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Machine Tool Industry, 1993

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Backup Off. Mr. Cho, FTD/IR/GLO

Machine Tool Industry, 1993 (ISIC 3823)

1. Recent trends and current conditions

The world production of machine tools capped seven continuous years of growth in 1990 to peak at \$45.5-billion, then declined by 10% in 1991 and by more than 19% in 1992. The two-year loss in output was thus more than 28% and brought the total production down to \$32.5-billion. The collapse of markets in Eastern Europe and the former USSR combined with a recession that was nearly worldwide to bring decline to every region of the world except Asia. And in Asia the principal producing countries also declined while those just emerging as producers continued to grow. Consumption followed a similar pattern, though declines in consumption were generally greater in those countries that are most developed. Production and consumption for major regions are summarized in Figures 1 and 2. Western Europe continues as the major region for both production and consumption with the single country of Japan ranking second. Western Europe and Japan produce 72% of the world's machine tools, but these regions consume only 56%. The other regions are all net importers, consuming more than they produce. [1]

(a) Production

Table 1 reports individual countries in each region that are major producers and for which data are available. The regional totals in this table include estimates for other

countries in the region based on the trade data reported by OECD countries. Japan, the largest producing country, had the largest decline, \$3-billion. That was 30% in yen, but the stronger yen reduced it to 26% when converted to dollars. Even so, Japan produced about one-fourth of the world's machine tools in 1992. Germany, the second most important producer, had a decline in production of \$1-billion, 17% when measured in Deutschemarks, but only 11% when converted to dollars. The decline left Germany with 22.5% of world production. The United States, once the major producer, moved up to third place because its decline was only a little over 2%, while Italy dropped to fourth place with a decline of 12%. The principal exception to the general decline was China, where production increased by \$293-million, a 24% increase when measured in the internal currency used by China. That was reduced to 20% when converted at the official rate for the Yuan, China's international currency. This made China the fifth largest producing country. Two countries of the former USSR had a level of production that would have slightly exceeded that of China, but separately Russia was 7th and Ukraine was 11th. Each had drastic declines in production as did all the countries of Eastern Europe.

Switzerland, United Kingdom, France, Spain, and Sweden were the other European countries among the 15 largest producers. In Asia, Taiwan Province was in 9th place and the

Republic of Korea in 13th. A Latin American country, Brazil, rounded out the top 15.

(b) Consumption

Consumption declined even more in Japan than did production, falling by 36% when measured in yen, 32% in dollars, as the industry sought to increase exports. Table 2 shows production for the principal producing countries in each region and includes estimates for consumption by other countries in the regional totals. Such estimates can be made based on the detailed export data provided by many producing countries. The top five producing nations were also the top five consuming nations, and in the same order. Like Japan, Germany, United States, and Italy all had declines in consumption that were greater than their declines in production as they increased export effort. China was again the exception, with consumption not only increasing but at a faster rate than did production, with a 27% increase compared with 20% for production.

Consumption is measured as the value of production reduced by the value of exports and increased by the value of imports. The level of production is a measure of the state of the machine tool industry in a country while the level of consumption is a measure of the rate of development of the durable goods and metalworking industries that use machine tools as a critical part of their manufacturing operations. A better measure of this effect of consumption is provided by Table 3, which divides total consumption by

the population to give the consumption per person in each country. On this basis the range is from \$100.49 per person for Singapore to 29 cents per person in India. By this measure, developed countries like Switzerland, Germany, Japan, Austria, and Italy are continuing to develop, while United Kingdom and United States lag behind. Among the developing countries, aside from Singapore, Taiwan Province and Republic of Korea are the leaders. Despite its impressive totals, the China investment of \$1.98 shows how far it still must go to achieve a living standard comparable to the developed countries for its population.

(c) International trade

There is extensive international trade in machine tools, not only between the major producing countries, but to supply machines to those countries that do not produce them. Table 4 reports the imports, exports, and trade balance for the major producing countries. In this table, the regional and world totals are only for the listed countries, thus exports exceed imports by the nearly \$2.5-billion that are supplied to other countries and the totals do not include the estimated production of unlisted countries (about \$225-million).

Germany dominates exports with nearly 28% of the total, followed by Japan with 21%. These two countries, with nearly half of the total, are followed by Switzerland, Italy, and the United States. Germany is also the major importer, taking nearly 14%, followed by the United States, with 12%.

Then France with 8%, China with 6%, and Italy and United Kingdom with 5% each. Considering the level of its consumption, Japan is a small importer, though it has increased from 2% to 4% in the last five years, and "trade friction" is increasing with the other major producing countries.

A broader picture of machine tool trade with developing countries is provided by Table 5 which summarizes the trade in metalworking machinery of 17 OECD countries with 79 countries. Metalworking machinery is a broader category than machine tools, and includes tools, dies, jigs, fixtures, accessories, and measuring machinery. The table shows the development of Israel and Ireland and the emergence of Turkey and Thailand as producing nations. Because the latest year available for this table was 1991, it does not reflect the broad declines of 1992, especially in Japan and Eastern Europe but also in Western Europe. Although the import levels of the developing countries are still small, the table does show the impressive growth in imports for most of these countries during the five years from 1986 to 1991.

(d) Major companies in the global industry

Most machine tool producers are relatively small companies, often privately owned. A few large firms have had success with machine tool divisions, notably Thyssen in Germany and Mitsubishi Heavy Industries, Toyoda, and Komatsu in Japan, but there are very few cases where large diversified companies have been successful when they

acquired machine tool operations. The 25 companies listed in Table 6 each had machine tool sales of more than \$300-million in 1991. Of these 16 are Japanese, 6 are German, and 3 are based in the United States. Most of these companies are international in manufacturing as well as distribution. Half of the Japanese companies have plants in the United States and some have plants in Europe. All of the US companies have plants in Europe and half of the German companies have plants in the US.

There were large state-owned companies in Eastern Europe but comparable data was lacking. Now that their operations are being rationalized and privatized, they are shrinking to much smaller size. The three top companies in the list each had sales of more than \$1-billion in 1991. Of the three, Yamazaki Mazak, listed third, was actually the largest producer of machine tools. Amada produces some machines but is primarily a marketing company selling machine tools produced by others. Many of these are made by Amada Wasino and Amadasonoike (No. 21 and No. 23 on the list) partially owned by Amada. Fanuc is the primary producer of numerical control systems in the world, although it does also produce machine tools, robots, and plastics machinery. More than half of the sales of Ingersoll Milling are by three companies it owns in Germany. Giddings & Lewis acquired Cross & Trecker late in 1991; if they had been combined for the full year sales would have been about \$600-million.[2]

2. Manufacturing capacity of developing countries and areas

(a) China

Manufacturing capacity began to expand in the early '80s, reaching a peak in 1989 of \$1.1-billion. Production fell back almost a third in the following year as economic reform faltered. It has since resumed and output has increased each of the past two years, reaching \$1.7-billion last year. However, production figures are reported in renminbi, an internal currency, and experience with the soft currencies of Eastern Europe suggests the difficulties of making accurate conversions. Export and import data are reported in dollars. Exports, which peaked in 1990, have declined each year since, but imports after several flat years are said to have increased by 43% in the past two years. It is difficult to match these gains with the trade data reported by other countries. The data in Table 5 indicates a substantial drop in imports from 1987 to 1991. However, the very real rise in re-exports from Hong Kong, for example, which is also not reflected in Table 5, suggests that much of China's imports are coming indirectly through third countries.[3]

(b) Taiwan Province

With a capacity that is now close to \$1-billion a year, Taiwan Province had its first drop in production in many years in 1992. Exports to both the United States and Europe were down and though focusing on the market in China, this did not fully make up the difference. Although trade is prohibited with China it takes place openly through third

countries. Several companies are producing CNC (computer numerically controlled) lathes and machining centers on a commodity basis using Japanese controls. In focusing on the market in China some 30 companies exhibited at a show in Shanghai in 1993. There has been very little demand for the more advanced types of equipment in Taiwan Province though this seemed to change in 1992 with a 27% increase in imports despite the decline in domestic production. The industry in Taiwan Province is made up of a large number of small companies. The largest firm had sales in 1990 of \$60-million.[4][5]

(c) Republic of Korea

Capacity peaked in 1991 when production reached almost \$800-million. In 1992 production fell by 25% as recession cut into the domestic market and exports not only failed to cut the loss but were also reduced slightly. Although the capacity is less than that in Taiwan Province the state of manufacturing is viewed as more advanced. Korean industry has been a heavy investor in imported machine tools and the volume increased last year, despite the recession, to account for more than 60% of consumption. There are fewer, and larger companies in Korea than in most of the Pacific Rim states. The largest is Saeilo which had sales of about \$450-million in 1990. It was formerly known as Tong-Il. Another large company is Kia Machine Tool, with sales of \$405-million in 1990, which builds presses and special

machines for the auto industry, much of which goes into their own vehicle parts plants.[5][6]

(d) Brazil

Brazil built a protected market which excluded imports of any machine type produced in Brazil. Under that system capacity expanded rapidly and reached a peak of \$575-million in 1987. Contributing to the expansion were a number of plants built by German and Italian firms. Imports were generally around \$40-million, but exports were even less. The new economic policies begun in 1990 both restricted the market and opened it to imports. As a result both consumption and production have fallen each year and the industry is operating at about 50% of capacity. Although consumption last year was only a third (\$200-million) of its 1987 peak and imports have more than doubled to \$85-million, the production level was as high as it was because exports (\$190-million) are more than seven times what they were in 1987.[7][8]

(e) India

India has aggressively promoted the development of the machine-tool industry and one government company and some 325 private companies have a capacity that is about \$300-million a year but this level of production has not been reached since 1988 as both domestic demand and exports declined. Russia accounted for 70% of the export as recently as 1991, but that market was already in decline and total exports in 1992 were less than 7% of production. Emphasis

has been put on the development of CNC machine tools and this has been accomplished primarily through licensing of foreign technology. By last year 32 companies had a total of 46 such agreements on CNC technology. As a result, the percentage of machine-tool production represented by CNC machines has grown steadily from 20% in 1987 to 37% in 1991.[9]

(f) Singapore

Production consists primarily of the assembly of machines from imported and domestic parts and the production of parts for export. Although parts are generally not counted in the production statistics used for this report, they are in this case. Part of the imports are for re-export to the developing countries in Asia. A fully computer-integrated plant has been established by Yamazaki Mazak to produce machine-tool components for export to Japan. Singapore's developing role as a manufacturing and technical center for this part of Asia is spurring the development of local supporting companies providing such services as tool and mold production, metal stamping, fine blanking, die casting, and precision machining. However, the recession in the United States and Europe caused a reduction in both exports and imports in 1992.[10]

(g) Hong Kong

Production figures become available very slowly for Hong Kong. Production in 1990 increased by 38% over 1989, though the number of firms involved shrank from 93 in 1989 to 80 in

1990. All later figures are estimates. Export and import data are more current. Production capacity is obviously very limited in Hong Kong and is not likely to expand. In general, all manufacturers are shifting their operations across the border into the Cuangdong Province of China, where labor costs are much lower and the rapid pace of economic development is creating opportunities for both industrial and consumer products. It is evident that the Hong Kong based firms are serving both as a conduit for machine tools into China and for exports of machines from China.

3. Capacity utilization and expansion plans

(a) Japan

Production of metalcutting machines peaked in 1990 at 1303 billion yen and of metalforming machines in 1991 at 302-billion yen. This probably was close to capacity at that time, and represented more than 27% of the world production of machine tools. Because Japanese firms upgrade their plants almost continuously, capacity has been increased some since then. However, the collapse both of domestic demand and of increased problems with exports has reduced output by about a third. It has been the rapid expansion of Japan's manufacturing base in combination with restrictions on imports that has caused the almost uninterrupted growth of machine-tool capacity. Expansion efforts have been slowed, but efforts to improve efficiency will likely mean that some investment in new equipment will continue. Increasing

resistance to Japanese imports in Europe and North America will limit the ability to increase exports which will make it more difficult to return to capacity operations.[8][11][12]

(b) Germany

The boom that followed the unification of Germany when the former German Democratic Republic became the New Federal States came to a halt in 1991. The capital costs of reconstructing the eastern part turned out to be much higher than anticipated, the high interest rates imposed to prevent inflation restricted the flow of capital, and the almost complete loss of the markets in the former Soviet Union and the other Eastern European states combined to create a severe recession. Machine tool production declined by more than 16% when measured in Deutschemarks. The difference between the two areas is indicated by the fact that the decline was 14% in the former Federal Republic and 35% in the New Federal States. Production in the Federal Republic had peaked at \$8.7-billion in 1990 and had been about \$1-billion in the Communist Democratic Republic. In 1992 the combined output was \$7.8-billion. A further decline of about 13% in 1993 is forecast by VDW, the German machine-tool builders association with production being down about a third from the 1990 peak.[13]

(c) United States

Although consumption of machine tools decreased by almost 11% because of the recession, imports decreased by 14%, and

exports increased by 12% in 1992.[14] As a result, production declined by less than 3% and the share of world production increased from 7.6% to 9.2%. This was partly due to the improved prices possible because of the shrunken value of the dollar, but that change was less in 1992 than in several previous years and the dollar has since increased in value. The comparatively good performance of the United States was an indication that the downsizing, restructuring, and modernizing of the industry that has been going on for several years is beginning to show results. By the end of the year, as the country was clearly coming out of the recession, the forecast of the Commerce Department that machine tool shipments would increase by 8% in 1993 began to seem reasonable.[15] While excess plant and equipment capacity still exists after the downsizing, the skilled employees needed to expand production are gone and may not be easily replaced. The many apprentice programs that existed in the industry at one time have all been abandoned in the turmoil that saw the industry volume sink to less than half of its former level.

(d) Italy

Capacity level is indicated by the production peak in 1990 of 4440-billion lire. This ended a steady 15-year increase that had made Italy the second largest producer and the third largest exporter in Europe. The level of orders began to decline in 1990 and moved steadily down through 1992. Capacity of the industry is still about \$4-billion

with the industry operating at about 75% of capacity and the decline in output is expected to continue in 1993. Imports, which come mainly from Germany and Switzerland have declined even more than domestic production. Exports also declined more than domestic consumption, most sharply to Europe which was partially offset by development of new markets. Metalforming machines have done better on the domestic market and worse in exports than metalcutting machines.[16]

(e) Switzerland

Switzerland has a highly developed industry with the world's most intense consumption of machine tools (though currently the consumption per capita is exceeded by Singapore's rapid development). The machine-tool industry has traditionally specialized in producing the most precise machines available. One result has been that more than 80% of the output is exported and imports of more standard types make up the majority of local consumption. Production peaked in 1990 at 4-billion Swiss francs but has declined since by more than 40%.[17] Some restructuring has taken place that has reduced capacity in the past two years but it is probably still close to \$3-billion and the industry is operating far below this level.

(f) Russia and Ukraine

These two countries, members of the Commonwealth of Independent States, were the major machine-tool producing areas of the USSR. In 1990, the last year for which CIS data could be obtained, total production was 199,196 units. For

1991 and 1992 combined data was no longer available and separate data was obtained from Russia and Ukraine. Production in Russia in 1991 was 90,198 units, and in 1992 was estimated at 41,400 units.[18]

In Ukraine 1991 production was 46,642 units (35,829 metalcutting and 10,813 metalforming) and for the first nine months of 1992 was 38,402 units (30,517 metalcutting and 7,885 metalforming). Exports were 867 units in 1991 and imports were 556 units. In 1992 exports declined further (205 units at the rate through September) while imports increased (776 units at the 9-month rate).[19]

(g) Spain

Capacity in Spain is indicated by the level of production reached in 1990, about \$1-billion. Because of falling demand both in the home market and for exports, production has fallen more than 35% since then. In 1992, the decline in exports, which go primarily to Germany and France, was held to 12%, although the decline in consumption was 20% when measured in pesetas. The fact that imports increased by 5% in the face of this decline was the result of the completion of orders placed earlier by the multinational automotive industry.[20]

(h) Yugoslavia

Yugoslavia had a capacity and produced in 1990 machine tools worth \$630-million, 73% of which were exported, mostly to the USSR and Eastern Europe. The collapse of that market, and the developing political crisis in Yugoslavia combined

to reduce production in 1991 to \$375-million. In 1992 the country was divided as civil war continued. The new Federal Republic of Yugoslavia, which includes the machine-tool producing areas in Serbia had production of \$150-million much of which was evidently added to producer's inventories rather than consumed. Exports were only \$47-million and that was all in the early part of the year before the UN resolution.[21] The other machine-tool producing area was Croatia which had production of \$75-million in 1992, one third of which was exported, mostly to Russia and Germany.[22]

(i) Poland

Capacity in 1990, measured realistically, was about \$125-million. Poland produced 15,539 metalcutting machines in 1991, of which 182 were numerically controlled. That was a reduction of more than 40% from the 1990 level. In 1992, production in the first eleven months was 7,479, down 45% from the same period the previous year, and only 72 were numerically controlled. Exports were 7,179 machines in 1990, but only 3,990 in 1991 (2300 to the West). Imports were 9,287 machines in 1990 (5,481 from the West) and 2,777 in 1991 (1,990 from the West). Because of liberalization of foreign trade both government and private factories can export and import machine tools in addition to the foreign trade conducted by Metalexport, the government agency, so there is no precise data for 1992, but it is estimated to be down another 40-50%. Although privatisation of the industry

has been discussed for several years there has been no action so far. The present plan is to divide the industry into three groups, five factories that are the best in the first group, a second group of 18 factories that are believed able to survive, and a third group of all the rest which are to be liquidated.[23]

(j) South Africa

There is limited capacity for production in South Africa with more than 90% of the demand normally being filled by imports which have come mainly from China, Czechoslovakia, Japan, Taiwan, and Europe. The armament industry, once the major customer, has virtually disappeared. The demands from the railroad and motor vehicle industries have declined steadily. The combination of devaluation of the Rand and the imposition of import duties have caused real prices to increase 400% in the past decade. This has made the purchase of machine tools by small business prohibitive and is said to have virtually killed entrepreneurial industry.[24]

(k) Hungary

As the data supplied from Hungary became more reliable there was a scaling down of the capacity figures suggesting that it was something over \$100-million, but less than the \$210-million that had been reported in 1987. About 90% of the country's production was based on exports to the USSR and other Eastern Europe countries. This market has collapsed at the same time that the internal economic problems caused capital investment within the country to

come almost to a halt. The two major machine-tool builders were privatised and established joint ventures with German companies: Szerszámgyártó Művek with Maho and Csepel with F+K. But the combination of the chaos in the East and the recession in the West put the German partners in danger of bankruptcy and failed to provide the anticipated support. The capacity still exists, but production in Hungary which had already dropped by half appears to have fallen another 75% in 1992, even though the Hungarian machine-tool industry was considered to be one of the more advanced in Eastern Europe.[25]

4. Restructuring and deployment

The most massive restructuring is taking place in the German New Federal States where the state-owned manufacturing companies in the former German Democratic Republic are being restructured by Treuhandstalt, the German trust that took over the companies and are downsizing, restructuring and ultimately shutting down where necessary and selling them where possible. In downsizing, companies are reduced to their core businesses, with dormitories, day-care centers, and other peripheral activities stripped away. New management is brought in to handle purchasing and cost control, functions that did not exist in the former regime. Other steps include converting power from the pollution-laden soft coal mined locally to gas or oil and providing capitalization to make the business viable. As an example, Heckert, a machining manufacturer in Chemnitz had 4500

employees when the trust took it over is being reduced to 500.[26] While the capital being provided the German trust does not exist to the same extent in the other Eastern Europe countries similar efforts at reconstruction are being made throughout the area, notably in the Czech Republic, Poland, and Hungary.

In Western Europe the combination of the economic union and the recession is forcing many companies to restructure to survive. Some companies in Germany are combining functions short of complete merger to reduce costs.

5. Environmental considerations

Ozone-depleting compounds must be phased out by the end of 1995 in the United States, and similar action is coming in other countries. The most widespread understanding of this is what it will do to refrigerating and air conditioning equipment. More critical in metalworking plants is the need to replace chlorinated solvents used in vapor degreasing. Many new types of parts washers have been developed and they became a major factor in the "Environmental Pavilion" at the 1992 International Machine Tool Show.

One type of system uses water with regulated chemical injections and heated drying in a system with closed-loop water treatment. Others use ultrasonic cleaning in combination with liquid detergent.

6. Technological trends

(a) Numerical control

Numerical control has not only changed the nature of most types of machine tools, in combination with computers used for design, scheduling, and inventory control, it is changing the basic nature of the manufacturing process itself. Numerical control operates a machine tool with a program that provides digital information covering all of the machine motions, speed, and such functions as the changing of tools and workpieces. It involves not only the control itself, but the servomotors on the machine that carry out the commands from the control, may include sensors to keep the control informed on the position and condition of machine elements, and the programs (or software) that instruct the control. For the auxiliary functions it requires tool and work changing mechanisms equipped to respond to the control impulses. It is possible for such machines to be so equipped and programmed that they will operate for long periods unattended.

Virtually all numerical controls today contain a computer in the form of one or more microprocessors, though a few contain more elaborate minicomputers. Initially such controls were called CNC (for computer numerical control) but today the term NC is understood to mean computer control.

The controls market is dominated by Japan. Table 7 compares NC machine tool production in 12 countries for

which information is available. These countries accounted for about 80% of world production of all types in 1991 and probably an even larger share of production of NC types. Among these countries, Japan had a 45% share of production of NC machine tools. Almost all Japanese machines use Japanese controls. A major share of the controls used in the United States, Korea, and Taiwan Province are also Japanese and the share is growing in Europe. Fanuc is the major control builder in Japan and in the world. Fanuc supplies the machine tool builder with a complete package that includes the control, the servomotors, and the software. Fanuc operates alone in Asia; elsewhere, in a joint venture with General Electric, once the principal control builder, GE Fanuc supplies Fanuc control systems and GE-developed related equipment.

Almost half (by value) of the machine tools produced in 1991 were numerically controlled, as the NC portion increased from 39% in 1987 to 48% in 1991. The fastest growth was shown by Taiwan Province, India, Japan, and Spain in that order, all of whom more than doubled the value of NC machine output. Japan and Spain each had more than 60% of production in NC machine tools; France and Germany had 54% (the German production figures include only the Federal Republic, not the former Democratic Republic). The only decline was in Italy, where the value of NC machines produced fell by 32% and NC machines accounted for less than 13% of production.

Japan is also the principal user of NC machines, as shown in Table 8, installing more than a third of the NC machines installed in these countries. Germany was close behind accounting for about a fourth of the NC machines installed (including for 1991 an estimate of consumption for the New States). Spain had the third highest rate of installation with 53% of consumption being in NC machines. The biggest increases in consumption were in Taiwan Province and the Republic of Korea, though the rate remains well behind that in the leading countries. Again Italy is the lone holdout against NC, with the rate of consumption of NC machines falling by nearly 40% from 1987 to 1991. It should be noted that Italy has a higher proportion of production in metalforming machines, 36%, than average, 29%, and much higher than Japan, 21%, though not much higher than Germany, 35%.

The application of numerical control varies widely between machine types, as shown in Table 9. Based on the production of a dozen countries that report production by type, 59% of metalcutting machines are numerically controlled, but only 18% of metalforming machines. Among individual types, 100% of machining centers, 76% of lathes, and 72% of milling machines produced were numerically controlled.

Control systems have been getting smaller. The use of edge technology permits more components to be mounted on a single board. The software has gotten more user friendly,

making it easier for operators to program a machine. The 32-bit processor has become standard in NC control systems and in some cases, more than one is included. In high-speed machining lag in the response time of servos to lag behind the path the control is calling for. By combining two 32-bit processors in a single control, a RISC (reduced instruction set computing) processor can look ahead at future blocks in the program, calculate what this lag will be, and make adjustments to the rate of acceleration and deceleration.

Communications is a key function in integrating NC into the factory. Most NC systems now have some communications capability, most often for receiving distributed programs, and for generating status reports. The requirement of compatible interfaces between the control and the network is the principal problem in developing a factory system. However, the OSI (Open System Interconnect) protocols from the ISO (International Standards Organization) show promise of standardizing network software.[27]

(b) Turning machines

The most common NC machines are lathes, including horizontal spindle machines with flat, slant, and vertical beds and vertical machines. Most of these machines now have been originally designed as NC machines and tend to look less and less like the traditional lathe. The traditional way to machine a round part was to turn one end of it in a lathe, move it to a second lathe to turn the other end, and then move to a milling machine for milling and drilling

operations that required rotating tools. Now many NC turning machines can complete such parts in a single machine. Making a controlled axis of the spindle permits stopping the work in controlled positions and indexing it to various stationary positions. Providing powered positions in the tool turret makes it possible to use rotating tools on this workpiece.

Automatic loading of work has advanced from accessory devices that were bolted to the machine or free standing robots to integral robot or gantry devices that can supply workpieces from a variety of sources: tables, racks, or bins. Twin spindle machines for chucked parts, usually with automatic transfer of the work from one spindle to the other, complete the cycle and permit complete machining of a part in one continuous operation. On front loading machines the part is turned end for end as it is moved from the first spindle to the second. In the conventional lathe design, the second spindle is at the tailstock end of the lathe and transfer is usually accomplished by advancing this second spindle to grasp the machined end from the first spindle. In some machines both spindles have longitudinal movement under NC control.

A variety of different configurations have been developed to combine these functions. On some machines both spindles are equally powered and have equal tooling characteristics. In such a case, the spindles can be programmed to operate separately on different workpieces or to work together on

the two ends of a single workpiece. In other designs, the second spindle is a subspindle with size and power less than that of the main spindle. The simplest machines may be a simple three-axis machine with a single tool turret and a small sub-spindle. At the other end of the range are complex machines with six or more axes, three or more tool turrets and a second spindle equal in size and power to the first.

The choice of machine depends on whether most of the work is done on one end of the work or is fairly equally divided. In either case the goal is to shorten production time and costs by eliminating the use of extra machines, the moving of parts between machines and the waiting time between operations. Ultimately a twin spindle machine with automatic handling can operate for long periods without an operator.[28]

(c) Machining centers

Machining centers are at the heart of the revolution in manufacturing that numerical control has created. Despite their complexity and comparatively high price, the value of machines produced each year is about the same as for NC turning machines. In the countries included in Table 9 the value of machining centers produced is 13% higher but the value of NC lathes consumed is 7% higher. Production of NC turning machines, especially the simpler types, is much more widespread than of machining centers so that there is more export of machining centers from these countries.

The machining center was created to take advantage of numerical control. Originally a horizontal-spindle machine with an automatic tool changer and work mounted on a turntable, it could machine four sides of a prismatic workpiece in one series of operations. Later tilting turntables added the top to the sequence. Vertical-spindle machines proved much less costly because they did not require as heavy a frame as needed for an accurate horizontal spindle. And vertical-spindle machines could perform all the operations on the top of the workpiece as well as milling the four sides, though it could not drill holes or make undercuts on the sides.

But then universal machines were developed in which the spindle could shift horizontal to vertical. Designs vary but generally the universal spindle cannot perform as heavy, accurate work as a horizontal. Methods to increase the efficiency of machining centers have included the addition of pallet changing devices that could change workpieces, methods to automatically replace worn tools, and methods to mount a number of smaller workpieces on the sides of a "tombstone" fixture. Such parts could be in any combination of different parts that could be programmed.

At some point as the refinements added to the machining center increase, such as on-machine gaging of the work, broken tool detection and replacement, the machine begins to be thought of as a "cell", a complete unit for manufacturing a certain class of parts. Cells may contain more than one

machine, the second machine often being an NC turning machine, but if two or more machining centers are combined in a cell with computerized scheduling and programming of them both, it becomes a flexible manufacturing system. Early experience with such systems was often disappointing, but as all the components have become more reliable their use is increasing.

(d) Grinding machines

Grinding machines have been slower in the conversion to NC even though the first NC applications were made to plain cylindrical grinders more than 20 years ago. But by 1991 43% by value of the grinders produced in the twelve countries in Table 9 used numerical control. The leading developers have been in Europe, principally Germany, Switzerland, and the United Kingdom. Special purpose grinders for cutting tools and other precision work have been developed but NC is also finding a home in more conventional grinders. The controls developed for grinders tend to be more complex than those for most metalcutting operations, requiring extensive feedback from the machine on the progress of not only the size of the work, but the size and condition of the wheel and the temperature being maintained.

Grinding is particularly susceptible to problems caused by vibration or distortion caused by temperature changes in either the machine or the work. An early approach to greater precision was to use granite for the base of the machine. In recent years a special form of concrete has been more common.

Concrete was first used by an Italian manufacturer in a horizontal boring machine more than 20 years ago and later was developed into a composite of crushed stone held together by a plastic binder. They are becoming more common and are particularly useful for grinders. Such structures are usually crushed stone held together with a plastic binder. These epoxy-concrete or polyester-concrete structures are superior to either cast iron or fabricated steel both in damping vibration and in thermal stability. On a composite base attaching points for the rest of the machine and any accessories must be carefully planned and steel mounting pads cast into the original structure. Sometimes a thin metal casting or steel plate case is filled with the composite in order to provide a surface that can be drilled and tapped. One NC grinder introduced last year has gone beyond the base and uses a polyester-composite construction for all major components, including the base, saddle, and wheelhead.[29]

(e) Punching and shearing machines

The principal application of numerical control in metalforming is in punching and shearing machines. NC punching machines, for working sheet and plate, are virtually a new class of machine, as is the machining center in metalcutting. They have a tool changing mechanism that changes both the punch above the work and the die below the work. These tools are carried in turrets and in some machines operate from the turret which rotates under the

machine ram to change tools. In another design the punch and its mating die are transferred from the turrets to a position under the ram. The table does not move but the sheet is held by grippers that move it on the table (equipped with ball rollers on the surface) to the position for the stroke. These machines reposition the sheet between strokes with precision, often in about a second, and when a tool change is required it takes only seconds longer than the repositioning. Punches are relatively small, large openings are produced by overlapping punches.

Contours that cannot be produced with punches can be cut with a machine designed in essentially the same way that cuts with either plasma or a laser. Some machines are capable of both punching and contour cutting. The development of this class of machines, which account for about two-thirds of NC metalforming machines, has made a major change in metalforming and made it possible to design many products from sheet or plate that were formerly designed as castings or to be machined from solid stock.

(f) Programing

One of the reasons for the rapid growth of NC has been the success in making the programs more user friendly. For many operations, the control can be programed by the operator. More complex machines have controls specifically designed for the type of machine that are simple to program in comparison with the early years of numerical control. In fact the capabilities of many machines are determined as

much by the systems built into the control as by the machine. Thus two lathes equipped with the same model control will have virtually identical capability. For this reason, some machine tool builders either produce their own controls or have a control customized for them with the particular system characteristics they want.

At the same time that programing has been simplified the desire to accomplish more has introduced complications. With increasing use being made of computer-aided design, the desire grows to be able to transfer these designs into manufacturing programs automatically. The ultimate is called CAPP, for computer-aided process planning. In theory such a system could take a CAD design, determine which of the available machine tools should be used to manufacture it, plan the sequence of operations, and then prepare the programs.

Such a system must be customized for a particular plant. For a medium-sized manufacturer this may take two to four man-years of engineering implementation time. The program must have access to all the manufacturing process knowledge databases that relate to the equipment and materials that will be involved. Because of the time and cost involved in installing a CAPP system, the process is more talked about than used. There have been a few such systems put into place and a much larger number of cases in which simpler applications have been automated to create parts of the

planning process that can be pasted into the overall plan as it is developed in the traditional way by the engineers. [30]

7. Short- and long-term outlook

The short-term outlook is discouraging because of the severe recession in Europe and Japan. There may be some improvement late in 1993 and 1994 but it is not assured. The United States should continue to improve in the short term although the strengthened dollar may hurt exports. Continued growth is expected in China, Singapore, and the Malay peninsula.

The longer term outlook is for some recovery from the low reached in 1992, but there is still substantial overcapacity for machine tools in the world and consolidation and restructuring are likely to continue..

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World machine-tool consumption 1992

Western Europe	39.4	13525.9
Eastern Europe	6.9	2381.8
Japan	16.5	5678.2
Latin America	3.8	1320.4
Asia	18.2	6264.5
Other	2.1	712.4
North America	13.0	4454.2
Total		34337.4

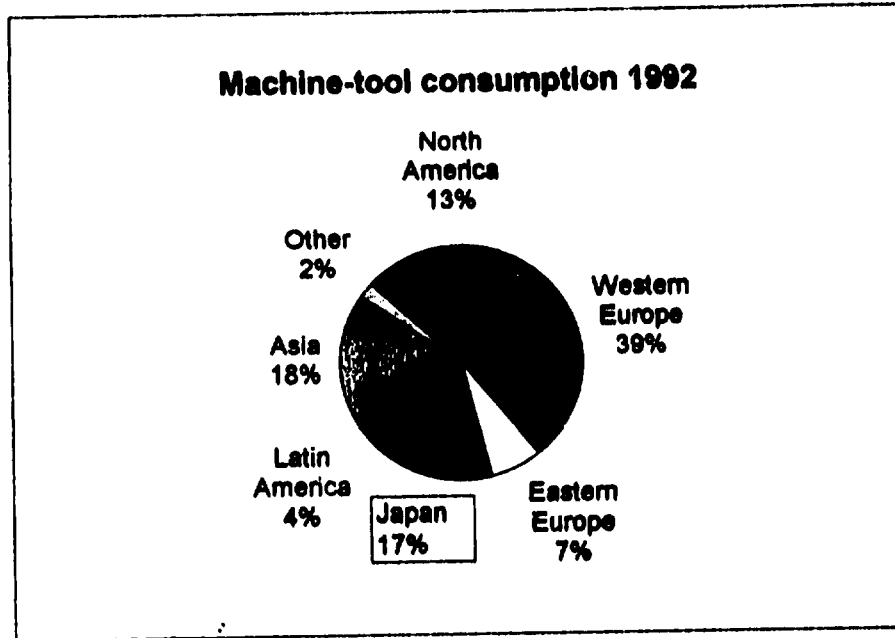


Table 1. World machine-tool production, 1987, 1991, and 1992

(millions of US dollars)

	Production			World share			Percentage change	
	1987.0	1991.0	1992.0	1987.0	1991.0	1992.0	1986-1991	1991-1992
World	32549.8	43178.3	34837.4	100.0	100.0	100.0	32.7	-19.3
North America	2829.1	3588.2	3477.7	8.7	8.3	10.0	26.8	-3.1
Canada	244.1	322.2	290.7	0.7	0.7	0.8	32.0	-9.8
United States	2585.0	3266.0	3187.0	7.9	7.6	9.1	26.3	-2.4
Western Europe	14021.8	18993.8	16510.3	43.1	44.0	47.4	35.5	-13.1
Austria	155.0	272.5	246.2	0.5	0.6	0.7	75.8	-9.7
Belgium	179.3	272.7	193.7	0.6	0.6	0.6	52.1	-29.0
Denmark	76.8	75.4	67.2	0.2	0.2	0.2	-1.8	-10.9
Finland	35.3	52.4	49.4	0.1	0.1	0.1	48.4	-5.7
France	766.1	1021.4	926.2	2.4	2.4	2.7	33.3	-9.3
Germany	6402.6	8841.9	7852.0	19.7	20.5	22.5	38.1	-11.2
Italy	2235.2	3470.1	3056.4	6.9	8.0	8.8	55.2	-11.9
Netherlands	47.3	112.3	99.9	0.1	0.3	0.3	137.4	-11.0
Portugal	18.7	31.6	29.1	0.1	0.1	0.1	69.0	-7.9
Spain	575.0	750.6	630.5	1.8	1.7	1.8	30.5	-16.0
Sweden	257.7	352.4	329.5	0.8	0.8	0.9	36.7	-6.5
Switzerland	1652.4	2011.9	1695.0	5.1	4.7	4.9	21.8	-15.8
United Kingdom	1058.4	1293.6	1049.3	3.3	3.0	3.0	22.2	-18.9
Yugoslavia	515.0	367.0		1.6	0.8		-28.7	-100.0
Croatia			75.0			0.2		
Rep. of Yugoslavia			150.9			0.4		
Eastern Europe	6240.0	4776.0	1956.3	19.2	11.1	5.6	-23.5	-59.0
Czechoslovakia	405.0	130.8	91.4	1.2	0.3	0.3	-67.7	-30.1
German Dem Rep	1312.0							
Hungary	210.0	40.6	9.0	0.6	0.1	0.0	-80.7	-77.8
Poland	322.7	92.6	50.9	1.0	0.2	0.1	-71.3	-45.0
USSR	3976.3			12.2				
Russia		3200.0	1050.0		7.4	3.0		-67.2
Ukraine		1280.0	740.0		3.0	2.1		-42.2
Japan	6419.4	11638.7	8671.3	19.7	27.0	24.9	81.3	-25.5
Other Devlpd Countries	161.3	176.6	170.5	0.5	0.4	0.5	9.5	-3.5
Australia	45.0	14.0	17.0	0.1	0.0	0.0	-68.9	21.4
South Africa	12.3	27.6	28.5	0.0	0.1	0.1	124.4	3.3
Latin America	631.7	404.4	369.6	1.9	0.9	1.1	-36.0	-8.6
Argentina	34.8	30.4	36.8	0.1	0.1	0.1	-12.6	21.1
Brazil	575.5	350.0	305.8	1.8	0.8	0.9	-39.2	-12.6
Mexico	21.4	24.0	27.0	0.1	0.1	0.1	12.1	12.5
Asia	2246.5	3600.6	3681.7	6.9	8.3	10.6	60.3	2.3
China	821.7	1445.5	1738.6	2.5	3.3	5.0	75.9	20.3
Hong Kong	1.4	28.3	34.1	0.0	0.1	0.1	1921.4	20.5
India	277.7	221.6	197.6	0.9	0.5	0.6	-20.2	-10.8
Republic of Korea	530.9	798.4	600.0	1.6	1.8	1.7	50.4	-24.8
Singapore	35.0	89.6	100.7	0.1	0.2	0.3	156.0	12.4
Taiwan Province	577.8	992.2	983.7	1.8	2.3	2.8	71.7	-0.9

Source: American Machinist, Vol. 137 No. 3, March 1993, pp 34-35 and Vol. 133 No. 2, February 1989, p61

with adjustments for regional and world totals for countries

for countries not reported there based on trade data of OECD countries.

Table 2. World machine-tool consumption, 1987, 1991, and 1992

	Consumption			World share			Percentage change	
	1987	1991	1992	1987	1991	1992	1986-1991	1991-1992
World	32549.9	43178.3	34837.4	100.0	100.0	100.0	32.7	-19.3
North America	4675.6	4903.7	4454.2	14.4	11.4	12.8	4.9	-9.2
Canada	708.4	563.6	576.7	2.2	1.3	1.7	-20.4	2.3
United States	3967.2	4340.1	3877.5	12.2	10.1	11.1	9.4	-10.7
Western Europe	11203.2	15912.3	13525.9	34.4	36.9	38.8	42.0	-15.0
Austria	159.0	338.6	333.5	0.5	0.8	1.0	113.0	-1.5
Belgium	206.1	347.0	256.9	0.6	0.8	0.7	68.4	-26.0
Denmark	133.8	113.6	101.2	0.4	0.3	0.3	-15.1	-10.9
Finland	120.9	95.7	62.8	0.4	0.2	0.2	-20.8	-34.4
France	1219.9	1924.5	1583.7	3.7	4.5	4.5	57.8	-17.7
Germany	4001.4	6046.6	5033.7	12.3	14.0	14.4	51.1	-16.8
Italy	1753.0	2718.0	2384.7	5.4	6.3	6.8	55.0	-12.3
Netherlands	229.0	266.3	299.0	0.7	0.6	0.9	16.3	12.3
Portugal	42.3	137.4	125.9	0.1	0.3	0.4	224.8	-8.4
Spain	606.9	803.4	751.7	1.9	1.9	2.2	32.4	-6.4
Sweden	377.3	362.3	290.0	1.2	0.8	0.8	-4.0	-20.0
Switzerland	576.7	704.3	565.7	1.8	1.6	1.6	22.1	-19.7
United Kingdom	1087.1	1364.6	1141.2	3.3	3.2	3.3	25.5	-16.4
Yugoslavia	356.6	220.0		1.1	0.5		-38.3	
Croatia			56.0			0.2		
Rep. of Yugoslavia			124.9			0.4		
Eastern Europe	7214.2	5212.6	2381.8	22.2	12.1	6.8	-27.7	-54.3
Czechoslovakia	160.0	173.5	72.8	0.5	0.4	0.2	8.4	-58.0
German Dem Rep	308.5							
Hungary	164.0	25.8	6.1	0.5	0.1	0.0	-84.3	-76.4
Poland	428.5	263.3	127.9	1.3	0.6	0.4	-38.6	-51.4
USSR	5303.2			16.3				
Russia		2900.0	1080.0		6.7	3.1		-62.8
Ukraine		1320.0	780.0		3.1	2.2		-40.9
Japan	3649.1	8327.3	5678.2	11.2	19.3	16.3	128.2	-31.8
Other Developed Countries	411.0	714.8	312.4	1.3	1.7	0.9	73.9	-56.3
Australia	177.3	82.0	101.0	0.5	0.2	0.3	-53.8	23.2
South Africa	73.7	454.8	48.4	0.2	1.1	0.1	517.1	-89.4
Latin America	1276.0	1377.4	1320.4	3.9	3.2	3.8	7.9	-4.1
Argentina	57.1	113.1	106.6	0.2	0.3	0.3	98.1	-5.7
Brazil	601.5	320.3	200.8	1.8	0.7	0.6	-46.7	-37.3
Mexico	267.4	324.0	513.0	0.8	0.8	1.5	21.2	58.3
Asia	3345.7	5920.2	6264.5	10.3	13.7	18.0	76.9	5.8
China	1033.5	1819.8	2313.6	3.2	4.2	6.6	76.1	27.1
Hong Kong	70.4	33.8	41.3	0.2	0.1	0.1	-52.0	22.2
India	389.6	311.8	260.2	1.2	0.7	0.7	-20.0	-16.5
Republic of Korea	979.5	1643.9	1492.5	3.0	3.8	4.3	67.8	-9.2
Singapore	90.0	266.6	281.4	0.3	0.6	0.8	180.6	5.6
Taiwan Province	412.7	646.3	759.8	1.3	1.5	2.2	56.6	17.6
Middle East	350.0	450.0	400.0	1.1	1.0	1.1	28.6	-11.1
Africa	425.0	360.0	500.0	1.3	0.8	1.4	-15.3	38.9

Source: American Machinist, Vol. 137 No. 3, March 1993, pp. 34-35 and Vol. 133 No. 2, February 1989, p. 61

Table 3. Consumption per capita for selected countries, 1992

Country	Consumption (million \$)	Population (Thousands)	Per Capita (dollars)
Singapore	281.4	2800	100.49
Switzerland	565.7	6900	81.99
Germany	5033.7	60600	82.45
Japan	5678.2	124400	45.64
Austria	333.5	7900	42.21
Italy	2384.7	58000	41.11
Taiwan Province	759.8	20800	36.53
Republic of Korea	1492.5	44300	33.69
Sweden	290.0	8700	33.33
France	1583.7	56900	27.83
Belgium	256.9	10000	25.69
Canada	576.7	27400	21.05
United Kingdom	1141.2	57800	19.74
Netherlands	299.0	15200	19.67
Spain	751.7	38600	19.47
Denmark	101.2	5200	19.46
United States	3877.4	255600	15.17
Ukraine	780.0	52100	14.97
Finland	62.8	5000	12.56
Yugoslav Republic	124.9	10000	12.49
Croatia	56.0	4600	12.17
Portugal	125.9	10500	11.99
Hong Kong	41.3	5700	7.25
Mexico	513.0	87700	5.85
Australia	101.0	17800	5.67
Czechoslovakia	72.8	15700	4.64
Russia	1080.0	274572	3.93
Poland	127.9	38400	3.33
Argentina	106.6	33100	3.22
China	2313.6	1165800	1.98
Brazil	200.8	150800	1.33
South Africa	48.4	41700	1.16
Hungary	6.1	10300	0.59
India	260.2	882600	0.29
Total	31428.6	3627472.0	8.66

Source: American Machinist, Vol. 137 No. 3, March 1993, p33.

Table 4. Imports, Exports, and Trade Balance of selected producing countries, 1987 and 1992

	(millions of US dollars)						Percentage Share		
	1987			1992			Imports		
	Imports	Exports	Balance	Imports	Exports	Balance	1987	1992	1987
World	12386.9	14863.9	2477.0	13732.0	16913.6	3181.6	100.0	100.0	100
North America	2496.9	650.4	-1846.5	2186.6	1210.1	-976.5	20.2	15.9	4
Canada	528.0	63.7	-464.3	491.6	205.6	-286.0	4.3	3.6	0
United States	1968.9	586.7	-1382.2	1695.0	1004.5	-690.5	15.9	12.3	3
Western Europe	5275.1	8379.9	3104.8	7010.1	10349.3	3339.2	42.6	51.0	56
Austria	173.7	169.7	-4.0	408.5	321.2	-87.3	1.4	3.0	1
Belgium	321.1	294.3	-26.8	434.2	371.0	-63.2	2.6	3.2	2
Denmark	115.5	58.5	-57.0	122.8	88.8	-34.0	0.9	0.9	0
Finland	114.9	29.3	-85.6	51.4	38.0	-13.4	0.9	0.4	0
France	738.1	284.3	-453.8	1176.6	519.0	-657.6	6.0	8.6	1
Germany	1253.5	3654.7	2401.2	1881.0	4699.3	2818.3	10.1	13.7	24
Italy	566.3	1048.5	482.2	702.6	1374.3	671.7	4.6	5.1	7
Netherlands	361.2	179.5	-181.7	369.8	170.7	-199.1	2.9	2.7	1
Portugal	33.0	9.4	-23.6	113.5	16.7	-96.8	0.3	0.8	0
Spain	250.7	218.8	-31.9	449.7	328.4	-121.3	2.0	3.3	1
Sweden	312.3	192.7	-119.6	266.6	306.1	39.5	2.5	1.9	1
Switzerland	360.1	1435.8	1075.7	324.5	1453.8	1129.3	2.9	2.4	9
United Kingdom	529.7	501.0	-28.7	681.9	590.0	-91.9	4.3	5.0	3
Yugoslavia	145.0	303.4	158.4			0.0	1.2	0.0	2
Croatia				6.0	25.0	19.0	0.0	0.0	C
Rep. of Yugoslavia				21.0	47.0	26.0	0.0	0.2	C
Eastern Europe	2251.5	2113.3	-138.2	250.3	124.7	-125.6	18.2	1.8	14
Czechoslovakia	85.0	330.0	245.0	43.0	61.5	18.5	0.7	0.3	2
German Dem Rep	198.9	1202.4	1003.5			0.0	1.6	0.0	8
Hungary	124.5	170.5	46.0	4.3	7.2	2.9	1.0	0.0	1
Poland	203.9	98.1	-105.8	105.0	28.0	-77.0	1.6	0.8	C
USSR	1639.2	312.3	-1326.9			0.0	13.2	0.0	2
Russia				50.0	20.0	-30.0	0.0	0.4	C
Ukraine				48.0	8.0	-40.0	0.0	0.3	C
Japan	264.8	3035.1	2770.3	560.7	3553.8	2993.1	2.1	4.1	20
Other Dvlpd Cntries	201.1	7.4	-193.7	124.1	20.2	-103.9	1.6	0.9	C
Australia	137.2	4.9	-132.3	90.0	6.0	-84.0	1.1	0.7	C
South Africa	63.9	2.5	-61.4	34.1	14.2	-19.9	0.5	0.2	C
Latin America	336.0	41.7	-294.3	660.3	209.5	-450.8	2.7	4.8	C
Argentina	38.3	16.0	-22.3	75.0	5.2	-69.8	0.3	0.5	C
Brazil	49.0	23.0	-26.0	85.3	190.3	105.0	0.4	0.6	C
Mexico	248.7	2.7	-246.0	500.0	14.0	-486.0	2.0	3.6	C
Asia	1561.5	636.1	-925.4	2939.9	1446.0	-1493.9	12.6	21.4	
China	494.0	93.0	-401.0	780.0	205.0	-575.0	4.0	5.7	C
Hong Kong	75.0	6.0	-69.0	314.4	307.2	-7.2	0.6	2.3	C
India	146.6	34.7	-111.9	75.3	12.7	-62.6	1.2	0.5	C
Republic of Korea	486.1	37.5	-448.6	994.0	101.5	-892.5	3.9	7.2	C
Singapore	145.0	85.0	-60.0	353.9	173.3	-180.6	1.2	2.6	C
Taiwan Province	214.8	379.9	165.1	422.3	646.3	224.0	1.7	3.1	

Source: American Machinist, Vol 33, No. 2, February 1989, p61 and Vol 137, No.3, March 1993, p34

producing countries, 1987 and 1992									
rs)	1992			Percentage Share				Percentage Change	
	Imports	Exports	Balance	Imports		Exports		Imports	Exports
				1987	1992	1987	1992		
0	13732.0	16913.6	3181.6	100.0	100.0	100.0	100.0	10.9	13.8
5	2186.6	1210.1	-976.5	20.2	15.9	4.4	7.2	-12.4	86.1
3	491.6	205.6	-286.0	4.3	3.6	0.4	1.2	-6.9	222.8
2	1695.0	1004.5	-690.5	15.9	12.3	3.9	5.9	-13.9	71.2
8	7010.1	10349.3	3339.2	42.6	51.0	56.4	61.2	32.9	23.5
0	408.5	321.2	-87.3	1.4	3.0	1.1	1.9	135.2	89.3
8	434.2	371.0	-63.2	2.6	3.2	2.0	2.2	35.2	26.1
0	122.8	88.8	-34.0	0.9	0.9	0.4	0.5	6.3	51.8
6	51.4	38.0	-13.4	0.9	0.4	0.2	0.2	-55.3	29.7
8	1176.6	519.0	-657.6	6.0	8.6	1.9	3.1	59.4	82.6
2	1881.0	4699.3	2818.3	10.1	13.7	24.6	27.8	50.1	28.6
2	702.6	1374.3	671.7	4.6	5.1	7.1	8.1	24.1	31.1
7	369.8	170.7	-199.1	2.9	2.7	1.2	1.0	2.4	-4.9
6	113.5	16.7	-96.8	0.3	0.8	0.1	0.1	243.9	77.7
9	449.7	328.4	-121.3	2.0	3.3	1.5	1.9	79.4	50.1
6	266.6	306.1	39.5	2.5	1.9	1.3	1.8	-14.6	58.8
7	324.5	1453.8	1129.3	2.5	2.4	9.7	8.6	-9.9	1.3
7	681.9	590.0	-91.9	4.3	5.0	3.4	3.5	28.7	17.8
4			0.0	1.2	0.0	2.0	0.0		
	6.0	25.0	19.0	0.0	0.0	0.0	0.1		
	21.0	47.0	26.0	0.0	0.2	0.0	0.3		
2	250.3	124.7	-125.6	18.2	1.8	14.2	0.7	-88.9	-94.1
0	43.0	61.5	18.5	0.7	0.3	2.2	0.4	-49.4	-81.4
5			0.0	1.6	0.0	8.1	0.0		
0	4.3	7.2	2.9	1.0	0.0	1.1	0.0	-96.5	-95.8
8	105.0	28.0	-77.0	1.6	0.8	0.7	0.2	-48.5	-71.5
9			0.0	13.2	0.0	2.1	0.0		
	50.0	20.0	-30.0	0.0	0.4	0.0	0.1		
	48.0	8.0	-40.0	0.0	0.3	0.0	0.0		
3	560.7	3553.8	2993.1	2.1	4.1	20.4	21.0	111.7	17.1
7	124.1	20.2	-103.9	1.6	0.9	0.0	0.1	-38.3	173.0
3	90.0	6.0	-84.0	1.1	0.7	0.0	0.0	-34.4	22.4
4	34.1	14.2	-19.9	0.5	0.2	0.0	0.1	-46.6	468.0
3	660.3	209.5	-450.8	2.7	4.8	0.3	1.2	96.5	402.4
3	75.0	5.2	-69.8	0.3	0.5	0.1	0.0	95.8	-67.5
0	85.3	190.3	105.0	0.4	0.6	0.2	1.1	74.1	727.4
0	500.0	14.0	-486.0	2.0	3.6	0.0	0.1	101.0	418.5
4	2939.9	1446.0	-1493.9	12.6	21.4	4.3	8.5	88.3	127.3
0	780.0	205.0	-575.0	4.0	5.7	0.6	1.2	57.9	120.4
0	314.4	307.2	-7.2	0.6	2.3	0.0	1.8	319.2	5020.0
9	75.3	12.7	-62.6	1.2	0.5	0.2	0.1	-48.6	-63.4
8	994.0	101.5	-892.5	3.9	7.2	0.3	0.6	104.5	170.7
0	353.9	173.3	-180.6	1.2	2.6	0.6	1.0	144.1	103.9
1	422.3	646.3	224.0	1.7	3.1	2.6	3.8	96.6	70.1

Table 5. Total trade in metalworking machinery of individual countries and areas with 17 OECD countries, 1986 and 1991									
Country	(millions of US dollars)				Percentage Share				Percent Import
	Imports		Exports		Imports		Exports		
	1986	1991	1986	1991	1986	1991	1986	1991	
A. Developed Economies									
North America									
Canada	712.7	692.9	235.3	277.7	4.2	2.6	2.2	1.5	-2
United States*	2878.0	2861.9	501.8	1104.1	17.1	10.8	4.6	5.9	-4
Western Europe									
Austria*	358.9	585.3	187.8	490.7	2.1	2.2	1.7	2.6	63
Belgium-Luxembourg*	505.7	1059.4	256.8	466.3	3.0	4.0	2.3	2.5	105
Denmark	178.2	204.2	74.4	141.6	1.1	0.8	0.7	0.8	14
Finland*	127.2	136.2	35.6	85.2	0.8	0.5	0.3	0.5	7
France*	954.3	2034.7	384.4	863.0	5.7	7.7	3.5	4.6	113
Germany*	1607.2	3266.6	2847.6	4865.0	9.6	12.4	26.0	26.1	103
Greece	39.8	84.9	1.5	7.9	0.2	0.3	0.0	0.0	113
Iceland	3.7	4.0	0.2	0.2	0.0	0.0	0.0	0.0	8
Ireland*	55.0	105.9	25.8	42.2	0.3	0.4	0.2	0.2	92
Italy*	521.7	1182.6	937.9	1805.9	3.1	4.5	8.6	9.7	126
Netherlands*	406.4	642.9	212.0	398.4	2.4	2.4	1.9	2.1	58
Norway*	117.6	103.3	14.3	27.2	0.7	0.4	0.1	0.1	-12
Portugal	49.9	168.1	10.1	21.5	0.3	0.6	0.1	0.1	236
Spain*	185.6	715.1	169.7	346.7	1.1	2.7	1.6	1.9	285
Sweden*	364.5	435.5	261.5	390.2	2.2	1.6	2.4	2.1	19
Switzerland*	500.3	713.0	1244.4	1956.5	3.0	2.7	11.4	10.5	42
United Kingdom*	790.4	1293.7	489.0	949.5	4.7	4.9	4.5	5.1	63
Yugoslavia	193.5	124.5	24.4	97.7	1.2	0.5	0.2	0.5	-35
Eastern Europe and USSR									
Bulgaria	185.9	79.9	7.1	16.9	1.1	0.3	0.1	0.1	-57
Czechoslovakia	131.6	190.5	54.1	137.3	0.8	0.7	0.5	0.7	44
German Dem. Rep.	66.1		47.7		0.4	0.0	0.4	0.0	-109
Hungary	57.7	148.4	17.8	58.4	0.3	0.6	0.2	0.3	157
Poland	99.9	182.3	25.2	52.8	0.6	0.7	0.2	0.3	82
Romania	19.3	30.9	6.5	18.4	0.1	0.1	0.1	0.1	60
USSR	775.9	1306.8	36.5	56.5	4.6	4.9	0.3	0.3	68
Japan*	387.1	465.4	2419.5	3030.9	2.3	1.8	22.1	16.3	20
Other									
Australia	272.4	217.5	7.9	21.6	1.6	0.8	0.1	0.1	-20
Israel	88.0	106.5	25.1	35.3	0.5	0.4	0.2	0.2	21
New Zealand*	46.0	16.7	2.5	4.1	0.3	0.1	0.0	0.0	-63
South Africa	82.3	159.3	5.5	8.2	0.5	0.6	0.1	0.0	93
B. Developing Economies									
Latin America									
Argentina	40.3	101.9	1.2	2.4	0.2	0.4	0.0	0.0	152
Bahamas	0.4	1.1	0.0	0.0	0.0	0.0	0.0	0.0	175
Brazil	137.1	266.9	29.8	71.8	0.8	1.0	0.3	0.4	94
Chile	18.4	55.8	0.0	0.0	0.1	0.2	0.0	0.0	203
Columbia	21.3	27.4	0.0	0.1	0.1	0.1	0.0	0.0	28
Ecuador	11.5	12.8	0.0	0.0	0.1	0.0	0.0	0.0	11
Guatemala	2.2	6.3	0.0	0.0	0.0	0.0	0.0	0.0	186
Netherlands Antilles	0.6	2.8	0.0	0.2	0.0	0.0	0.0	0.0	333
Mexico	372.8	570.7	5.0	8.3	2.2	2.2	0.0	0.0	53
Peru	8.6	13.6	0.0	0.0	0.1	0.1	0.0	0.0	58

working machinery of individual countries and areas									
1986 and 1991									
(millions of US dollars)				Percentage Share				Percentage change	
Imports		Exports		Imports		Exports		1986-1991	
1986	1991	1986	1991	1986	1991	1986	1991	Imports	Exports
712.7	692.9	235.3	277.7	4.2	2.6	2.2	1.5	-2.8	18.0
2878.0	2861.9	501.8	1104.1	17.1	10.8	4.6	5.9	-0.6	120.0
358.9	585.3	187.8	490.7	2.1	2.2	1.7	2.6	63.1	161.3
505.7	1059.4	256.8	466.3	3.0	4.0	2.3	2.5	109.5	81.6
178.2	204.2	74.4	141.6	1.1	0.8	0.7	0.8	14.6	90.3
127.2	136.2	35.6	85.2	0.8	0.5	0.3	0.5	7.1	139.3
954.3	2034.7	384.4	863.0	5.7	7.7	3.5	4.6	113.2	124.5
1607.2	3266.6	2847.6	4865.0	9.6	12.4	26.0	26.1	103.2	70.8
39.8	84.9	1.5	7.9	0.2	0.3	0.0	0.0	113.3	426.7
3.7	4.0	0.2	0.2	0.0	0.0	0.0	0.0	8.1	0.0
55.0	105.9	25.8	42.2	0.3	0.4	0.2	0.2	92.5	63.6
521.7	1182.6	937.9	1805.9	3.1	4.5	8.6	9.7	126.7	92.5
406.4	642.9	212.0	398.4	2.4	2.4	1.9	2.1	58.2	87.9
117.6	103.3	14.3	27.2	0.7	0.4	0.1	0.1	-12.2	90.2
49.9	168.1	10.1	21.5	0.3	0.6	0.1	0.1	236.9	112.9
185.6	715.1	169.7	346.7	1.1	2.7	1.6	1.9	285.3	104.3
364.5	435.5	261.5	390.2	2.2	1.6	2.4	2.1	19.5	49.2
500.3	713.0	1244.4	1956.5	3.0	2.7	11.4	10.5	42.5	57.2
790.4	1293.7	489.0	949.5	4.7	4.9	4.5	5.1	63.7	94.2
193.5	124.5	24.4	97.7	1.2	0.5	0.2	0.5	-35.7	300.4
185.9	79.9	7.1	16.9	1.1	0.3	-0.1	0.1	-57.0	138.0
131.6	190.5	54.1	137.3	0.8	0.7	0.5	0.7	44.8	153.8
66.1		47.7		0.4	0.0	0.4	0.0	-100.0	-100.0
57.7	148.4	17.8	58.4	0.3	0.6	0.2	0.3	157.2	228.1
99.9	182.3	25.2	52.8	0.6	0.7	0.2	0.3	82.5	109.5
19.3	30.9	6.5	18.4	0.1	0.1	0.1	0.1	60.1	183.1
775.9	1306.8	36.5	56.5	4.6	4.9	0.3	0.3	68.4	54.8
387.1	465.4	2419.5	3030.9	2.3	1.8	22.1	16.3	20.2	25.3
272.4	217.5	7.9	21.6	1.6	0.8	0.1	0.1	-20.2	173.4
88.0	106.5	25.1	35.3	0.5	0.4	0.2	0.2	21.0	40.6
46.0	16.7	2.5	4.1	0.3	0.1	0.0	0.0	-63.7	64.0
82.3	159.3	5.5	8.2	0.5	0.6	0.1	0.0	93.6	49.1
40.3	101.9	1.2	2.4	0.2	0.4	0.0	0.0	152.9	100.0
0.4	1.1	0.0	0.0	0.0	0.0	0.0	0.0	175.0	
137.1	266.9	29.8	71.8	0.8	1.0	0.3	0.4	94.7	140.9
18.4	55.8	0.0	0.0	0.1	0.2	0.0	0.0	203.3	
21.3	27.4	0.0	0.1	0.1	0.1	0.0	0.0	28.6	
11.5	12.8	0.0	0.0	0.1	0.0	0.0	0.0	11.3	
2.2	6.3	0.0	0.0	0.0	0.0	0.0	0.0	186.4	
0.6	2.6	0.0	0.2	0.0	0.0	0.0	0.0	333.3	
372.8	570.7	5.0	8.3	2.2	2.2	0.0	0.0	53.2	66.0
8.6	13.6	0.0	0.0	0.1	0.1	0.0	0.0	58.1	

v. Timed

Table 5. Total trade in metalworking machinery of individual countries and areas with 17 OECD countries, 1986 and 1991									
Country	(millions of US dollars)				Percentage Share				Percent Imports
	Imports		Exports		Imports		Exports		
	1986	1991	1986	1991	1986	1991	1986	1991	
Trinidad and Tobago	5.3	6.4	0.0	0.0	0.0	0.0	0.0	0.0	2
Venezuela	101.2	177.5	0.0	0.1	0.6	0.7	0.0	0.0	7
Africa									
Algeria	112.8	121.1	0.2	0.4	0.7	0.5	0.0	0.0	
Cameroon	4.2	3.2	0.1	0.0	0.0	0.0	0.0	0.0	-2
Egypt	66.2	82.9	1.2	0.4	0.4	0.3	0.0	0.0	2
Gabon	3.3	2.2	0.0	0.0	0.0	0.0	0.0	0.0	-3
Ghana	4.2	15.5	0.0	0.4	0.0	0.1	0.0	0.0	26
Liberia	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-10
Libya	44.9	43.3	0.0	0.1	0.3	0.2	0.0	0.0	-
Ivory Coast	4.1	2.9	0.2	0.1	0.0	0.0	0.0	0.0	-2
Maroc	18.6	28.0	0.1	0.1	0.1	0.1	0.0	0.0	5
Nigeria	58.5	18.5	0.0	0.7	0.3	0.1	0.0	0.0	-6
Tunisia	22.8	27.9	0.1	0.8	0.1	0.1	0.0	0.0	2
Zaire	5.6	6.4	0.0	0.0	0.0	0.0	0.0	0.0	1
Western Asia									
Abu Dhabi	5.2	1.4	0.0	0.0	0.0	0.0	0.0	0.0	-7
Iran	127.1	457.0	0.6	0.3	0.8	1.7	0.0	0.0	25
Iraq	25.8	0.0	0.5	0.0	0.2	0.0	0.0	0.0	-10
Kuwait	9.3	12.9	0.0	0.1	0.1	0.0	0.0	0.0	3
Oman	7.6	5.3	0.0	0.1	0.0	0.0	0.0	0.0	-3
Qatar	2.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	
Saudi Arabia	56.3	89.9	0.7	0.6	0.3	0.3	0.0	0.0	5
Syria	6.5	6.7	0.0	0.7	0.0	0.0	0.0	0.0	
Turkey*	121.6	278.2	1.5	20.7	0.7	1.1	0.0	0.1	12
United Arab Emirates	7.9	29.9	0.3	0.6	0.0	0.1	0.0	0.0	2
Asia, Developing Mkt									
Brunei	0.6	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1
Hong Kong	87.5	148.8	6.1	9.6	0.5	0.6	0.1	0.1	
India	252.0	285.6	7.2	11.8	1.5	1.1	0.1	0.1	
Indonesia	72.2	259.8	0.2	0.1	0.4	1.0	0.0	0.0	2
Malaysia	33.6	269.1	0.4	2.7	0.2	1.0	0.0	0.0	7
New Guinea	1.3	0.9	0.0	0.0	0.0	0.0	0.0	0.0	-
Pakistan	37.0	44.6	0.0	0.0	0.2	0.2	0.0	0.0	
Philippines	31.1	65.5	0.2	3.3	0.2	0.2	0.0	0.0	1
Republic of Korea	684.4	1580.8	33.6	104.4	4.1	6.0	0.3	0.6	1
Singapore	108.5	329.0	26.5	57.5	0.6	1.2	0.2	0.3	2
Taiwan Province	248.6	530.8	230.1	407.3	1.5	2.0	2.1	2.2	1
Thailand	43.3	461.0	0.5	29.6	0.3	1.7	0.0	0.2	9
Asia, Centrally Planned									
China	1002.0	632.1	17.6	115.7	6.0	2.4	0.2	0.6	
TOTAL	16800.0	26406.4	10933.8	18628.9	100.0	100.0	100.0	100.0	

*Countries whose import and export data are combined in the tabulation.

Source: OECD Foreign Trade by Commodities, Vol 1, 2, and 3 (Paris, 1992)

Working machinery of individual countries and areas 1986 and 1991								<i>Continued</i>	
(millions of US dollars)				Percentage Share				Percentage change	
Imports		Exports		Imports		Exports		1986-1991	
1986	1991	1986	1991	1986	1991	1986	1991	Imports	Exports
5.3	6.4	0.0	0.0	0.0	0.0	0.0	0.0	20.8	
101.2	177.5	0.0	0.1	0.6	0.7	0.0	0.0	75.4	
112.8	121.1	0.2	0.4	0.7	0.5	0.0	0.0	7.4	100.0
4.2	3.2	0.1	0.0	0.0	0.0	0.0	0.0	-23.8	-100.0
66.2	82.9	1.2	0.4	0.4	0.3	0.0	0.0	25.2	-66.7
3.3	2.2	0.0	0.0	0.0	0.0	0.0	0.0	-33.3	
4.2	15.5	0.0	0.4	0.0	0.1	0.0	0.0	269.0	
1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-100.0	
44.9	43.3	0.0	0.1	0.3	0.2	0.0	0.0	-3.6	
4.1	2.9	0.2	0.1	0.0	0.0	0.0	0.0	-29.3	-50.0
18.6	28.0	0.1	0.1	0.1	0.1	0.0	0.0	50.5	0.0
58.5	18.5	0.0	0.7	0.3	0.1	0.0	0.0	-68.4	
22.8	27.9	0.1	0.8	0.1	0.1	0.0	0.0	22.4	700.0
5.6	6.4	0.0	0.0	0.0	0.0	0.0	0.0	14.3	
5.2	1.4	0.0	0.0	0.0	0.0	0.0	0.0	-73.1	
127.1	457.0	0.6	0.3	0.8	1.7	0.0	0.0	259.6	-50.0
25.8	0.0	0.5	0.0	0.2	0.0	0.0	0.0	-100.0	-100.0
9.3	12.9	0.0	0.1	0.1	0.0	0.0	0.0	38.7	
7.6	5.3	0.0	0.1	0.0	0.0	0.0	0.0	-30.3	
2.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	-9.5	
56.3	89.9	0.7	0.6	0.3	0.3	0.0	0.0	59.7	-14.3
6.5	6.7	0.0	0.7	0.0	0.0	0.0	0.0	3.1	
121.6	278.2	1.5	20.7	0.7	1.1	0.0	0.1	128.8	1280.0
7.9	29.9	0.3	0.6	0.0	0.1	0.0	0.0	278.5	100.0
0.6	1.4	0.0	0.0	0.0	0.0	0.0	0.0	133.3	
87.5	148.8	6.1	9.6	0.5	0.6	0.1	0.1	70.1	57.4
252.0	285.6	7.2	11.8	1.5	1.1	0.1	0.1	13.3	63.9
72.2	259.8	0.2	0.1	0.4	1.0	0.0	0.0	259.8	-50.0
33.6	269.1	0.4	2.7	0.2	1.0	0.0	0.0	700.9	575.0
1.3	0.9	0.0	0.0	0.0	0.0	0.0	0.0	-30.8	
37.0	44.6	0.0	0.0	0.2	0.2	0.0	0.0	20.5	
31.1	65.5	0.2	3.3	0.2	0.2	0.0	0.0	110.6	1550.0
684.4	1580.8	33.6	104.4	4.1	6.0	0.3	0.6	131.0	210.7
108.5	329.0	26.5	57.5	0.6	1.2	0.2	0.3	203.2	117.0
248.6	530.8	230.1	407.3	1.5	2.0	2.1	2.2	113.5	77.0
43.3	461.0	0.5	29.6	0.3	1.7	0.0	0.2	964.7	5820.0
1002.0	632.1	17.6	115.7	6.0	2.4	0.2	0.6	-36.9	557.4
16800.0	26406.4	10933.8	18628.9	100.0	100.0	100.0	100.0	57.2	70.4

and export data are combined in the tabulation.

made by Commodities, Vol 1, 2, and 3 (Paris, 1992)

Table 6. World's 25 largest machine-tool companies, 1991							
Rank	Company and country	Turnover (million dollars)	Percent change	Profit (million dollars)	Percent change	Margin	Number of employees
1	Amada Co., Ltd. (Japan)	1330.6	0.7	112.7	-15.7	8.3	1696
2	Fanuc Ltd. (Japan)	1027.0	-14.8	246.1	1.6	20.2	2181
3	Yamazaki Mazak Corp. (Japan)	1911.3	-19.5				3800
4	Okuma Machinery Works (Japan)	847.9	4.8	43.1	31.0	5.2	1954
5	Thyssen Maschinenbau GmbH (Germany)	684.6					6400
6	Mori Seiki Co., Ltd. (Japan)	684.0	-5.5	107.1	32.0	16.6	1874
7	Toyoda Machine Works (Japan)	565.8	11.3	6.0	-69.3	0.4	4876
8	Komatsu Ltd. (Japan)	531.7	3.2	209.3	7.3	3.2	15033
9	Pittler Consolidated Group (Germany)	527.0		-16.5	-211.3	-3.1	5766
10	Toshiba Machine Co., Ltd. (Japan)	475.8	16.1	52.2	46.7	4.8	3395
11	Ingersoll Milling Machine Co. (United States)	460.0	15.0				4250
12	Trumpf Group (Germany)	454.6	1.8	14.0	-32.6	3.1	2914
13	Fuji Machine Manufacturing Co. Ltd. (Japan)	451.2	-5.4	47.3	-2.2	10.5	1027
14	Schuler Group (Germany)	439.7	-2.8				4015
15	Hitachi Seiki Co., Ltd. (Japan)	420.5	5.2	14.2	-37.6	3.4	1280
16	Citizen Watch Co., Ltd. (Japan)	392.8	20.2	109.6	35.5	4.0	3273
17	Maho. AG (Germany)	384.1	-10.2	-17.3	-298.3	-4.5	3459
18	Cincinnati Milacron Inc. (United States)	383.7	-11.5	-100.2	312.3	-13.3	6903
19	Gildemeister Group (Germany)	380.5	-12.0	-17.4	-270.1	-4.6	3510
20	Makino Milling Machine Co., Ltd. (Japan)	379.5	3.0	29.1	-8.8	7.0	1134
21	Amada Wasino Co., Ltd. (Japan)	364.3	3.4	18.3	20.5	5.5	545
22	Nippei Toyama Corp. (Japan)	361.4	23.7	13.9	51.0	3.8	1133
23	Amadasonoike Co., Ltd. (Japan)	325.2	-18.6	21.4	-10.4	7.2	710
24	Giddings & Lewis Inc (United States)	304.9	31.3	22.0	11.5	6.7	4520
25	Mitsubishi Heavy Industries Ltd (Japan)	302.7	11.2	736.9	51.9	4.3	45433

a/ Turnover figures represent the portion of total figures represented by machine tools (including numerical controls)

b/ Net profit figures represent the after-tax profit for the total turnover of the company.

c/ Calculated on total turnover

Source: American Machinist. Blue Bulletin (August, 1992)

Table 7. Production of numerically controlled machines by country, 1987 and 1991

(millions of US dollars)

Country	1987					1991			Percent NC
	NC machine prodn		Total prodn	Percent NC	Share	NC machine prodn		Total prodn	
	Units	Value	Value			Units	Value	Value	
Japan	35460	3364.7	6419.4	52.4	37.1	55032	7240.3	11638.7	6
Germany	18965	3299.7	6402.6	51.5	36.4	19145	4422.3	8122.5	5
United States	6409	931.0	2585.0	36.0	10.3	8212	1118.2	3312.1	3
Switzerland	na	na	1652.4	na	na	a/4090	a/702.5	a/1730.2	4
France	na	na	766.1	na	na	na	500.6	912.9	5
Italy	na	645.5	2235.2	28.9	7.1	na	439.3	3470.1	1
Spain	na	214.9	575.0	37.4	2.4	na	452.7	750.6	6
United Kingdom	b/1862	b/291.2	b/1058.4	27.5	3.2	b/1816	b/430.7	b/1146.2	3
Republic of Korea	2039	160.3	530.9	30.2	1.8	3675	291.2	798.4	3
Austria	na	na	155.0	na	na	b/2179	b/126.0	b/272.5	4
Taiwan Province	2714	114.5	577.8	19.8	1.3	5944	275.9	962.6	2
India	193	35.9	277.7	12.9	0.4	679	82.9	221.6	3
Total	67642	9057.7	23235.5	39.0	100.0	100772	16082.6	33339.0	4

Notes: a/ Switzerland does not report NC production. These are export figures. Total production was \$2092.3.

b/ United Kingdom and Austria include major NC machine types only.

Source: International exchange of statistics compiled by CECIMO; Economic Handbook of the Machine Tool Industry, Association for Manufacturing Technology, McLean, Va. 1992-93 edition

Table 8. Consumption of numerically controlled machines by country, 1987 and 1991

(millions of US dollars)

Country	1987					1991			Percent NC
	NC machine cnsmpn		Ttl cnsmpn	Percent NC	Share	NC machine cnsmpn		Ttl cnsmpn	
	Units	Value	Value			Units	Value	Value	
Japan	22661	2030.2	3649.1	55.6	25.7	38934	4916.3	8327.3	
Germany	6206	1342.7	4001.4	33.6	17.0	22434	3399.1	5326.9	
United States	15474	1842.3	3967.2	46.4	23.4	15316	1913.8	4452.1	
France	na	896.0	1219.9	73.4	11.4	na	790.0	1815.9	
Republic of Korea	2341	216.0	979.5	22.1	2.7	5305	584.4	1643.9	
United Kingdom	na	390.0	1087.1	35.9	4.9	1784	a/520.1	1364.6	
Spain	na	301.3	606.9	49.6	3.8	na	430.4	803.4	
Italy	na	662.3	1753.0	37.8	8.4	na	407.7	2718.0	
Switzerland	na	120.0	b/576.7	20.8	1.5	2368	b/253.2	422.7	
Taiwan Province	na	87.7	412.7	21.3	1.1	2880	c/242.0	627.0	
Total	46682	7888.5	18253.5	43.2	100.0	89021	13457.0	28519.0	

Notes: a/ United Kingdom includes major machine types only.

b/ Switzerland does not report NC production. This is the figure for imports only.

c/ Taiwan Province does not report imports. This is production minus exports only.

Source: International exchange of statistics compiled by CECIMO; Economic Handbook of the Machine Tool Industry, Association for Manufacturing Technology, McLean, Va. 1992-93 edition

ed machines by country, 1987 and 1991

Country	1987			1991			Percent change		
	Total prdn	Percent NC	Share	NC machine prdn	Total prdn	Percent NC	Share	change 87-91	
	Value	NC		Units	Value	Value			
USA	6419.4	52.4	37.1	55032	7240.3	11638.7	62.2	45.0	115.2
Canada	6402.6	51.5	36.4	19145	4422.3	8122.5	54.4	27.5	34.0
Japan	2585.0	36.0	10.3	8212	1118.2	3312.1	33.8	7.0	20.1
Germany	1652.4	na	na	a/4090	a/702.5	a/1730.2	40.6	4.4	na
France	766.1	na	na	na	500.6	912.9	54.8	3.1	na
Italy	2235.2	28.9	7.1	na	439.3	3470.1	12.7	2.7	-31.9
UK	575.0	37.4	2.4	na	452.7	750.6	60.3	2.8	110.7
Other	b/1058.4	27.5	3.2	b/1816	b/430.7	b/1146.2	37.6	2.7	47.9
Spain	530.9	30.2	1.8	3675	291.2	798.4	36.5	1.8	81.7
Sweden	155.0	na	na	b/2179	b/126.0	b/272.5	46.2	0.8	na
Belgium	577.8	19.8	1.3	5944	275.9	962.6	28.7	1.7	141.0
Australia	277.7	12.9	0.4	679	82.9	221.6	37.4	0.5	130.9
Other	23235.5	39.0	100.0	100772	16082.6	33339.0	48.2	100.0	77.6

Production. These are export figures. Total production was \$2092.3.

For NC machine types only.

Compiled by CECIMO; Economic Handbook of the Machine Tool Industry, McLean, Va, 1992-93 edition

ed machines by country, 1987 and 1991

Country	1987			1991			Percent change		
	Total prdn	Percent NC	Share	NC machine cnsmpn	Total prdn	Percent NC	Share	change 87-91	
	Value	NC		Units	Value	Value			
USA	3649.1	55.6	25.7	38934	4916.3	8327.3	59.0	35.5	142.2
Canada	4001.4	33.6	17.0	22434	3399.1	5326.9	63.8	24.6	153.2
Japan	3967.2	46.4	23.4	15316	1913.8	4452.1	43.0	13.8	3.9
Germany	1219.9	73.4	11.4	na	790.0	1815.9	43.5	5.7	-11.8
France	979.5	22.1	2.7	5305	584.4	1643.9	35.5	4.2	170.6
Italy	1087.1	35.9	4.9	1784	a/520.1	1364.6	38.1	3.8	33.4
UK	606.9	49.6	3.8	na	430.4	803.4	53.6	3.1	42.8
Other	1753.0	37.8	8.4	na	407.7	2718.0	15.0	2.9	-38.4
Spain	b/575.7	20.8	1.5	2368	b/253.2	422.7	36.0	1.8	111.0
Sweden	412.7	21.3	1.1	2880	c/242.0	627.0	37.4	1.7	175.9
Belgium	18253.5	43.2	100.0	89021	13457.0	28519.0	47.2	97.3	70.6

Machine types only.

n. This is the figure for imports only.

This is production minus exports only.

Compiled by CECIMO; Economic Handbook of the Machine Tool Industry, McLean, Va, 1992-93 edition

Table 9. NC machine production and consumption by type, 1991									
(Millions of dollars)									
	Japan		Germany		United States		Italy		Sw
	Production	Consumpti	Production	Consumpti	Production	Consumpti	Production	Consumpti	Export
Total machines	11632.3	8290.3	8122.5	5326.9	3312.1	4452.1	3470.1	2718.3	173
NC machines	7240.4	4811.9	4422.3	3399.1	1118.2	1913.8	439.3	456.6	70
Percent NC	62%	58%	54%	64%	34%	43%	13%	17%	4
Metalcutting	9394.9	6771.1	5685.7	4185.9	2281.8	3367.5	2352.9	2050.7	132
NC metalcutting	6810.3	4590.6	3858.1	2967.3	969.4	1743.5	439.3	456.6	60
Percent NC	72%	68%	68%	71%	42%	52%	19%	22%	4
Machining Centers	2290	1584.5	739.3	207.4	379.7	633.4	291.7	287.5	5
NC machining centers	2290	1584.5	739.3	207.4	379.7	633.4	291.7	287.5	5
Percent NC	100%	100%	100%	100%	100%	100%	100%	100%	10
Lathes	1941.4	1220.8	1191.9	911.5	341.0	650.9	353.2	320.2	18
NC lathes	1749.0	1057.1	877.8	1022.3	267.0	513.4	214.0	228.2	10
Percent NC	90%	87%	74%	112%	78%	79%	61%	71%	5
Drilling & boring mach.	466.6	292.4	245	264.8	133.3	190.6	115.0	64.2	12
NC drilling & boring	324.1	172.6	123.5	129.1	64.7	109.2			5
Percent NC	69%	59%	50%	49%	49%	57%			7
Milling machines	457.2	357.1	686.8	504.6	214.2	251.4	243.6	249.8	7
NC milling	284.3	225.3	560.5	397	181.2	201.7	225.3	232.0	5
Percent NC	62%	63%	82%	79%	85%	80%	92%	93%	7
Grinding machines	1205.6	934.8	753.8	578.8	476.4	608.2	308.0	201.3	33
NC grinding	477.3	337.2	476.3	257.8	175	234.9			19
Percent NC	40%	36%	63%	45%	37%	39%			5
Metalfforming machines	2237.3	1519.2	2436.7	1514.7	1030.3	1084.6	1117.2	667.6	40
NC metalfforming	430.1	325.7	564.2	431.8	148.9	170.3			10
Percent NC	19%	21%	23%	29%	14%	16%			2

Source: International exchange of statistics compiled by CECIMO: Economic Handbok of the Machine Tool Industry, Association of Manufacturing Technology, McLean, Va. 1992-93 Edition

Italy		Switzerland		United Kingdom		Taiwan Province		France		Spain		Rep
Production	Consumpt	Exports	Imports	Production	Consumpt	Production	Consumpt	Production	Consumpt	Production	Consumpt	Produ
2470.1	2718.3	1730.2	422.7	1146.8	1226.6	962.6	627.0	912.9	1815.9	750.6	803.4	7
439.3	456.6	702.5	253.2	430.7	520.1	275.9	242.0	500.6	790.0	452.7	434.4	
13%	17%	41%	60%	38%	42%	29%	39%	55%	44%	60%	54%	
2352.9	2050.7	1328.4	329.9	753.1	789.5	681.3	384.3	658.6	1345.9	506.6	425.7	6
439.3	456.6	601.7	226.2	387.0	435.0	273.5	219.8	387.3	649.2	354.2	297.4	2
19%	22%	45%	69%	51%	55%	40%	57%	59%	48%	70%	70%	2
291.7	287.5	56.8	79.5	131.8	88.9	126.0	82.5	58.9	183.0	47.3	43.4	9
291.7	287.5	56.8	79.5	131.8	88.9	126.0	82.5	58.9	183.0	47.3	43.4	9
100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	10
353.2	320.2	188.1	98.7	232.2	246.1	224.6	114.5	92.7	227.9	83.5	82.1	2
214.0	228.2	107.7	84.9	97.8	139.5	123.3	96.2	83.0	188.3	56.0	67.9	1
61%	71%	57%	86%	42%	57%	55%	84%	90%	83%	67%	83%	8
115.0	64.2	122.9	27.9			84.4	19.6			32.1	31.9	4
		91.6	13.7			2.0	8.0			9.4	14.7	
		75%	49%			2%	41%			29%	46%	
243.6	249.8	75.8	24.6	68.7	153.6	83.2	25.2			171.9	61.6	9
225.3	232.0	59.7	14.2	41.6	120.9	16	10.7			132.4	59.1	
92%	93%	79%	58%	61%	79%	19%	42%			77%	96%	2
308.0	201.3	338.1	53.7	126.7	153.6	49.3	40.0	32.8	169.6	44.9	59.2	3
		199.6	25.1	76.4	120.9	6.2	18.3	6.2	89.6	29.7	20.8	
		59%	47%	60%	79%	13%	46%	19%	53%	66%	35%	
117.2	667.6	401.6	92.7	393.8	437.1	281.2	242.8	254.3	470.0	244.0	377.6	1
		100.6	27.0	43.7	85.1	2.3	22.2	113.3	140.8	98.6	137.0	
		25%	29%	11%	19%	1%	9%	45%	30%	40%	36%	
Line Tool												

	Republic of Korea		India		Denmark		Total	
in	Production	Consumpti	Production	Consumpti	Production	Consumpti	Production	Consumption
803.4	798.4	1643.9	218.0		75.3	113.5	33131.8	27440.6
434.4			82.9		26.7	56.7	15692.2	12877.8
54%			38%		35%	50%	47%	47%
425.7	659.3	1247.4	200.1		34.0	77.9	24536.7	20975.8
297.4	291.1	514	81.3		5.6	49.2	14458.8	12148.8
70%	44%	41%	41%		16%	63%	59%	58%
43.4	93.7	134.4	26.6		0.0	17.0	4241.8	3341.5
43.4	93.7	134.4	26.6		0.0	17.0	4241.8	3341.5
100%	100%	100%	100%			100%	100%	100%
82.1	269.8	305.4	62.7		0.5	22.9	4981.6	4201.0
67.9	158.4	169.2	31.8		0.0	17.2	3765.8	3584.2
83%	59%	55%	51%		0%	75%	76%	85%
31.9	40.6	130.3	24.3		12.5	14.3	1276.7	1036.0
14.7	2.7	50.1	8.2		1.2	8.0	627.4	505.4
46%	7%	36%	34%		10%	56%	49%	49%
61.6	94.6	135.8	23.9		0.1	2.6	2120.0	1766.3
59.1	19.1	44.7	2.6		0.0	0.0	1522.7	1305.6
96%	20%	33%	11%		0%	0%	7%	74%
59.2	33.3	188.7	21.4		17.6	7.7	3407.9	2995.6
20.8	2.4	69.3	3.9		4.4	2.5	1457.4	1176.4
35%	7%	37%	18%		25%	32%	43%	39%
377.6	139.1	396.6	17.9		75.3	113.5	8628.7	6916.4
137.0			1.6		26.7	56.7	1530.0	1396.6
36%			9%		35%	50%	18%	20%