, it is true that in a few of the firms in the interview sample, some of the work force was college educated. These workers found that pay in the metalworking machinery industry was better than what they would receive in other, white-collar jobs. Some workers had quit their jobs as school teachers, for example, in order to make more money as tool and die makers and machinists.

Another factor that influences the relative availability of labor in the New England region concerns the types of jobs that are being created in the industry. As was noted in Chapter Four, the industry is now demanding a greater number of engineers, computer programmers and operators, and electricians. To the extent that these occupational groups prefer the amenities of the New England region (as opposed to, say, the amenities of Detroit or Cinncinnati), then the labor supply situation in New England is probably in better shape than in other regions (with the exception, perhaps, of the growing concentration of

the industry in California).

It is also necessary to consider the relative wage issue. On the one hand, the fact that wages are lower in New England than elsewhere (see Table 24, Chapter Four) is certainly an advantage to employers in the region. On the other hand, however, the labor shortage in New England will be exacerbated if employees decide to migrate to other regions in order to take advantage of higher wages.[1] Related to the wage issue is the question of unionization. Recall that firm representatives seem to feel that, at worst, the degree of unionization in New England is a neutral factor affecting their competitive position, and quite probably is actually an advantage. While it cannot be documented, most industry spokespersons seem to feel that firms in New England are probably less unionized than firms in the Mid West.

And finally, the issue of agglomeration economies was discussed. Location in an industrialized area provides for a large pool of skilled workers. Is this an important influence on the locational decisions of metalworking machinery firms? The results of this study are somewhat equivocal on this point. Location in a heavily urbanized area does

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[1]Whether or not workers will migrate to take advantage of higher wages is debatable. Heath Paley, in a study of a metalworking machinery firm in Maine, found that workers were very attached to their employer; their wages were substantially lower than those of similar workers in other parts of New England, but the workers were willing to accept this negative wage differential in order to live in rural Maine. (Heath Paley, "Business Success in a Rural Environment: The Case of Dexter Maine," Paper prepared for the Regional Institute of Employment Policy, Boston University, 1979.)

provide a larger pool of workers, but, at the same time, there is also more competition from other industries in the area for the same workers. Some firms, particularly larger ones, are located off the beaten track; they are able to secure a large enough labor force by paying somewhat higher wages than other rural employers and they draw their workforce from a rather large geographical area.

Firm Size

The data presented in Chapter Three (see Figures 10 and 11) suggest that metalworking machinery firms have become more reluctant to lay off workers in business cycle troughs, even in the face of declining productivity. This phenomenon would appear to be beneficial for the labor force, but its effect on firms is probably less so. The data in Chapter Four (Table 28) suggest that larger firms are more likely to effect employment decreases through contractions than closings, while the reverse is true for smaller firms. This finding is reasonable, in that it is likely that employees and employers in smaller firms know each other better and this makes it more difficult for owners and managers of small firms to lay off people. Moreover, smaller firms may have more difficulty replacing laid off workers in periods of expansion (especially if they pay lower wages than the larger firms in the area) and so would have better reason to hold onto their employees even when business is bad. As a result, it appears that small firms hold onto their work force as long as they can (until they are forced out of business), while larger firms are more apt to (or better able to) lay off and hire with cyclical fluctuations. The implication of this

for the metalworking machinery industry in New England, however, is not differentially more severe than it would be for other areas. Specifically, it appears that firms in other locations also experience labor shortages and also engage in similar management tactics. Nonetheless, these results are not especially encouraging for small firms in the industry, either in New England, or in other parts of the country.

Ownership Status

The issue of ownership status was raised both with respect to short term and long term investment behavior in Chapter Four. It was found that firms owned by corporations or conglomerates in New England have experienced greater mortality (closings) over recent business cycles. However, it is important to recall that there were not data available to see if this is the case for other locations of the industry. Therefore, it is not known if corporate or conglomerate ownership of metalworking machinery firms is disadvantageous to the New England region.

Government

The influence of government policies on metalworking machinery firms was discussed in a number of places. First, the fact that the metalworking machinery industry in New England is probably more dependent upon federal government defense procurement policies was noted. In the discussion of short term investment, it was found that government regulations, particularly Occupational Health and Safety Administration (OSHA) and Environmental Protection Agency (EPA) regulations may be

affecting the character of demand for metalworking machinery. These regulations have timetables for compliance which enable the regulated industries to place orders for capital equipment well in advance. In turn, metalworking machinery firms have a better picture of their future production requirements and are themselves better able to pursue long range capital investment programs.

In the discussion of long term investment behavior, it was found that the differentially higher taxes and stricter environmental regulations in the New England do not appear to have had a substantial influence on the locational decisions of metalworking machinery firms. International government policies, particularly those which limit the ability of American firms to compete successfully in world markets, were seen as detrimental to the domestic metalworking machinery industry. That is, if firms want to compete successfully in world markets, they may decide to locate plants overseas in order to circumvent some of these policies (such as import quotas in some countries). It is assumed that, were it not for these restrictive policies, the investment might have taken place in areas in the U.S. However, it is not possible to ascertain whether or not the investment would have taken place in New England or in other regions of the country.

Agglomeration Economies

The question of agglomeration economies in the metalworking machinery industry was raised in connection with long term investment behavior. It was found that agglomeration economies are not very important for firms in the interview sample; that instances of sharing

equipment are rather limited, and that firms view this as a convenience rather than as a necessity. Moreover, as discussed above, location in very industrialized areas may be advantageous or disadvantageous in terms of securing labor (that is, the disagglomeration economies of having to compete with other industries or firms for a given labor supply must be taken into consideration). However, it is true that urbanization economies are important for tool and die firms. These firms provide services for industrial customers, and the need for close contact and consultation between the tool and die shop and these customers is extremely important. Therefore, the extent to which New England is losing its industrial base clearly has important negative implications for tool and die shops in the region.

Regional Attachment

It was noted at the end of Chapter Four that New England metalworking machinery firms appear to have strong attachments to the region. The historical reasons for this attachment were discussed: many metalworking machinery firms have been in the same location for over a hundred years; the descendants of some of the early figures in the industry still run a number of these companies; and there is a substantial number of family owned (or closely held) firms in this industry. The high costs of moving were also mentioned in this discussion. It was noted that the fact that it is so expensive and time consuming for metalworking machinery firms to change locations is probably related to the locational stability of the industry.

Implications for the Metalworking Machinery Industry in New England

The principal findings reviewed above would appear to paint a fairly sanguine picture for the metalworking machinery industry in New England. It is ironic that, although the metalworking machinery industry is very unstable over business cycles, it is rather stable in its geographical distribution in this country. Miller notes that "there has been little change (in locational patterns) since the establishment of the spatial pattern of production of machine tools early in the twentieth century."[2] This is perhaps less true for the tool and die and "other" metalworking machinery sectors of the industry. Since these sectors are more dependent upon the existence of industrial customers in the region, and since New England has been losing manufacturing employment under the period under consideration, the markets for these firms have diminished.

The New England region's share of metalworking machinery sales, however, has decreased over the last twenty years, from 14% of total industry sales in 1958 to 11% in 1976. Two considerations should be noted, however, before assuming that the industry in the region is in decline. First, New England maintained a constant proportion of industry sales from 1958 to the peak period ending in 1967. When business dropped off, from 1967 to 1971, however, New England's share of sales

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[2]E. Willard Miller, Manufacturing: A Study of Industrial Location, University Park, Pennsylvania, The Pennsylvania State University Press, 1977, p. 212.

dropped to about 12% of the industry total. This share has remained relatively constant up until 1976, the latest year for which data were available. Therefore, it was really only in the 1967 to 1971 recession that New England lost ground; its share is quite constant for the rest of the period. As noted earlier, it is probable that this severe decline in New England is related to federal defense cutbacks that were differentially more important in this region.

The second consideration is that the data for New England cited above includes only the states of Connecticut, Massachusetts, Vermont and Rhode Island after 1972, since information was not published for either New Hampshire or Maine after the 1972 Census of Manufactures. Therefore, the figures for New England after 1972 are underestimates of the region's sales, and as a result, they overstate the "decline" that has taken place in New England, relative to other areas.

On the whole, then, the prospects for metalworking machinery firms in New England appear to be good. The industry does not experience any overwhelmingly unfavorable cost differentials here; the labor situation in this region seems to be at least as good as in other areas; and the owners and managers interviewed do not seem to be unhappy here. However, there are a number of external factors that may work against metalworking machinery firms in this area: the ties to the government, and the possibility that federal procurement activities may adversely affect firms in this region; the exodus of other manufacturing firms from the region and consequent drying up of markets for some sectors of the metalworking machinery industry; and the possibility that international

political considerations may be encouraging American metalworking machinery firms to invest abroad as opposed to investing domestically. Moreover, it should be noted that business in this industry was extremely good at the time the interviews took place. Most of the firms in the interview sample were operating at or near capacity. The opinions of the interviewees, then, may be somewhat optimistic. It would be interesting to interview these firms in both a period of expansion and a period of decline in order to get a more complete perspective. Unfortunately, given the limitations of this analysis, this was not possible.

Finally, it is of interest to see what the implications of the metalworking machinery industry's presence are for the New England region. In 1976, over two and a half percent of New England's manufacturing employment was in this industry. Is this concentration of employment in this industry good or bad for the region? The major disadvantage is the cyclical instability of demand for metalworking machinery. When the industry is on the downswing, there are enormous displacements of workers, as Tables 11-14 (in Chapter Three) show. On the other hand, metalworking machinery is "a clean, high-skill, decently paying, non-objectionable, regionally tenacious industry of which New England does not have very many. One might be tempted to wave the flag and say thank God for SIC 354, without which we would be further in the soup than we already are."[3] However, it is beyond the scope of this study to decide if the advantages of metalworking machinery outweigh its disadvantages for the New England economy.

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[3]Personal correspondence from Benjamin H. Stevens

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APPENDIX

Products of the Metalworking Machinery Industry

SIC 3541 - Machine Tools, Metal Cutting Types

Automatic chucking machines
Boring, drilling, and milling machine combinations
Boring machines (machine tools)
Boring mills
Broaching machines
Brushing machines (metalworking machinery)
Buffing and polishing machines (machine tools)
Burnishing machines (machine tools)
Centering machines
Chemical milling machines
Countersinking machines
Cutoff machines
Cutting machines, pipe (machine tools)
Cylinder reboring machines
Deburring machines
Die sinking machines
Drill presses (machine tools)
Drilling machine tools (metal cutting)
Duplicators (machine tools)
Electrical discharge erosion machines
Electric dishcharge grinding machines
Electrochemical milling machines
Electrolytic metal cutting machine tools
Electron-discharge metal cutting machine tools
Facing machines
Filing machines, metal (machine tools)
Flange facing machines
Gear chamfering machines (machine tolls)
Gear cutting and finishing machines
Gear tooth grinding machines (machine tools)
Grinding machines
Grooving machines (machine tools)
Home Workshop machine tools, metalworking
Honing and lapping machines
Jig boring machines
Jig grinding machines
Keyseating machines (machine tools)
Lapping machines
Lathes, metal cutting
Lathes, metal polishing
Machine tool replacement and repair parts, metal cutting types
Machine tools, metal cutting, exotic (chemical explosive, etc.)
Metal polishing lathes
Milling machines (machine tools)
Pipe cutting and threading machines (machine tools)
Planers, metal cutting (machine tools)
Pointing, chamfering, and burring machines
Polishing and buffing machines (machine tools)

Polishing machines (machine tools)
Plasma process metal cutting machines, except welding machines
Reaming machines
Rebuilt machine tools, metal cutting types
Regrinding machines, crankshaft
Rifle working machines (machine tools)
Sawing and cutoff machines (metalworking machinery)
Saws, power (metalworking machinery)
Screw and nut slotting machines
Screw machines, automatic
Shapers and slotters
Shaving machines (metalworking)
Slotting machines (machine tools)
Tapping machines
Threading machines (machine tools)
Turning machines (lathes)
Turret lathes
Ultrasonic assisted grinding machines (metalworking)
Ultrasonic metal cutting machine tools
Valve grinding machines
Vertical turning and boring machines (metalworking)

SIC 3542 - Machine Tools, Metal Forming Types

Arbor presses
Beaders, metal (machines)
Bending and forming machines
Brakes, metal forming
Bulldozers (metalworking machinery)
Can making machines
Chemical explosives metal forming machines
Die casting machines
Drop hammers, for forging and shaping metal
Elastic membrane metal forming machines
Electroforming machines
Extruding machines (machine tools), metal

Forging machinery and hammers
Hammers, power (forging machinery)
Headers
High energy rate metal forming machines
Knurling machines
Machine tools, metal forming types: including rebuilding
Magnetic forming machines
Mechanical-pneumatic or hydraulic metal forming machines
Metal deposit forming machines
Nail heading machines
Plasma jet spray metal forming machines
Presses: forming, stamping, punching and sizing (machine tools)
Presses: hydraulic and pneumatic,
Punching and shearing machines
Rebuilt machine tools, metal forming types
Riveting machines
Rolling machines, thread and spline
Shearing machines, power
Sheet metalworking machines
Shock wave metal forming machines
Spinning lathes
Spinning machines, metal
Spline rolling machines
Spring winding and forming machines
Stretching machines
Swaging machines
Thread rolling machines
Ultrasonically assisted metal forming machines
Upsetters (forging machines)

SIC 3544 - Special Dies and Tools, Die Sets, Jigs and Fixtures, and Industrial Molds

Diamond ides, metalworking
Die sets for metal stamping (presses)
Die springs
Dies and die holders for metal cutting, forming, die casting, etc.
Dies, paper cutting
Dies, plastics forming
Dies, steel rule
Extrusion dies
Forms, metal (molds): for foundry, plastic working machinery, etc.
Industrial molds
Jigs and fixtures (metalworking machinery and accessories)
Jigs: inspection, guaging and checking
Punches, forming and stamping
Subpresses, metalworking
Welding positioners (jigs)
Wire drawing and straightening dies

SIC 3545 - Machine Tool Accessories and Measuring Devices

Angle rings
Arbors (machine tool accessories)
Balancing machines (machine tool accessories)
Bits for use on lathes, planers, shapers, etc.
Boring machine attachments (machine tool accessories)
Broaches (machine tool accessories)
Calipers and dividers
Cams (machine tool accessoires)
Chasers (machine tool accessories)
Chucks: drill, lathe, and magnetic (machine tool accessories)
Collars (machine tool accessories)
Collets (machine tool accessories)
Comparators (machinists' precision tools)
Counterbores, metalworking
Countersinks and countersink drill combinations (machine tool accessories)
Cutters, milling
Cutting tools and bits, for use on lathes, planers, shapers, etc.
Diamond cutting tools for turning, boring, burnishing, etc.
Diamond dressing and wheel crushing attachments
Dies, thread cutting
Dressers, abrasive wheel: diamond point and other
Drill bits, metalworking
Drill brushings (drilling jig)
Drilling machine attachments and accessories (machine tool accessories)
Drills (machine tool accessories)
Files, machine tool
Gauge blocks
Gauges except optical (machine tool accessories)
Headstocks, lathe (machine tool accessories)
Hobs
Honing heads
Hopper feed devices
Knives, shear
Lathe attachments and cutting tools (machine tool accessories)
Letter pins (gauging and measuring)
Loading, unloading, and transfer devices
Machine knives, metalworking
Machine tool attachments and accessories
Mandrels
Measuring tools and machines, machinists' metalworking type
Micrometers
Milling machine attachments (machine tool accessories)
Optical measuring devices
Precision tools, machinists'
Pushers
Reamers, machine tool
Scales, measuring (machinists' precison tools)
Shaping tools (machine tool accessories)

Shear knives
Sockets (machine tool accessories)
Tables, rotary
Taps, machine tool
Threading tools (machine tool accessories)
Tool holders
Tools and accessories for machine tools
Verniers (machinists' precision tools)
Vises, machine (machine tool accessories)
Wheel turning equipment, diamond point and other (tool accessories)

SIC 3546 - Power Driven Hand Tools

Attachments for portable drills
Buffing machines, hand: electric
Calking hammers
Cartridge-activated hand power tools
Chain saws, portable
Chipping hammers, electric
Drills (except rock drilling and coring), portable: electric and pneumatic
Drills, hand: electric
Flexible shaft metalworking machines, portable
Grinders, pneumatic and electric: portable (metalworking machinery)
Grinders, snagging
Guns, pneumatic: chip removal
Hammers: portable electric and pneumatic chipping, riveting, calking, etc.
Hand tools, power driven: woodworking or metalworking
Masonry and concrete drilling tools, power: portable
Riveting hammers
Saws, portable hand held: power driven - woodworking or metalworking

SIC 3547 - Rolling Mill Machinery and Equipment

Bar mills
Billet mills
Blooming and slabbing mills
Cleanings lines, electrolytic (rolling mill equipment)
Cold forming type mills (rolling mill machinery)
Ferrous and nonferrous mill equipment, auxiliary
Finishing equipment, rolling mill
Galvanizing lines (rolling mill equipment)
Levelers, roller (rolling mill equipment)
Mill tables (rolling mill equipment)
Picklers and pickling lines, sheet and strip (rolling mill equipment)

Pipe and tube mills
Rod mills (rolling mill equipment)
Roller levelers (rolling mill machinery)
Rolling mill machinery and equipment
Steel rolling machinery
Straightening machinery (rolling mill equipment)
Structural mills (rolling mill machinery)

SIC 3549 - Metalworking Machinery, Not Elsewhere Classified

Automotive maintenance equipment
Balancing equipment, automotive wheel (garage equipment)
Coil winding machines for springs
Coilers (metalworking machinery)
Cradle assemblies (wire making equipment)
Cutting-up lines
Degreasing machines, automotive (garage equipment)
Draw benches
Drawing machinery and equipment, except wire drawing dies
Frame straighteners, automobile (garage equipment)
Marking machines, metalworking
Pack-up assemblies (wheel overhaul)
Pail mills
Propeller straightening presses
Rotary slitters (metalworking machines)
Screw downs and boxers
Screw driving machines
Soldering machines, except hand
Welding and cutting apparatus, except electric, laser, ultrasonic, etc.
Wheel mounting and balancing equipment
Wire drawing and fabricating machinery and equipment, except dies

Source: Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual 1972, Government Printing Office, Washington, D.C., 1972.