A list of Working Papers on the last pages

No. 134, 1984

FIRM STRATEGIES IN THE MACHINE TOOL INDUSTRY IN THE UNITED STATES AND SWEDEN: Responses to Technological Challenges and Global Competition

by

Bo Carlsson

November, 1984

FIRM STRATEGIES IN THE MACHINE TOOL INDUSTRY

IN THE UNITED STATES AND SWEDEN:

Responses To Technological Challenges And Global Competition*

Bo Carlsson

*Paper presented to the Prince Bertil Symposium on Strategies in Global Competition. Stockholm, November 7-9, 1984.

This paper is based on a larger study of the machine tool industry in the United States and Sweden, initiated while the author was visiting scientist at the Center for Policy Alternatives at the Massachusetts Institute of Technology in 1982, and is still in progress. The project has been funded by the Swedish National Board for Technical Development (STU), The Institute for Economic Historical Research at the Stockholm School of Economics, the Marianne & Marcus Wallenberg Foundation, and the Industrial Institute for Economic and Social Research (IUI), Stockholm.

I would like to thank the following persons for insightful comments on earlier versions of this paper: John Culbertson, Erik Dahmen and Frank Stafford, as well as many of my former colleagues at the IUI. I bear sole responsibility for all remaining errors and omissions.

October 1984

FIRM STRATEGIES IN THE MACHINE TOOL INDUSTRY IN THE UNITED STATES AND SWEDEN:

Responses to Technological Challenges and Global Competition

by

Bo Carlsson

Case Western Reserve University

ABSTRACT

The machine tool industry, even though it is tiny, is often considered strategic because of its role as supplier of technology to all metalworking industry. In recent years, the machine tool industry in Western countries has had to face major new challenges, especially in the form of new technologies and intensified international competition. The object of the present paper is to examine the basic forces at work in the industry and study the choice of strategy of machine tool firms in response to these challenges. Utilizing the analytical framework developed by Porter, the study is based on in-depth interviews with a dozen machine tool firms in the United States and Sweden.

The results of the study show that there is no single way to survive or prosper in the machine tool industry. The competitive environment varies from one sub-industry to the next, causing firms to choose widely differing strategies. The transition now taking place in the machine tool industry is a good example of the Schumpeterian process of "creative destruction."

Section I of the paper contains a brief description of the industry background. Section II sketches out the new strategic challenges facing the industry. The theoretical framework is presented in Section III and the data in Section IV. The analysis of firm strategies is carried out in Section V. Section VI contains a summary and evaluation of the viability of various strategies, and also draws out the policy conclusions.

I. INDUSTRY BACKGROUND: A FRAGMENTED INDUSTRY

Even though the machine tool industry is one of the smallest sectors of manufacturing industry in most industrial countries - representing only three-tenths of one percent of the value of shipments of manufactured goods in the United States and about 0.9 percent of value added in manufacturing in Sweden at the end of the 1970s - it is nevertheless of strategic importance. [2, p.1.] Machine tools, defined as power-driven machines that are used to cut, form or shape metal, represent the core of production machinery in the whole metalworking industry. However, the role of machine tools is not confined to hardware alone; the whole "software", i.e., the organization and control of production machinery, in the metalworking industries is closely linked to the characteristics and use of machine tools. Thus, the machine tool industry may be regarded as a "node" for supplying both production machinery and concepts (both hardware and software) to all metal working industries, therefore playing a crucial role in determining the performance of large sectors of manufacturing in terms of both productivity and international competitiveness.

The machine tool industry is highly fragmented in the sense that no company has a large enough market share or otherwise dominant position to significantly influence conduct or performance in the industry. Entry barriers are low, and there seem to be no significant economies of scale. The industry is made up almost exclusively of small firms, most of which are single-plant operations: in 1977, there were 1,343 establishments in the United States machine tool industry, with an average of 62 employees per establishment. In

Sweden, there were 129 establishments with an average of 70 employees each. [2, p.1.) Many machine tool firms are family held companies, often still in the hands of the founders or their descendants. They are often located in small towns and have a strong commitment to the local economy. For these reasons, barriers to exit from the industry are relatively high. The few large companies that do exist - the largest in the industry has approximately 14,000 employees - are not large enough to dominate. The basic reason for this is that the machine tool industry is also very heterogeneous. The output consists of literally hundreds of products. No company can cover the whole spectrum of products; each firm specializes in only one or a few narrow segments.

Because of the character of its products as investment goods, and because industrial investment is one of the most cyclical components of final demand, the machine tool industry is characterized by extreme volatility of output.

These industry features are generally characteristic of fragmented industries. Their continued presence significantly constrains the set of feasible strategies which firms in the industry can choose. But in recent years there have been some developments which have made the choice of firm strategy even more difficult than before and in many cases have required companies to re-think their whole strategic posture.

II. NEW STRATEGIC CHALLENGES FACING THE INDUSTRY

II.1 Declining Output

In the postwar period, and particularly in the last decade and a half, the machine tool industry has suffered from stagnating or even declining output.

Measured in constant (1982) dollars, U.S. shipments of metal cutting machine tools reached a cyclical peak of only $4.4 billion in 1981, compared with peaks of $5.0 billion in 1967 and $7.9 billion in 1953. [7, p. 42.]

Part of the overall decline in output in the United States is explained by the rate and pattern of industrial investment in general and particularly in the major machine tool using industries: fabricated metal products, machinery, and transportation equipment. Another part of the explanation has to do with rising import shares -- see below.

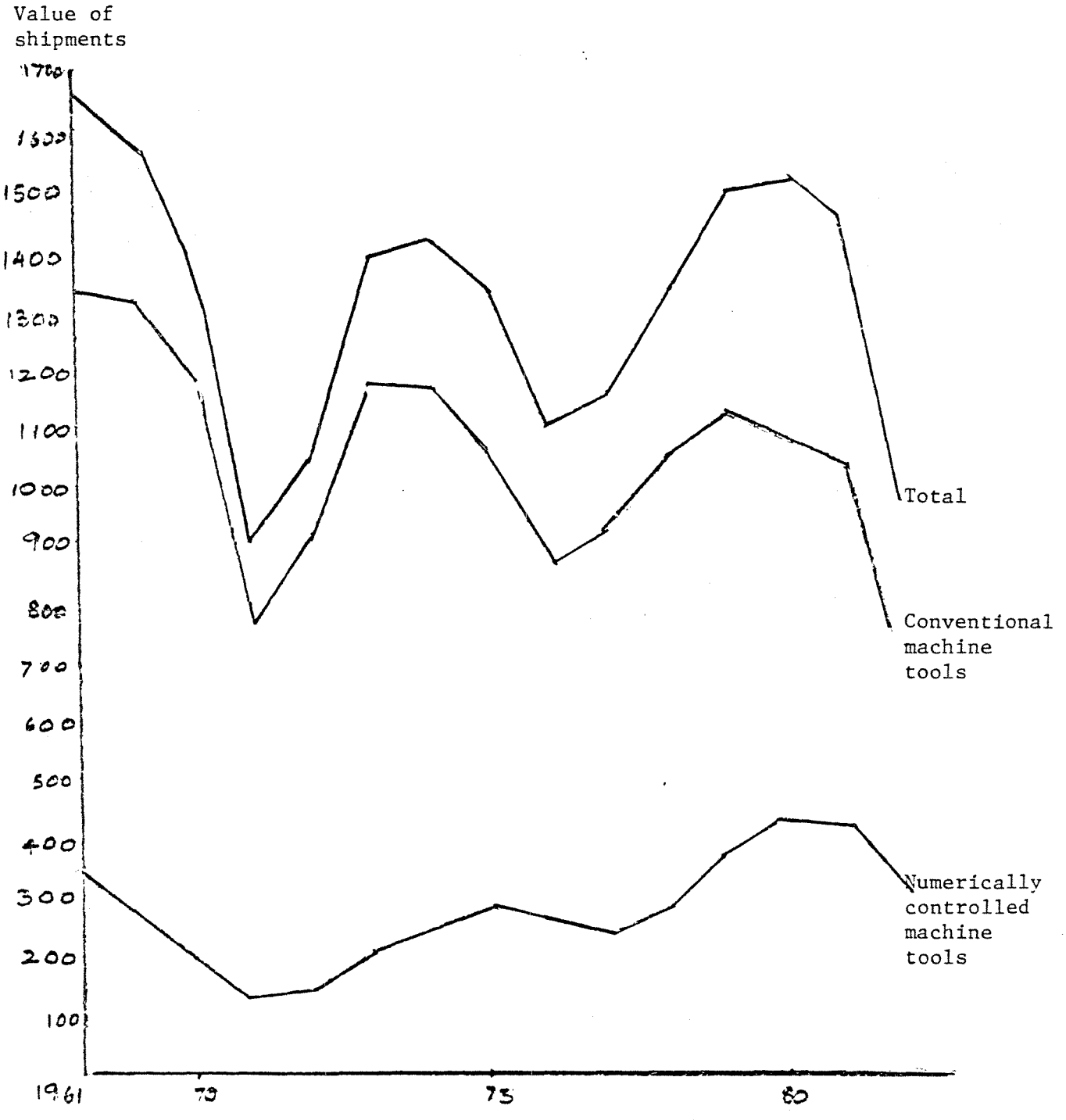
However, the decline in output has not been uniform across the industry. As shown in Figure 1, the decline has been confined to one part of the industry, albeit the largest part, namely conventional machine tools. At the same time, the output of numerically controlled machine tools (both metal cutting and metal forming) has tended to increase over the past fifteen years.

II.2 Technological Change: The Shift to Numerical Control

One of the major challenges facing the machine tool industry today has to do with a major technological change. Numerically controlled machine tools came on the market in the early 1950s but their diffusion was very slow until the late 1970s.[1] Part of the reason for the slow diffusion of the technology is that numerically controlled machine tools require a fundamental change in the philosophy and organization of manufacturing. When NC machine tools are integrated into larger cells or systems, possibilities arise of automating

Figure 1. Machine Tool Shipments in the United States 1968-1982

$ million in 1967 prices.



Source: National Machine Tool Builders' Association, Economic Handbook of the Machine Tool Industry, 1983-1984. NMTBA, McLean, VA, 1983, pp. 41, 93, and 100.

production at small and medium scale, an area where automation and mechanization have not generally been contemplated previously. For various reasons, however, the technology was originally perceived as applicable primarily in large scale manufacturing, a misconception from which the industry is still suffering. As far as machine tool producers are concerned, this has meant that they have faced not only the strategic decision as to whether or not to go into numerical control, but also, if NC is adopted, to what extent to develop the engineering knowhow required to assist customers in their particular applications. It was not really until the Japanese came up with a whole new concept of numerical control, a more generic approach with more versatile, yet cheaper machines, that rapid diffusion set in. This led to a dramatic shift in the market which left many Western machine tool firms in a precarious position.

II.3 Increased Import Competition

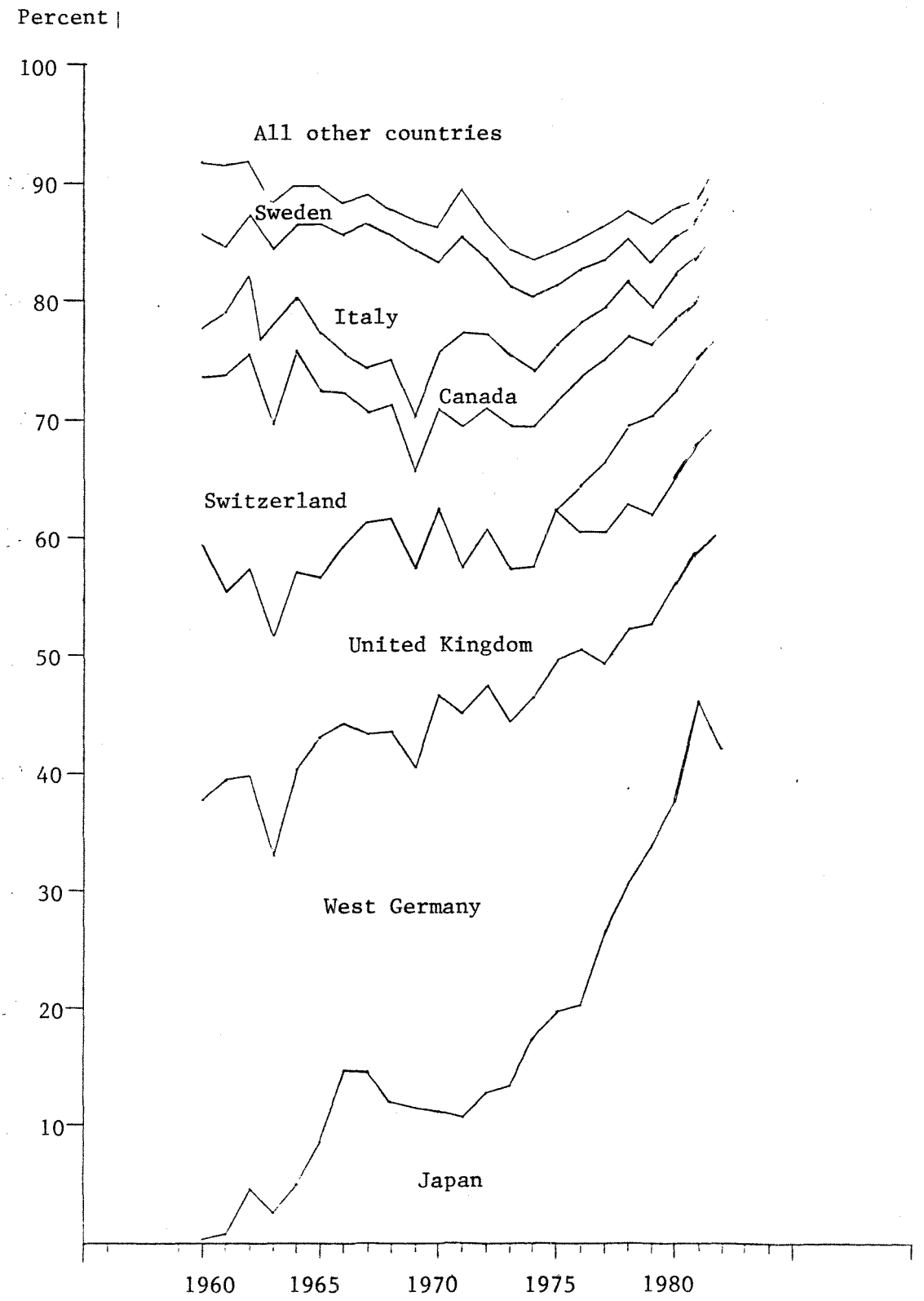
In addition to this technological challenge, but closely allied with it, has been the emergence of tough new competitors, especially Japanese firms. This is reflected in sharply increasing ratios of imports to apparent consumption in many countries. In Sweden, this ratio increased from 0.60 in 1960 to 0.80 in 1982; in the United States, the corresponding ratio rose from 0.06 to 0.36 over the same period. ([2], pp. 33-34, and [7]) Thus, the machine tool industry is yet another example of an industry which has had to face up to the challenge of global competition to an extent never dreamed of a few decades ago. But at the same time as competition has become more global, the trade

gains have been very unevenly distributed, with Japan and the newly industrializing countries rapidly gaining market shares at the expense of the old industrial countries. The distribution by country of machine tool imports to the United States over the period 1960-82 (see Figure 2) is a good illustration.

Not only has import competition increased dramatically; it has also increased the most in the technologically most dynamic part of the industry, namely numerically controlled machine tools. Thus, while over 40% of all metal forming and nearly 50% of all metal cutting the machine tools sold in the United States in 1982, were imported, it has been estimated that the Japanese alone had a market share of over 50% in NC machine tools as early as 1980. [3, p.24] In the two most common types of NC machine tools, NC lathes and machining centers, the Japanese share of the U.S. market is undoubtedly considerably higher today.

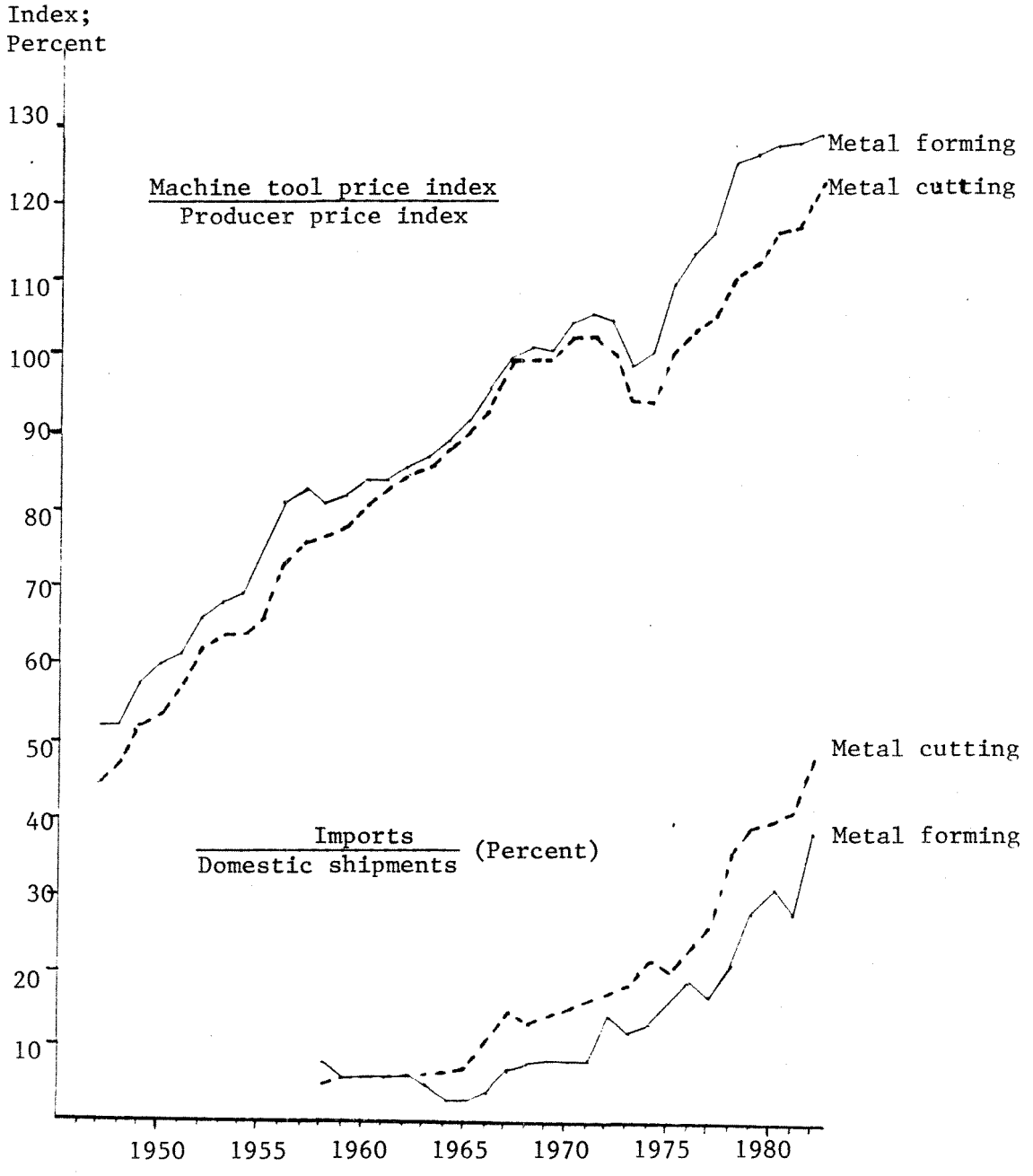
It is not surprising that this increasing import competition has brought with it a certain downward pressure on prices. Unfortunately, data are not available for individual product categories, but Figure 3 gives a rough idea of what has happened. As shown in the lower part of the diagram, imports have gained a larger share of the U.S. market in metal cutting than in metal forming machine tools. The curves in the upper part of the diagram show that machine tool prices tended to rise considerably faster than the producer price index until the mid-1960s. But when the import share for metal cutting machine tools started to rise around that time, their relative price stayed constant or even fell. The same thing happened in the early 1970s in metal forming machine tools. After the mid-1970s, the relative prices for machine tools

Figure 2. Distribution by Country of United States Machine Tool Imports, 1960-1982. Percent.



Source: NMTBA Handbook, 1981-82, pp. 96 and 100; NMTBA Handbook, 1983-84, p. 128.

Figure 3. Relative Prices and Import Shares of Metal Cutting and Metal Forming Machine Tools in the United States, 1947-1982.



Source: NMTBA Handbook, 1983-1984, pp. 41, 77, and 146.

8 71 2000

have resumed their climb, but the greater import share in metal cutting machine tools seems to keep more pressure on prices there than in metal forming machine tools.[2]

What is suggested here, although present data availability makes it impossible to prove, is that the area most desirable from the long-term technological point of view, NC machine tools (which are not yet very common in metal forming machine tools), is also the area most exposed to price pressure. This price competition was the result of a change in the strategies of some major Japanese machine tool producers in the mid-1970s and which led to their rapid penetration of Western markets soon therafter. The key element of this strategy was the design of lower performance, smaller and cheaper CNC machine tools than those produced before. While machine tool producers in the West had based their machine tool designs on the needs of large customers, the Japanese directed their efforts at medium and small users. The result was the opening up of a new market, small CNC machine tools sold to small firms, which had not been tapped by Western firms before. [6, pp.9-10.] Thus, the Japanese entry into the world market dramatically changed the rules of the game. This has not made the transition from conventional to numerically controlled machine tools any easier for the firms in the industry.

How have firms in the industry tried to deal with these new challenges? That is the main question dealt with in the remainder of this paper.

III. THEORETICAL FRAMEWORK

In his book Competitive Strategy, Porter (1980) provides a framework for

analyzing industries and competitive strategies. According to Porter, "the essence of formulating competitive strategy is relating a company to its environment. Although the relevant environment is very broad, encompassing social as well as economic forces, the key aspect of the firm's environment is the industry or industries in which it competes." [8, p. 3.]

In Porter's theory, there are five forces determining the strength of industry competition and hence industry profitability: (1) rivalry among existing firms within the industry; (2) threats of new entry; (3) threats of substitute products or services; (4) bargaining power of buyers; and (5) bargaining power of suppliers. [8, p. 3 ff.]

These structural features probably go a long way towards explaining the generally poor profitability of the machine tool industry throughout the Western world. The rivalry among firms in the industry is intense; the entry barriers are generally very low, which means that there is constant threat of potential entry; and there are numerous techniques which are actual or potential substitutes for machine tools. In some product segments, the bargaining power of buyers is substantial. However, the bargaining power of suppliers does not generally play much of a role in the industry, since most of the raw materials, parts, and components purchased are standard products available from a large number of suppliers.[3] In the following analysis, the bargaining power of suppliers is therefore ignored.

Porter identifies three generic strategies which firms can adopt to try to outperform other firms in the industry:

(1) Overall cost leadership; by pursuing economies of scale and cost minimization;

(2) Differentiation of products through design or brand image, technology, customer service, special features, etc.; or
(3) Focusing on a particular buyer group, segment of the product line, or geographic market. [8, pp. 35-46]

Given that the object of a strategy is to guide firms in dealing with their environment, firms in a similar environment tend to choose similar strategies. Porter distinguishes between five different types of "generic industry environments", namely fragmented industries, emerging industries, mature industries, declining industries, and industries in global competition. In each type of industry, the competitive forces at work constrain the set of feasible strategies. Even though the whole machine tool industry can be characterized as fragmented, there are sub-industries which can more appropriately be classified differently.

As indicated earlier, even a very cursory examination of the machine tool industry reveals that no company can hope to cover the entire spectrum of products throughout the whole industry. Only some major Japanese firms seem to have adopted the overall cost leadership strategy.

The strategy most commonly adopted by Western machine tool firms is that of specializing in particular segments of the product line. The number of segments typically varies from one to four. A segment usually consists of a particular type of machine, e.g. milling machines, but there may also be sub-segments made up of machines of a particular size or specification for a specific type of buyer, e.g. bed-type milling machines.

In order to analyze firm strategy choice, it is necessary, therefore, to classify firms into various fields of specialization. The classification used in this study is shown in Table 1. Each field may be thought of as a sub-industry. We distinguish first between conventional and NC machine tool producers. Within conventional machine tools, we distinguish between producers of standard conventional machine tools and producers of special (custom built but non-NC) machines. For reasons indicated earlier, the standard conventional machine tool sub-industry is a declining industry; the same is true of certain special machines as well. Concerning NC machine tools, it is useful to distinguish between manufacturers of standard general-purpose NC machine tools without any tooling or ancillary devices and manufacturers of machine tools with more customized engineering features: tools and fixtures, materials handling devices, and NC programming. The NC sub-industries are classified as fragmented. Finally, I have chosen to include flexible manufacturing systems (FMS) as a separate sub-industry, even though it is represented by only one of the interviewed firms. The output here is customized machine tools along with the necessary ancillary hardware and software as well as engineering to solve the customers' manufacturing problems with respect to particular parts or sets of operations. This is truly an emerging industry which may eventually consist only partially of machine tool builders; firms with other backgrounds may enter this sub-industry in the future. The content and characteristics of each of these sub-industries will be explained in detail below.

There is a wide variety of ways in which firm strategies may differ from each other even within fairly narrowly defined sub-industries. The dimensions considered in the following analysis (even though they may not be commented on specifically in each case, for reasons of brevity) are the following: specialization, product quality, technological leadership, service, price

policy, relationship with parent company, and selection of sales channels.

Table 1. Classification of Sub-industries

	Sub-industries	Characteristic
I.	Conventional machine tools	
	1. Standard machine tools	Declining
	2. Special machines	
	A. Transfer machines	Declining
	B. Other special machines	Fragmented
II.	Numerically controlled machine tools	
	1. Standard machines without tools and fixtures	Fragmented
	2. Standard machines with tools, fixtures and other ancillary equipment	Fragmented
III.	Flexible manufacturing systems	Emerging

IV. THE DATA

Because of the nature of the required information, there is only one feasible method of data collection, namely in-depth interviews with firms. The strength of this method is that it opens up possibilities of obtaining a rich and detailed view of the industry's problems. Among its weaknesses are the facts that it makes it impractical to include a very large number of firms in the study and that for reasons of both space and confidentiality it is not possible to present the results in detail. Yet, generalizations based on

interview results often do not do justice to the material and may even be misleading; there is always the problem of representativity. The analysis that follows represents an attempt to strike a balance betweeen these two positions.

Interviews were carried out with 6 American and 6 Swedish machine tool firms in the spring and summer of 1982. The Swedish firms represent most of the types of machine tools manufactured in Sweden. They also cover the whole size spectrum of firms in the Swedish machine tool industry, ranging from $2 million to around $50 million in sales and from less than 50 to over 500 employees in 1981. The share of output exported varied between 30 and 75 percent, and the share of output consisting of numerically controlled machine tools varied between 0 and 100 percent.

For the six United States firms interviewed, the volume of sales varied between $10 million and nearly $1,000 million, with employment varying between over 100 and nearly 14,000. The machine tool products covered in the American interviews were both large and small transfer machines, NC lathes, NC machining centers, NC aerospace profilers, NC grinders, broaching machines, precision spindles and slides, and presses (both mechanical and hydraulic). As could be expected, the export shares of the American firms were lower than those reported for Swedish firms, ranging between 0 and 29 percent. The share of output represented by numerically controlled machine tools varied between essentially 0 and nearly 100 percent.

V. ANALYSIS OF SUB-INDUSTRIES

V.1 Standard Conventional Machine Tools

Rivalry among Current Competitors

As pointed out in Section II, the market for conventional machine tools has been shrinking during the last decade, primarily because of the substitution of NC for conventional machine tools. This is true particularly of standard conventional machine tools. Among major producers of machine tools in the OECD, only West Germany has had a growth in investment in conventional lathes, for example, in recent years. [6, p.2.] Consequently, many producers have been forced to leave the market. In the early 1970s, the Japanese decided to leave the export market for conventional machine tools to the newly industrializing countries while they themselves concentrated their export efforts on numerically controlled machine tools. Therefore, there is not much competition from Japanese firms in Western markets for conventional machine tools today. Similarly, many of the larger American and West European firms have also shifted into numerically controlled machine tools, merged with other firms, or gone out of business. The result has been that most of the remaining conventional machine tool firms in the United States and Western Europe are relatively small. The most serious competition now comes from Taiwanese and South Korean firms, as well as from firms in other developing countries and in Eastern Europe. However, it has been estimated that even in less developed countries the market for conventional machine tools may shrink rather than increase, thus forcing LDC producers into NC and CNC markets instead. [6, pp.3-5.]

Threat of Entry

While it seems that the rivalry among existing firms has eased somewhat in recent years as a result of many Western firms leaving the market, the main competitive pressure now comes from new entrants, mostly from developing countries, cutting into the American and West European market.

Entry into this industry is not very difficult. Entry barriers are low: As we have seen, firms are numerous and economies of scale and capital requirements are fairly insignificant. Product differentiation is modest; there is virtually no cost to the customer of switching to a new supplier. And access to distribution channels is easy: standard conventional machine tools are generally sold through independent agents rather than through outlets controlled by each manufacturer. Due to the openness of the industry, frequent international machine tools shows, and continuous transfer of technical knowhow through hiring of engineers from other companies in the industry, technological information is easily available; patents are generally not important. However, because of frequent family ownership and strong impact on employment in local labor markets, exit barriers are relatively high.

In view of these industry characteristics, and considering the strategic nature of the machine tool industry in building up the industrial base in the early phases of industrial development, it is not surprising that many developing countries have become involved in the production of machine tools. One of the most outstanding features of the machine tool industry in the past twenty years is the internationalization of its market. Few people in the

developed countries would have even considered buying a milling machine from a developing country 20 years ago. Today that is commonplace. Whereas at that time the main entry threat came from Western and Southern Europe, it now comes increasingly from non-European countries: Taiwan, South Korea, People's Republic of China, Brazil, etc.

The main entry vehicle into the conventional machine tool market is and has been cheap, simple machines which are then gradually improved in terms of quality, complexity and sophistication. Thus, the main entry threat today comes from improved machines from Taiwan, South Korea and India and also new entry in the form of cheap, simple machines from China, the Philippines, etc. However, the threat of entry from less developed countries seems to be different, or is at least perceived differently, in the United States from Sweden. Of course, this has to do with the fact that imports play a much greater role generally in Sweden than in the United States. In 1981, nearly 100% of the conventional machine tools manufactured in Sweden were exported; by the same token, nearly 100% of the conventional machine tools sold in Sweden were imported (i.e., 100% of apparent consumption). The corresponding figures for the United States were 20% and 25%, respectively. (The corresponding figures for metal cutting NC machine tools were 42% export share and 49% imports out of apparent consumption in Sweden in 1981, and 10% and 30%, respectively, for the United States.) ([4] and [7]) Therefore, the threat of new entry from less developed countries is perceived as much more real in Sweden than in the United States, where the only real import threat is seen to come from Japan in NC machine tools while there is not thought to be much of an import threat at all in conventional machine tools. Instead, one of the U.S. companies reported that it felt the main threat was that of having

to go into new lines of business and into the export markets because of dwindling domestic sales and of having to face new competitors in doing so. Another U.S. firm, a manufacturer of machine tool components, felt more of an entry threat from captive suppliers (i.e., machine tool companies manufacturing their own parts and components rather than buying them from independent suppliers) than from foreign competitors. The need to work closely with the customers, they felt, gives domestic manufacturers a communications barrier which is difficult for foreign firms to penetrate.

A further element related to entry, reported by at least one of the Swedish firms, is the problem of unpredictable pricing behavior on the part of East

European competitors whose prices are often arbitrary or politically motivated without consideration to actual costs.

Threat of Substitution

As noted already, the substitution of NC for conventional machine tools is the primary cause of the shrinking market for conventional machine tools. For example, conventional milling and drilling machines are increasingly being replaced by numerically controlled machining centers. The substitution threat is becoming even greater because of the greater flexibility offered by NC machines, including the possibility of linking them together by industrial robots or other materials handling systems. Thus, further systems development, not just NC machines per se, constitutes a threat to conventional machine tools. Highly dedicated mechanical systems (transfer lines) face increasing difficulties as their users are forced to become more flexible by

adopting modular designs and producing families of parts rather than larger numbers of single parts, hence requiring more flexible, yet at the same time more automated production equipment.

In addition to the threat from NC machines, there is the possibility that new non-iron materials, e.g. plastics, aluminum, and composite materials, will make metalworking equipment obsolete. There is also the possibility that laser technology will be applied to many operations which are performed by machine tools today. However, these threats are generally perceived as being gradual and distant rather than sudden and immediate, giving firms ample time to react.

Bargaining Power of Buyers

The buyers of standard conventional machine tools range from small workshops to large industrial firms. The interaction between buyers and suppliers is usually very limited. The contact is mainly indirect via distributors, and the products are standard, off-the-shelf items.

Examples of Firm Strategies

How then, have standard conventional machine tool firms adjusted their strategies to deal with these threats? Three of the interviewed firms have been classified in this sub-industry; each has its own strategy. The youngest of them is over 50 years old; the older two have a long history of production spanning over a very wide product range, mainly within mechanical engineering but also outside. This means, on the one hand, that they have never developed the expertise and "mark of excellence" that follows with specialization, nor

have they grown very large. On the other hand, the very diversity of their activities has been the salvation for both firms in difficult times past. Without more than one leg to stand on, it is doubtful whether they would have survived several of the crises they have gone through in the past.

One of these companies has adopted a policy of flexibility, the main element of which is the division of the company's activities into a machine tool business and a consumer-oriented business of equal size which has nothing to do with machine tools or even with mechanical engineering. As far as the machine tool side of the business is concerned, the company has contemplated leaving conventional machine tools for at least 20 years but has decided not to do so as long as those machines can be sold at a profit. Instead, the company has continued to develop conventional machines. At the time of the interview, it was in the process of developing a hybrid between a conventional and an NC lathe. In 1979, the company went into commercial production of CNC lathes which constituted 20% of its machine tool business in 1982.

The other old, diversified firm also has roughly half of its total business in machine tools and the other half in other mechanical products. On the machine tool side, the company specializes in only two product lines. Both of these are conventional; there is no effort to go into numerical control. Here the strategy is to stick with the products with which the company has long experience and for which it is known, while at the same time improving the competitiveness of its products by providing better feeding and unloading devices for its machines and using the resulting higher labor productivity as a sales argument. Recently, the company has also increased its marketing effort, especially in connection with going into new geographical markets.

Both of these companies seem quite innovative, despite their age and small size. At the time of the interview, they each had at least one major new product at the prototype stage or beyond, both machine tools and other products. It is difficult to say how successful these new products will be, but it seems clear that without the diversified product range of both of these companies, they would have been unlikely to come up with these new products. But will they have the resources and competence to manufacture and market these new products? Whereas historical evidence indicates that this type of response to a difficult situation has been successful in both companies in the past, the question is whether a non-specialized strategy is viable in today's or tomorrow's business environment with much more exposure to foreign trade and specialization than in earlier days.

The third company classified as a producer of standard conventional machine tools has also adopted a policy of concentrating on the types of machines that it knows best. Therefore, it is reducing its assortment of conventional machines (from its own point of view but not the customers') by going to a modular design of its machines. The new system is designed to be easier and cheaper to manufacture, providing greater flexibility and longer production runs. This part of the strategy is designed to deal primarily with competition from developing countries.

At the same time, however, the company has formed a new subsidiary for special purpose machines, reflecting an attempt to upgrade the company's competence into more sophisticated markets requiring closer cooperation with customers. The company is working toward a capacity to deliver total systems including feeding and unloading devices so that the company's machines can ultimately be

used in unmanned production systems. It is recognized that the company's future lies in this direction. The question is whether this part of the business can grow fast enough to take up the expected fall in the standard conventional machines.

The company is also trying to intensify its sales efforts while at the same time lowering costs and getting better results by linking up with local companies in major markets. Recently, the company signed a five-year agreement with its largest competitor in one of its most important markets concerning sales of a particular type of machine in that market. This in effect trebles the number of agents for the company in that market and also cuts down transport costs. Only the "core" of the machine (drive head) is shipped from the home base while all the heavy supporting parts are supplied by the local company. This cuts down the capital requirements by reducing the necessary inventory of raw materials, goods in process, and finished goods; instead, more resources can be devoted to product development.

Until the mid-1970s the company tried to diversify into new types of machines. At the present time, by contrast, the company is trying to concentrate on existing lines of business instead but at the same time to move into areas within these where there is less competition and more skill required.

Thus, the interviewed manufacturers of standard conventional machine tools provide examples of two basic strategies. One is to diversify out of machine tools altogether. Having positioned themselves also in non-machine tool markets, these firms can simply abandon their machine tool business when the prospects become too dim, putting all their resources into their non-machine

tool business instead. The other strategy is to upgrade the technological skill within the machine tool market by going into either NC or special machines, or perhaps both.

V.2 Conventional Special Machine Tools

As we have seen in the preceding section, among the main characteristics of standard conventional machine tools are the following: they are simple, general-purpose, off-the-shelf machines which do not require much service and which are normally purchased from independent distributors rather than directly from manufacturers. These machines may be said to represent one end of the spectrum of conventional machine tool products. At the other end of the spectrum of non-NC machine tools there are highly complex, built-to-order, special-purpose transfer machines which require extensive interaction between supplier and user and which therefore are sold mainly through direct contacts between buyer and seller.

In between these two extremes there is a whole range of machine tools, referred to as "special machines," which have both standard and custom designed components and which are generally smaller and designed to perform fewer operations than transfer machines. It is difficult to give a very precise meaning to the term "special machines", but for our present purposes the definition is not crucial. Since a common method of customizing standard machines is to design a set of interchangeable modules within a common overall machine concept, I have chosen to employ a wide defintion of special machines which includes such modular designs as well as truly special machines made up entirely of customized components.

V. 2.a Transfer Machines

Rivalry Among Existing Firms

There are two firms among those included in this study which manufacture transfer machines. Both are U.S. companies. One produces very large transfer machines, the other relatively small ones. Both have competition from several other U.S. producers, some of which are considerably larger than the interviewed firms. However, every company seems to find its own niche in this market, so there is little direct competition except in some product lines. For example, a certain manufacturer is dominant in engine cylinder head manufacturing, while another one is dominant in brake caliper housing equipment. But in other areas, such as components for off-road vehicles, farm implements, etc., there has not been enough volume for any one company to establish unique engineering expertise. In these areas, the bidding is done on a more equal basis among transfer machine manufacturers.

Until the last couple of years, there has been practically no foreign competition in this field. But recently a few Japanese firms have come in, along with some Italian and German firms. The Japanese have specialized in standard (NC) machines rather than in special machines such as transfer machines.

Threat of Entry

As just noted, the Japanese have entered the market in the last few years, especially in the lower production volume area where they have grown on the

basis of their standard machines expertise upward into higher production volumes. They have done this not only in conventional machine tools but also in NC, where they have gone heavily into FMS. For example, they have put in more than one spindle on their NC machines and linked them together into FMS. According to one of the interviewed firms, the Japanese are not doing anything vastly different, but they seem to have recognized earlier than others where the market is going. They have understood the need for integrated systems, and they seem to have taken a lead over Western firms in systems engineering for manufacturing. They have structured themselves organizationally and have begun to make investments in research and other areas that will probably result in drastic changes before too long.

Threat of Substitution

Thus, the main threat against transfer machines comes through new technology rather than through new competitors. There are two aspects of the technological threat, namely (1) a greater need for flexibility in the production equipment, and (2) a greater need for systems design capability on the part of machine tool builders.

The Challenge of Greater Flexibility

The market for highly dedicated, automated, synchronous transfer line type production equipment is shrinking. As the traditional customers for this type of equipment - large-volume producers, particularly auto manufacturers - are threatened by new competitors, new products, rapid changes in demand or tastes, etc., they try to become more flexible. One way of achieving this is

to use modular designs, i.e. families of parts and components, rather than single parts. For example, whereas in the past car manufacturers tried to anticipate demand for V-8, V-6, 4-cylinder enginers, etc., and bought dedicated production equipment for each of these, they are now more inclined to tool up for any type of engine on a particular production line. Fifteen years ago there were far fewer car models, engine combinations, and options available than there are today. The same is true of many other products, not just automobiles.

This is where flexible production equipment based on electronics comes in: easily programmable NC or CNC (computer numerically controlled) machines, flexible manufacturing systems, etc. A transfer machine can perform several operations simultaneously at each work station while a traditional NC machine can only perform one operation at a time. But if one wants to change the size of the workpiece, it has until recently been possible only with difficulty and through manual operations to make the necessary adjustments on transfer machines, while such changes can easily be carried out on an NC machine by pushing a button or changing a tape.

To meet this challenge, transfer machine producers are trying to make their machines more flexible and at the same time more competitive with NC systems at low production volumes. Traditionally, transfer machines are built to produce at least 100 units per hour, but recently there have been machines built for only 20-30 pieces an hour.

Transfer machines with automatic devices for changing heads and fixtures are now being built. Flexibility can also be obtained through better control mechanisms and non-synchronous transfer. Concerning the former, there now

exist transfer machines that can handle 20 varieties of workpieces in 6 families of parts by simply turning some switches on a control panel to index heads, change fixture locations, etc. Changes from one family to the next can be carried out between shifts.

The advantage of non-synchronous transfer is that by having a continuously running pallet transport chain, pallets are allowed to accumulate anywhere in the loop. Therefore, each work station can function independently of others; the slowest station does not dictate cycle time by holding up the other stations in the machine until it has completed its operation. Operators are free to work at a variable pace, relieving some monotony from their tasks, and automatic station cycle times can be allowed to vary.

The Need for Increased Systems Design Capability

According to statements made by several of the interviewed firms, in years past coustomers would take on the responsibility of integrating several pieces of equipment to perform a total operation or a whole production process. They would buy pieces of equipment from several manufacturers and supply the integrating automation equipment themselves. By contrast, in recent years it has often happened that customers have asked machine tool firms for total manufacturing systems (turnkey systems) in which it is the vendor's responsibility to subcontract all the pieces of equipment which he himself cannot supply and see to it that they are properly integrated and that they will perform the total manufacturing process. In other words, machine tool companies are asked to supply engineering services that were formerly supplied by the customers themselves. Many customers no longer have the required engineers in-house in the numbers they have had before.

As a result of this, the bargaining power of buyers of transfer machines has declined in recent years. This is certainly true of the United States but may be less true elsewhere. However, in spite of this, the competitive pressure on transfer machine builders has not really declined. The reason, of course, is the increased threat of substitution from NC machines.

Examples of company Strateies

In the face of these threats, what strategy choices do transfer line firms make?

There are essentially four courses of action taken by the two firms interviewed in this category. One involves making traditional transfer machines more flexible along the lines just outlined above. Another option is to widen the range of application of the machines the company has traditionally been making. Like other machine tool firms, transfer line manufacturers are usually narrowly targeted for a particular market segment, e.g. small parts for high volume production or large parts for somewhat smaller production volumes. By making the machines more flexible, companies open up possibilities of competing in market segments where they have not been active before.

A third option is to develop entirely new products, outside transfer machines or outside machine tools altogether, in order to go into new markets. One possibility is to take advantage of the company's knowhow in metalworking by going into the metal fabrication business - which, however, is not usually very profitable. Another possibility is to draw upon accumulated knowledge of

manufacturing systems in general. Examples here include attempts to go into flexible manufacturing systems (FMS), robotics, and automated systems (e.g. for automatic assembly). However, such efforts may require more expertise and capital than are available to a small, independent firm. Companies which can draw upon the resources of a larger industrial group clearly have an advantage here.

A fourth possibility is that of going into new geographical markets. U.S. transfer machine manufacturers have traditionally been heavily oriented towards the American market, but now some of them are considering entering new markets in Europe, Latin America, and the Far East.

IV. 2.b Other Special Machines

Rivalry among Existing Firms

There are three firms in the special machines strategic group. One of these, a Swedish firm, faces competition mainly from other small European firms specializing in similar machines. The Japanese left the market around 1970 to concentrate instead on machining centers and CNC lathes. The major U.S. manufacturers have also discontinued manufacture of similar machines. Thus, the competitive pressure from existing companies has eased in the last decade, but the threat of entry by firms in developing countries and the technological threats more than make up for this.

One of the three firms is a manufacturer of special machine tool components. Here the main competition comes from captive suppliers, i.e., major machine

tool companies which manufacture their own components. But there is also a handful of non-captive suppliers of roughly the same size as the interviewed firm. Imports are not very significant in this market, but competition from Taiwan is beginning to emerge.

The third firm in this category is a U.S. company whose competitors are mainly other American firms of a size similar to its own, and also some very large Japanese companies.

Threats of Entry and Substitution

One of the major changes in this market in the last twenty years is the internationalization of the market. Many of the older, domestic competitors have been replaced by new competitors, some Japanese, some from developing countries. At the same time, the share of imports has increased substantially. The same type of development is likely to continue in the future. However, the need for close cooperation with customers gives domestic firms a much stronger position vis-a-vis foreign competitors, especially firms in developing countries, than is the case in standard conventional machine tools.

Along with the threat of new entry, the main long-term problem for conventional special machinery manufacturers is the same as that facing transfer machine producers, namely the rapid development of electronically based manufacturing systems.

Firm Strategies

As we have seen earlier, one of the ways in which manufacturers of standard conventional machines try to cope with the problems afflicting them is to adopt modular designs. One firm has chosen the twin approach of designing its standard conventional machines for maneuverability, robustness, and high metal-cutting capacity while at the same time developing a modular system which new competitors in developing countries have difficulties matching. The modular system includes both conventional and numerically controlled components, thus offering customers a great deal of flexibility. This can be viewed as an attempt to diversify away from standard conventional machine tools into both numerically controlled and custom-designed conventional machine tools.

However, the limited resources of a small, independent firm severely limit the available options as far as the choice of a technology strategy is concerned. A product which is too large or sophisticated in relation to the firm's financial (risk-bearing) resources is simply too risky. This is essentially the reason why the NC share of the company's output does not exceed 25 percent. The company stresses other features instead.

In an attempt to broaden its business, the company has recently gone into rebuilding old machine tools - a profitable business which varies countercyclically with new machine tool sales. A few years ago, the company also became importing agent for several foreign firms selling both smaller machines of the same type but also other machines complementing the company's assortment. In addition, the company is now considering going into

manufacturing of robots, materials handling equipment, chips removal equipment, etc., all connected to the machines it manufactures.

Summing up this company's strategy: Recognizing its limited size and the constraints this imposes, the company has tried to combine an economic and a market strategy for long-run survival: don't try anything too big or sophisticated; don't stray too far from existing competence; upgrade the flexibility (or degree of customization) through modular design, while at the same time going partly into special machines, partly into NC; also diversify by becoming importing agent and by going into the rebuilding market.
The second company in this category has followed a similar strategy. Twenty years ago, only 15-20% of its business was in special machinery; now it is about 80%. Standard conventional machines have been gradually phased out as their market has dwindled as a result of plastics replacing metals and also of metal polishing and buffing becoming less common.

Instead, the company has put its resources into the special machinery side of its business and has tried to strengthen its role as an engineering company. It has also specialized in precision machinery. It has recently entered into a licensing agreement with a foreign firm which gives the company exclusive rights to market and service the foreign firm's precision high speed machinery in the domestic market, thus strengthening the company's competence in the high speed area.

The specialization in engineering has brought with it several other major changes: It has required using a direct sales force rather than working through agents. It has also required setting up a field service crew who can

take care of problems on location, whereas competitors normally require machines to be dismounted and sent in for testing and repair.

For the third company in this category, the major new development in its market is the penetration of Japanese firms into the domestic market. One of the reasons for the Japanese success is that they have done thorough market research to determine what the market wants and have then designed their products accordingly. The basic design of their machine tools does not differ very much, but the Japanese machines are technologically ahead in terms of flexibility and materials handling. Yet, this American company feels it has not lost many orders because of technical factors. The real competition is in price.

However, the company has only begun to respond to this challenge. A year prior to the interview, it had started its own strategic planning. At the time of the interview, it was considerng a restructure involving the establishment of profit centers to become more responsive and more market oriented.

V.3 Strategy Choice of NC Machine Tool Manufacturers

Of the eight firms interviewed which produce numerically controlled machine tools at all, only four have an NC share of total machine tool output exceeding 25%. In fact, in these four firms the NC share is between 90 and 100%, so there is a clear stratification here. One of these firms has been classified as a manufacturer of standard, general-purpose NC machine tools.

However, it is only with some stretching of the classification that it can be said to represent this category. As will be shown below, it is only recently that this company has changed its basic strategy so as to directly confront the Japanese competition. In a way, this may be regarded as a testimony to the success of the Japanese in capturing this part of the market: by standardizing NC machine tools (i.e., making them general-purpose rather than tailored to specific tasks), manufacturing them in large numbers, stressing certain quality aspects but not making them too sophisticated to sell through ordinary market channels (agents) and by making them available off-the-shelf for almost immediate delivery, the Japanese have lowered the price of NC machine tools substantially and essentially created a new market.

It has been difficult for Western machine tool builders to meet this challenge directly through price competition. There are some that have tried, including some of the interviewed firms, but none appears to have been very successful thus far. Many of these firms were making NC machine tools long before there was any Japanese competition. In order to sell these machines, they had to supply at least some of the engineering necessary to integrate the NC machine tools into the customers' manufacturing process. Thus, NC machine tools were regarded as a form of special machinery. But the entry of the Japanese changed all that. Still, unable to compete directly with the Japanese in the new market for general-purpose NC machine tools, American and West European producers have mostly chosen to go on producing tooled-up, partially customized NC machine tools. Two of the four interviewed firms specializing in NC machine tools are in this category.

The fourth NC firm interviewed exhibits sufficient FMS ambitions and degree of tailoring of its products to warrant classifying it in that category.

V.3.a NC Machine Tools

Rivalry among Existing Firms

Standard NC machine tools may be regarded as the segment of the whole industry where the rivalry among existing firms is the most intense. This is, after all, where all of the firms remaining in the industry which aspire to a technologically advanced position have had to turn. For many firms in the industry, success in this segment is necessary for survival. With the Japanese clearly dominating standard "bare" NC machine tools, a market which in a sense they themselves have created, the only growth market left to Western firms has been in standard tooled-up NC machine tools, especially NC or CNC machining centers and lathes. However, these sub-segments are also strongholds of Japanese firms. Taken together, these factors have resulted in intense competition among existing firms.

This competitive pressure takes many forms. One, of course, is price competition, especially in depressed market conditions, as noted earlier. But most Western firms have chosen to compete in technology and service rather than price, following the traditions established in the industry long before the Japanese entered the market. Thus, Western firms tend to emphasize speed, accuracy, and dependability of the machines, as well as customer service in the form of help with tooling, fixtures, materials handling equipment, process engineering, etc. By contrast, the largest Japanese firms have emphasized simplification and cost reduction. The pursuit by these firms of an overall cost leadership strategy fundamentally altered the nature of competition in the industry. Price competition increased in importance in a way never known

before. An important element in the success of the Japanese strategy was the development of CNC units based on low-cost microcomputers rather than more expensive control units consisting of either a minicomputer or a hardwired control system. [6, pp.12-14.]

Threat of Entry

All of the interviewed firms are unanimous in their opinion that the Japanese penetration of Western markets will continue. In addition, entry by other Asian producers is also likely. For example, Taiwan came from nowhere into the position as the fourth largest importer into the United States machine tool market in only four years (cf: figure 2). South Korea, the People's Republic of China, India, and Indonesia have also been mentioned as potential entrants, especially in standard "bare" machines, but also in the longer term in tooled-up machines. The main entry barriers seem to be a shortage of high-level engineers and the need to establish marketing and service networks. In terms of production facilities, at least the major producers in developing countries seem to have the most advanced computer controlled technology in their plants. [6,p.30.]

Threat of Substitution

The greatest short-term threat to most producers, of course, is that their machines will become obsolete overnight through innovation by competitors. According to several of the firms interviewed in this study, the product life cycle has shortened considerably in recent years. This corroborates the finding by Jacobsson that the expected life-time of a CNC

lathe has decreased from approximately eight years in the mid-1970s to about three years today. [6, p.23.] Given this, and the increasing complexity of the products, it seems as though it will become more and more difficult for smaller firms to survive.

In the longer term, too, the technological threats are substantial. New ways to cut metal, e.g. with lasers, increased use of non-metallic materials (such as composites), and improved methods of molding and forging are examples of technologies which diminish or eliminate the need for machining in certain applications. Also, further use of electronics in manufacturing, often involving miniaturization or use of other materials than metals will probably also lead to a diminishing demand for machine tools in the future. However, in the judgement of the interviewed firms, these changes are long-term and gradual and therefore easier to deal with than the more short-term competitive pressures.

Bargaining Power of Buyers

As a result of the intense competitive pressure in the industry in combination with the depressed market conditions in recent years, the bargaining power of buyers has increased tremendously. This has led to lower prices, shorter delivery times, and greater commitments on the part of machine tool builders vis-a-vis their customers. For example, in Sweden some customers now require 95% time availability on newly purchased machine tools. If after two years only 93% is reached, the machine may be returned and the supplier required to pay damages to the buyer, amounting to perhaps 10% of the purchase price. One of the firms reported that a commitment of this sort contributed to the

bankruptcy of a Swedish machine tool firm. In the United States, product liability laws have presented similar problems for machine tool firms in their dealing with customers.

Strategy of a Firm Trying to Confront the Japanese

This company is a division within a large industrial group. There are two main threats with which the company's strategy is designed to deal. The most difficult and immediate competitive threat, of course, is that of the Japanese. There are several ways in which the company is trying to meet the Japanese competition. At the time of the interview, it appeared as though the company's basic strategy was in a state of transition. Before, the basic strategy vis-a-vis the Japanese threat was that adopted by most Western machine tool firms, namely to compete mainly with engineering rather than price and volume. But now the company seemed to have made a reevaluation of its strategy, reaching the conclusion that it had to take on the Japanese more directly. The basic reasoning was the following.

This firm is relatively large. This means, on the one hand, that it is better equipped than most of its Western competitors to take on the Japanese competition. On the other hand, it also means that a niche strategy is not feasible: it does not yield a large enough sales volume to sustain the present level of operations. Therefore, the company strives to develop small, standard, general-purpose machines (without tooling and fixtures) that can be sold in large quantities at low cost. The basic philosophy here is that if one can make a profit on a small machine, it is also possible to do it on a larger one. But there is no way one can make a small machine out of a large, complex one; the basic design is just too different.

This basic strategy change also involves a change in product development strategy. Development of standard machines with fixtures and tools requires a fair amount of collaboration with customers. Semi-special and special machines ("one of a kind") require even more customer contacts. The company does not like to get into these. If it does engage in such a project, it will do it only if it sees a potential market with similar customers.

As far as dealing with the long-term technological threats are concerned, the company is in a unique position by virture of being part of a larger industrial group. Besides machine tools, the group also includes plastics machinery, non-metallic aircraft machinery, robots, and electronic systems. This diversification is designed to deal with the long-term technological threats.

Thus, summing up this strategy, it can be said to rest on three fundamental strengths: (1) relatively large size which makes it possible to reach certain economies of scale in production, distribution, and product development; (2) a strong technological position, particularly in electronics: and (3) diversification into other areas so that the company is relatively invulnerable to the long-term technological threats.

Strategies of Firms Producing Tooled-up NC Machine Tools

There are two companies in this category. One of these made some important strategic changes around 1970, necessitated by changes in the competitive situation. The company decided that it could no longer support a full product line as it had tried to do earlier. For example, it found that it could not

compete with the Japanese in small, general-purpose, high volume, standard machines. Instead, it decided to import such machines from Japanese manufacturers and sell them in the domestic market, in a slightly modified version. These machines are complementary to the company's own machines and help absorb overhead costs.

An important part of the strategy review in the early 1970s was an effort to consider niches and a concentration on certain types of machines. The company observed that the one thing the Japanese do not do well is to customize their machines. This leaves opportunities for Western firms to do this. Also, Japanese companies do not like to get involved in marketing, service, etc. They want to sell only standard, off-the-shelf machines with no optional accessories.

The main strategy, therefore, became that of specializing in larger, more expensive and more customized machines in order to obtain a large market share and enough dominance to be the price leader and thereby attain high profits. The company's products are generally high in price. Instead, quality (reliability, rigidity, accuracy, metal removal rates, many optional accessories) is regarded as the most important means of competition. But experience has shown that customers are looking more at price now than they used to because of the Japanese who entered the market largely on price and delivery. The result has been that all suppliers have been forced to cut prices. By obtaining a dominant position it is also easier to get good distributors. The best distributors generally try to get the top of the line in each product.

However, at the same time as it pursues this main strategy, the company also tries to meet the Japanese head-on in one particular area: CNC lathes. In 1981, it brought out a new, small, standard CNC lathe without any optional equipment. It was offered at a price lower than that of comparable Japanese machines. The only problem was that it was brought out just when the market nose-dived and prices were cut drastically.

On its more typical and expensive products, this company puts a lot of emphasis on customer service, customer traning, etc. The company builds its own numerical controllers and writes its own computer software. Thus, it delivers totally tooled-up machines, even including program tapes and robot loading devices. But the company has elected not to go into manufacturing of FMS, robots, feeding devices, chucks, tools, etc., but to collaborate with other firms in these areas instead.

The second company in this sub-industry company has tried a similar strategy of specialization. Previously it tried to cover both knee-type and bed-type milling machines, although they really cater to different markets: a bed-type machine has greater rigidity and therefore greater accuracy and can handle larger, heavier workpieces.

Faced with toughening competition, the company decided in 1981 on a major strategy change. There were three main elements of the new strategy:

1) concentration on numerical control, i.e., discontinuation of manufacture of conventional machines;
2) concentration on bed-type milling machines, i.e., discontinuation of manufacture of knee-type milling machines; and
3) diversification into machining centers.

The company felt that by concentrating on fewer machines rather than spreading it resources over a larger area, it could strengthen its position both technically and in the market place. Given the decision to specialize entirely in NC, it was felt that bed-type machines were more compatible with this strategy through their higher degree of precision and their inherently greater flexibility. It also made the judgement that there is less competition and higher profits in bed-type than in knee-type machines.

The machine tools manufactured by the company consist of a basic standard machine with certain interchangeable modules. In addition, there are certain tailored components, e.g. indexing tables, feeding and unloading devices, etc.

Another aspect of this strategy is increased emphasis on engineering and service: helping customers with systems design for particular parts to be machined, conducting MTM studies for customers, providing courses in computer programming, service, maintenance, and operation. The company is also trying to build up its capability of delivering turnkey systems consisting of milling machines fully equipped with indexing table, fixtures, and loading equipment. It is obvious that a strategy such as this requires intimate contacts with customers. This is true especially in developing new products.

A Strategy for FMS

The one company interviewed in the FMS sub-industry has also changed its basic strategy in recent years. The strategy change consists essentially of the decision to equip all of the company's machines with computer numerical control (CNC) devices and, in conjunction with this, to develop these

computers within the company itself. To this end, the company has built up technical competence in electronics, mechanics, and software. The integration of these is what gives the company unique strength. The reasoning is that in order to be able to build machines of superior quality, it is not sufficient to buy the controllers; one has to have a certain competence concerning how the electronic components are to be applied to mechanical parts, what software is to be used, etc. (A company making standard CNC machine tools could presumably simply buy the controllers from outside sources.)

Because the Japanese have more or less appropriated the small, job-shop end of the market, this company is turning increasingly to larger customers. The company feels it could meet Japanese price competition in standard NC machines, but this would require expanding the volume. Therefore, it has decided not to increase volume but to go the other way instead, taking the systems approach and trying to help customers solve integrated manufacturing problems. Thus, the company tries to find good solutions to the customers' production problems rather than just selling lathes. It is felt that it is easier for a Western firm to do this than for Japanese firms because of language, cultural background, etc.

This firm has always had a "high technology" profile. It was the first among European firms to introduce CNC lathes. But in the past 10 years, as a result of increased competition, the gap between the technological leader and the industry average has narrowed from an estimated two years to one year. The company regards itself as being somewhat ahead of the competition, possibly along with one of the Japanese producers, which has the same general philosophy and also manufactures its own control equipment.

The basic strategy now is to maintain a leading technological position while not losing the market orientation. The main thrust is to make machines which are better tailored to customer needs and to integrate them into larger production systems. This requires a substantial amount of engineering for each order. About 40-50% of output is now tailored, vs. 20-25% earlier. The company delivers entire flexible manufacturing systems, but given its own product specialization, it would prefer to concentrate on lathes and how they, fit into such systems. The deliveries made so far have been mostly to the domestic market and in collaboration with other domestic suppliers.

Because the company has gone further into flexible manufacturing systems than its competitors, it sees more opportunities than threats as far as technology is concerned. Instead, the main perceived threat is that the Japanese will copy the company's products and offer price competition.

VI. CONCLUSION AND POLICY RECOMMENDATIONS

VI.1 Summary of Company Strategies

The analysis was organized along the lines suggested by Porter (1980). Four competitive forces were dealt with: rivalry among existing firms, potential new entry, new technology (substitution), and bargaining power of buyers. Two of these were found to be particularly important at the present time, namely the technological challenge associated with the microelectronic revolution and the internationalization of the machine tool market. In NC machine tools, this is seen most clearly in the Japanese invasion of the market. In conventional machine tools, the major change is the increasing role of the developing countries.

Given the suddenness and force with which these forces have appeared, it is not difficult to understand why a lot of machine tool producers are still searching for strategies to deal with them and why the market is in a state of disequilibrium.

What are the strategy choices made by Swedish and American machine tool firms, and how well are they coping with these problems? What conclusions can be drawn about corporate strategy and industrial policy in the machine tool industry, and what policy recommendations can be made?

Because of the heteogeneity of the industry and the resulting differences among various segments in their competitive situation, the analysis was arranged according to sub-industries. One way to summarize that discussion is to evaluate the degree of exposure of each sub-industry to various forms of competitive threats. Such an attempt is illustrated in Table 2.

If competitive pressure is measured on a (subjective) scale from low (one +) to high (three +'s), it can be clearly seen that in conventional machine tools the most intense competitive pressures arise from threats of substitution and threats of entry. The threats of substitution consist mainly of continued substitution of NC machine tools and NC-based manufacturing systems for conventional machines, whereas the entry threats stem primarily from producers in developing countries. Since many of the largest and technologically most advanced companies have already left the market for conventional machine tools, the degree of rivalry among existing firms is not very high. The bargaining power of buyers also appears rather small.

Table 2. Degree of Exposure of Sub-industries to Competitive Threats

Sub-industry	Rivalry	Entry	Substitution	Bargaining Power of Buyers
Standard conventional	+	+++	+++	+
Transfer machines	+	++	+++	+
Special conventional	+	++	+++	+
General-purpose NC	+++	+++	+	++
Special-purpose NC	+++	+++	++	++
FMS	++	++	+	+

In NC machine tools, by contrast, the rivalry among existing firms is intense, and the threats of potential entry are very real. The bargaining power of buyers is substantial, especially in the depressed market situation which has characterized the industry in recent years. On the other hand, the threats of substitution are not very important here.

In addition to this, however, one needs to keep in mind that the demand for conventional machine tools is generally shrinking, thus severely increasing the competitive pressures. In standard conventional machine tools, long-term strategy appears to be only a matter of choice between well-planned, orderly withdrawal on the one hand and unplanned, sudden collapses on the other. Indeed, given the low historical profitability, the ease of entry, and the dim market prospects, one wonders why there are as many American and Swedish firms left in this segment as there are. High exit barriers in the form of family

ownership, strong ties to the local economy including large shares of local employment, and fairly narrowly specialized technical knowhow, are surely among the reasons.

The demand prospects are considerably brighter for NC machine tools, but the number of existing and potential producers is so large that no individual company can hope to reap more than a small share of the benefits. It may well be that it is not possible to survive in the machine tool industry in the long run without numerical control, but choosing the NC route certainly does not guarantee survival.

Thus, even if it is true that the industry as a whole has to move gradually out of conventional machine tools and into numerically controlled machine tools, it would be wrong to conclude that every company can or should do so. Also, it appears as though this movement, gradual in the past, has become more and more precipitous. The experience of the companies studied here suggests that it is very difficult to move from standard conventional machine tools into numerically controlled machine tools. The most natural route would seem to be to go into standard, general-purpose NC machine tools, but that is where the Japanese have already achieved a clearly dominant position in terms of both technology and price. The only alternative is to go into customized NC machines -- quite a large step which is associated with considerable risk of failure. Given the small size and deeply eroded financial base of most machine tool companies, this transition is often too difficult. It is suggestive that most of the NC machine tool firms interviewed in this study have had to make basic strategy changes in recent years, even after they went into NC, whereas such changes seem much more rare among producers of

conventional machine tools -- hardly a sign of health, given the changing circumstances.

VI.2 Performance of Various Sub-industries

As pointed out in the previous section, the standard conventional machine tool builders interviewed in this study pursue strategies which offer possibilities of an orderly withdrawal. Two of the firms have roughly half of their business outside machine tools, while a third firm is trying to move into both NC and special machines. Thus, although none of them seemed to have any immediate plans for leaving the machine tool market, it is clear that they could withdraw quickly if circumstances so required. None of the firms is trying to meet new competition from developing countries directly through price competition.

The manufacturers of transfer machines interviewed have positioned themselves much more favorably for long-term survival as machine tool producers. They have taken steps to make their transfer machines more flexible and hence more competitive with NC-based systems, even though that technological threat remains serious. They have also diversified into new products and new geographical markets.

The companies in other special conventional machines are trying in a variety of ways to carve out niches for themselves, particularly by going more heavily into engineering and custom design. Through this type of strategy they can isolate themselves from competition from both other existing firms and new entrants. However, the long-term technological threat of substitution by numerical control still remains.

Proceeding now to producers of NC machines, it is surprising how few companies in America and Sweden are willing and able to take up the Japanese challenge head-on. Only one of the interviewed firms can be said to have based its strategy on facing the Japanese, and this only fairly recently. How successful this effort will be still remains to be seen, of course. It certainly requires a fairly large production volume and a solid financial base.

The market for fully tooled-up, customized NC machine tools is rather crowded these days, with most major Western machine tool firms concentrating in this segment and trying to defend their positions, with plenty of Japanese competition and looming threats of entry by firms in developing countries. Many of the firms in this category, those interviewed here as well as others, have been forced to specialize in a narrower set of products than they covered earlier. Instead, they strive for market dominance within these specialties. They also emphasize close customer contacts, special engineeering services, and turnkey systems, i.e., they are moving in the direction of FMS.

Only one of the interviewed companies was classified as specializing in FMS; the difference between this firm and those in the previous group is obviously only a matter of degree. But even though there are relatively few competitors in this segment at the present time, it is certainly not a secure market. Perhaps the greatest problem is the potential threat of a Japanese invasion of this market, too. Experience from other parts of the machine tool industry, and from other industries as well, suggests that once the Japanese have established themselves on the market at the lower end in terms of price and sophistication of the products (but at the same time in large-volume

products), they then move gradually "up-market" into more expensive and sophisticated products. What is particularly suggestive here is the fact that virtually all of the interviewed firms seemed to think that Western firms are leading in machine tool technology per se, while at the same time they thought Japanese users are more sophisticated in the use of machine tools. This suggests that the Japanese advantage lies in knowledge of a more generic type involving the organization of manufacturing systems and the use of production equipment.

An important reason for this may be that in the United States, the aerospace industry has been the technologically most dynamic user industry in the postwar period [2, pp. 102-108], thus heavily influencing the development of new machine tools. By contrast, in Japan where the aerospace industry is very small, the automobile industry has performed that role. [9, p. 20.] The production requirements of the automobile industry and the close relationships between Japanese car manufacturers and their suppliers of parts and components have had a great deal to do with the development of new, general-purpose machine tools in Japan. In addition, it has been suggested that Japanese firms may be less specialized in their R&D than their Western counterparts. They seem to include more marketing and manufacturing engineers, not just design engineers in their product development projects. Also, by zeroing in from the beginning on the needs of small customers, Japanese machine tool manufacturers have had a close working relationship with their customers in Japan all along. Based on this experience, they have been able to design products which they have sold successfully in the West as well. [9, pp. 70-72.]

It is quite possible that it is this long-standing cooperation with customers which has enabled the Japanese to come up with more flexible, general-purpose machine tools which may also in the not-so-distant future lead to further inroads into Western markets.

VI.3 Lessons for Firm Strategy Choice

What are the lessons of strategy choice which can be drawn out of the firms studied here? Are there any elements of strategy which seem to be general?

Perhaps the most important point to be made is that it is necessary to face up to the threats rather than ignoring them. In studying the machine tool industry, one is easily left with the impression that many companies have simply not bothered to pause and analyze the competitive threats which they face. Some firms have recognized the threats facing them in time, while others have been slow to respond.

Once the threats have been recognized, the coherence of a strategy seems to be more important than its content. Coherence here means that various elements of the strategy support one another. One aspect of the coherence of a strategy is that it must take account of the economic realities facing the firm, i.e. its financial (risk-bearing) resources. This means, for example, that the choice of products must be compatible with the company's size: A company which sells only 5 units of output per year has probably made a poor choice. Each unit then accounts for 20% of total sales; a shortfall in sales by one unit may cause financial difficulties, and an increase by one unit may strain productive capacity. If, on the other hand, no product costs more than 2% of total sales, the company is much less exposed to this lumpiness problem.

This means that a small company cannot go into too highly sophisticated products whose unit price inevitably becomes very high. Also, they tie up too great technical and productive resources and require technical expertise in the sales force, perhaps even a different sales organization if existing distributors cannot handle the business. In addition, from the customer's point of view, a more sophisticated machine requires a larger investment and makes it difficult to make reasonably accurate rate of return calculations. Thus, the more sophisticated the machine, the fewer the potential customers. It is also likely that these customers are relatively sophisticated and exert relatively great bargaining power compared to buyers of less sophisticated products.

For a small company, the only possibility of raising capital for expansion may be through internal finance. Therefore, cash flow is very important: tight economic control may be necessary to make sure that not too much capital is tied up in any part of the process. For example, in one of the interviewed firms, a great deal of emphasis is put upon an advanced computerized system for all bookkeeping, inventory control, personnel and payroll information, word processing, purchasing information, accunts receivable, as well as a CAM system which provides production capacity and scheduling information. Even though this was not an area covered i detail in most of the interviews, it seems obvious that many of the interviewed firms could gain a great deal from more of this type of thinking.

Another aspect of strategy coherence is that small, independent firms have a position which may differ considerably from that of companies which are a part of large industrial groups which can absorb some of the risks. But at the

same time, the present investigation suggests that only a few of these industrial groups are in fact willing to put much money into the machine tool business. Especially conglomerate groups seem to put their resources into other types of business instead. Therefore, the machine tool firms which are owned by conglomerates are not necessarily in a better position with respect to availability of financial resources than independent firms.

One suspects that the primary reason why so few firms in the West have gone into general-purpose NC machine tools or into FMS is their limited resource base. In the case of general-purpose NC machines, one needs large volume production and extremely large financial resources, both in order to finance inventory build-up by distributors (for quick, off-the-shelf delivery rather than to customer order with delivery several months later) and in order to absorb the risk of failure. The FMS approach also requires large financial resources to bear the risks. But what is perhaps even more important is that it requires a much broader technical base than is available to most firms. Because of their narrow specialization in just a few types of machine tools, their systematic knowhow is too limited to support large, versatile manufacturing systems involving several types of operations, machine tools, materials handling systems, software, etc. Specializing in certain components for such systems may not be a viable strategy because the bigger companies (prime contractors) may want control over the components they use in the systems they offer to customers.

But the complexity of machine tools is increasing, not just in the area of FMS. The number and complexity of components in a machine tool are growing rapidly. Small companies have difficulties keeping up. They have to rely on

outside suppliers for electronics, software, laser and fiber optics technology, etc. 30 years ago, technology in machine tools basically involved knowing certain metal-cutting equations and similar formulae. The big companies knew this a little better than the small ones, but the difference was not great. It was possible to go out and hire a chief (mechanical) engineer who knew all that one needed to know. Hiring a new chief engineer today is not sufficient to close the technology gap as far as software, robotics, and servomechanisms are concerned. Thus, at the same time as the differences in technology among the leading firms seem to have shrunk, the distance between the leaders and the industry average has probably widened. The market leaders' design teams now have between 30 and 50% electronic engineers. [6, p.24.]

In addition, the sophistication of the business is increasing not only technologically but also in terms of capability with respect to law, finance, product liability, etc.

The cyclical nature of demand for machine tools is one of the perennial problems of the industry. It is often made worse by the narrow specialization in which firms are forced to engage. For example, profilers are sold to only two industries, namely aerospace and tool & die, both of which are even more cyclical than the machine tool industry itself. One company reported shipping 100 aerospace profilers in one year but only two the next!

Many of the interviewed firms have put a lot of effort into finding a solution to this problem, but none seems to have been very successful. Several of the firms reported difficulties in finding products which are countercyclical to

the own main product but which also fit into the company's overall strategy, organization, manufacturing facilities, sales channels, etc. In order to be successful, it is necessary for such countercyclical products to be thoroughly understood throughout the organization, from the president of the board on down. Even companies which are highly diversified in machine tools find that most machine tools move toghether with the business cycle. It seems that the volatility of demand is something the machine tool industry will continue to have to live with.

VI.4 Policy Conclusions for Corporate Strategy

The main conclusion that follows from this analysis is that the best hope for success in the machine tool industry lies in taking the systems approach. That is where the needs of the customers are. That is also where sophisticated domestic buyers can offer machine tool companies a challenge which, if met successfully, can give domestic producers an advantage over their foreign competitors.

But, given the fragmentation of the industry, the small size and narrow specialization of firms, their long history of independence and family ownership, their differences in business philospohy, etc., that is a tall order indeed. Factors such as these, and many others, probably explain why there have not been more mergers among machine tool firms than we have observed to date. But the dynamic forces now at work in the industry are such that the resistance will be whittled down in many firms.

However, merger with other machine tool firms is only a partial answer and certainly not universal. If a manufacturer of drilling machines merges with a milling machine company, the technical competence of the new firm is not significantly widened. In order to be able to respond to the systems needs of customers, it may be necessary to look for broader and more flexible arrangements. Perhaps the customers themselves will have to assume a greater role, in collaboration with several machine tool firms and other suppliers. Another possibility is joint ventures for individual projects involving major systems purchases in which several machine tool firms join with each other and perhaps also with other equipment suppliers and engineering consultants.

One is also left with the impression that the time may be ripe for new entrants of an entirely different kind: companies with a strong computer and systems background, but not necessarily with any machine tool hardware experience. The software applicable to the use of machine tools seems to become increasingly important, and it is not clear that machine tool firms are the most likely to take up this challenge.

Because of the heterogeneity of the industry and the different threats and challenges facing its various sub-industries, the machine tool industry seems to be singularly ill-suited for the kind of industrial policy that we observe in e.g. the steel and automobile industries. The transition now taking place in the machine tool industry is difficult but necessary; it is a perfect example of the process of creative destruction as described by Schumpeter. If it is prevented, i.e. if the present disequilibrium is preserved, the result can only be a set of domestic firms unable in the long run to face foreign competition and unable to supply domestic users with the best available

technology. If, on the other hand, policies were instituted to speed up the adjustment process - a policy which seems to have few, if any, advocates - the likely result would be unneccessary unemployment and destruction of both physical and immaterial capital.

FOOTNOTES

[1]For a description of numerically controlled machine tools and their diffusion, see [5]. For a broader description of the development of machine tool technology and its use, see [1].

[2]This is, of course, much too simple a model and is meant only as an illustration. A more thorough analysis is clearly called for.

[3]The bargaining power of suppliers may be more than negligible in one area, however, namely in numerical control units which are sold primarily by relatively large firms. See [6], pp. 25-29.

BIBLIOGRAPHY

1. Carlsson, B., The Development and Use of Machine tools in Historical Perspective. Journal of Economic Behavior and Organization, 5 (1984), pp. 91-114.

2. _____. The Machine Tool Industry - Problems and Prospects in an International Perspective. IUI Working Paper No. 96, Stockholm 1983.

3. Commission of the European Communities (CEC), The European Machine Tool Industry. Commission statement, Situation and Prospects, SEC (83) 151 final. CEC, Brussels, 1983.

4. Foreningen Svenska Verktygsmaskintillverkare, Statistical reports, various years.

5. Gebhardt, A., and Hatzold, O., Numerically Controlled Machine Tools. In: L. Nabseth and G.F. Ray, Eds., The Diffusion of New Industrial Processes: An International Study. Cambridge University Press, Cambridge, 1974, pp. 22-57.

6. Jacobsson, S., Entry Into the Production of Electronic Based Machine Tools, Mimeo, Research Policy Institute, University of Lund, 1983

7. National Machine Tool Builders' Association (NMTBA), Economic Handbook of the Machine Tool Industry 1983-1984. NMTBA, McLean, VA 1983.

8. Porter, M.E., Competitive Strategy: Techniques for Analyzing Industries and Competitors. The Free Press, New York, 1980.

9. Watanabe, S., Market Structure, Industrial Organisation and Technological Development: The Case of The Japanese Electronics-Based NC-Machine Tool Industry. World Employment Programme Research Working Paper WEP 2-22/WP.111 International Labour Organisation, Geneva, 1983.

WORKING PAPERS (Missing numbers indicate publication elsewhere)

1976

1. Corporate and Personal Taxation and the Growing Firm
by Ulf Jakobsson

8. Estimation and Analysis with a WDI Production Function
by Göran Eriksson, Ulf Jakobsson and Leif Jansson

1977

15. Pay Differentials between Government and Private Sector Employees in Sweden
by Siv Gustafsson

1980

25. On Unexplained Price Differences
by Bo Axell

34. Imperfect Information Equilibrium, Existence, Configuration and Stability
by Bo Axell

1981

36. Energi, stabilitet och tillväxt i svensk ekonomi (Energy, Stability and Growth in the Swedish Economy)
by Bengt-Christer Ysander

38. Utiliy in Local Government Budgeting
by Bengt-Christer Ysander

40. Wage Earners Funds and Rational Expectations
by Bo Axell

42. The Structure of the ISAC Model
by Leif Jansson, Tomas Nordström and Bengt-Christer Ysander

43. An Econometric Model of Local Government and Budgeting
by Bengt-Christer Ysander

44. Local Authorities, Economic Stability and the Efficiency of Fiscal Policy
by Tomas Nordström and Bengt-Christer Ysander

56. Central Control of the Local Government Sector in Sweden
by Richard Murray

59. Longitudinal Lessons from the Panel Study of Income Dynamics
by Greg J. Duncan and James N. Morgan

1982

61. Var står den nationalekonomiska centralteorin idag?
av Bo Axell

63. General Search Market Equilibrium
by James W. Albrecht and Bo Axell
General Equilibrium without an Auctioneer
by James W. Albrecht, Bo Axell and Harald Lang

64. The Structure and Working of the ISAC Model
by Leif Jansson, Thomas Nordström and Bengt-Christer Ysander

65. Comparative Advantage and Development Policy Twenty Years Later
by Anne O. Krueger

67. Computable Multi-Country Models of Production and Trade
by James M. Henderson

69. Relative Competitiveness of Foreign Subsidiary Operations of a Multinational Company 1962-77
by Anders Grufman

71. Technology, Pricing and Investment in Telecommunications
by Tomas Pousette

72. The Micro Initialization of MOSES
by James W Albrecht and Thomas Lindberg

75. The MOSES Manual
by Fredrik Bergholm

76. Differential Patterns of Unemployment in Sweden
by Linda Leighton and Siv Gustafsson

77. Household Market and a Nonmarket Activities (HUS) - A Pilot Study
by Anders Klevmarken

1983

79. Energy Prices, Industrial Structure and Choice of Technology; An International Comparison with Special Emphasis on the Cement Industry
by Bo Carlsson

81. ELIAS - A Model of Multisectoral Economic Growth in a Small Open Economy
by Lars Bergman

84. Monopoly and Allocative Efficiency with Stochastic Demand
by Tomas Pousette

86. The Micro (Firm) Foundations of Industrial Policy
by Gunnar Eliasson

87. Excessive Government Spending in the U.S.: Facts and Theories
by Edward M. Gramlich

88. Control of Local Authority Expenditure - The Use of Cash Limits
by Noel Hepworth

89. Fiscal Containment and Local Government Finance in the U.K.
by Peter Jackson

90. Fiscal Limitations: An Assessment of the U.S. Experience
by Wallace E. Oates

91. Pricing and Privatization of Public Services
by George E. Peterson

96. The Machine Tool Industry - Problems and Prospects in an International Perspective
by Bo Carlsson

97. The Development and Use of Machine Tools in Historical Perspective
by Bo Carlsson

100. Quit Behavior under Imperfect Information: Searching, Moving, Learning
by Bertil Holmlund and Harald Lang

102. Collecting Data for Micro Analysis. Experiences from the Hus-Pilot Study
by N. Anders Klevmarken

103. The Swedish Micro-to-Macro Model - Idea, Design and Application
by Gunnar Eliasson

105. Estimation of Wage Gains and Welfare Gains from Self-Selection Models
by Anders Björklund and Robert Moffitt

106. Public Policy Evaluation in Sweden
by Bengt-Christer Ysander

112. Schumpeterian Competition in Alternative Technological Regimes
by Sidney Winter

113. The Industrial Finance Systems; Europe, U.S. and Japan
by Tad Rybczynski

117. Micro Heterogeneity of Firms and the Stability of Industrial Growth
by Gunnar Eliasson

118. The Initialization Process - The Moses Manual, Part 2
by Fredrik Bergholm

1984

119. Forestalling the Demise of Empirical Economics: The Role of Microdata in Labor Economics Research
by Frank Stafford

120. Unemployment and Mental Health - Some Evidence from Panel Data
by Anders Björklund

121. Comparative Keynesian Dynamics
by Richard H. Day

122. The Firm and Financial Markets in the Swedish Micro-to-Macro Model (MOSES)
- Theory, Model and Verification
by Gunnar Eliasson

123. What Can Be Learned from the Chrysler Experience?
by Frank Stafford

125. Estimates of Bounds for Export Price Elasticities in an Underidentified Simultaneous Two Equation System
by Eva Christina Horwitz

126. An Easy Fixup of the Flaw in Lucas' "Neutrality of Money"
by Harald Lang

127. Comment on Feldstein and Poterba's "Unemployment Insurance and Reservation Wages"
by Harald Lang

128. Information Criterion and Estimation of Misspecified Qualitative Choice Models
by David Brownstone

129. Organisation och styrsystem i ett modernt storföretag
av Gunnar Eliasson

130. Fertility and the Opportunities of Children: Evidence on Quantity-Quality Interactions in Sweden
by Bertil Holmlund

131. CONRAD - A Maximum Likelihood Program for Estimation of Simultaneous Equations Models that are Non-Linear in the Parameters
by Leif Jansson and Erik Mellander

132. A General FIML Estimator for a Certain Class of Models that are Nonlinear in the Variables
by Erik Mellander

133. Effects of Tax Reform on the Demand for Owner-Occupied Housing: A Microsimulation Approach
by David Brownstone, Peter Englund, Mats Persson

134. Firm Strategies in the Machine Tool Industry in the United States and Sweden: Responses to Technological Challenges and Global Competition
by Bo Carlsson