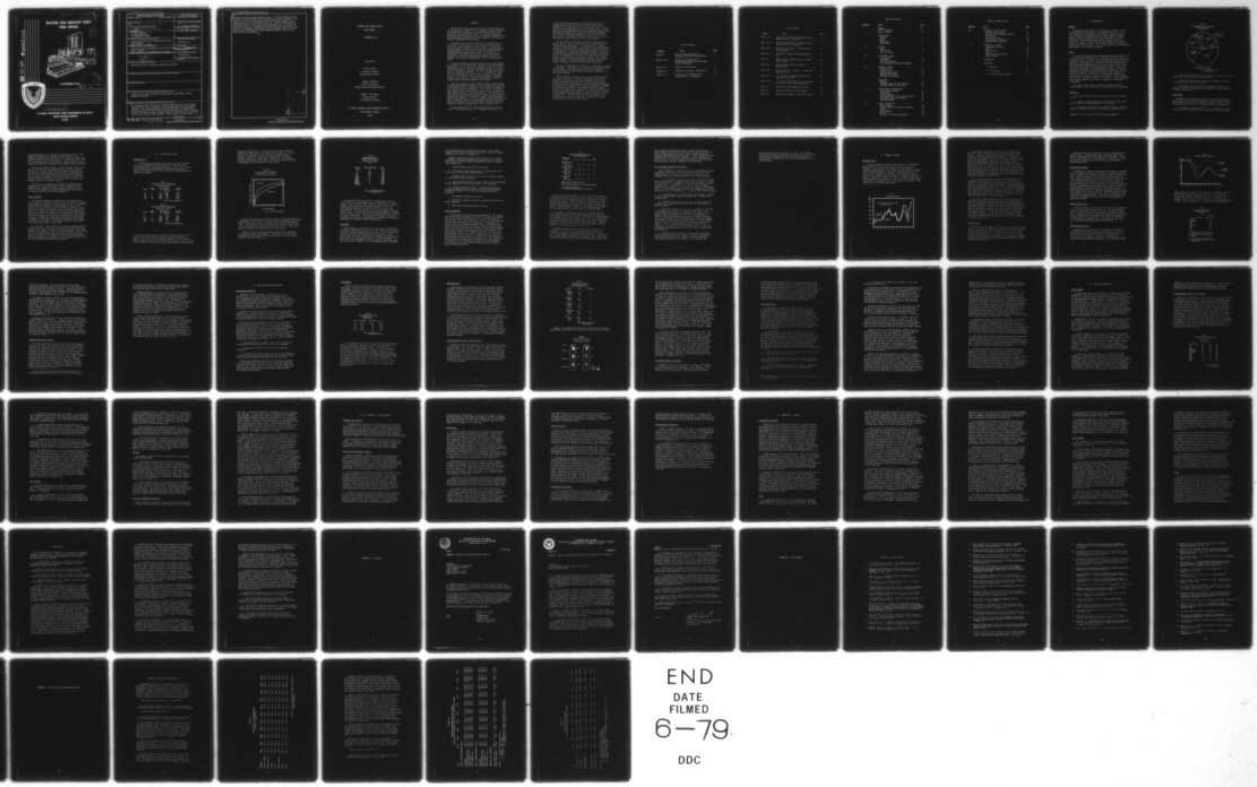
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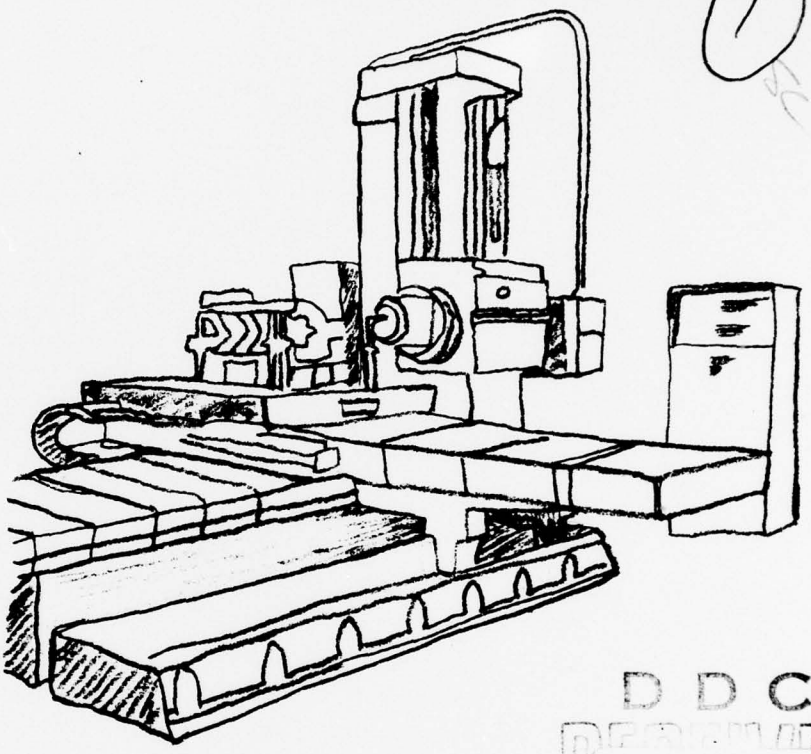


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The purpose of this study was to review various aspects of the machine tool industry such as leadtimes, foreign competition and technological standing. The industry consists, for the most part, of small firms. Annual sales for the entire industry total less than 2.5 billion dollars. The most noteworthy economic characteristic of the industry is the severe cyclic nature of new order bookings. During periods of high orders,

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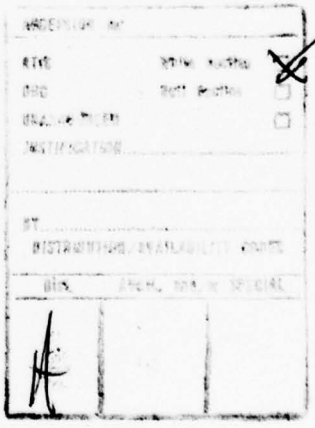
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shortages of highly skilled workers occur. Cash flow problems during business cutbacks interfere with productivity improving programs. The industry has not kept pace with national productivity gains. R & D expenditures are at an extremely low level. Foreign competition has increased with the result that foreign purchases of U. S. tools have diminished while U. S. purchases of foreign tools have increased. The industry is currently experiencing a period of good times; new orders are at an all time high. DOD procurement of machine tools is not a major factor in the market.



MACHINE TOOL INDUSTRY STUDY

FINAL REPORT

1 NOVEMBER 1978

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SUMMARY

The purpose of this study was to review various aspects of the machine tool industry such as leadtimes, foreign competition and technological standing. The study was initiated at the request of the Assistant Secretary of the Army for Research, Development and Acquisition because of problems encountered with Army procurement of machine tools and concern for the general health of the machine tool industry.

The machine tool industry consists, for the most part, of small firms. According to the 1972 census of manufacturers, the latest census available, there were 857 U.S. firms manufacturing metal cutting tools and 375 firms manufacturing metal forming equipment. These firms operated 1277 manufacturing establishments producing machine tools. To provide an indication of the size of the industry, the estimated 1978 shipments for the entire machine tool industry are $2,475 million. This figure is approximately 4.5% of General Motors' sales.

The most noteworthy economic characteristic of the machine tool industry is the severe cyclic nature of new order bookings. Manufacturers try to order great quantities of machine tools during good periods, but reduce purchases sharply at the first sign of a decline in business. New order fluctuations year-to-year have exceeded 25 percent in 11 out of the last 20 years. The cyclic fluctuations in new orders, combined with the dispersion of the industry, create special problems. One major problem is the shortage of highly skilled workers needed to expand production during periods of high orders.

Cash flow problems during business cutbacks interfere with productivity improving programs. Company research and development programs suffer in good times from personnel shortages and in poor times from cash shortages. As a result, the machine tool industry has not even kept pace with the U.S. productivity gains which are about 2.4 percent annually. The small size of many machine tool firms and the cyclic nature of order bookings make the maintenance of an adequate research and development program very difficult. A survey of machine tool firms indicated that the average research and development expenditure was only about 1-1/2 percent of sales--an extremely low level when considering a high technology product such as machine tools.

Foreign competition has increased dramatically in recent years. This has affected the U.S. industry in two ways. As

foreign countries have become more self-sufficient in producing their own machine tools, they have reduced their purchases of U.S. machine tools. Traditionally the U.S. has experienced an annual trade surplus in machine tools. Recently, however, foreign manufacturers in Japan and West Germany have developed into aggressive competitors for the world machine tool market. At one time exports of machine tools were as high as 5 times the imports of machine tools into the U.S. In 1978 however, imports are expected to equal exports.

Foreign machine tool builders have the advantage of subsidies, grants, loans, tax write-offs and special incentives offered by their governments. For instance, the Japanese government has established a complicated system of interlocking industrial agencies and has participated in the launching of a large number of technology enhancement programs. Consortia arrangements are condoned and encouraged in many foreign countries. The advantages of consortia are that they avoid duplication of research, pool resources and spread risks. These cohesive units, made up of government agencies, universities, private industry, trade associations, societies and labor unions, cooperate to improve manufacturing technology.

Currently the machine tool industry is experiencing a period of good times. New orders are at an all-time high and backlogs are increasing. The industry is plagued by a problem of finding sufficient skilled workers to increase production to meet order bookings.

DOD procurement of machine tools is not a major factor in the market, only about 1 percent. Additional machine tool business is generated by orders from producers of military hardware who do not use government furnished machine tools, but even with this inclusion the peacetime military consumption of machine tools remains a minor factor in the market, probably on the order of 5 percent. The volume of defense related business in machine tools, coupled with complex specifications, red tape and procurement practices, is not sufficient to place the government on most machine tool builders "highly valued customer" list. However, because of the visibility of Army procurement actions, objections can be expected to actions deemed adverse to machine tool builders.

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I. INTRODUCTION

Purpose

The purpose of this study is to conduct a preliminary review of the machine tool industry. The Assistant Secretary of the Army (Research, Development and Acquisition) requested that the U.S. Army Materiel Development and Readiness Command (DARCOM) examine problems encountered with Army procurement of foreign machine tools and problems within the machine tool industry as a whole. The U.S. Army Industrial Base Engineering Activity (IBEA) was tasked to conduct a preliminary study of the domestic machine tool industry and to issue a written report on the findings (See Appendix A for tasking documents).

Scope

The Metal Working Machinery and Equipment Industry produces all of the production equipment used by manufacturers and consists of machine tools, tools and dies, perishable cutting tools, welding equipment, foundry equipment, industrial heating equipment and a variety of other products. The study treats only the portion of this industry manufacturing machine tools. Machine tools consist of metal cutting tools and metal forming machines. Exhibit I-1 shows the relationship of the Machine Tool Industry to the other components of the Metal Working Machinery and Equipment Industry. This entire industry, while very important to the productive capacity of the U.S., is actually a rather small industry with total volume of shipments expected to be under 11 billion dollars in 1978. 1*/ The entire industry if treated as a single corporation would rank as number 14 on a list of largest U.S. industrial corporations.

The scope of this study is limited to metal cutting and forming machine tools, identified in approximately 350 categories.

Objective

The specific objectives of this study as assigned by DARCOM are to:

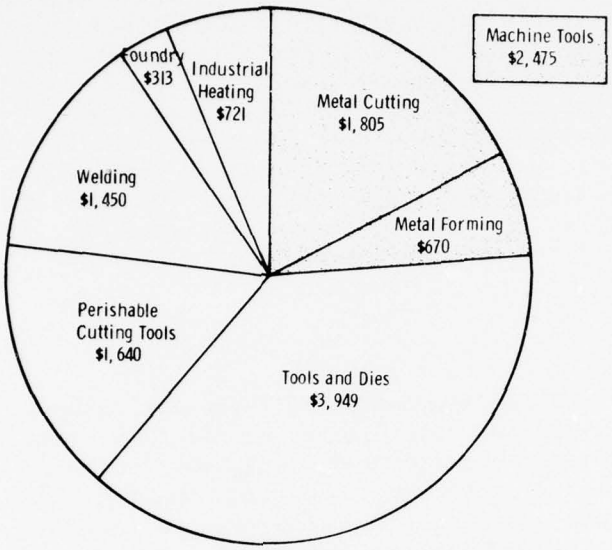
1. Analyze the causes and effects of the 18-24 month lead time prevalent in certain segments of the industry.

2. Determine the effect of a DX priority rating as a means of gaining procurement priority with machine tool manufacturers.

*Numbers refer to references in Biblography, Appendix B.

Exhibit I-1

METAL WORKING MACHINERY AND EQUIPMENT
ESTIMATED 1978 SHIPMENTS
(million dollars)



Total Industry Shipments $10,548

Source: U.S. Dept of Commerce, 1978 U.S. Industrial Outlook

3. Evaluate the industry's ability to meet current private and governmental industrial machine tool demands.

4. Determine the impact on the domestic industry of purchase of foreign machine tools by US buyers.

5. Investigate the technological standings of the domestic industry's products and manufacturing techniques compared to those of foreign manufacturers.

Methodology

As directed in the tasking letter, the study made maximum use of existing reports or previous studies in order to conserve time and resources. An extensive literature search was made to locate existing data and reports. The principal sources covered were:

1. Department of Commerce reports, e.g., census data, economic outlook, Current Industrial Reports, and other periodic releases.

2. Industry association publications such as those prepared by the National Machine Tool Builders Association.

3. Periodicals showing the tenor of current thinking in industry and the levels of foreign and domestic technology in use.

4. Special studies found by the literature search.

During the conduct of the literature search, other on going efforts related to the machine tool industry were identified.

1. The Department of Commerce, Industry and Trade Administration, is conducting a Global Market Survey of approximately twenty countries.

2. The General Accounting Office, Logistic and Communication Division, is planning a follow-up study of their 1976 Productivity Study.

3. The Lawrence Livermore Laboratory of the University of California is conducting a program for the Department of Defense on machine tool manufacturing technology with the following objectives:

a. To review and summarize the present state of technology of machine tools, primarily relating to mechanical metal removal.

b. To serve as a foundation for expansion of this technology into general application.

c. To identify needed advances in the technologies of machine tools. 2/

Selected interviews were held with machine tools suppliers, users, association officials and Department of Defense and Department of Commerce personnel. Their views were solicited on the following factors: lead times, foreign competition, exports, domestic and foreign technology levels, use of priority ratings, and economics of foreign versus domestic machine tool acquisition.

The study addresses a relatively diverse set of factors influencing the domestic machine tool industry. Each factor, e.g., economic factors, lead times, technology, or sub-facets of these, could in itself be the subject for an in-depth, complex study. This study provides an overview of the machine tool industry for informational purposes. More in-depth studies would be required before definitive actions could be recommended.

II. HISTORY*

Origin

The present structure of the American Machine Tool Industry had its origin in the economics and culture of the Nineteenth and early Twentieth Centuries. During this period, the United States grew from a weak agrarian nation to a world leader in industrial production. This change was the result of many factors. One of the most important, and most overlooked, was the evolution of the machine tool.

The industrial revolution started in America several decades after it did in Europe. Prior to the end of the Eighteenth Century the economy of the United States could not support industrial development. Around 1800, four factors combined to change this situation: (1) investment capital became available to support industrial development; (2) internal communications began to improve, allowing goods to be transported at lower prices; (3) a shortage of skilled craftsmen existed; and (4) the textile and small-arms industries became large volume operations.

For several reasons New England became the early center of the industrial revolution in America. The density of population provided a sufficient supply of skilled and unskilled labor and its many streams supplied water power necessary for early industry. New England's investors and workers were oriented towards new technology.

Since there was no machine tool industry at the time, early manufacturers found it necessary to design and build their own equipment. The benefits of industrialization were obvious and the use of machine tools spread quickly, but the machine tool industry was slow to develop. Because of simple design and construction, large users found it easy to build their own machines and smaller concerns could usually find a local mechanic who would build a machine on demand. Until the middle of the nineteenth century, the number of companies which specialized in machine tools was small.

1850 to 1900

Around 1850, the pattern began to change. Machine design had improved past the point where an up to date machine could be built by the average mechanic. Reduced transportation cost and increased demand, caused by the growing inpact of railroads, made a

*Data supporting Section II. History was obtained from References 3, 4 and 5 of the Biblography.

specialized machine tool industry economically possible. New England continued to be the center of the industry. The mechanics who built the machines for its textile and small-arms industry became machine tool builders. By the time of the Civil War, New England was the focal point of American machine tool production, with many companies producing many types of machines.

Machine tool builders began to expand to other parts of the Nation. The transportation advantages of Cincinnati made it the natural focus for a machine tool industry in the Mid-West. With the overcrowded market in New England, the demands from the Civil War, the increasing Mid-West and Praire populations and the general acceptance of the steam engine, more and more builders found the Mid-West a good place to set-up shop. New England soon lost its dominant position.

As machine tools improved in design and performance many companies put their efforts into building a limited line of good machines. Demand for machine tools continued to grow. A patent or significant design improvement and a small amount of capital were the start of many companies.

1900 to Present

The westward movement of machine tool production and the specialization of producers continued into the Twentieth century. Many significant changes were made during this period: grinding changed from a finishing to a metal removal process; metal cutting practices and tools were significantly improved; direct motor drive removed the dangerous clutter of belts and pulleys; and the new automobile industry made unprecedented demands for machining accuracy. The pattern of the industry did not change, however; most producers were in the Mid-West and a large number of small or medium sized companies produced specialized lines of machines. Other than some mergers of machine tool builders, there was little change in the overall pattern of the machine tool industry from 1900 to about 1960.

In the 1960's a major shift occurred in the buying pattern of machine tool users. Rising labor costs and improved technology suddenly made computer control and large machining centers major factors in the industry. These and other processes, such as laser and electro-chemical machining, created technological demands beyond the skills of many producers, especially the smaller firms. Foreign competition also became a serious problem for the first time for the American Machine Tool Industry.

III. THE INDUSTRY TODAY

Industry Size

The 1972 census of manufacturers shows that there were 857 U.S. firms manufacturing metal cutting tools and 375 firms manufacturing metal forming equipment. 6 / These firms operated 1277 manufacturing establishments producing machine tools. Tables III-1 and III-2 show the distribution of shipments among these establishments.

Table III-1

METAL CUTTING MACHINE TOOL MANUFACTURERS

Ranked by Value of Shipments

Ranking	Number of Firms	Group Shipments		Cumulative Shipments
		Total	Avg. per Firm ($ millions)	
1-4	4	311.98	77.996	311.98
5-8	4	155.99	38.998	467.97
9-20	12	311.98	25.999	779.96
21-50	30	283.62	9.454	1063.58
51-857	807	354.53	.439	1418.1

Source: 1972 Census of Manufacturers

Table III-2

METAL FORMING MACHINE TOOL MANUFACTURERS

Ranked by Value of Shipments

Ranking	Number of Firms	Group Shipments		Cumulative Shipments
		Total	Avg. per Firm ($millions)	
1-4	4	124.85	31.212	124.85
5-8	4	104.04	26.010	228.89
9-20	12	145.66	12.138	374.54
21-50	30	180.34	6.011	554.88
51-375	325	138.72	.428	693.6

Source: 1972 Census of Manufacturers

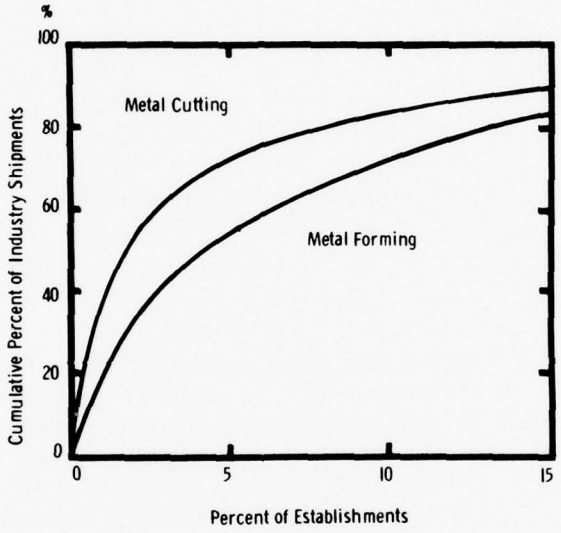
It can be seen from these tables that the largest machine tool firms are not at all large in comparison with the industrial giants. The 1978 estimated industry shipments of $2.5 billion 1 / amount to only about 4.5% of General Motors' sales; there will be only a handful of machine tool firms shipping between $100 and $200

million of machine tools. For instance, only eight producers shipped over $100 million of machine tools in 1977. 7 / On the other hand, a majority of the firms have shipments under $2 million. Exhibit III-1 shows the concentration of industry shipments among a few large firms. Because of specialization, however, the smaller firms cannot be overlooked. Many key items of equipment are produced only by small firms.

Exhibit III-1

Machine Tool Manufacturers' Establishments

Ranked by Decreasing Value of Shipments



Source: 1972 Census of Manufacturers

Most of the machine tool builders operate a single manufacturing establishment. Only about 1/5 of these firms operate more than one plant, and in most cases the second plant is not producing machine tools. In many cases, these firms are little different than typical tool and die shops who also manufacture machine tools. Thus, even today, the industry is composed of many small firms.

Table III-3 shows the employment distribution among machine tool manufacturing establishments. Two-thirds of the 1277 establishments have fewer than 20 employees and only 34 establishments have more than 500 employees.

Table III-3

MACHINE TOOL INDUSTRY
MANUFACTURING ESTABLISHMENTS

Ranked by Number of Employees

1972

Employment	Number of Establishments	Employees
Industry	1,277	76,600
1-4	380	800
5-9	212	1,500
10-19	248	3,400
20-49	194	6,000
50-99	89	6,200
100-249	83	12,500
250-499	37	12,600
500-999	24	17,600
1000-2499	8	16,200
2500 or more	2	NA

Source: U.S. Bureau of the Census, 1972
Census of Manufacturers

Most machine tool firms are very closely held. They are owned either by a single individual or a small group of individuals. Only about 52 public companies closely associated with machine tools are listed on a stock exchange. Of the 1277 establishments shown in the 1972 census, 189 were not even incorporated. No single machine tool company produces an entire product line. There has been an accelerating tendency in recent years for these firms to be acquired by and operated as a division of larger corporations. This trend will probably continue as pressures for increased capitalization are generated by advanced technology and increased foreign competition.

Investment

Rapid advances in technology in recent years have generated pressures on many machine tool firms. The machine tool industry is made up of three general types of firms: the top strata which have made requisite investments in R&D and capital to meet competition; the middle strata which recognize the problems and could recoup their declining position if higher management can make the proper commitments to R&D and capital investment; and the lower strata of smaller and older companies whose management

has no appreciation for contemporary problems. These latter companies will either be absorbed, merge with firms with similar interests, or go out of business. 8 /

Numerous factors were found to stand in the way of greater investment in advanced manufacturing automation and are the key issues involved in the survival and growth of the U.S. Machine Tool Industry: 8 /

1. Cyclical demand and industry dispersion.

2. Low profits, high operating costs, limited capital and poor capital recovery through depreciation.

3. Changing organizational structures and increased emphasis on worker comfort and convenience.

4. Rapidly advancing manufacturing systems and R&D methodology and the high cost to produce new machine tool technology.

5. Foreign competition factors, including sophisticated automated production plants abroad, foreign national programs, non-tariff barriers to U.S. goods and foreign monopolistic practices.

6. Governmental regulation and taxes.

7. Ecological programs, pollution abatement and health and safety standards.

8. Metrication and international standards.

Capital Equipment

A survey made by American Machinist Magazine in 1976 showed that the productive equipment in use by the machine tool industry was, on the average, older than that in use by all machinery manufacturers. 9 / The proportion of machine tools over 20 years old in use by the machine tool industry was 36% greater than those in use by all machinery manufacturers. The machine tool industry has not been able to maintain a modern production base. Only in the area of numerically controlled metal cutting machine tools did the machine tool industry surpass the average of all manufacturers; most of this equipment is owned by a few of the larger firms. Table III-4 shows a comparison of the productive equipment used by the Machine Tool Industry with that used by all Machinery, except Electrical manufacturers. The reliance on aging, obsolete and depreciated equipment can only be expected to weaken the U.S. competitive position in the world market. This applies to the entire metal working industry, as well as machine tool manufacturers.

Table III-4

INVENTORY OF METAL WORKING EQUIPMENT
BY AGE (Percent of Total)

Equipment Type Industry	0-4	5-9	10-19	20 -over	NC Mach
Metal Cutting Machines					
Total*	11	22	35	32	3.0
Machine Tools**	7	16	37	40	3.9
Metal Forming Machines					
Total	11	20	36	33	0.5
Machine Tools	7	18	36	39	--
Joining Equipment					
Total	23	36	30	11	0.1
Machine Tools	16	30	37	17	--
Other Equipment					
Total	18	31	32	19	0.1
Machine Tools	12	25	33	30	--

Adapted from American Machinist, December 1976.

Based on a 25% sample of companies with 20 or more productive employees.

* SIC 35, Machinery, Except Electrical
** SIC 3541 and 3542, Metal Cutting and Metal Forming Machines

Much of the capital spending in the 1960's was directed at improving production, while the capital spending in recent years has been directed at compliance with the requirements of OHSA and EPA. 10/ Hence, capital spending for productivity improvements and new capacity is lower than the overall figures for capital investment would indicate. Thus, machine tool producers are hit from two sides, in their own investment programs and in the competition for their customers' investment funds.

For economic reasons, the machine tool industry has been substituting labor for capital investment since the advent of the current recovery early in 1975. Employers have been responding to increasing sales with variable labor costs like overtime and extra shifts, which can be dropped later if business slacks off, instead of with fixed-cost capital investments. 11/ Currently production in the industry is limited by a shortage of skilled personnel for further expansion by this route.

The above discussion on the Machine Tool Industry is not indicative of all U.S. machine tool companies. There are exceptions. Companies were identified, both large and small, who are implementing new manufacturing technologies. One medium size private company (employment approximately 150 people) interviewed indicated they made a heavy commitment about eight years

ago to computer-aided manufacturing. Another large private owned company said they had a very modern manufacturing facility and that they utilized the latest computer-aided design and computer-aided manufacturing techniques. Other companies visited stressed they were utilizing numerically controlled equipment where feasible. Some have implemented computer numerical control systems as well as direct numerical control systems.

U.S. Overseas Production Facilities

Recent examples of technology transfer were identified during the course of the study. This transfer came about due to the establishment of U.S. production facilities overseas and U.S. companies signing licensing agreements with foreign companies.

1. A U.S. company, claiming to be the world leader in orbital forming technology, is planning to move their operation to Taiwan. This firm has no U.S. competitors and copied the machine concept from the Swiss. In addition to the line of orbital forming equipment this company is a distributor for Japanese built machine tools. In light of observation at the 1978 International Machine Tool Show, it is not unusual for U.S. firms to have overseas plants.

2. A representative of LeBlond Machine Tool Company, a large privately-owned company, indicated LeBlond has a totally owned foreign plant.

3. Olofsson Corporation has a license in Japan under the agreement that Japanese built machines will not be exported to specific markets.

4. The Warner & Swasey Co., one of the largest U.S. machine tool builders, has signed a licensing agreement with a West German builder of special turning machinery to market a line of modular computerized machines in the U.S. Unlike Warner & Swasey's lines of general purpose horizontal turning machines, the German machines are for high-volume parts with each machine dedicated to a single part or a small family of closely related parts. Initial U.S. orders will be filled with German built machines. An agreement on manufacturing in the U.S. may follow. 12/ (This contract is most unusual since it has been negotiated and signed between the world's largest manufacturers of lathes). 13/

5. Production of two Kearney & Trecker milling machines will be transferred from the company's Milwaukee operations to Daewoo Heavy Industries, Ltd., under a licensing agreement reached recently between the Milwaukee based machine tool

manufacturer and the south Korean firm. 14/ The agreement included both technical licensing and marketing provisions and gives the Korean conglomerate the engineering knowledge to build Kearney & Trecker's SA and S-12 milling machines in their own facilities.

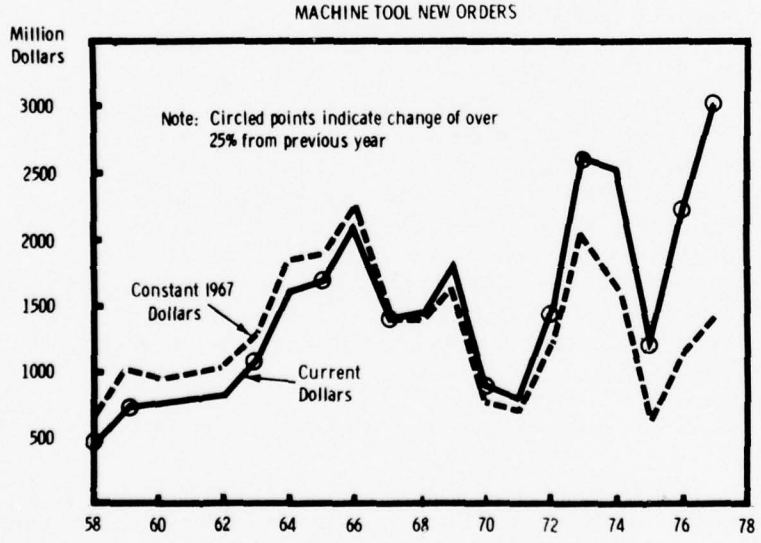
IV. ECONOMIC FACTORS

Business Cycle

The most noteworthy economic characteristic of the Machine Tool Industry is the severely cyclical nature of new order bookings. To the extent that machine tool purchases are deferable, manufacturers try to order great quantities of machine tools during good periods, but reduce purchases sharply at the first sign of a decline in business. The severely cyclical nature of the industry can be observed by looking at new order figures. Exhibit IV-1 shows new orders from 1958 through 1977. 7 / The fluctuations are obvious; the circled points highlight those years where the change from the previous year exceeds 25%. This occurred in 11 of the 20 years shown.

Exhibit IV-1

MACHINE TOOL NEW ORDERS



In the past, some major cycles in sales of machine tools have been caused by changes in military and aerospace expenditures. The severity of the fluctuation in machine tool sales over certain periods has been drastic. World War II offers the most dramatic indication of degree to which changes in defense expenditures affect the machine tool industry. To meet the weapon demand of World War II, the Metal Cutting Machine Tool Industry increased its annual output from about $200 million to $1.3 billion a year over a three-year period. When the war was over, the industry had manufactured more than a million machine tools costing $4.6 billion; more than it had made in the previous 40 years. 16/ This was accomplished by pressing non-machine tool manufacturing firms into machine tool production during the mobilization.

The cyclical fluctuations in new orders combine with the dispersion of the industry to create special problems in the industry. The cyclical fluctuations make it very difficult for small firms to retain qualified personnel. Skilled machinists, released during slack periods, find other more stable employment and become unavailable for rehire. At the present time machine tool firms have a large order backlog, but they are limited in their ability to produce by shortages of personnel. In many instances production facilities cannot be operated on a second shift because of lack of skilled personnel.

The cyclical fluctuations also make it very difficult for small firms to maintain an adequate research and development program. During times when funds would be available because of good order bookings, personnel and facilities are required for production purposes. During times when facilities and personnel might be available because of reduced orders, the firm lacks the capital resources to maintain a substantial research and development program. At the same time, the recent influx of high level technology into the machine tool industry has increased the amount of research and development effort required to remain competitive.

Current Trend

Currently the U.S. Machine Tool Industry is experiencing good times. The total new orders for metal cutting and metal forming machine tools for 1977 were $2,996.9 million. 7 / New orders continue to exceed the pace of machine tool shipments. The current order backlog is $3.1 billion, over one year's output. Earnings are increasing; the number one U.S. producer, Cincinnati Milicron, reported record breaking 2nd quarter earnings, sales, orders and backlogs. 15/

Several factors have contributed to the surging demand for machine tools. Energy conservation, pollution control and safety regulations have forced large scale retooling. Another factor is retooling by the auto industry to build smaller cars and increase truck and van capacity and incorporate major engineering changes.

Technological Impact

Technological changes have decreased the amount of productive effort in-house and increased the amount of purchased material used. Formerly, the complex gear boxes and power transmission units required to keep all of the machine axes operating in their proper relationship constituted a relatively large portion of the manufacturing content of the machine tool. With the advent of electronic controls, much of this coordination is accomplished electronically through the use of servo mechanisms, with an independent motor and simple gear reducer for each separate drive. Most machine tool manufacturers purchase the specialized electrical and electronic equipment required. This has decreased the amount of "make" in the machine tool producers plant, while, at the same time, made him more dependent on his electronic equipment supplier. This results in a smaller percentage of the machine tool price on which a manufacturing profit may be made.

Machine Tool Prices

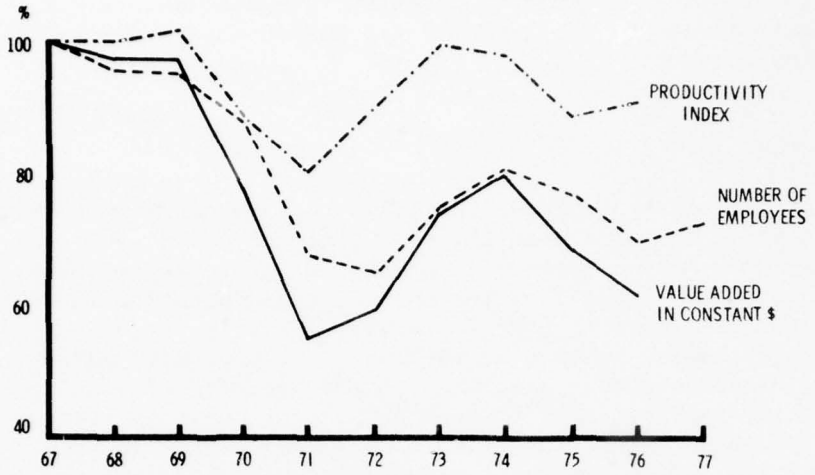
Prices of machine tools have increased at an average annual rate of 7.8% during the past decade. 7/ This has accounted for all of the dollar increase in orders and shipments since 1967. Shipments of the U.S. Machine Tool Industry, deflated by use of the Wholesale Price Indexes for metal cutting and metal forming machine tools, declined by 39% during this period. As can be seen from Exhibit IV-1, constant dollar new orders were essentially unchanged between 1967 and 1977.

Industry Productivity

During the period 1967 to 1976, manpower in the industry declined about 26%. 17/ When this is compared to the 36% decline in constant dollar value added by manufacturers for the industry, it indicates a decrease in productivity. Exhibit IV-2 shows number of employees, constant dollar value added and the value added per employee on an index basis from

Exhibit IV-2

MACHINE TOOL INDUSTRY PRODUCTIVITY



1967 to 1976. The decline in productivity during this nine year period averaged 0.96% per year. Table IV-1 shows selected productivity changes between 1967 and 1977. From this it can be seen that the U.S., and especially the U.S. Machine Tool Industry, has not fared well in comparison to other industrialized nations. (Refer to Appendix C for productivity calculations).

TABLE IV-1

PRODUCTIVITY IN MANUFACTURING
AVERAGE ANNUAL CHANGE

1967 to 1977

	Percent Change
U. S. Machine Tool Industry	About -1.00
United Kingdom	2.39
United States	2.41
Canada	3.66
Italy	4.96
West Germany	5.42
France	5.55
Japan	7.53

Sources:

1. Machine Tool Industry, IBEA estimate from U. S. Dept of Commerce, Annual Survey of Manufacturers data and U. S. Dept of Labor Wholesale Price Indexes.

2. Country data, rates calculated by IBEA from U. S. Dept of Labor, Bureau of Labor Statistics, Output per Man-Hour Indexes.

U.S. gains in productivity are unimpressive. The average rate of productivity growth in the past 10 years has been only half that of the preceeding two decades. The present rate of U.S. productivity growth is considerably less than that of other industrial nations. 18/ Last year U.S. productivity growth was only 2.2 percent, two-thirds of the rate in the 1960's, and lowest among the major industrial countries. 19/ Lower productivity rates contribute to high production costs and lead to a loss in trade competitiveness.

In the struggle to increase productivity, the Machine Tool Industry suffers from the same problems as the remainder of U.S. industry, but the issue is complicated by the dispersion of the industry among many small firms and the lack of diversification of machine tool firms. Inflationary forces render capital formation through depreciation insufficient to replace equipment, requiring additional capital from profits. Capital from profits made during good times, however, is often absorbed by operating costs during cyclical business declines. Competition for capital for other investments which do not directly improve productivity, such as safety and pollution control measures, has also been high in recent years.

V. LEAD TIMES

Backlog

Long lead times appear to be a built-in characteristic of the machine tool industry. A portion of this backlog is the result of the specialized nature of the industry. Since many machines offer numerous customer options, and in many cases specially designed attachments, only a limited number of standard machine tools are carried in inventory.

Discussions with numerous exhibitors at the International Machine Tool Show provided lead time estimates from 3 months to 3 years. The shorter lead times were quoted for standard machine tools, delivered from stock, while lead times of over 18 months were generally for transfer lines, built to order. In some cases, estimates were given that lead times, at the present time, are inflated from 6 to 14 months by order backlogs.

At the end of September 1978, there was a backlog of $3.1 billion of unfilled orders, more than a year of work. 7/ This represents a built in lead time of at least 12 months. The industry uses this backlog as a cushion to fall back on in the event of a decline in the demand for its products.

Cyclical Nature of the Industry

In studying the cause and effect of the relatively long lead times in the production of machine tools one must consider the cyclic nature of the industry as well as the history of the industry itself. There is a reluctance to expand rapidly during periods of strong demand because of the effect on fixed costs during a future decline. The cyclic nature of the industry also creates personnel problems. Skilled personnel, released during slack periods, find other employment and become unavailable for rehire when business picks up. The industry loses a sizeable number of skilled people in this way. The machine tool industry is presently operating at between 90 and 95% of capacity. 20/ Productive facilities are available to increase operations above this level, but a shortage of qualified production personnel has prevented a further increase.

The desire to retain a backlog as a cushion against a cyclic downturn appears to harm the industry in several ways. In the recent inflationary period, industry's long lead time has created

a price-cost squeeze. By not building the ordered tools promptly, the manufacturers have incurred cost increases after the selling price was fixed by contract. Secondly, because of the long lead times and delayed delivery, many customers are looking to foreign machine tool builders who are promising prompt delivery at more economical prices. 21/

The industry consists primarily of small and medium-sized manufacturers. The majority of its customers are large companies in the automotive, aerospace, farm and construction equipment industries. These customers insist upon fixed-price contracts, even during periods of rapid inflation. While long term, fixed prices contracts can lead to normal profits in periods of stable prices, they also lead to dramatic losses in times of severe inflation. 22/ In 1976, the machine tool company profits were only 4.9 percent of total sales compared to 5.4 percent for all other manufacturers. 7/

Because of long lead times, former customers are looking to foreign machine tool builders. An example can be found in the August 7, 1978 issue of the American Metal Market, Metal Working News Edition, as quoted "As previously reported, the tooling program for this engine facility marks the first time in memory that Ford has included foreign machine tool builders in the transfer machine groupings or line-up's. This move is said to have been prompted by extended delivery times and rising prices of domestic transfer machines." 23/ The tooling program cited was for $200 million.

Standard Items for Inventory

The larger machine tool companies do build some standard machines for stock. Most smaller machine tool builders interviewed at the 1978 International Machine Tool Show said they custom build the machines once an order is received. A vice-president of Warner & Swasey said they generally build their automatic bar machines in lots of from 50 to 150 machines. These are normally completed, except for the optional features, and placed in inventory against future customer orders. He indicated that at the present time, however, all machines scheduled for the next 11 months are committed to customer orders. Most machine tool companies, including the smaller manufacturers, do carry an inventory of long lead time components and machine modules to expedite completion of the machine once an order is received.

Several manufacturers indicated that availability of purchased components would be a major factor in any attempt

to shorten lead times. Difficulty in obtaining such items as ball screws, servo motors, electronic and electrical controls and large castings were cited as problem areas.

Foreign producers, on the other hand, are forced to carry their standard products in inventory. Long ocean shipping times would make them non-competitive with any domestic firms that carry machines in inventory or could produce a machine from stocked components in a short time. Distributors of foreign machines have turned this requirement to their advantage, quoting short delivery times on most machines which sell with sufficient regularity to warrant carrying an inventory. One exhibitor at the tool show was promising delivery on tool room lathes and radial drills manufactured in Mainland China in whatever time would be required for shipment from his U.S. warehouse, a matter of weeks.

Because foreign producers have entered the market recently and are largely limiting themselves to the higher volume products, they often have newer and more productive manufacturing facilities. Foreign machine tool builders mastered U.S. machine tool technology and currently are able to provide comparable hardware in considerably less time, at competitive price and quality. While most U.S. firms are quoting delivery times from six months to more than three years, some foreign producers, particularly the West Germans and Japanese, have shortened their lead times by use of extremely automated production methods. In some cases, numerical control machining centers are produced on a production line, not singly as in the U.S. 8/

VI. DOD POLICIES AND PRIORITIES

Preparedness Planning

Planning for the procurement of machine tools is an integral part of the Army Industrial Preparedness Program. Two considerations govern the purchase of machine tools. One is to provide the productive facilities necessary to support the peace time procurement of military materiel and the other is to provide the stand-by facilities necessary to support projected war time production. Both of these must be evaluated in considering any machine tool purchase.

Because of the specialized nature of much military hardware (ammunition is the prime example), producers are unwilling to invest in the necessary productive facilities. For this reason, it is often necessary to include the cost of productive facilities, including machine tools, in the procurement contract.

War time production requirements must also be considered. In many instances, peace time volume is only a fraction of the projected war time needs. Industrial Preparedness Planning is conducted to plan the efficient use of existing commercial and government facilities to meet the materiel production and maintenance requirements of the Army in the event of an emergency. Actions deemed essential for the elimination of production deficiencies in the Army industrial base fall under the general category of Industrial Preparedness Measures. These corrective actions may be accomplished through:

1. Engineering and/or economic studies which consider the specification and costing of skills, tools, and equipment.

2. Development of improved production and inspection techniques.

3. Preparation of projects which provide for raw materials, component parts, special tooling/special test equipment, and/or industrial plant equipment, including machine tools. 24/

Industrial Preparedness Measures are specifically designed to shorten production lead time, increase required production capacity and/or reduce inspection time. Those that require the acquisition of machine tools and industrial plant equipment are supported under the Production Base Support Program of the Procurement Appropriations.

Procurement

Table VI-1 shows recent DOD contract awards for machine tools. 25/ When the $31 million of contracts awarded in 1977 is compared with the $3 billion of new orders received by U.S. machine tool producers, or the $2.5 billion of U.S. machine tool consumption in this same year, it can be seen that military orders are not a major factor in the market. The additional machine tool business generated by orders from producers of military hardware who do not use government furnished machine tools is also a minor factor in the market, probably on the order of 5% (the portion of GNP represented by Defense Purchases).

Table VI-1

MILITARY PRIME CONTRACT AWARDS
FOR MACHINE TOOLS
(Thousand Dollars)

YEAR	METAL CUTTING	METAL FORMING	TOTAL
1974	$19,449	$12,621	$38,070
1975	21,756	7,925	29,681
1976	15,291	3,417	18,708
1977	24,927	6,384	31,311

SOURCE: Department of Defense,
OASD (Comptroller), Feb 1978

The procurement policy when buying Industrial Plant Equipment is no different than when buying military hardware - the Defense Acquisition Regulations apply. DOD elements are required to screen the Defense Industrial Reserve maintained by the Defense Industrial Plant Equipment Center prior to procurement of industrial plant equipment (includes machine tools). The reserve is used to the maximum extent practicable to obtain assets and re-utilize available DOD equipment. When procurement of machine tools is necessary, the amount of documentation and the depth of the economic analysis required is proportional to the size of the proposed investment and the degree to which economics are a factor in the decision making process.

Specifications

Several machine tool builders at the International Machine Tool Show complained about procurement specifications. Specifications are described as too detailed in some areas and not sufficiently specific in others. Military specifications are often included on minor items which preclude use of normal commercial practice, while at the same time, the functional specifications are inadequate. Many times a small or unknown company will submit a proposal for a machine that barely meets the minimum specifications at a lower price. Because of the lower price the inferior machine is selected. It should be noted that these complaints were heard both from machine tool suppliers and users. Army personnel complained that modification of specifications to avoid the appearance of specifying a particular brand sometimes compromises functional specifications.

The DOD procurement process is in contrast to one used by Ford Motor Company, where most emphasis is placed on qualifications of the supplier, with minimal reliance on specification. When machine tool procurement is instituted by Ford, a list of the acceptable bidders is furnished to Purchasing by Manufacturing Engineering. This list is accompanied by a statement of the manufacturing problem to be solved, part to be produced or other appropriate functional requirements, with no specification on the methods to be used or the equipment to be supplied. In about 2/3 of the cases the lowest bidder is selected. In other cases, the bidder for the item is selected for technological reasons or delivery schedule.

Foreign Machine Tools in DOD Inventory

Foreign machine tools constitute only a minor portion of the DOD inventory. The total DOD inventory of metal cutting and metal forming machine tools consists of 108,115 items, 96.7 percent domestic and 3.3 percent foreign. 26/ Table VI-2 shows the DOD inventory of machine tools divided by age, showing domestic and foreign portions. There is no comparable data available on the non-DOD inventory of machine tools. Analyzing the acquisitions during the last 20 years, comparing DOD with non-DOD, it becomes obvious that it is not DOD that is buying the larger quantity of foreign equipment.

Table VI-2

DOD MACHINE TOOL INVENTORY

FOREIGN AND DOMESTIC BY AGE

AGE GROUP	UNITS	PERCENTAGE
0 to 5 years		
Domestic	2,725	2.5
Foreign	216	.2
5 to 10 years		
Domestic	6,621	6.1
Foreign	136	.1
10 to 20 years		
Domestic	14,708	13.6
Foreign	494	.5
20 years and over		
Domestic	80,552	74.5
Foreign	2,663	2.5
Total		
Domestic	104,600	96.7
Foreign	3,509	3.3

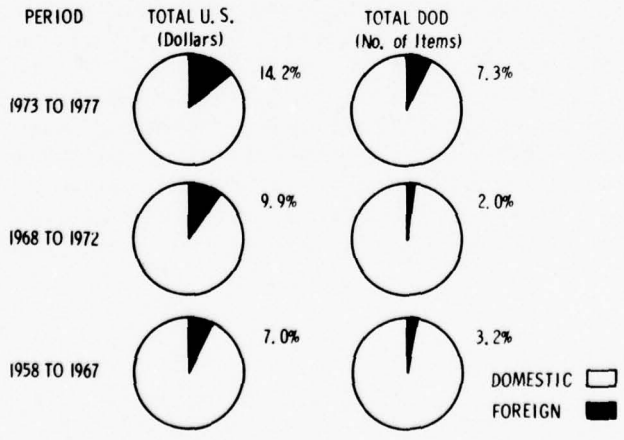
SOURCE: Defense Industrial Plant Equipment Center

Exhibit VI-1 compares DOD machine tool acquisitions, domestic and foreign, with total U.S. acquisitions during the past 20 years.

Exhibit VI-1

ACQUISITIONS OF MACHINE TOOLS

FOREIGN SHARE OF THE MARKET



It can be seen that, during each period, DOD foreign acquisitions were substantially lower than the total U.S. While there has been an upward trend, doubling the foreign market share during the 20 year period, DOD percentage of foreign purchases remain only about half the U.S. percentage of foreign purchases.

When considering the purchase of a foreign made machine, adherence to the policies and procedures of the Buy American Act is required. Waivers and exceptions to the Buy American Act are approved, in special circumstances, for the purchase of machine tools. An agreement has been made with the Swiss Government to purchase commodities from Switzerland as offset payment for the Swiss purchase of military aircraft. Although machine tools are not mentioned specifically in the Swiss Memorandum of Understanding, it is recognized that machine tools would be one of the principal Department of Defense purchases. At least one other such Memorandum of Understanding is also in effect today, between the U.S. and the Government of the United Kingdom of Great Britain and Northern Ireland, signed 2 April 1976. The memorandum covers "the principles governing cooperation in R&D, production, and procurement of defense equipment." The document states regarding sales that, "Offers will be evaluated without applying price differentials under Buy-National laws..." and that "Offers will be evaluated without the cost of import duties..." 28/ These types of advantages make it difficult for the domestic machine tool industry to compete.

The DOD also influences the export of machine tools. The Export Administration Act, as amended, states that "It is the policy of the United States...to restrict the export of goods and technology which would make a significant contribution to the military potential of any other nation or nations which would prove detrimental to the national security of the United States," and further states, "It is the policy of the United States to use export controls...to the extent necessary to exercise the necessary vigilance over exports from the standpoint of their significance to the national security of the United States." It is under these provisions and the International Coordinating Committee (COCOM) regulations that the Department of Defense exercises a very effective control over the export of machine tools. 29/

Government Impact on Industry

Government policies in procurement of machine tools have contributed to the cyclical problems of the industry. During times of mobilization, the government enters the market for machine tools in a large way. This large influx of orders

creates an overload situation on the machine tool industry and also results in a large inventory of machine tools in the hands of the government and their contractors. As the mobilization winds down, the government policy of liquidating surplus production equipment throws a large portion of this inventory on the market in direct competition with the firms manufacturing new equipment. Thus, the manufacturers are faced with not only a downturn in defense related business, but the competition from the large volume of used machine tools thrown on the market. Several cycles of this nature have occurred since World War II.

*Priority Ratings**

The Defense Priority System (31/), together with the Defense Materials System (32/), implements the priorities and allocation powers granted in Title I of the Defense Production Act. The DPS requires acceptance and performance of contracts or orders bearing authorized ratings issued by the "Defense Agencies" for authorized military assistance, atomic energy, space, stockpiling and directly related programs. Users of the Defense Priorities System and the Defense Materials System are authorized to request Special Priorities Assistance from procurement activities and the Department of Commerce when the normal operation of the system fails to provide timely delivery of materials.

The Administration of programs authorized by the Defense Production Act (DPA) is provided for under Executive Orders 11051 and 10480, as amended. The latter order delegates to the Director of the Federal Preparedness Agency overall authority for the direction, control, and coordination of programs under the DPA. The Director of the Federal Preparedness Agency has established policy guidance and redelegated authority for certain aspects of these programs. Specific authority for the various functions of Title I of the DPA have been redelegated as follows:

1. The Secretary of the Interior with respect to petroleum, gas, solid fuels and electrical power;

2. The Secretary of Agriculture with respect to food and with respect to the domestic distribution of farm equipment and commercial fertilizer;

3. The Commissioner of the Interstate Commerce Commission with respect to certain limited, domestic transportation functions; and

*Data supporting this sub-section was obtained from Reference 30 of the Bibliography.

4. The Secretary of Commerce with respect to all other materials and facilities.

The Secretary of Commerce has assigned the implementation of his responsibilities to the Bureau of Trade Regulations of the Industry and Trade Administration. The Bureau has in turn delegated standing authority for issuing priority ratings to the Energy Research and Development Administration for atomic energy programs and to the Department of Defense for its own programs and those of "associated agencies". Authority has been delegated to GSA for Federal Supply Service procurement for DOD and its associated agencies.

Within the Department of Defense, the Army, Navy, Air Force and the Defense Logistics Agency may issue defense priority ratings on contracts under standing authority granted by the Secretary of Defense. Other Defense Department agencies derive their rating authority from the Secretary of Defense.

The Defense Priorities System is a relatively simple one. It consists of two priority ratings: DO and DX. DX rated orders, (usually reserved for Presidentially designated programs such as the missile and space projects), take precedence over all other orders. Between conflicting rated orders of equal priority, precedence is given to the first order received.

Under the terms of the DPS Regulation, Defense Agencies are required to use their rating authority in acquiring products, materials, and services needed for completion of authorized programs, including inventory replacement. Likewise, prime contractors, or sub-contractors accepting defense rated contracts or orders are in turn required to place the same priority rating on contracts or orders which they conclude with suppliers or sub-contractors to fulfill the original rated contract. This mandatory extension of ratings, the self-authorization concept of DPS, is aimed at expediting all phases of contract work and at familiarizing contractors with the DPS.

Products and materials which may be obtained by a person pursuent to the self-authorization provisions of the regulation to fill a rated order shall include only those which will be physically incorporated into the product or material covered by the rated order and the portion of such products and materials normally consumed in the course of processing. Products and materials excluded from the self-authorizing provisions of the regulation include production equipment or products and materials to be used for the manufacture of production equipment. On this basis, a priority rating may not be automatically extended to

machine tools. A rating may, however, be extended to machine tools by the Defense agency with original rating authority for the military program requiring the tools.

There are certain restrictions in the DPS Order 1, July 1, 1974, regarding rated orders for machine tools. Unless specifically directed by the Bureau of Trade Regulations, no producer shall be required to accept DO rated orders calling for the delivery in excess of 60% of his scheduled production. A producer must accept a DX rated order even though the specified 60% will be exceeded by such acceptance. Unless specifically directed by the Bureau, a producer need not accept a rated order, other than a DX rated order, for a metal working machine which he receives less than 3 months prior to the beginning of the month in which delivery is called for. A DX rated order must be accepted without regard to the lead time, unless it is impractical for the producer to make delivery within the required delivery month, in which event he must accept the DX rated order for the earliest practical delivery date.

A sampling of various Department of the Army users who are currently on contract for machine tools found no current DX rated orders. Upon reviewing lead times and delivery dates, it is apparent that some of the DO rated orders have not received preferential treatment. It is doubtful that even a DX rating would receive preferential treatment during this upswing in the machine tool industry, unless strictly enforced, and then legal delaying tactics by the firm would probably negate any potential benefits.

Discussions about priority ratings with machine tool builders indicated that most appear to accept rated orders with the impression that ratings have no effect except during mobilization. This is also borne out by an Army machine tool user who reported that a builder requested an extension of the delivery on a rated order based on the volume of orders from industry.

It appears that only in the event of a national emergency and full mobilization will a DX order be readily accepted by machine tool builders. Then special priority assistance will probably be necessary to obtain castings, electric motors, bearings, and under the Defense Materials System, copper. Because of environmental regulations and the inability of foundries to meet those regulations, large castings needed by the machine tool industry are becoming more difficult to obtain. Companies which have been able to satisfy environmental and safety requirements are operating at or near total capacity. This is one area of concern mentioned repeatedly by machine tool builders.

VII. FOREIGN COMPETITION

Market Impact

Foreign competition in the machine tool industry has increased dramatically in recent years, impacting on the U.S. industry in two ways. As many foreign countries have become more self-sufficient in producing machine tools, they have reduced their purchases of U.S. machine tools. In 1965, exports of machine tools were over 5 times the import of machine tools into the U.S. 6/ Since 1965, while the dollar value of machine tool exports has increased due to price increases, the quantity of machine tools exported has remained relatively static. The quantity of machine tools imported has increased, until in 1978 it is expected to approximately equal exports. Thus, while the export market for machine tools has not been a growth market, an ever increasing share of the domestic market has been taken by foreign equipment.

Traditionally, the U.S. has experienced an annual trade surplus in machine tools. Recently, however, foreign manufacturers in Japan and West Germany have developed into aggressive competitors for the world machine tool market (approximately $15 billion in 1977). During the last decade, the U.S. share of world production has slipped from 33 to 16 percent, a decline of approximately 50 percent. 29/

"In any competition it is dangerous to underrate the enemy. Machine tool competition is no exception," says Lee Musser, Vice President of Marketing and Corporate Development, Kearney & Trecker Corp. "There was a time when we could look tolerantly at the efforts being put forth by Japan, West Germany, Italy, and even England, to meet the standards we had set for ourselves. We had only to shrug and tell a customer considering a foreign product: 'It is foreign made, you understand,' and the customer would catch the implication of inferior materials and assembly. Not so today." 33/

In some cases complete segments of the market have been abandoned to imports by American firms. This has occurred primarily because of price competition for a given product area. Most imports are related to those machine tools that are relatively standard. Logistic problems imposed by distance have limited foreign penetration into those markets where a substantial amount of interaction between the supplier and the user is required in development of the tools. Heavy duty, special purpose machines, such as those used by the automotive and construction equipment

industry, are still largely the province of U.S. firms. Companies which specialize in this type of equipment have not been as vulnerable to foreign competition as firms making relatively standard items which have been in production for some time.

Foreign Suppliers and Size of Market

Table VII-1 shows imports from the top ten foreign suppliers of machine tools to the U.S. 7/ Nearly half of the imports come from Japan and West Germany. Japan supplies about 26 percent of U.S. imports and West Germany about 23 percent. West Germany is the world's number one exporter of machine tools and parts, as well as number one in terms of production, exporting approximately 70 percent of their production. 34/ Imports from East European communist countries have shown the greatest growth rates, but these countries still account for under 3 percent of U.S. machine tool imports. In 1973, East Germany replaced the U.S. as the world's number two machine tool exporter. 35/ In the five year span, 1972-1977, the greatest penetration into the U.S. machine tool market has been made by Japan and Taiwan. These two countries accounted for 13 percent of machine tool imports in 1972 and for 32 percent in 1977. Five years ago Taiwan exported only $5 million worth of machine tools while last year it had nearly $56 million dollars in sales. 36/

Table VII-1

U.S. IMPORTS OF COMPLETE MACHINE TOOLS

Ranked by 1977 Volume

(million dollars)

Country of Origin	1967	1972	1977
Total	178.1	114.0	400.9
Japan	26.2	14.7	105.7
West Germany	50.7	39.2	91.2
United Kingdom	32.9	15.0	46.1
Switzerland	15.5	11.8	35.3
Taiwan	--	0.2	22.6
Canada	6.8	7.0	19.2
Italy	22.2	7.6	15.1
Sweden	4.3	3.0	11.5
France	7.6	3.0	9.7
Spain	1.8	2.5	7.7

Source: U.S. Dept of Commerce
Bureau of the Census

Table VII-2 shows the percent of the domestic machine tool markets taken up by imports. This table shows the substantial in-roads into the domestic market by foreign machines. This is especially true of boring machines, gear cutting machines and lathes where a fourth of the investment is in foreign machines. Despite a four-fold increase in average prices since 1972, Japanese built lathes took 8.5 percent of the U.S. turning machinery market in 1977. Other nations' exports of lathes to the U.S. seem to be growing even faster. 37/

Table VII-2

U.S. MACHINE TOOL IMPORTS AS A PERCENTAGE OF THE U.S. MACHINE TOOL CONSUMPTION

By Types Based on Dollar Value (a), 1969 to Date

	1969	1970	1971	1972	1973	1974	1975	1976	1977
ALL MACHINE TOOLS	9.4%	9.1%	9.4%	9.4%	9.7%	12.7%	13.8%	14.9%	15.8%
METAL CUTTING TYPES	10.7	10.3	7.0	10.0	10.7	13.9	14.5	15.6	17.1
METAL FORMING TYPES	5.4	6.3	6.2	8.0	7.5	7.9	11.8	13.0	12.2
BORING MACHINES (INCL. VERTICAL TURRET LATHES)	16.6	23.9	18.7	15.9	14.8	22.3	29.5	26.5	N.A.
GEAR CUTTING AND HOBBING TYPES	4.2	7.4	8.2	N.A.	9.6	16.0	27.2	24.9	N.A.
LATHES (EXCL. VERTICAL TURRET LATHES)	13.6	12.7	11.8	12.3	15.0	19.2	17.3	18.6	24.0
MILLING MACHINES	12.9	12.1	15.6	8.9	11.4	13.5	17.0	18.0	N.A.
DRILLING TYPES	8.8	6.4	7.0	6.5	6.2	10.9	10.1	14.2	17.6
GRINDING AND POLISHING MACHINES	8.0	8.2	9.3	9.3	10.5	14.2	13.2	14.8	15.4

(a) Dollar Values based on shipments of complete machine tools. N.A. - Not available.

Sources: U.S. Dept of Commerce Domestic Shipments -- "Current Industrial Reports, Series MQ-35W, Metal Working Machinery", and U.S. Bureau of the Census, "IM 146".

In 1964 21% of the world's machine tool exports were produced in the U.S. 29/ Today that figure has fallen to 7%. That is a 67% decline in the market share in just thirteen years, and it represents a substantial gain for the foreign machine tool industries. The top four machine tool producing countries are West Germany, United States, Soviet Union and Japan with 1977 estimated sales of $2.62, $2.35, $2.30 and $1.56 billion respectively. 34/ These four countries account for 59% of the world production.

Japan

The Japanese have set domination of the world machine tool market, including the U.S., as a national goal for the 1980's. 8/

Japan employs approximately 32,000 in the metal cutting machine tool industry. 34/ According to Japan's Machine Tool Builders Association, 110 companies belong to their association. These companies account for about 85 percent of total machine tool production in Japan.

According to a national sales manager representing seven Japanese machine tool builders, "The Japanese are significantly aware of the needs of industry and trend developments and are very sensitive to adding new technology to the products they are building. They are very quick to innovate and their manufacturing techniques are extremely advanced." 37/ A Japanese publication released at an international machine tool show reviewed the current trends of machine tool development in Japan. It was noted that most of the research and marketing efforts are being focused on the more-sophisticated machines. While it is unlikely that the Japanese intend to abandon the standard universal-type machine tool industry entirely, they are well along in developing the automation devices needed to operate unmanned machining lines. These lines will include grinding machines as well as lathes and machining centers. 38/

In January 1978 a check price system was established, on instructions from the Japanese Ministry of International Trade and Industry, after U.S. machine tool builders complained of unfair pricing of Japanese exports. The check price system and the rise in the Japanese yen value appear to have little effect so far on Japanese exports of NC lathes and machining centers to the U.S. The strong U.S. demand was attributed to several factors, including speedy delivery and enhanced quality of Japanese machines. U.S. machines tend to be more expensive and sophisticated. In addition, the Japanese NC lathe builders respond quickly to development trends. Executives from Japanese machine tool companies say that the Americans have just about given up in NC lathes and that there is hardly any competition among U.S. builders except in the field of heavy duty machines. The Japanese produce a machine far more suited to the needs of the smaller and medium-sized users. 39/

Whereas the U.S. machine tool industry has no "full line" manufacturers, this is not the case in Japan. In Japan, a wide variety of machine tools are manufactured by divisions of large corporations. The following paragraphs briefly describe several of the larger Japanese machine tool builders.

1. Misubishi Heavy Industries, for example, is a large firm which manufactures electronics, machine tools, consumers products, and a variety of other items. This enables Misubishi to support high levels of technology and at the same time manufacture almost all of the product in-house.

2. Toyoda Machine Works Limited does approximately $75 million worth of machine tool business annually. Grinding machines are their main product, having gained 50 percent of the Japanese market. Toyoda plans to install a flexible manufacturing system. They operate 20 percent of their own machines under numerical controls and the average age of all their machine tools is 11 years. 40/

3. Toshiba Machine Company Limited, with 1976 sales of $65 million, is one of the top four machine tool builders in Japan. According to an Air Force survey, Toshiba's manufacturing operations are modern in every respect. Numerical control is used to a greater extent than has been seen in U.S. machine tool companies. 40/

4. Okuma Machine Works is one of the avant-garde machine tool builders in Japan and the world. It was the first builder in Japan to produce its own numerical control system and specializes in unmanned manufacturing. Okuma uses its most advanced machines in its own production facilities. 41/ This is not the practice of most U.S. machine tool builders. Okuma is ranked in the top 10 Japanese Machine Tool Builders, with gross 1977 sales of about $50 million. They specialize in numerical control lathes and universal machine tools (i.e., those not targeted for a particular industry). Okuma has invested in an entirely new factory to build machine tools capable of machining a specific family of parts. Included in the factory were transfer line assembly operations. Machine tool sales failed to materialize and the factory was closed to be re-opened if the sales of all Okuma machine tools reach 50 per month. 40/

West Germany

The West German machine tool industry is characterized by its labor-intensive nature and high wages. Recently, West Germany began to experience many of the problems faced by the U.S. Machine Tool Industry.

1. In West Germany there are 450 to 500 firms employing 97,000 employees. 34/ Three-fourths of these firms employ less than 25 employees. There is a shortage of skilled personnel and the wage problem is critical. Total average hourly compensation

is $7.25 compared to $3.62 in Japan. 34/ Until 1971 the German machine tool manufacturers could compete in the U.S. market with equal machines (in some instances - superior due to lower prices). Since then, the situation has been practically reversed. Today German manufacturers offer similar machines at a price between 20 and 30 percent higher. For this reason sales propects are optimistic only for unique designs. 43/

2. Mass production is virtually an impossibility due to individual requirements and advanced technology. West Germany clearly lags behind its American competition in computer-operated machinery even though they are implementing computer aid manufacturing systems within their own machine tool factories. 44/

3. The Heller Company of Nurtingen is one of the largest machine tool manufacturers in Germany, employing 1600 people. It is currently developing a flexible manufacturing system to machine gear and mill head boxes. Another company, Heidelberg Press, installed a flexible manufacturing system in 1969 whose apparent success is such that there is great reluctance by the owners to show or document the system. 45/

Britain

Investment in machine tools in Britain has declined during the past several years.

1. The number of machine tools installed in the last 5 years was 21% less than in previous years. The average age of all machine tools is 14 years. 46/ In 1976, the Prime Minister of Britain publically criticized Britain's machine tool industry, saying it has become much less competitive. Over the past 10 years the world output of machine tools has risen while in Britain both demand and production have declined. The industry's share of the home market is also declining. Industry's products appear to be old fashioned and research and development expenditures have declined. 47/

2. Alfred Herbert, Ltd, a government owned British machine tool builder recently announced major cutbacks due to lack of orders and the decision to build more sophisticated machines. The company expects to produce fewer, more sophisticated machines, with less people. Although the recent cutback affects only 700 people, it brings Herbert's employment down to about 5,000 worldwide compared with 11,000 during the early 1970's. 48/

Reasons for Market Penetration

Where production volume and uniformity have been sufficient to interest foreign machine tool manufacturers, these firms have

been able to meet the technological challange of the U.S. Machine Tool Industry. In those cases where substantial market penetration has been made, foreign firms, especially Japanese, are offering technological innovations extremely attractive to U.S. machine tool users. Because of severe price competition, U.S. firms have been either unable or unwilling to commit research and development funds for these particular product lines. The foreign advantage of lower manufacturing costs has enabled them to move into the market and subsequently to take over in technology as well as market penetration. The capability exists in U.S. firms to reverse this process, but the economic incentive is lacking.

Foreign competition has proved especially difficult for U.S. producers to meet. Most foreign countries recognize the criticality of industrial production equipment to national productivity and support or subsidize production of machine tools in a variety of ways. In some cases this is done by direct government production, as for example in the Eastern European countries. In other cases, it is through subsidies of one form or another which encourage local industries to modernize their productive equipment base or through refund of taxes which provide for a reduction in the price of an exported machine. The situation is further complicated by the relatively high price of U.S. products. This latter problem has led many U.S. firms to turn to overseas production of their machines, with the net result that many so-called "American" products sold by U.S. firms are produced overseas. In the case of competition from Communist countries, exports may be subsidized for political reasons. In some cases this is done to enhance their technological image and in other cases to obtain hard currency for foreign exchange. In these cases quotas may be established for a particular country without regard to the market and the sales effort and price adjusted to place the desired number of machines in that country. 49/ Even if laws prevent this sort of marketing in the U.S., these machines are in competition with the exports of the U.S. industry.

U.S. machine tool exports have also been limited by rules for export licensing established under the International Coordinating Committee (COCOM). The U.S. has been more restrictive in enforcing COCOM regulations than the other participating countries. In some cases, at the insistance of DOD, machines have been added to the list requiring export licenses. Machine tool builders have complained that they have seen machines on the U.S. restricted list shown at East European machine tool shows by COCOM participants. Machine tool producers claim they are placed at a disadvantage in competing for East European business. 29/

Off-set agreements made in connection with foreign military sales provide an additional incentive for importing machine tools. In a number of instances where the U.S. has agreed to accept imports from a foreign country in payment for military hardware, machine tools are among the principle products available for import. 29/

VIII. TECHNOLOGY - UNITED STATES

Computers and Control

A technological revolution in manufacturing, world wide has been initiated. The main tool for accomplishing that revolution has turned out to be the digital computer. Many industrialized nations have launched major programs to promote computer control, automation and optimization of manufacturing in their industry. Many are devoting the major portion of their national manufacturing technology funding and manufacturing R&D funds to these programs. 50/

Machine tools are becoming mechanically simpler yet more capable. Technological developments in electrical and electronic control are bringing new capability at lower manufacturing cost, with increased reliability. 51/ Numerical control is being applied to both the cutting tools and metal forming machines.

Research and Development Efforts

Changes in machine configuration required by adaptation to electronic controls have increased research and development effort. Recent developments in cutting tools have also made many earlier machines obsolete. The newer cutting materials have increased speeds and feeds to such an extent that major re-design efforts are required to accommodate the increased speeds and horsepowers. This places a research and development load on small firms who are ill-equipped to handle such a load.

The U.S. machine tool industry has always been noted for its superior technology. This is still generally true, but the U.S. advantage has deteriorated in certain areas. In some cases economic pressures have forced U.S. firms to abandon certain segments of the market to the foreign competition. In these areas technology has been allowed to lag behind foreign competition. In most cases the technological position could be recouped if the economic conditions were favorable. The price competition provided by foreign imports, however, has limited funds available for research and development efforts.

A survey of 43 machine tool firms indicated that an average research and development expenditure was about 1.5% of sales. Industry leaders perform independent broad-based research to improve overall machine tool capabilities. Due to the lack of resources, however, the smaller companies do not perform this broad research, but instead colloborate with customers in

meeting specific requirements. Over the past 10 years, the U.S. has been devoting a decreasing percentage of its GNP to research while R&D investments in Japan, West Germany and the Soviet Union have increased. 29/ The U.S. now only spends 2 percent on R&D compared with a high of 3% in 1964. 53/

Forecasting

A study of trends in technological innovation has measured the time lag between invention and innovation. This process is a multistep one with many contributing factors. Some of the steps are: conception, invention, prototype, specifications and acceptance. The process ends with recovery of investment. The tangible factors that influence the process are: material resources, labor, and capital. Environmental factors such as government intervention and market structure also affect the process. 54/ National measures of the time lag between invention and innovation indicate that the U.S. does not have a competitive advantage in moving new technology through the process of innovation to the market place. International technology transfer is more likely to occur in the United Kingdom, West Germany, Japan, or Canada, than in the U.S. or France. These conclusions are qualitative and are only broad indicators of trends. 54/

Tabulations of patent activity provide one way of gaging changes in technology. Activity in patents on metal working machinery and equipment has peaked in 1965, 1969, and 1971, but there has been a steady increase in the portion that originated in other countries. In 1963, 84% originated in the U.S. In 1972 this had fallen to 67% of the total. In 1965 there were 2642 patents on metalworking machinery of U.S. origin. By 1973 this was down to 1976. 55/

Several Delphi type forecasts have predicted the availability and adoption of computer automated manufacturing and manufacturing optimization systems during the 1980's and a major shift in the design and application of machine tools, away from "stand-alone" use toward incorporation in versatile manufacturing systems. 56/

U.S. industry leads the world in the production and use of numerically controlled machine tools. 1/ Seventy-five percent of today's machine tools are being used in low to medium-volume production. This area has the major potential for numerical control, computer numerical control and direct numerical control. 11/ The Delphi Forecast of Manufacturing Technology recently performed by the Society of Manufacturing Engineers predicts that application of numerical control will exceed 33%

of machining output in plants employing less than 30 workers by 1987. 57/ The majority of this output will be produced by machining centers, since flexibility to respond to changing demand is becoming increasingly important, and flexibility is a major advantage of machining centers.

State-of-the-Art

The U.S. is still the world leader in machine tool engineering and design and in the production of the more technologically advanced machine tools, but the gap is constantly narrowing. 29/ Two main reasons for the closing gap are the aggressive marketing efforts of other countries and the transfer of technology via multinational corporations. (For additional information on multinational corporations see the last segment of this Section.) U.S. firms are exporting technology to maintain world market position and earnings.

After pioneering numerical control 25 years ago, the U.S. now leads in adapting microprocessors into machine tools. While many machine tool builders outside the U.S. are developing and implementing their own numerical control technology, the U.S. has taken another technological step forward with microprocessors. 58/

Although the U.S. Machine Tool Industry has not widely adapted flexible manufacturing systems within their own plants, they have developed and installed advanced systems for other industries. For example the U.S. auto industry, a major user of machine tools, recently announced its first formal request for quotations for a flexible machining system for low- and mid-volume parts. 59/ U.S. machine tool builders feel optimistic about meeting the automakers needs. Examples of parts currently being made on flexible manufacturing systems include airplane engine components, diesel engine components, off-highway transmission housings and truck transmission cases and covers. Overall there were more flexible metal cutting systems displayed at the 1978 International Machine Tool Show then ever before. These included displays by Giddings & Lewis, Kearney & Trecker and Cincinnati Milicron.

Technological Challenge

If the economic incentive is present, the U.S. Machine Tool Industry can generally meet the technological challenge. Cincinnati Milicron was recently faced with the possibility of losing major customers of broaching machines when General Motors anticipated broaching problems with new thin-walled cast iron and aluminum engine blocks. Milicron builds virtually all of the broaches used

in engine lines to machine mating surfaces for cylinder heads, exhaust manifolds and main bearing journals. To preserve its market, Milicron started a R&D program and apparently has solved the problem by changing tooling, broaching speeds and alloys. 60/

Multinational Corporation

There is a marked tendency on the part of a growing number of U.S. firms to export technology as a means for maintaining world market position and global corporate earnings. These technology exports are on the balance, beneficial to the U.S. economy in the sense that, unless the U.S. firm moved (or sold) its technology abroad, it would lose market share and suffer a net decline in earnings. 61/

The multinational corporation is basically a product of modern technology. The combination of superior technology and managerial skills provided the economic advantage necessary to establish subsidaries in foreign countries. This assists the transfer of technology from one geographic area or nation to another. Although the figures on multinational corporations are not precise, the U.S. Department of Commerce estimates sales by majority-owned foreign affiliates of U.S. companies totaled $291.5 billion in 1973. 62/ Of course the inverse of this is also true. European corporations in most cases do not invest in U.S. subsidiaries to acquire U.S. technology, but to exploit their own technology. Researchers discovered that the direction of the flow of technology between the European parent and the U.S. subsidiaries was over whelmingly into the U.S. by a ratio of 5 to 1. 63/

IX. TECHNOLOGY - FOREIGN

Government Assistance

Virtually all of the industrial nations of Europe and Japan have established formal productivity centers to develop, promote, and enhance productivity in their respective countries. These centers generally focus on management technology and productivity improvement in the service sector of their economies. They do not play a major role in the process of manufacturing technology invention, innovation, or diffusion. Some of their activities include: managerial exchanges, extensive expansion of training facilities for European management and labor, pilot plant development and advisory and informational programs for particular manufacturing branches, including agriculture, marketing, distribution, and the building industry. The European Association of National Productivity Centers includes 16 countries. The United States has no comparable institutional arrangements and no formal national productivity or technology development goals. 64/

Foreign nations offer subsidies, grants, loans, tax write-offs and special incentives to promote industry. They set up non-tariff barriers that give them an advantage in world markets. 8/ Eastern European nations belonging to the Council for Mutual Economic Assistance (COMECON) cooperate internationally and divide manufacturing R&D into hardware and software development. 50/ Guidelines have been established for modules and their interfaces and the various countries divide up the work of developing the modules, working to these guide lines.

Consortia arrangements are encouraged in many foreign countries. The advantages of consortia are that they avoid duplication of research, pool resources and spread risks. 65/ These cohesive units, made up of government agencies, universities, private industry, trade associations, societies and labor unions, cooperate to improve manufacturing technology. Their specific activities include: formulating and achieving national goals for productivity, effectively channeling available public and private funds, distributing information between organizations, carefully screening potential projects and recommending better use of research and manufacturing facilities. 64/

Japan

As shown previously in Table VII-1, Japan is the principal foreign competitor for the U.S. machine tool market, supplying, about 4.2% of U.S. machine tool consumption in 1977. The postwar

economic "Miracle" in Japan caused the rest of the world to take note of the distinctive features in its business industry, such as lifetime employment patterns, wages determined by seniority, warm bonds of personal loyalty between bosses and workers and close cooperation between government and business. 66/ Today, Japan is the largest and most technologically advanced shipbuilder in the world. Japan is the third largest producer of steel and is second only to the U.S. in the auto industry. 62/

Japan's success in the machine tool industry is due to a very large amount of government funding, direct and indirect, for development and implementation of advanced manufacturing technology. 50/ The Japanese government has established a complicated system of interlocking industrial agencies and has participated in a large number of technology enhancement programs. Large scale programs involving active support and participation by the central government began in Japan in 1961. The Research Development Corporation of Japan was established as part of the technology enhancement program. The Corporation provides funding for high-risk scientific projects with industrial application potential. This program has been immensely successful; the ratio of success in development exceeds 90 percent. Two-thirds of its current operating budget derives from returns on earlier investments. The National R&D Program fully subsidizes nine projects that are laying the foundation for the development of whole new industries. There are a large number of joint projects between the Japanese government and industry. The government also uses a number of tax incentives to encourage private investment in R&D and diffusion of newly developed technologies. 65/

Japanese universities appear to be widely separated from industry. Few of the faculty have worked or consulted with industry. University research is theoretically oriented, rather than orientated towards practical applications for industry. There is little or no industrial funding of education or research and no contributions of funds for laboratory equipment. However, through a network of committees formed by government agencies, the academic community in Japan is able to effectively contribute to manufacturing research. These committees are formed for specific tasks, such as guidance in the case of the Methodology for Unmanned Manufacturing Projects, and include governmental, industrial and academic representatives. 67/

Most research and marketing efforts in Japan are focused on the more sophisticated machines. Japan, for example, is on a par with U.S. industry in the area of electronic control of machine tools. At a recent annual meeting of the American Institute of Industrial Engineers, the Honorable Kohei Goshi,

Chairman of the Board of the Japan Productivity Center presented a paper on Japan. He indicated one of the major factors behind Japan's remarkable advances was the transfer of technology to Japan from American and European countries. 61/

One area where the Japanese seem to have an advantage is in regard to standarization; this is encouraged by the Japanese system for dividing up markets to avoid having Japanese firms competing with each other in foreign markets. Most Japanese builders use numerical control systems built by the Japanese firm, Fujitsu-Fanuc, while the U.S. and European machine tool builders have married their machines to several kinds of numerical control systems. Fanuc probably produces more numerical controls than any country in the world. Japanese builders have more standarized designs for automatic tool changers than is the case elsewhere. Their mechanisms are standarized and the machining capacities are in uniform increments. In the U.S. and Europe, tool changer magazine capacity is not standarized. 68/

Integration of the mechanical and electrical parts of numerically controlled machine tools has become an established trend in Japan where 60 percent of the numerically controlled lathes and 40 percent of the machining centers are now built using this concept. In conventional machines, a standard induction motor is used which requires gears, belts, and other parts to drive the spindle. With a direct current spindle motor, the motor itself is a part of the spindle head. Simplification is accomplished by controlling the motor electronically. 39/

Japan has accomplished major implementation of computer-controlled manufacturing systems in industry - several are the most advanced in the world. 50/ Japanese machine tool builders are persuing three different avenues in development of the ideal flexible machining system. Interest in systems for batch production of a wide range of parts is so keen that development of one of the three approaches has been designated a six-year national project. The national project, which started last year, is concerned with the building block modular approach, employing standardized modules of beds, tables, columns and other parts of a diversified machining system, whose production capabilities can be expanded or reduced to meet the manufacturers needs. This concept was originated by Kearney & Trecker in their Moduline machine which can be converted into about 40 types of machines from a single system using modular components.

The other two flexible machining system concepts include direct numerical control and technology aimed at giving flexibility to a single machine by adding four 30-tool drums and at least two work tables capable of handling different workpieces. 39/

At present there are close to 100 direct numerical control systems operating. Interestingly enough, pratically all of these employ Fujitsu Fanuc's controllers.

Yamazaki Machinery Works introduced "flexible machining-single machine" technology. In this system the machine moves to the workpiece while conventional systems require transporting the workpiece to the machine or machines. Yamazaki has implemented this concept to machine frames for punch presses and lathes, reducing operator personnel from six to one. Yamazaki is planning to install one of these systems at its Florence, Kentucky plant and employ it for the production of lathes. 39/

West Germany

West Germany is the second largest supplier of foreign machine tools to the U.S., supplying about 3.6% of machine tool consumption in 1977. 34/

In West Germany, unlike Japan, direction is provided by a combination of Federal and State government, the academic community and the private sector. West Germany gives tax incentives to encourage research and supports projects with low interest or no-interest loans for which repayment may be excused in case of failure. 65/

There is a very close working relationship between industry and the universities in West Germany. Some observers have gone so far as to say that, in West Germany, universities are the research arm of industry. Their faculties consult and have joint projects with industry. In fact, it is typical for PH.D.'s to have a period of industrial employment before becoming a part of the permanent academic staff. Industries also provide research funds and laboratory equipment for universities. 67/ The University of Berlin operates a large, well organized, program in its Institute for Machine Tools. 69/ The University of Stuttgart has an extensive research program in industrial manufacturing systems. Their program is divided into three institutes: Institute for Machine Tool Control Systems, Institute for Production and Automation and Institute for Machine Tools. 69/

There is a high percentage of students studying manufacturing - 6.01% in West Germany, compared to only 0.37% in the U.S. 67/ At one major West German university, 2500 undergraduates were studying manufacturing. This may be more than the total number studying manufacturing at all U.S. universities.

German consortiums for machine tool technology development have been established. 8/ The funding of machine tool research

in Germany is complex, with government and industry supplying funds both to technical universities and the research departments of some large producers. 70/ There is an informal, but nevertheless structured, institutional relationship which enables the West German government to pour millions of dollars into computer aided design and computer aided manufacturing machinery. 64/ According to a research engineer at the Institute for Machine Tool Technology at the Technical University of Berlin, the current major research areas in Berlin are production technology and automation processes. 70/

A consortium of four universities, Berlin, Stuttgart, Aachen and Hanover, and representatives from industry and industry associations, with the encouragement and participation of the government, are undertaking technology development programs as a cooperative effort. The universities' work is supported jointly by government and industry on roughly a fifty-fifty basis. Each of these four universities has developed specialized knowledge centers focused on individual manufacturing functions such as turning, milling, forming, computer control and computer design. Each of these universities can stand alone as a productivity center in their own area. 8/

The Confederation of Industrial Research Associations is a non-profit organization of 78 research associations which represent 60 percent of West Germany's total industrial production. They are operated by the industrial sectors they represent. These industrial sectors are composed of a large number of small firms, many of which lack R&D facilities. The purpose of the Confederation is to foster and assist in funding cooperative research performed by member associations. 65/

France

The French government has also been involved in technology enhancement programs. The General Delegation for Scientific and Technical Research is the principal agency which dispenses government development funds. This program has a great deal of influence because of the large number of nationalized industries. Nearly 10 percent of the industrial output in France is produced by government owned factories and about 30 percent of French industrial investment is government funded. 65/ France has an association composed of the fifty largest firms to promote technology applications to increase productivity in small and medium-sized firms. Nearly 50% of the funds come from the French government. The French government approved a plan costing the equivalent of $160 million to help develop the country's electronic and machine tool industries and make them less dependent on imports. The machine tool industry will receive

special development contracts underwritten by the government and special emphasis will be placed on research and training to increase growth in the field. 71/

Other Free World Nations

Government programs help the machine tool industry in many countries.

1. The British government has committed nearly $28 million to the metalworking industry to develop the use of microprocessors. 72/

2. Until the 1950's, very little of Canada's R&D was Canadian based. Technology was imported from parent companies in other countries. The Canadian government then initiated a number of programs to establish Canadian R&D. The National Research Council has the largest budget, $134 million, of science funds among all government agencies. About 70 percent of its laboratory research effort pertains to items which will have industrial use. 65/ The National Research Council also pays the salaries of engineers and scientists in approved R&D projects and acts as the government's primary patent licensing agency. Canada, like many other countries, has tax incentives. Expenditures for scientific research may be deducted and there is an accelerated depreciation allowance for certain research related machinery. 65/

3. Korean manufacturers can supply standard boring, drilling, sawing, filing and cutoff machines. The Korean government is now making generous loans available to Korean industry for upgrading and expansion, particularly to machine tool users. 73/

4. Norway has an association, made up of the University of Norway, the Central Institute of Industrial Research and four of the country's leading industrial concerns, that cooperates to develop technology. 8/

Eastern Europe

Technological developments in the machine tool industry of Eastern Europe appear to be centered on improving the sophistication of the controls and accessories to increase productivity. 74/

1. Russia has two government institutes carrying on computer aided manufacturing programs, one for hardware and one

for software. ENIIMS, the government machine tool institute in Moscow, has an operating prototype computer-controlled manufacturing system. This institute has a long range plan to develop large, fully computer automated factories. The main developments needed to make these practical are full adaptive control of machining parameters and robot systems capable of working effectively in small-lot production. 50/ There is a shortage of computer numerically controlled machines in the Soviet Union. 74/

2. The Democratic Republic of Germany has a national effort to promote manufacturing technology for machine tools. They are expending considerable effort to apply new technology to batch process manufacturing and computer numerical control. East Germany appears to be among the world leaders in flexible manufacturing systems. One system, the Prisma II, is among the most sophisticated flexible manufacturing systems in the world. Sixty percent of the resources for development of Prisma II came from the national budget. 45/ Production of computer numerical control units has not actually begun, but the development work has been completed. It is expected that microprocessor technology will be available on their machine tools beginning in 1980. For now, East Germany sells Western-built computer numerical controls with its machine tool exports to the West. 74/

3. The Czechoslovakian programs tend to have a rather strong hardware orientation. One of their latest programs is a 5-year (1976-1980) program, funded with $100 million, to develop 5 advanced prototype computer controlled manufacturing systems. The government machine tool institute in Prague received the funding and will design, develop and build the systems through contracts with 5 different machine tool builders. 8/

4. In Poland modernization of machine-tool plants is being accomplished at Pruszkow and new plants are being built in Tarnow and Zawiercie. 42/

X. CONCLUSIONS

The U.S. Machine Tool Industry is in the midst of a dynamic period of economic change. Numerous small firms find themselves confronted with factors largely beyond their control, which threaten their very existence:

1. Introduction of high level technology to the industry has mandated research and development programs beyond the capability of many small firms.

2. High U.S. production costs have fostered strong foreign competition for many standard "bread and butter" products.

3. The severely cyclical nature of machine tool orders creates financial constraints on maintaining an orderly investment program.

4. Critical shortages of skilled workers limit the ability of the industry to meet peak demands.

The industry is currently undergoing a shake-out of numerous small firms. These are either being acquired as divisions of larger firms, merging with other firms or going out of business. This results in the consolidation of the industry into fewer, larger firms who are better able to support the necessary levels of investment and other programs required by today's industrial climate. This has happened in the past in the automotive industry, the farm equipment industry, the refrigeration industry, and other consumer product industries.

The U.S. Machine Tool Industry has been noted for its leadership in technology and, in general, continues to hold this lead. Equivalency in technology has developed in areas which have been invaded by strong foreign competition, especially lathes, boring machines and gear cutting and grinding machines. The U.S. industry leads in the adaptation of microprocessors to machine tool control and is increasing its efforts in developing and implementing flexible machining systems. Flexible machining systems integrate programmable materiel handling equipment with computer numerical control and direct numerical control machine tools. Transfer equipment such as shuttle pallets, robots, positioning equipment and automated clamping devices can be used to lower labor costs and enhance productivity in batch process manufacturing of various sizes of families of similar metal products. The foreign machine tool builders are building such systems to use in their own plants. Many of them are receiving financial aid from their governments and assistance from the universities.

Productivity in the machine tool industry has been declining. No data is available to determine which segments of the industry account for this decline. The larger machine tool companies have been investing heavily in productivity improving numerical control machine tools. This prompts the conclusion that it is probably the smaller firms who have become less productive and therefore more vulnerable to foreign competition. These firms do not need new machine tools to increase productive capacity and cannot afford an investment program to increase productivity.

The cyclical nature of machine tool orders is one of the industry's most critical problems. Because all machine tool builders expect sudden and precipitous declines in orders, they are reluctant to commit themselves to investment programs which will increase fixed costs during slack periods. This especially inhibits investment in new production equipment whose fixed charges continue whether the equipment is in use or standing idle during a period of low orders. The larger firms, or those operating as a division of a large industrial corporation, manage to overcome these problems, but at an increase in the cost of U.S. manufactured machine tools.

There is currently a critical shortage of skilled personnel for manufacture of machine tools in the U.S. Personnel continually leave the industry during slack times for more secure employment in less volitile industries. The precise nature of the manufacture of machine tools requires skilled machinists whose training normally requires several years. This cadre of workers cannot be increased rapidly, leading to large backlogs and long lead times during business upturns.

This personnel problem is probably the most critical factor in considering the industry's ability to support industrial mobilization. Comparing past sudden increases in machine tool orders with industry shipments shows that shipments build up much more slowly as personnel are hired and trained to add production. During this period, backlogs and lead times increase. Use of Defense Priority System ratings could, of course, take production from non-rated orders, but would do little to increase overall machine tool production.

Use of priority ratings to move defense orders ahead of commercial orders during peace time would probably be extremely unpopular and would be resisted in many cases. The volume of defense related business in machine tools is not sufficient to place the government on most machine tool builders "highly valued customer" list. Any interference with commercial customers would be resented. Interviews with machine tool builders indicated that

most accept rated orders during peace time only because they are permitted to schedule them in the normal course of business. Political pressure would undoubtedly be applied if enforcement of ratings interfered with other business.

Import of foreign machine tools into the U.S. is eroding the domestic production base for certain types of tools. These are mostly the more "standard" type of machines, especially lathes, boring machines and gear cutting equipment. DOD purchases of foreign machine tools have had a negligable effect on this trend, since they have not been a significant share of the imports. Foreign purchases by DOD which have been publicized, however, have been strongly resented by machine tool producers.

Certain machine tool components would be a critical problem in any attempt to expand machine tool production during a mobilization. Large castings, ball screws, servo components and electronic equipment were cited by machine tool builders as examples. Many components are specialized and production volumes are not sufficient for automated production. These items tend to be labor intensive and capacity is limited by the same skilled manpower shortages which limit the machine tool producers. In many cases the small firm supplying these components have the same productivity improving investment problems as the machine tool builders themselves.

Government procurement practices "turn off" many machine tool builders from doing business with the government:

1. The overly complex specifications which attempt to specify tool construction rather than performance requirements, interfere with normal commercial practice.

2. The volume of forms and data become a critical overhead burden, especially for smaller firms who can not afford personnel specializing in compliance with these requirements.

3. The practice of seeking competititve bids after a supplier has spent considerable time and money helping the government develop a solution to its problem stifles this type of assistance.

APPENDIX A. References

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310

27 MAR 1978

SARDA

SUBJECT: Problems in the Machine Tool Industry

Commander
US Army Materiel Development
and Readiness Command
ATTN: DRCPP
5001 Eisenhower Avenue
Alexandria, VA 22333

1. Request preparation of a response to the attached letter for Dr. Pierre's signature. That response should identify someone within the Army who will meet with Mr. Flick to discuss the problem. Request a reply by 3 April 1978.

2. In addition a serious look must be taken at the problems identified in the letter and within the machine tool industry as a whole. Request a recommended plan of action be prepared which results in a briefing for Dr. Pierre giving the results of your findings and appropriate recommendations. A planning date for this briefing is 28 April 1978; however, request you confirm a final date with this office.

FOR THE ASSISTANT SECRETARY OF THE ARMY (RDA):

Arthur Daoulas

ARTHUR DAOULAS
Colonel, GS
Assistant Deputy for
Materiel Acquisition

Incl
as

DEPARTMENT OF THE ARMY
HEADQUARTERS US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND
5001 EISENHOWER AVE., ALEXANDRIA, VA. 22333

DRCPP-IO

5 JUN 1978

SUBJECT: Study of Problems Associated with the Machine Tool Industry

Director
US Army Industrial Base Engineering Activity
Rock Island, IL 61299

1. On 28 Mar 78, this Headquarters was tasked by the Assistant Secretary of the Army (Research, Development and Acquisition) to examine various problems associated with the domestic machine tool industry, Incl 1. These problems were the subject of letters written to the President and the Assistant Secretary of the Army by Mr. Mark Flick of Cincinnati, Ohio, Incl 2. HQ DARCOM sent an initial reply on this matter to ASA (RDA) on 6 Apr 7, Incl 3.

2. IBEA is now tasked to conduct a preliminary study of the domestic machine tool industry, to issue a written report on the study findings and to present a briefing to Dr. Pierre, ASA (RDA), on the findings and offer any appropriate conclusions and recommendations concerning the industry's problems, including recommendation for further detailed study. It is understood that a complete study requirements and a definite time schedule for the study effort cannot be determined, until a meeting is conducted between Mr. Flick, representatives of HQ DARCOM, and IBEA in Cincinnati, Ohio, in late June. Final details for this meeting will be released at the earliest possible date.

3. However, in order to expedite the beginning of the study effort, the following preliminary subject areas should be addressed. Additional study topics may be developed as a result of the Cincinnati meeting and may be incorporated following that meeting.

a. Initially, the study should address the causes and effects of the industry-wide 18 to 24 months manufacturer's leadtime associated with machine tool purchases for the Army as well as most DOD production programs. The XM-1 tank program and the M-109 Surge Study from ARRCOM will provide ready references concerning the effects of the leadtime on procurement of Industrial Plant Equipment.

DRCPP-IO 15 JUN 1978
SUBJECT: Study of Problems Associated with the Machine Tool Industry

b. The effect of a DX priority rating, should its application be expanded to include production facilities, as a means of gaining procurement priority with machine tool manufacturers, also should be investigated. Once again, based on experiences with the XM-1 tank and the M-109 SP Howitzer programs, there appears to be a widespread misunderstanding on the part of both contractor and government personnel as to the effect a DX rating can have on reducing the procurement time of machine tools.

c. The study should examine the present status of the domestic machine tool industry and report on the industry's ability to meet current private and governmental industrial machine tool demand requirements.

d. The study should attempt to determine if there is, in fact, an erosion of the domestic machine tool production base, caused by United States machine tool buyers purchasing foreign produced rather than domestically made machines. (Mr. Flick's criticism of DOD Industrial Plant Equipment procurement programs seems to be centered around this matter of foreign procurement of IPE.)

e. The study should also investigate the technical standing of the domestic industry's products and manufacturing techniques as compared to those of foreign manufacturers.

5. In order to conserve time and resources, the study effort should make maximum use of any existing reports or previous studies relative to the current study effort.

6. DARCOM Headquarters point of contact for this study is Captain Corker, DRCPP-IO, AV 284-8218.

FOR THE COMMANDER:

3 Incl

CHESTER W. McDOWELL, JR.
Colonel, GS
Associate Director for Industrial Base
Directorate for Procurement
and Production

APPENDIX B. Bibliography

APPENDIX B. BIBLIOGRAPHY

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APPENDIX C. Machine Tool Industry Productivity

MACHINE TOOL INDUSTRY PRODUCTIVITY

A productivity index for the machine tool industry was developed for comparison to the data on Productivity in Manufacturing for selected countries, including the U.S., published by the U.S. Department of Labor, Bureau of Labor Statistics. Bureau of Labor Statistics data for the countries listed in Table IV-1 are shown in Table C-1. The average percent change figures were calculated from the data shown for 1967 and 1977 by use of the compound growth formula,

$$\text{Final Index} = \text{Initial Index } (1 + \text{Growth})^{\text{Years}}.$$

Upon solving this formula for growth and substituting an Initial Index value of 100 and a period of 10 years it becomes:

$$\text{Growth} = (\text{Final Index}/100)^{1/10} - 1.$$

The Growth given by the formula is expressed as a ratio. This has been converted to a percentage for Table IV-1.

The productivity indexes published by the Bureau of Labor Statistics measure labor productivity, i.e. physical output related to manpower used. To prepare a comparable measure for the Machine Tool Industry, it is necessary to have some measure of the physical output of the industry. Since available physical statistics on the industry output can not be added to form an overall industry output series, another measure must be used, e.g. the total industry shipments expressed in dollars.

There are two problems with dollar shipment figures which must be resolved. Not all of the goods shipped are produced by the machine tool industry, materials and some components are purchased, and the dollar figures include price increases necessitated by both quality changes and inflation.

The first problem is handled by deducting the cost of purchased materials from the shipments. This yields a data series measuring the increase in value of the products as they pass through the industry's manufacturing plants, i.e. the "value added" by the efforts of the industry's employees.

TABLE C-1

PRODUCTIVITY IN MANUFACTURING
Indexes, 1967 = 100

Country	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
United Kingdom	100.0	107.1	108.4	108.6	112.9	121.2	126.3	127.6	124.4	128.7	126.6
United States	100.0	103.6	104.9	104.5	110.3	116.0	119.4	112.8	116.3	124.2	126.9
Canada	100.0	107.3	113.3	114.7	122.8	128.1	133.4	135.6	133.4	137.8	143.3
Italy	100.0	108.4	112.2	117.8	123.5	132.9	147.8	155.9	150.2	161.5	162.3
West Germany	100.0	107.6	113.8	116.1	121.4	128.7	136.6	145.0	150.4	162.8	169.6
France	100.0	111.4	115.4	121.2	128.5	136.8	143.7	147.8	151.1	165.3	171.6
Japan	100.0	112.6	130.0	146.5	150.5	161.0	179.0	180.3	172.4	194.8	206.6

Source: U.S. Department of Labor, Bureau of Labor Statistics

Solution of the second problem involves adjustment of the resulting series to remove the effects of inflation, but to leave price changes caused by quality improvements. The Wholesale Price Index, published by the Bureau of Labor Statistics, solves part of this problem. This index measures, as nearly as possible, only those price changes which are due to inflation. The adjustment is accomplished by dividing the Value Added series by the corresponding price index, expressed as a ratio to the base year value.

Table C-2 shows these adjustments. Separate adjustments have been made for Metal Cutting Machine Tools and Metal Forming Machine Tools. The Department of Commerce Industry Shipments and Industry Cost of Materials series are used to calculate an unadjusted Value Added series for each industry. These series are then adjusted to remove the effects of inflation by dividing by the corresponding Bureau of Labor Statistics Wholesale Price Index divided by 100 (the base year value). The resulting constant dollar value added series, each representing physical output of an industry segment, are then added to produce a series representing the physical output of the Machine Tool Industry. This series has also been converted to an index for use in plotting Exhibit IV-2 by calculating the ratio to the base year, 1967, and expressing the result as a percentage.

Table C-3 shows the calculation of the productivity index. The Constant Dollar Value Added series is divided by the Industry Employment to produce a series of Constant Dollar Value Added per Employee or, in other words, a Productivity series. The Employment series and the Productivity series have been converted to indexes for use in plotting Exhibit IV-2.

The Growth in productivity has been determined in a manner similar to that used for the National index. However, data for 1967 and 1976 were used since a 1977 value is not available. The elapsed period is nine years, the formula becomes:

$$\text{Growth} = (\text{Final Index}/100)^{1/9} - 1.$$

Application of this formula yields a minus growth rate, expressed as a percentage, of .96% per year.

TABLE C-2

INDUSTRY SHIPMENTS AND VALUE ADDED
Development of Constant 1967 Dollar Value Added Index

Year	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
METAL CUTTING MACHINE TOOLS										
Shipments	2,127.2	2,099.1	2,108.3	1,821.7	1,351.1	1,418.1	1,891.1	2,480.5	2,727.8	2,496.2
Purchased Material	766.9	718.9	744.5	664.0	473.2	536.3	764.1	1,017.9	1,050.3	852.3
Value Added by Mfg	1,391.3	1,377.1	1,441.5	1,112.1	819.8	901.7	1,214.1	1,617.0	1,640.3	1,664.1
Price Index	100.0	103.0	106.8	113.5	117.1	120.2	128.2	152.0	177.1	190.9
Value Added 1967 $	1,391.3	1,337.0	1,349.7	979.8	700.1	750.2	947.0	1,063.8	926.2	871.7
METAL FORMING MACHINE TOOLS										
Shipments	714.0	718.2	726.5	776.1	667.7	693.6	886.2	1,099.3	1,106.6	1,070.7
Purchased Material	295.4	270.0	290.2	328.6	278.0	285.3	370.8	505.4	483.2	433.9
Value Added by Mfg	437.2	453.3	453.1	469.6	363.9	417.7	546.5	633.7	618.3	621.1
Price Index	100.0	104.1	107.4	115.6	121.0	125.3	133.0	161.7	192.2	212.9
Value Added 1967 $	437.2	435.5	421.9	406.2	300.7	333.4	410.9	391.9	321.7	291.7
MACHINE TOOL INDUSTRY										
Value Added 1967 $	1,828.5	1,772.5	1,771.6	1,386.0	1,000.8	1,083.6	1,357.9	1,455.7	1,247.9	1,163.4
Value Added Index	100.0	96.9	96.9	75.8	54.7	59.3	74.3	79.6	68.2	63.6

Notes: 1. Values in Million Dollars
2. Indexes 1967 = 100
3. Sources: U.S. Department of Commerce, Bureau of the Census
U.S. Department of Labor, Bureau of Labor Statistics

TABLE C-3

MACHINE TOOL INDUSTRY
Development of Productivity Index

Year	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Value Added 1967 $	1,828.5	1,772.5	1,771.6	1,386.0	1,000.8	1,083.6	1,357.9	1,455.7	1,247.9	1,163.4
Employment	116,400	112,200	110,600	100,200	78,400	76,600	86,900	94,000	88,800	81,000
Value Added per Employee Const $	15,709	15,798	16,018	13,832	12,765	14,146	15,626	15,486	14,053	14,363
Employment Index	100.0	96.4	95.0	86.1	67.4	65.8	74.7	80.8	76.3	69.6
Productivity Index	100.0	100.6	102.0	88.1	81.3	90.1	99.5	98.6	89.5	91.4

Notes:
1. Value Added in Million Dollars
2. Employment in Number of Employees
3. Value Added per Employee in Dollars
4. Source for Employment, U.S. Department of Commerce, Bureau of Census
5. Indexes 1967 = 100