THE MACHINE TOOL INDUSTRY IN JAPAN

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Abstract:

This paper studies the industrial structure of the machine tool sector in Japan. We tried to face both the evolution of its economic variables, and the most important factors of its strength and weakness. After having considered the start-up and the development of this industry (chapter 1), in the second chapter we underline the role played by industrial policy. Thanks to a policy based on the managed competition Japanese firms overcome rapidly the oil shocks in the Seventies, and the technological change in the Eighties. Within the economic variables our analysis is based on production (chapter 3) and exports (chapter 4). After having considered the industry as a whole, we studied the main industrial groups (chapter 5), their strategies in the technological field (chapter 6), their external growth (chapter 7). The evidence of some relationships between firm's strategy and policy instruments (chapter 8) gives us an optimistic view about the success of Japanese firms in the serious crisis of the Nineties.

La ricerca affronta l'esame della struttura dell'offerta del settore delle macchine utensili in Giappone cercando di evidenziare sia l'evoluzione nel corso del tempo di alcune variabili economiche, sia i principali punti di forza e di debolezza delle imprese giapponesi.
Dopo aver esaminato le determinanti della nascita e della prima fase di sviluppo del settore (cap.1), nel secondo capitolo si sottolinea l'importanza della politica industriale nel consentire alle imprese una rapida risposta agli shock degli anni Settanta e all'evoluzione del progresso tecnologico degli anni Ottanta. Tra le principali variabili economiche si approfondisce l'analisi dei dati di produzione (cap.3) e delle esportazioni (cap.4). Successivamente si passa dall'analisi dell'aggregato settoriale a quella dei singoli gruppi industriali (cap.5), del loro controllo sull'innovazione tecnologica (cap.6) e delle loro strategie di crescita esterna (cap.7). L'evidenza di chiare relazioni tra le strategie seguite dai grandi gruppi e gli strumenti di politica industriale a disposizione nel Paese (cap.8) forniscono segnali positivi per il rapido superamento della pesante crisi congiunturale dei primi anni Novanta.

1. The pattern of growth of the machine tool industry in Japan

1.1 Until the end of world war II: growth towed by the military industry

The origin of the industry of machine tools in Japan goes back to the nineteenth century. Some studies [Chokky 1986] indicate that the various military arsenals, previously equipped with imported machine tools, began their own production in around 1870 to cover very specific needs.

Along side this core of user-producers there was soon a high concentration of small handicraft enterprises that dedicated the know-how they had accumulated in mechanical technology to the imitation of imported machine tools in order to duplicate performance at a lower cost.

Moreover, several service workshops that worked for the arsenals converted their own businesses into the more profitable production of such machinery.

According to other sources [MEM 1982] it is not so important to single out the precise origin of the sector but rather to underline that already at the end of the nineteenth century industrial statistics revealed, very significantly, a high number of independent machine tool manufacturers and a continuously expanding market.

The strategic character of this newborn industry and its particular connection with the military sector clearly stood out during the Russian-Japanese War of 1904-1905 when the arsenals considerably increased the demand for machine tools. It is noteworthy, however, that most of this demand for machine tools was fulfilled by imports, generally European, especially in segments of high technology.

The autarchic period of the First World War substantially reduced the amount of imports and provided further opportunities for the consolidation of the national sector.

The industrial statistics point out - in the period from 1915 to 1921 - the first real expansion of the sector: production grows from 1.5 to 18 billion yen and exports reach, at the end of the period, 11% of total production.

The evolution of this sector became evident immediately at the first trade fairs of machine tools where there were not only various types of lathes, a product which represents the historical nucleus of the newborn industry, but also numerous other metalcutting and metalforming machines.

Subsequent phases of expansion did not occur until World War II broke out, during which the Japanese machine tool industry had a series of “special war facilities” granted by an “ad hoc legislation” in 1938 (Kosakukikai Seizo Jigyo-ho) in favour of the sectors which were strategically important for military purposes [1].

The remarkable prosperity of the war period (production tripled between 1938 and 1944) was followed by a severe crisis in the post-war period, during which the machine tool sector’s recovery was even weaker than that of the Japanese industry as a whole. The reasons for this slackening are to be found in the fading out of the main outlet market, the military one, and in the greater pressure of imports, which grew easily in a market that had been highly

[1] It is noteworthy that the “war economy” in Japan lasted from the invasion of Manchuria in 1931 till the end of world war II.

protected until then. Moreover, only half of the amount of machines that had to be taken away from Japan after the agreements on war damages was actually taken over and therefore the old machinery remained and did not favour the demand for replacement. In this context, the number of manufacturers decreased drastically, both due to the disappearance of marginal enterprises that were unable to withstand the crisis, and to the reorganization process that resulted from the crisis: there were 446 manufacturers in 1944, 80 in 1948 and 21 in 1951.

1.2 From the post-war period to the present: the yen economy and the technological competition

Only in the 50s did the machine tool sector hitch onto the recovery of the automobile sector (with which it was highly integrated) and the railway and naval sectors, having terminated its reconversion process from military production. In this period the growth was towed by domestic demand, especially of public origin (among the various examples, the reorganization plan of Japanese railways that was aimed almost exclusively toward national production). It was precisely the Japanese growth model, towed by domestic investment, that favoured the machine tool industry.

As will be seen later, in this period the role of government was decisive in the development of the sector. For example, with the law of 1956 for the modernization of strategic sectors (Kikaikogyo Rinji Sochi-ho) the machine tool industry was favoured directly, with tax-incentives and financial grants, and indirectly through investment-incentives in other sectors.

Throughout the 50s and 60s the quantitative growth of the sector was accompanied by a parallel qualitative development of technological updating.

In this sector, as well as in most of Japanese industry, technological change came from outside the country. The purchase of technology from Europe was a determining factor, with which it set up a series of R&D activities for imitation. In this regard one might recall that the manufacturers' association (JMTBA) even established a work group in that period, made up of representatives from MITI, companies, universities, and other research institutions, for the purpose of ascertaining which technologies would be most suitable for importation (in order to later attain the qualitative levels of European manufacturing). They decided on the strategy of imitation, which made it possible, all the same, to improve the more advanced technologies and to make use of licence contracts obtained from mostly European companies (29 licences in the years 1961-64). The granting of licences from French companies prevailed among the agreements made.

Once again the decisive role of government came forth: the law of 1950 that concerned foreign investments in Japan (Gaishy-ho) selected the purchase of foreign technology to promote the development of national sectors [2].

The brilliant results obtained in the 60s by Japanese industry are partly attributable to the success of this strategic choice. They were generally happy years for the machine tool

[2] The aforesaid law, administered by the MITI, was withdrawn only in 1980, when it was no longer necessary to have authorization for foreign investments in Japan.

sector, except for the heavy recession from 1963 to 1965 which caused a drop in demand and a significant number of bankruptcies among the weaker manufacturers. Nonetheless, due to the flexibility of capital and labour markets, the effects of the crisis were toned down and the sector took advantage of the new upswing during the second half of the decade.

Entering into the difficult decade of the 70s was facilitated by the privilege attributed to R&D and technology as determinant strategic variables for gaining the competitive advantage. In fact, in the 60s there were already some NC machines produced nationally, and in the 70s there was a real boom of such production. In 1970 at the JMTOF Trade Fair in Osaka the companies belonging to the JMTBA exhibited 123 NC machines, of which 44 were lathes and 29 were machining centers.

In this case as well, the consolidation of NC machine manufacturing came about with the use of foreign technology: in the period from 1970 to 1973 the Japanese companies obtained 58 licences, mostly from U.S. manufacturers, who in the meantime had replaced the Europeans as a source of technology for Japan.

In this period a close relationship between technology and the propensity to export can be observed - in correspondence with periods of more intensive use of technological licences, one notices a sharp rise in the export and production data. The inverse is true for the amount of imports in relation to domestic demand. The Japanese case affirms that even R&D based on imitation can produce - obviously in the best of surrounding conditions - optimum results for the whole economy of the sector.

Though the first granting of Japanese licences started to appear abroad - 10 cases distributed throughout South Korea (5), Taiwan (3), Spain (1) and the U.K. (1) - the technological balance of the sector continued to remain negative for the entire decade, notwithstanding the fact that a JMTBA report on the development of the sector emphasized that at the end of the 70s the technological level of Japanese machinery was comparable to the level of European and American one [MEM 1982]. During the second half of the 70s another indication of this evolution appears: the cross-licensing process between Japan and foreign countries based on an increasing specialization in production.

The development of the sector in the 70s was closely related to the spreading of technology and the international division of labour. In fact, with the devaluation of the dollar in 1971, the prices of Japanese machinery were no longer competitive. To make things worse there were the two world oil crises: two digit inflation figures, zero growth in 1974, high unemployment, a sudden fall in machinery investments were some of the negative effects of those crises. In a nutshell, an entire pattern of growth, the so-called “yen economy”, faded out. This model had been based on the penetration of foreign markets throughout the post-war period by exploiting price competition, knowing well that the domestic markets were safeguarded by protective policies (tariff and non-tariff). Subsequently technological competition, based on non-price factors, ensued and replaced the previous pattern of growth - though with considerable difficulty. Also in this case, overcoming the crisis was fostered by domestic demand, mostly from the public sector, aimed at a labour-saving and energy-saving reorganization of industry, and no longer by the expansion of the production capacity as in the 60s.

The analysis of the sector’s growth model can be completed by considering the following aspects [Jacobsson 1986]:

- the increase in the number of manufacturers was favoured by the vertical integration of major users (essentially automobile groups), and by the establishment of independent and specialized manufacturers;

- we can notice a significant number of manufacturing joint-ventures between Japanese and American manufacturers, although none of quantitative significance;

- the close ties between industry and banks allowed for a substantial contribution of financial resources, not only debts but also equities. This favoured the financial structure of the major producers, by then no longer family enterprises (as they were after world war II) but part of the large economic groups.

2. Some aspects of the Japanese industrial policy for the machine tool industry

As seen previously, the machine tool sector has been traditionally supported by public demand for military purposes. However, after Japan's defeat in World War II this important outlet market faded out and an attempt was made to immediately replace the military demand with new industrial markets. Positive results were not obtained initially: lack of investments, low demand, and a total lack of infrastructures prevented the sector from taking off and it suffered - probably more than other sectors - the difficulties of rebirth. In fact, since the public demand (for example, the reorganization of the railway system) was not sufficient to inject new life into recovery, a large part of economic activity depended on the private sector, increasing the degree of competition between producers.

This brief introduction helps to interpret the attention that the public operator, from then on, has always dedicated to the machine tool industry.

We can affirm that the industrial policy for the machine tool industry has generally been prompted by the following strategic design: government assistance provides, firstly, a strong administrative guide superimposed on the rules of the game of competition; moreover, perhaps to a lesser degree, it grants financial, fiscal and trade benefits that are very carefully aimed and undoubtedly effective [Komiya-Irino 1989].

The principal instruments of this strategy were the development plans of the 50s and 60s, guided by the MITI on account of the undiscussed authority it could wield on entrepreneurs of the sector (in actuality much greater than its power over the rest of the industrial system).

Some examples of such guidance transpired in the 50s, when the JMTBA association furnished a precise plan for re-modernization upon the request of the MITI; or in the beginning of the 60s when the development plans favoured mergers and the elimination of marginal enterprises in accordance with MITI recommendations; and finally, when in 1965, in order to check the negative cycle of the demand, the MITI "advised" the operators to make cooperation agreements among competitive groups. For the entire duration of the crisis the entrepreneurs tried, in a certain sense, to self-limit domestic competition by colluding against foreign competition. Parallel to this role as a guide, the public operator provided financial backing through the Development Bank (Fukko Kinjn Kinko). This bank was very actively in favour of machine tools. Almost 20% of the total credits granted by the industrial reorganization law of 1956 (Kikaikogyo Rinji Sochi-ho) was directed to this sector.

The industrial policy of the last two decades has particularly fostered the diffusion and evolution of technology in the machine tool sector. At this point it must be remembered that Japanese machine tools in the 50s and 60s were distinguished by their poor quality, lack of reliability and low prices. As a matter of fact a survey by the automobile manufacturers' association in 1954 contained numerous complaints of the poor performance of domestic-

made cars and underlined the need to improve the quality of machine tools to promote development of the automotive sector [MEM 1982]. Such indications were taken into consideration by the government when it administered the access to financing laws (the above-mentioned Kikaikogyo Rinji Sochi-ho of 1956) and laws in favour of the diffusion of technology.

Among the more effective instruments of industrial policy was the imposition of some tariff barriers defending national products, based on the customs law of 1952 (Kigyo Gorika Sokushin-ho).

It is noteworthy however that the protectionist weapon was not aimed at short-term objectives, but was part of a precise strategy of long-term economic planning. In fact, the tariff barriers in the lower segments and the free entry into the higher technology lines allowed for diffusion of technology among users and, contemporaneously, a process of R&D based on imitation by the manufacturers (who could reinvest the profits, accumulated from the protected segments, in the new technologies). Not until 1983 were tariffs of all types completely removed - there was no longer a need for them because the sector had become a definitive exporter of technology and products.

Another provision of law that indirectly promoted this sector was the continuous devaluation of the yen in the 50s and 60s - the low labour cost and low export prices allowed the Japanese companies to win international competition in segments that were sensitive to the price variable. In this case as well a medium-long-term strategy was chosen: the profits accumulated were invested in R&D activities which would later be fruitful precisely at a time when - due to international causes (among these, the end of the "Bretton Wood system") the possibility to win competition exclusively through the price variable started failing.

The instruments used by modern-day Japanese industrial policy incorporate the learning process accumulated throughout the long period of growth of the sector. R&D action and international partnerships are given priority, rather than destining resources to safeguard the "status quo" (no matter how positive the status quo may be).

3. The evolution of machine tool production

3.1 Main statistical data

The data regarding the production of Japanese machine tools clearly show the different economic cycles. In particular, graph 1 shows the fall of production caused by the process of revaluation of the yen, which started very suddenly in 1985-1986and diminished over time.

At this point it is necessary to start by saying that the analysis of data expressed in current values should be verified in light of the variation of the relative prices of the productive factors and of terms of trade. The lack of disaggregated deflation indexes does not allow us to determine constant value, as was attempted in other, more aggregated surveys [Vitali 1990].

It is nonetheless worthwhile - and it will be taken into account, especially in the analysis of international trade - to examine the evolution of the real bilateral exchange rates of the yen with respect to the dollar and the ECU (considered along with the importance of the foreign trade of machine tools). Graph 2, which uses the wholesale price index as a deflator, shows that the devaluation/revaluation cycle of the yen with respect to the dollar is particularly

evident. In 1985-1980 period there was a 20% devaluation, which was recovered in the second half of the 80s (in 1990 there was a revaluation of 15% with respect to 1980). As concerns the EEC, the revaluation trend is continuous from 1982 to 1988, with an inverted tendency in the last two years.

Such a decline in the terms of trade could have an explosive effect on the structure of the international trade of a country's manufactured goods. Japanese industry's response to these changes was to use all forms of competition which did not involve prices, a variable in this case completely exogenous to company behaviour. As we shall see in the analysis of the technological content of Japanese exports, the country successfully used that strategy. Moreover, the efforts to implement it were considerable, if we take into account the high R&D expenses made by the Japanese companies (see chapter 6) and the substantial number of patents taken out: approximately 8,500 in 1986, 50% more than the amount for 1981 [MEM 1989]. Still in reference to acquiring the competitive advantage within technological competition, bear in mind that also the participation of Japanese industry in international R&D programmes [MEM 1990] is significative and based on the close links between universities, enterprises, and the government apparatus (MITI).

However, it should be pointed out that the major reason for the success of Japanese industry is basically loss containment: in fact we must not forget that the level of production in 1987 fell to the same levels as in 1980 and in the past few years there has been a loss of the international market share [Calabrese 1990].

Having duly verified the reliability of these statistical data expressed in current terms, we can proceed to analyse the evolution of the each segment of production.

It is immediately evident that the "historical" importance of lathes among metalworking machine tools - their share goes from 32% in 1980 to 24% in 1990 - fades out and is replaced by machining centers that go from 16% in 1980 to 26% in 1990 (see table 1). Moreover, in the play of relative weights the remaining lines are of little importance: the weight of drilling machines, boring machines, and milling machines remains quite small throughout time due not only to the appearance of new lines of greater technology, but also to the process of international specialization and the opening up of import.

A repercussion of the new growth model adhered to by this sector can be seen in the notable importance assumed by NC machinery in the total production of machine tools, as we will attempt to analyse in the following paragraph.

3.2 The NC machinery production

The technology needed to manufacture NC machines was obtained by means of certain forms of imitative innovation. In 1952 in the United States MIT developed the NC technology that was learned by the Japanese industry (by Fujitsu) only in 1956 and sold the following year when the first NC milling machine was presented at the Osaka Trade Fair.

The impact of new technology on the market was immediate.

The share of NC machines with respect to total production rose from 8% in 1970 to 50% in 1980 to 76% in 1990 (see graph 3). On an international level the content of Japanese NC production was the largest [Calabrese 1990]. The growth of NC with respect to total production very accurately reflects the application of innovations in microelectronics, as shown in table 2.

As regards the evolution of each product line (table 3) the machining centers are considered complete NC technology; the EDM (electrical discharge machine) are the most important components of NC technology (they exceed 90%); whereas lathes have a higher than average NC content which reached 91% in 1990 [3].

In this case as well, during this decade machining centers are surpassing lathes, as far as their greater weight among NC machinery is concerned (table 4).

The degree of specialization in NC technology of each segment can be singled out, also from the relationship between the weight of the NC product with respect to the total of NC machines and the weight of the entire family of machines (NC + conventional) with respect to the total machine tools sector: a ratio greater than one indicates a specialization of the segment in the NC context, and that is to say a greater presence in the NC technology, with respect to the importance detained by the segment as a whole. In brief, it is a matter of comparing the percentages of table 4 (numerator) to those of table 1 (denominator). The lathes have a share of NC technology which is 30% greater than the share they have of metalworking machine tools, while machining centers' share is 60% greater; to the contrary, drilling machines and grinding machines' shares are 40% and 80% lesser respectively (table 5).

The evolution of NC production with respect to that of the total of metalworking machinery, can be explained mainly by the rapid technological changes of the last decades, and even more so if we consider the quotas of NC in the different product segments. As we have seen in the previous chapter, the Japanese firms were initially users of this new technology (led by U.S. industry), and subsequently promoters of product and process innovations (whose great international success they fostered).

A more detailed exposition of the development of NC technology in Japan can be seen in table 6; comparing this list of innovations with the evolution of production it is clear that the increased importance and pervasiveness of microelectronic innovation correspondingly increased the content of NC in production (see graph 3 also).

Technological progress fostered by microelectronics was surprising considering that the first NC machine produced in the United States used thousands of valves and large magnetic tapes. Particularly useful was software evolution in connection to NC machines, which currently is perhaps the most critical element for the implementation of an automatic factory.

According to Jacobsson [1986], the winning strategy adopted by Japanese NC manufacturers gave preference to the production of small, low cost lathes with simple functions at the beginning of the 70s in order to stimulate the latent demand of national and foreign SMEs.

This strategy differed from that of the typical American builders (and partly from European builders as well), who generally produced large machines designed to satisfy the needs of big users. The consequential broadening of the market allowed the Japanese firms to increase their production volume and reduce unit costs. Among the statistical evidence,

[3] The data relative to Japanese production and export should be integrated with the activities of transplants abroad, and no longer formally Japanese. The commerce of foreign branches gradually took on larger proportion due to the considerable importance acquired by foreign direct investments aimed to overcome the protectionist laws.

that tend to prove such a theory, is the smaller unitary weight of Japanese lathes with respect to that of the lathes of international competitors, or the use of lower powered motors. Both these factors, along with the price variable, explain the different area of the market toward which the Japanese manufacturers of NC lathes initially directed themselves.

All in all, the results obtained by the Japanese industry in the dominion of NC technology are extraordinary: in 1975 the three areas of the Triad produced more or less the same number of NC lathes, 1359 in Japan, 1535 in the EEC and 1640 in the USA, whereas ten years later Japan produced 16,555 units, the EEC produced 4,818 and the USA only 1,524. Moreover, by calculating the market share of Japanese exports, the following evolution can be seen: out of every 2 NC lathes bought in the world today approximately 1 is of Japanese make [Jacobsson 1986].

4. The role of foreign trade in the development of the industry

The evolution of foreign trade of Japanese machine tools can be schematically divided into homogeneous periods.

Until World War II imports were determinant in satisfying domestic demand, especially in the field of high technology. In the 50s the slump in imports is actually the effect of extreme stagnation of the sector, which showed a recovery of demand only in the beginning of the 60s. Consequently, in the first half of the 60s there was a real boom of imports in absolute terms, even though the imports/domestic demand ratio decreased with respect to the previous levels (from 50% it went to 30%).

In the second half of the 60s the flow of machinery exports became significant, but still did not offset the amount of imports. This flow is characterized by machines of low technological content, that win world competition on account of their low prices (assisted by an accommodating exchange rate policy) and are directed especially toward the U.S. market.

At the end of the 60s and the beginning of the 70s there is another import boom, favoured by the further development of domestic consumption and by the need to stimulate the technological evolution of national producers. International division of labour obliged the Japanese industry to use machines that were more precise and productive: this requirement was satisfied mostly by imports.

Only during the first years of the 70s did the trade balance of the sector become positive. From that moment on the flow of exports prevailed structurally over the flow of imports and became a determinant of the sector's development. In this period, the devaluation of the dollar, following the declaration of its inconvertibility in 1971, forced Japanese exporters to diversify their outlet markets, previously concentrated in America.

Toward the end of the 70s the propensity of Japanese manufacturers to export became increasingly consolidated: the exports/production ratio reached 40% in 1980 and 43% in 1987, while the imports/domestic demand ratio fell to below 10%, with a 5% low in 1984 (see tables 7 and 8).

Production and exports were favoured by the massive process of industrial reorganization which in the industrialized countries was activated to react to the first oil shock, and later to the second as well (see table 9).

However, as shown in section 2 the large world demand for rationalization investments in the beginning of the 80s could only be exploited by exporters with the contemporaneous presence of numerous other conditions - besides the high technology of the products and an aggressive trade policy, Japanese industry was also fostered by a monetary and exchange rate policy that did not hinder expansion abroad. Sometimes these macroeconomic variables, exogenous to company policies, had effects that were much greater than the managerial tools available to entrepreneurs.

4.1 The export of machine tools: geographic and product breakdown

The areas of greater interest for Japanese exports can be clearly deduced from table 10. It is particularly useful to underline the different growth cycles of the European and U.S. markets.

In the European market, notwithstanding the revaluation of the yen, the importance of this area increases, whether we use the absolute data or the relative shares.

Still in reference to Europe, throughout time each European country become increasingly important for Japanese exports, with the exception of the United Kingdom, where model of commercial penetration of Japanese manufactures hinged on the direct investments and agreements, rather than on the export of finished products [4]. In the rest of the EEC the German market prevailed and took in over 8% of the exports of 1988, while Italy, though going from 0.4% to 1.7%, remained a marginal market.

As regards the flow of exportations directed toward the U.S.A., table 10 points out that the importance of the market varies exactly in correspondence with the devaluation/ revaluation cycle of the yen with respect to the dollar and that this assonance of direction indicates the flexibility of the Japanese exporters in directing themselves toward new markets that are not subject to losses in price competitiveness. The decrease in exports in quantitative terms reflects the difficulties encountered by exporters because of the loss of price competitiveness and the making of voluntary agreements of quota restrictions (VRA). From this point of view, the export data are invalidated by the weight of direct productive investments, as well as by the weight of manufacturing agreements with local firms.

There are some notable differences between the exports of the two large sub-aggregates of metalforming and metalcutting machinery (tables 11 and 12).

Metalworking machines reach absolute levels that are three times higher than the levels of metalforming machines, a clear indicator of the international division of labour [Calabrese 1990]. Also the geographic distribution of the markets is very different: in 1988 the United States makes up approximately 35% of the market in both areas, whereas Europe covers 28% of the exports of metalworking machinery and only 10% of metalforming machinery, which indicates the greater competitiveness of European countries in this segment. Moreover, one must remember that the weight of non-industrialized countries is different, with nearly 60% in metalworking machines and only about 45% in metalforming machines.

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[4] It is noteworthy that the technological evolution of the EDM was certainly favoured by their position on the frontier of metalworking machinery: in fact industrial statistics place this kind of machinery in the category of “non-conventional machines”.

Within different product lines the importance of lathes (nearly one-fourth of total exports) is worth emphasizing, as is their particular distribution per outlet market. Their exports are concentrated in industrialized countries with the prevalence of the U.S. with respect to Europe till 1989 (viceversa in 1990) [see table 13]. Regarding the machining centers we find the same areas: a reduction in the U.S. market while exports to the EEC increase in absolute and relative terms (table 14).

The export/production ratio has already been singled out in table 7. As can be seen, the point of maximum importance for the international market was reached in 1987 with the exportation of 43% of production.

Within each product line the general trend is more or less followed, but with a different degree of orientation. Lathes, drilling machines, boring machines and machining centers have values which are much higher than average.

In comparing the importance of each segment within exportation, with the importance of the total production, a form of export specialization can be observed. Lathes, grinding machines, and drilling machines are extremely important in exportation structure, much more so than in the production structure (see table 15).

4.2 The NC machinery exports

As shown in table 16, the content of NC machines in exportation is high: the average of the 80s was 72%, with a growing trend (82% in 1990). Within product lines lathes have a high coverage, averaging 90% Also within NC exportation, lathes and machining centers have the lion's share - together they make up almost 70% of total exports.

Nevertheless, if we compare these shares with their importance within national NC production, various degrees of export specialization stand out (the ratio between the importance of each NC segment within both NC exportation and NC production): note, in fact, how much the specialization of international commerce fosters the exportation of NC milling machines, grinding machines, and drilling machines (see table 17).

It is interesting to point out in table 18 that the degree of orientation toward the exportation of each NC product segment is over 40% for the total of NC machinery, with peaks higher than average for drilling machines (79%) and lathes (55%).

The analysis per outlet market was carried out only on NC lathes and machining centers, because they are the most representative lines of NC (see tables 19 and 20).

Both lines are very concentrated in the U.S. and European markets. Within the latter, the role of Belgium stands out as a "port of entry" for machining centers that, fictitiously, have quotas of importance almost equivalent to those of Germany.

Exportation "directed" toward Italy is minimal but has been sharply increasing in the past few years.

4.3 The structure and evolution of imports

The degree of penetration of imports [imports/ (production - exports + imports)] of machine tools in Japan tends to decrease gradually as international success in the sector becomes more solid. Starting from 18% in 1968 we observe a drop to 5% in 1984, which rises again to 7% in 1990 (table 8).

As regards each segment, this penetration does not exist for machining centers, and is minimal for lathes (3% in 1990) but significant for grinding machines (15%). Within importation a decisive role is played by grinding machines, which represent over one-fourth of total imports and point to a clear despecialization of the country in that segment (table 21). It is notable that mostly non-NC machinery was imported, though the NC content of total imports grew from 19% in 1982 to 43% in 1990 (table 22).

The analysis of country/product distribution shows the importance of European exporters of grinding machines, gear cutting machines, and lathes even if absolute values are very low.

As regards NC machines, the exiguity of import penetration is very clear: in 1990 only 5% of domestic demand [NC importation / (NC production - NC exports + NC imports)] was covered by foreign production, a figure which is however increasing with respect to the 1.9% in 1984 (see table 23).

The share of NC content in imports is quite low and equivalent to about half the corresponding quota of national production (table 24). This could confirm the international division of labour in the sector: Japan produces machinery with a high NC content and imports machinery with a low NC content, in which some LDCs are specialized.

A partial confirmation of this can be seen in table 25 in which a strong demand for grinding machines and gear cutting machines - an area of low NC content in Japanese production - stands out.

5. Strategy and structure of the major industrial groups

According to the statistics of "American Machinist", the Japanese industry is the main manufacturer and user of machine tools in the world [AM February 1991], with 10.8 billion dollars of production and 7.5 billion dollars of apparent consumption (production plus imports minus exports). From the aggregated data on the macro-sector we can go into detail regarding the company statistics in order to find further confirmation of the primary role played by big manufacturers. It is an important role, not so much from a quantitative point of view, but a qualitative one, due to the technological development incorporated in production of big industrial groups.

5.1 Size and structure of the groups

From the statistics on industrial groups, the importance of size of the Japanese company stood out: there are 11 giants in the list of the first 20 manufacturers in the world. The same kind of dominance is seen when we consider the list of the first 50 manufacturers: 25 of them are Japanese. On the contrary, on the list of the first 100 there are only 34 Japanese companies. This indicates a first typicalness of the Japanese system: the large size of the companies with respect to the average of world competitors.

Aspects of size can be seen in more detail in table 26. The Amada group contends with the Yamazaki Mazak for sectorial leadership: in 1990 Amada was first place, with 2,500 employees and a turnover of 1,200 million dollars, while Yamazaki Mazak followed with a 1,150 million dollar turnover and 3,500 employees.

In third place is the Fanuc group, with a turnover of 1,100 million dollars, followed by the Okuma Machinery Works group with a turnover of 739 million dollars in 1990.

In fifth place, the first non-Japanese group, is the U.S. group Litton Industries, followed by the Mori Seiki group (with a 661 million dollar turnover in 1990).

There are also numerous minor groups, which in the world context add up to a significant presence. Among these minor groups are the Komatsu group, with turnover in machine tools of 471 million dollars in 1990, the Toyoda Machine Works group (with a turnover of 464 million dollars) which belongs to the automobile group Toyoda Group, the Fuji Machine Manufacturing (with a total turnover of 436 million dollars), the Toshiba Machine group (which, with a turnover of 374 million dollars, has evidently recovered from the fall of sales in 1987 that occurred as a consequence of the well-known scandal in which they sold Cocom-banned five axis machines to the USSR), the Hitachi Seiki group (with a turnover of 365 million dollars).

The structure of these groups is very complex both in the way of company organization and product diversification. To cite an example, the Amada group is made up of some forty corporations dispersed all over the world. Among them the major corporations of the Japanese market are Amada Sonoike (metalforming machinery), Amada Wasino (lathers, grinding and other NC machinery), Amada Metrecs (control and automation systems, accessories), Amtec (software and OA systems).

As will be illustrated in the following paragraph, the complex domestic organization sometimes corresponds to a parallel complexity of international activity.

5.2 The process of internationalization of production

The location of plants abroad proves to be an extremely important strategic factor in getting around the protectionist laws of some countries.

As can be seen in table 27, there is a very large number of Japanese plants in the U.S. and Europe. Sometimes they are greenfield plants, other times acquisitions of local firms, and finally the option of joint-ventures or agreements is always a possibility.

For example, Amada owns manufacturing units in Germany (where it purchased the Promecam Maschinen), in France (where it purchased the Promecam Sisson Lehmann), in Austria (where its commercial subsidiary became a factory in 1986 in the segment of bandsaw blades, punches, and dies form press brakes) and in Italy (automated equipment in a equity agreement with Prima Industrie; presses in a joint venture with Schiavi). Amada's strategy of production decentralization becomes complete when we consider the production of their subsidiary in Taiwan (CNC turret punch presses for the Taiwanese market).

The complexity of the above example is repeated in numerous other groups. It is particularly interesting to note the greater or lesser concentration of factories that carry out domestic production activities or foreign production activities.

For example, the Fanuc group has added to its 5 factories in Japan a U.S. factory (which has been operating since 1974 and has exported all over the world since 1981) and an English factory (which has been producing since 1987 and has been exporting, to Japan as well, since 1988). The importance of the European structure, which has its general headquarters in Brussels and subsidiaries in the principal countries of Europe, is evident from the high number of people (over 600) it employs.

Especially the manufacturing presence of the Fanuc group in foreign areas was made possible through agreements and joint-ventures: their agreement with Siemens, joint-ventures with General Electric (GE Fanuc) and Cincinnati Milacron; a former joint venture with General Motors (GM Fanuc) is now a 100% controlled branch. As regards the company GE Fanuc, it is noteworthy that its growth in 1989-90 induced management to extend its productive plants in Europe, located in Germany and Luxembourg. Simultaneously GE Fanuc developed some commercial joint-ventures with European companies, among which the Italian one with Biglia in the segment of CNC lathes. In 1990 Fanuc intensified its productive presence on U.S. territory with the purchase of 40% of Moore Special Tool, which has 400 employees in the manufacture of jig-grinders and other high-precision machine tools [AM April 1991].

Another very significant example of the internationalization of production is that of Komatsu. Besides owning productive plants in Brazil, Indonesia, the U.S.A. and the U.K., in 1991 Komatsu started a joint-venture with Danly Machine, a U.S. company that manufactures presses. The new company, Danly-Komatsu will design and produce medium- and large-sized presses for the U.S. market. In this joint-venture Komatsu holds 30% of the shares (while Danly holds 70%) and it will allow Komatsu to expand its range of presses, from small to large (over 800 tons) [AM August 1991].

Other examples can be seen in table 27, like the Toyoda group, that owns productive plants not only in Japan but in France and the U.S.A., or the Hitachi Seiki group that owns a factory in the U.S.A. (along side which another is being purchased).

Nonetheless, in spite of this intense international activity, many groups continue to maintain their real manufacturing core in Japan. As regards the Fanuc group, besides the factories of the manufacturing joint-ventures in the U.S. and Europe, all the other production activities are concentrated in Japan. In the Mori Seiki case as well the subsidiaries abroad are commercial but not productive, and production is concentrated in three Japanese plants, which are highly automated. This strategy was intensified in 1990 with the purchase of the controlling share of the Japanese company, OKK (236 million dollar turnover).

Other examples are the production of Fuji, concentrated in Japan, even though in 1989 it constituted a service center in the United States.

The strategy followed by the large groups for international decentralization deeply influenced company organization and company export/turnover ratio. In fact, the more a group is internationalized, the lower that ratio is: Amada's ratio is 10%, Okuma's (with only one factory abroad) is 30%, Mori's Seiki and Fuji (totally concentrated in Japan) is 50% and 52% respectively.

For this reason, it would be interesting to examine the company data relative to the portion of turnover produced abroad, rather than merely export data.

5.3 Product diversification

The production range of the Japanese groups is extremely vast and tends to expand on account of the large number of international agreements. The productive disaggregation of the Amada group can, on the whole, be summarized as follows: punch press machines make up 40% of turnover, sheet metalworking machines 30%, and band saw machines 20%. By examining product disaggregation we can also infer the role played by technology. In fact, in some groups the product range is shifting toward high tech products: Yamazaki Mazak

produces only FMS, CIM, NC robots, CAD/CAM, laser machines, machining centers; in the case Fanuc, NC machines generate 77% of total turnover.

In other cases diversification is not high, but limited to a few families of products: in the Mori Seiki group the NC lathes cover nearly 60% of turnover and machining centers about 40%.

Besides internal diversification, among the different segments of machine tools, the large Japanese groups are very diversified externally as well, and among businesses that are distant from one another (as in the Komatsu's case).

There are also many manufacturers that belong to larger corporations, like Toyoda, Hitachi, Fuji, Toshiba. In these cases the machine tool company sometimes has the same market as the corporation (captive, as in the automobile segment), and sometimes the same technology (as in the electronics segment).

In any case, the degree of diversification outside the machine tool segment allows some groups to absorb periods of recession within their group.

The aggregate of the 10 major groups of instrumental mechanics diversified over various segments is shown in table 28. It is remarkable how rapid management was in taking advantage of the opportunities offered by the market in the two-year period of 1985-86, and in responding very quickly to the difficulties of the two-year period of 1986-87. In fact the weight of the production of machine tools went from 64% in 1984 to 73% in 1987, and fell to 43% in 1988.

Besides the product diversification it is interesting to examine the degree of vertical integration of the companies.

In most cases the companies are very integrated: their organization pushes on from R&D and planning to production and after sales services. However, direct contacts with customers, offering technical assistance and plant maintenance, allow a company to act with a truly comprehensive strategy, both regarding product range and market outlets. For example, Amada has established a special company, the Amada's Overseas Network, for this purpose.

To the contrary, some groups only concentrate on few phases of the production filière. A significant case is that of Okuma Machinery Works, which manufactures NC machinery, that is, however, sold through an agreement with Amada.

6. The technological change in the main industrial groups

The production of innovation inside large Japanese groups is substantial and besides being carried out inside the groups with a very high expense of resources (see table 26), it is conducted on an international level with R&D centers located abroad or through international technology agreements. For example, the Amada group has reached the world technological frontiers by using both outside R&D - in the U.S.A. with Amada Laser and Amada Engineering, and in Europe with Prima Industrie (an Italian firm with 49% controlled by Amada) - and inside R&D, with technological centers at Amada Headquarters and separate technological departments distributed according to the different markets.

The strategy of the Yamazaki Mazak group has concentrated its R&D function in the gigantic laboratory in the city of science of Tsukuba (Tokyo), while the contact between R&D and market is ensured by 63 technical centers, of which 34 are in Japan and 29 abroad.

R&D activity, aimed at controlling technological change, notably influences company strategies [Kodama 1986].

Among the numerous cases of interdependence between innovation and company's growth model we can recall the strategy followed by FANUC in developing NC technology.

Ever since the first prototypes of NC machinery were made, FANUC management always gave a great deal of importance to controlling peak technology and organizational innovation (aimed at completely exploiting all the potential of new technology).

As regards the first point, one notices how the choice of avant-garde technology have been necessary conditions for company development. For example, only with the immediate replacement of electro-hydraulic pulse motors with DC servo motors could all the economic potential supplied by the new paradigm of microelectronics be subsequently exploited [MEM July 1987]. The replacement of thermoionic valves with transistors as well further confirms the need for sudden changes in technology used, which may impose abrupt turns in the path followed by the technological pattern of the company ("We did a 180-degree turnaround", MEM July 1987, pg. 29).

In the meantime, the company's organization was aimed at the maximization of the benefits that technological evolution provided.

On the one hand, containment of the "break-even point" seems important: the cost of labour at 7% of total costs and an organization capable of producing even on night shifts allow for a high degree of output flexibility.

On the other hand, it is the same "Japanese model" that promotes success: firm's size (internal economies) and adequate infrastructures (external economies), but also networks of companies, sub-contracting [FNAM 1989], just-in-time production seem to be the main factors determining high competitiveness [Aoki 1990].

If we add the dominion of technology [Anderson 1986], in the Fanuc case with the R&D costs at 5% of costs (10% including the salaries spent in research activities), the mixture is pleasantly explosive.

The evolution of technology control, currently a towing factor of Japanese development, comes about with reference to international interdependencies.

In fact, due to the use of joint-ventures and agreements with the main international companies the big Japanese groups exploit the opportunity of international technological development, positioning themselves, at the same time, in several different technological areas. Such a dynamic strategy allows them to gather all the external technological economies from the different "technological windows" located all over the world.

7. The external growth in the major industrial groups

The strategic growth of Japanese groups moves with a balance between initiatives for external growth (acquisitions, joint-ventures and agreements) and initiatives for internal growth (the establishment of new branches and new factories). The same balance is seen in the case of the international growth and in the domestic one.

We shall present some significant, though not exhaustive, examples of this phenomenon (see table 29).

The large Japanese groups carry out acquisition campaigns, both nationally and internationally, when they are in a hurry to attain a technological, commercial or manufacturing target.

When the external growth's object on an international level is manufacturing protectionistic barriers (actual or potential) can be overcome in some markets: Amada in Germany purchased the Promecam Maschinen and in France the Promecam Sisson Lehman, in 1990 Fanuc bought 40% of the U.S. company, Moore Special Tool. There are also numerous commercial initiatives, as in the Fanuc case, which - through GE Fanuc - developed joint-ventures with European companies, among which we cite the one with the Italian company, Biglia, in the segment of CNC lathes, or the case of Hitachi Seiki which in 1988 bought an English trading company, Terex Berger (today Hitachi Seiki UK).

On a national level groups tend to reinforce their position in the domestic oligopoly: in 1990 Mori Seiki became the leading shareholder of OKK, a Japanese company with a turnover of 236 million dollars.

When the acquisition solution is not totally advantageous or when it is not possible, since Japanese groups usually do not do hostile take-overs, an agreement is preferred (equity or non-equity): market factors have made Amada choose the equity agreement solution to acquire the technology (and the market) of Prima Industrie; the characteristics of the partners stimulated Fanuc to make agreements with Siemens, General Electric (the GE Fanuc joint-venture), General Motors (the GM Fanuc joint-venture) and Cincinnati Milacron. The characteristics of the internationalization strategy followed by Komatsu allowed it to expand its product range and penetrate the U.S. market in 1991 as a result of a joint-venture with Danly.

The dynamic of expansion abroad is also developed through agreements with national partners, like in the case of the Okuma Machinery Works group which owns a manufacturing plant located in the United States, but it sells its NC machinery as the result of an agreement with Amada.

Besides agreements to expand market shares abroad, many manufacturers seek out new international partners to extend their own influence on the domestic market, thus emphasizing the high degree of domestic competition. There are numerous cases: the agreement in 1991 between Komatsu and the Italian company, Comau, with which the Japanese group will be able to sell and install the robots manufactured by Comau specifically for the press lines for the automobile market; the agreement in 1986 between Hamai and Novar, in which Hamai would use the technology of the Italian company, Novar, to manufacture and sell milling machines in Asia (but not in the United States or Europe); the agreement of 1989 between Matsushita and Asea Brown Boveri in the segment of automatic factories which permits Matsushita, through its subsidiary Matsushita Electric Industrial, to use and sell the robots of ABB Robotics on the Japanese market; the agreement between Fujitsu and McDonnel Douglas of 1991 that allows the Japanese group to sell McDonnel's production system for the manufacture of dies and matrixes in Japan; the agreement in 1989 between Conic-Sha and the Italian company, Salvagnini, in the segment of flexible sheet working machines started out as an agreement in which Conic-Sha distributes the Italian systems all over Japan and evolved into a manufacturing joint-venture which allows Conic-Sha to produce these flexible systems directly in Japan.

On the contrary, strategies of internal growth on an international level arise from particular company needs or from the exploitation of internal competitive advantages: the positive external effects in the form of government benefits for the construction of a factory in the United Kingdom offered to Yamazaki Mazak (5.2 million sterling pounds to build a plant in Worchester that employs 180 people and can produce up to 1,000 lathes and

machining centers per year); or the lack of suitable partners to make agreements with, like in the case of Komatsu, which opened manufacturing plants in Brazil and Indonesia; or the opportunity that greenfield investments provide for building a plant according to the most modern production needs, like in the cases of the Toyoda Machine Works in France and the USA, or Hitachi Seiki in the USA.

Such strategies have allowed Japanese groups to be present abroad with very significative structures, both directly (the European organization of the Yamazaki Mazak has its headquarters in Brussels and has a total of 650 employees) and indirectly through its partners (Fanuc through GE Fanuc, expanded its productive plants in Germany and Luxembourg).

As can be deduced from the analysis of the above-mentioned cases, the strategy of foreign market penetration through joint-ventures and agreements becomes increasingly important in reference to the U.S. market. In this market the existence of voluntary restrictions on exportation (VRA) since 1987 has compelled Japanese companies to redefine the commercial instruments available to them: as soon as the voluntary restrictions were further tightened from 6,200 units (2,600 lathes and 3,600 machining centers) in 1987 to 5,000 units in 1988 and 6,100 in 1989, their direct presence within the country, whether independently or in joint-ventures, made it possible to get around, or at least to limit, the negative effects of these quota restrictions [MEM May 1987 and 1988]. It is noteworth to add that VRA between U.S. and Japan has been updated in 1992 with more rigid clauses [5].

The penetration into the European market as well is significatively carried out through commercial subsidiaries and manufacturing plants. In this regard, we should bear in mind that there are not yet any quota restrictions on Japanese imports, but only a "monitoring" operation by the EEC Commission: if penetration increases significantly, it will be necessary to resort to self-regulating agreements - and in that case companies with European productive plants will have a competitive advantage.

At this point it should be emphasized how the strategy of external growth of each company is basically different from case to case, and therefore it is very difficult to create company stereotypes. A detailed analysis for each case-study would be needed to do so, as we tried to do in the Fanuc case.

Fanuc's strategy of external growth is aimed, above all, at expanding product range by using agreements with companies positioned in markets and segments in which Fanuc is not a leader. In these segments the agreement is generally for technology and marketing purposes. Among the latter, the aim of increasing market share and getting around protectionist barriers is the most important. In order to overcome the difficulties that each partnership presents, it is necessary to adapt the organizational structure to the characteristics of each partnership, in order to increase the probability of success. This intention is confirmed by the fact that among the causes of greater costs imposed by the partnership, precisely company reorganization takes first place.

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[5] The new VRA is focused on high technological products divided into two big groups. The first one, CNC lathes, machining centers and CNC punching and shearing machines, requires an approval for each export operation from Japanese government ("licensed items"). The second one, CNC milling machines, is to be monitored in volume by both U.S. and Japanese governments. In both groups, in 1992 VRA is going to maintain the same market share of the previous year, in 1993 to increase between 0.3 and 2.8 the 1992 export volume [MEM 1992].

8. Other characteristics of the machine tool industry

The firm's size structure of the Japanese machine tool industry reveals a large portion of big companies: the firm's size average of the 113 enterprises associated with the JMTBA is 304 employees per company, even if among the associates 70% has less than 300 employees (and the largest has 2,300 employees) [JETRO 1991]. From table 30 we can infer the high percentage of employees belonging to firms over 500 employees: roughly one third of the total.

Comparing these data with corresponding world data [EEC 1990] we discover, on an average, that big companies are more prevalent in Japan than in other parts of the world, especially more than in Italy, which is characterized by a SME structure. To the contrary, the comments from the Japanese affirm that "this industry mostly consists of medium-and-small-scale enterprises" [JETRO p. 1].

As is easily guessed, the large size of Japanese companies is reached at the group's level through a consistent network of relationship among SMEs. This kind of organization has given them synergies and facilities that are not attainable by most of their world competitors, especially the European ones.

Also regional distribution of the plants has, in a certain sense, favoured Japanese industry. In fact the machine tool industry is spread out over almost all the Japanese regions, though there is a higher concentration in the central regions. In particular the prefecture of Aichi, one of the prefectures in Japan's Chubu region, is among the major producers and end-users of machine tools and industrial automation. This is determined by the presence of end-users of the machinery and automobiles [MEM September 1991].

The implications of this kind of distribution are positive if compared with problems concerning the regional distribution of industrialisation that many competitor countries have, among which Germany (with the "eastern" Lander at a disadvantage with respect to the "western" ones), the United Kingdom (with the North more developed than the South), and Italy (with the long-standing "problem of the South").

As was seen earlier, (see section 6), the main barriers to entering the sector are essentially technological, but also commercial. These barriers have moulded the Japanese industrial system on a large-scale, in the attempt to exploit technical and financial economies of scale. In fact, only with the investment of substantial capital in large automated plants will the economic flows needed to overcome technological and commercial barriers, erected to defend the sector, be obtained. Therefore investments are needed to produce high tech machines at prices that beat the competition.

At this point of the analysis it is worthwhile focusing on the role and characteristics of the commercial barriers.

Commercial barriers are generated by the need to use a distribution network that has close ties with the end-users and supplies adequate after sales service.

Graph 4 indicates this kind of structure in which the producer-user relationship may be direct or mediate. In actual fact, the disaggregation of deliveries according to typology of the commercial structure indicates that the configuration in which a dealer is present, generally a special exclusive dealer, prevails (70% of total deliveries). To the contrary, the use of trading firms occurs in 15% of the cases and the use of sole agents in 13% of the cases (see table 31).

The winning distribution structure is therefore quite difficult to realise, unless enormous fixed investments are made. This is another element, again in favour of Japanese firms and detrimental to competitors. In fact the low degree of penetration into the Japanese market by imports from OECD countries is ascribable - in the 90s - above all to the need to adapt sales and service networks to the high standards offered by local manufacturers. Generally, when such adaptation is not possible, foreign competitors are caught of guard by the excellent organization of domestic manufacturers and they try to compensate for it with enterprises of the sector equipped with a sales network.

Other elements of the sector structure are favourable to the victory of Japanese competitors abroad.

For example it is noteworthy that even if in the Japanese industry there are many family enterprises, mostly of them are important, like Yamazaki Mazak and Miyano, or belonging to large industrial groups, of which they are subsidiaries. In both cases the firms can exploit all the economies of scale and scope.

We can distinguish the following categories of firms in more detail:

- the conglomerate groups, in which the machine tool segment is one of the several businesses (eg. Sanjo, O-M, Osaka Kiko);
- companies that manufacture only components or parts, sometimes only for specific sectors (eg. Toshiba Tungaloy, Mitsui, Asahi Diamond Industrial, OSG, etc.)
- subsidiaries of electric and electronic component manufacturers (eg. Fanuc, Hitachi Seiko, Mitsubishi Electric, Toshiba, Osaka Diamond Industrial, etc.).

The advantages are particularly evident for the last two types of firms: R&D synergies allow to exploit in the machine tool sector some technologies coming from other sectors; captive markets that make it possible to test a product and improve it before distributing it widely; resource backup (not only in the sense of providing financial support, but also in terms of engineering skills) are necessary in order to overcome all the barriers to entry.

9. Conclusions

The results of our survey show that the basic features of the Japanese machine-tool industry as well as the strategies of the companies involved underwent a process of deep transformation during the last decades.

The sector's strengthening in the national market is the outcome of a careful protectionist policy introducing tariff walls for the sake of national products in a wider context of medium-long term growth. On the other hand, the weakness of Japanese industry just after World War II would not have made it possible for Japanese entrepreneurs to face international competitors with some reasonable chance of success. This situation led to protectionist barriers and an industrial policy supporting new investments. As previously described, the main tools adopted were the allocation of financing at incentive rates aimed at restructuring old plants, the supervision and coordination of MITI in the industrial development policy focussed on encouraging agreements and cooperation between national companies and against foreign competitors, the promotion of R&D activities at a national level and in cooperation between companies (including foreign companies) for the purpose of internal production, acquisition of technologies from foreign countries and their diffusion over the whole *filière* of tool machines (and therefore both to upstream sections of small component manufacturers and to downstream sections of machine endusers).

In the seventies, a remarkable growth in terms of quality (in the sixties, Japanese products were considered rather unreliable) and of quantity (as shown by reported statistical data) was the reward to a successful development policy and enabled the sector's operators to stand up to international competition with their own market specialization: the use of new technological paths (from micro-electronics to informatics) allows Japanese firms to specialize in numerical controlled machines addressed to the "mass market" rather then to the restricted big users' market. Low sale price is the key to Japanese expansion in the world market (basically oriented to the fulfilment of the latent demand of small users) and to the application of new technologies to small and medium-sized machinery.

The establishment of new commercial and financial relationships among primary world areas in the eighties - and the consequent development in the exchange ratios of Yen, US$ and ECU - largely affected the strategical position of Japanese firms in world markets, and in particular the internationalization process and the control of the technological variable. The closing to international trade in the sixties developed into a completely different attitude in the seventies - when tariff walls were abrogated and exports largerly expanded - and finally came to production relocation in the eighties. Throughout the eighties, the relocation of Japanese production abroad is justified on one hand by demand expansion (the need to penetrate further into the US market, while facing a continuous revaluation of the Yen in terms of the dollar, requires production itself to be relocated within the US market) and the need to control production costs on the other hand (the relocation of production plants to south east Asian countries). In both cases, the growth strategies of Japanese firms are changing since observation and competition are no longer performed within the domestic market but at a worldwide level. As far as the technological factor is concerned, it is worthwhile noting the increased attention paid to R&D. In the sixties, the approach to R&D was basically imitative and functional to medium-long term technological development. As a matter of fact, the profits made as a result of protectionism were invested into R&D projects aimed to the development and improvement of technologies acquired abroad (mainly from the US market). Such improvements, which took place in the seventies, enabled the independent development of new branches of research, thanks to the cooperation between different companies and with public and private R&D institutions. The outcome of internal R&D became tangible in the eighties when international competition started to acknowledge the innovative content of Japanese machinery (however, the strength of Japanese products could no longer rely on low prices since this variable is difficult to control by the companies).

Internationalization process and production technological development had a considerable impact on the main structural features of the sector. An example is the production specialization in the international division of labour: the quota of numerically controlled machines is structurally growing when we move our focus from import to export. While imports mainly concern traditional products with low unit cost, exports mostly involve hi-tech machines with large profit margins.

During the early nineties, the competitive framework within which Japanese firms are operating shows no meaningful changes with respect to the eighties - to teh contrary, it represents a natural evolution.

The revalutation of the Yen, VRA quotas, intense international competition, initial difficulties in managing national production (the Japanese social context is also quickly changing and some shortages in the labour market of the manufacturing industry are taking place), are the main themes of the early nineties.

Adaptation to the change in the economic context can be seen in the continuing process of reorganization of Japanese firms that - on the one hand has favoured the reduction of costs and the increase of productivity, and on the other hand has at times reduced the importance of the "domestic" market of the sector and promoted the development of the large industrial groups that operate with a "worldwide" strategy.

The oligopolist structure is in fact concentrated on some companies that have global strategies, are present in foreign countries as manufacturers, and offer a very wide and diversified product range. A solid company structure makes it possible to withstand heavy financial losses caused by recession as in the case of these last two years.

We can infer a general characteristic of the Japanese economy from the machine tool case: mamagement capability marked with the dynamism and flexibility of the manufacturing factors, in particular the human resources, are the conditions needed to adapt company structure quickly to important environmental changes.

These environmental changes are sometimes forestalled by the continuous innovative process which replaces what becomes obsolete in the industrial system: men and means.

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TABLE 1

PRODUCTION OF METALCUTTING MACHINE TOOLS
% distribution and million Yen

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
Values (mln Y)	682102	851312	782776	702287	881485	1051127	899402	691156	881200	1135344	1302548	
TOTAL	100	100	100	100	100	100	100	100	100	100	100	
LATHES	32.3	27.0	28.9	22.6	27.4	25.3	23.7	25.8	26.0	24.6	24.2	26.2
DRILLING	2.0	1.9	1.9	1.9	2.0	1.5	1.7	2.1	2.7	2.6	2.7	2.1
BORING	4.5	4.1	3.9	3.7	2.6	2.4	2.1	2.0	2.3	2.4	2.3	2.9
MILLING	8.7	8.8	9.6	9.3	7.7	7.0	5.7	5.4	5.5	5.8	5.2	7.2
GRINDING	11.0	11.4	11.7	10.4	11.3	12.8	12.9	11.6	11.9	12.3	12.1	11.8
MACHINING CENTERS	16.3	19.4	20.7	23.7	24.2	25.4	25.3	24.3	23.5	25.2	25.7	23.1

Source: JMTBA, CECIMO, NTBA

TABLE 2 TECHNOLOGICAL CHANGE IN JAPANESE MACHINE TOOL INDUSTRY

Generation of NC		Birth date	Main elements
Hard-wired systems	The 1st	1954	Vacuum tubes, relay, (analog circuits)
	The 2nd	1959	Transistors (digital circuits)
	The 3rd	1965	ICs (digital circuits)
Soft-wired systems	The 4th	1970	Soft-wired methods, LSI, MSI, built-in minicomputers
	The 5th	1974	Soft-wired methods, 1-chip microprocessors built in
	The 6th	1979	Bubble memory; Ultra LSI; CRT widespreading
	The 7th	1981	Interactive method; customized FA, FMS-oriented software
	The 8th	1986	Digital control; MAP-convertible software

Source: METALWORKING Engineering and Marketing, July 1987

TABLE 3

PRODUCTION OF METALCUTTING MACHINES TOOLS
% CONTENT OF NC MACHINES

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
TOTAL	49.8	51.0	53.9	60.7	66.9	67.0	67.9	70.3	70.6	73.1	75.6	64.3
LATHES	69.2	70.3	62.0	76.6	79.7	83.1	85.2	87.7	89.6	89.5	90.9	80.3
DRILLING	14.7	13.1	12.1	31.4	27.9	29.6	45.5	62.4	65.4	69.6	71.7	40.3
BORING	26.3	36.2	36.7	39.0	44.9	36.5	58.9	56.1	48.1	70.9	71.7	47.7
MILLING	31.9	41.2	44.9	51.6	51.5	47.9	54.2	66.8	62.2	63.7	64.0	52.7
GRINDING	4.5	4.5	6.5	8.0	11.7	13.8	19.1	23.7	26.9	35.1	40.6	17.7
SPECIAL PURPOSE	8.6	9.8	8.6	16.3	40.3	39.3	35.2	34.9	36.1	35.4	49.0	28.5
OTHERS	1.2	1.4	4.5	4.3	6.0	3.9	3.2	27.4	33.5	49.3	49.8	16.8
EDM	73.8	79.0	84.4	91.1	93.9	95.5	97.0	93.6	95.3	95.4	96.6	90.5

Source: JMTBA, CECIMO, NTBA

TABLE 4

PRODUCTION OF NC METALCUTTING MACHINE TOOLS
% distribution and million Yen

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
Values (mln Y)	339422	434066	421779	426616	589703	703800	610547	486022	622336	829867	985337	
TOTAL	100	100	100	100	100	100	100	100	100	100	100	
LATHES	44.9	37.2	33.2	28.5	32.7	31.4	29.8	32.1	33.0	30.1	29.1	32.9
DRILLING	0.6	0.5	0.4	1.0	0.8	0.6	1.2	1.9	2.5	2.4	2.5	1.3
BORING	2.4	2.9	2.7	2.4	1.8	1.3	1.8	1.6	1.5	2.3	2.1	2.1
MILLING	5.6	7.1	8.0	7.9	5.9	5.0	4.6	5.1	4.9	5.0	4.4	5.8
GRINDING	1.0	1.0	1.4	1.4	2.0	2.6	3.6	3.9	4.5	5.9	6.5	3.1
MACHINING CENTERS	32.8	38.1	38.4	39.0	36.1	38.0	37.3	34.5	33.2	34.4	34.0	36.0

Source: JMTBA, CECIMO, NTBA

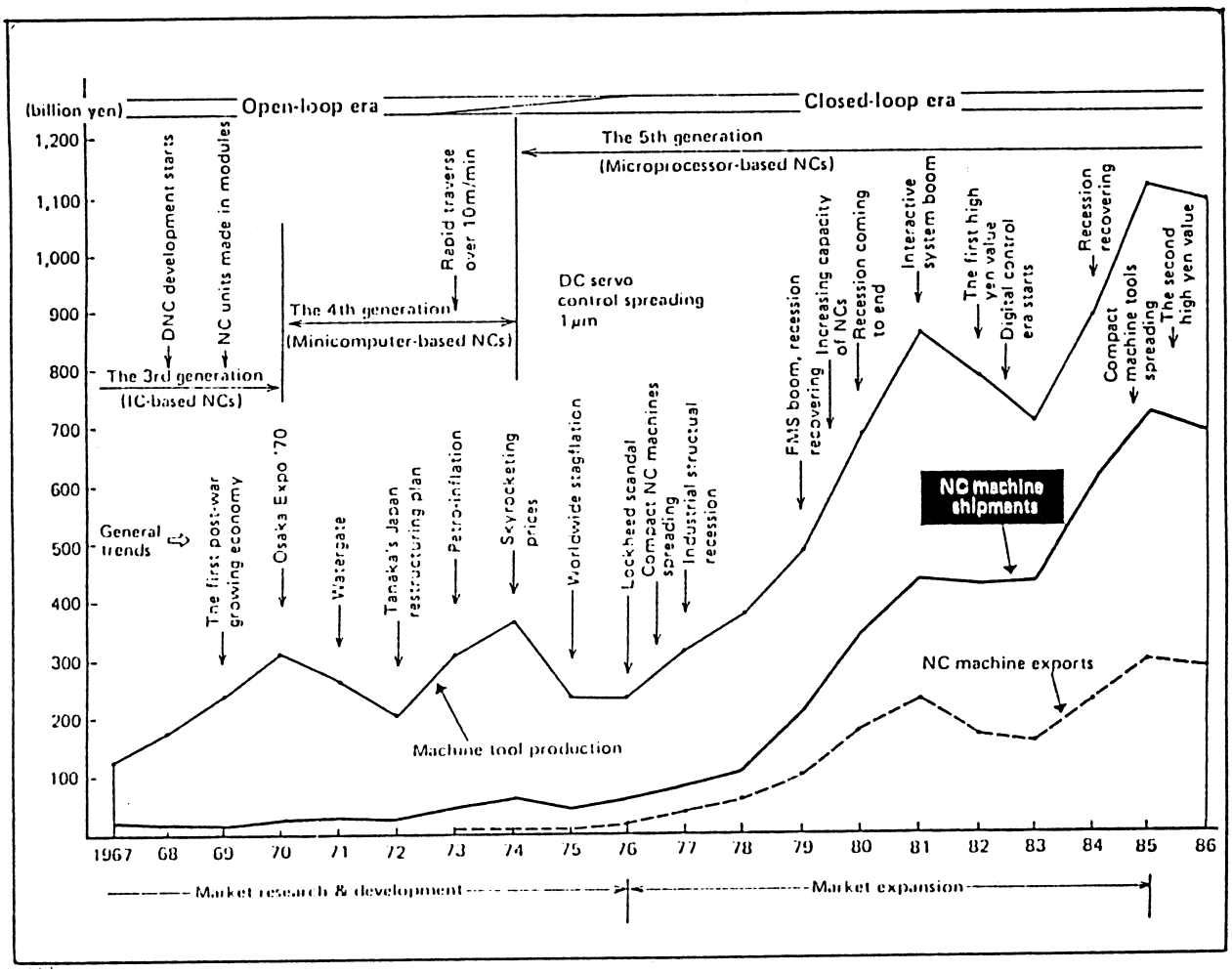
TABLE 5

PRODUCTION OF METALCUTTING MACHINE TOOLS
INDEX OF NC SPECIALIZATION

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
LATHES	139.0	137.9	115.1	126.0	119.2	124.1	125.5	124.7	126.8	122.5	120.2	125.5
DRILLING	29.4	25.7	22.5	51.7	41.7	44.2	67.0	88.8	92.7	95.2	94.8	59.4
BORING	52.8	71.0	68.0	64.1	67.1	54.5	86.8	79.8	68.0	97.0	94.8	73.1
MILLING	64.2	80.8	83.4	85.0	77.0	71.5	79.9	95.0	88.1	87.1	84.6	81.5
GRINDING	9.1	8.8	12.0	13.2	17.5	20.6	28.1	33.8	38.1	48.1	53.7	25.7
MACHINING CENTERS	201.0	201.0	196.1	185.6	164.6	149.5	149.4	147.3	142.2	141.6	136.8	165.0

Source: JMTBA, CECIMO, NTBA
* Index > 100 means high weight within NC machines, in comparison with the weight within the machine tool sector as a whole

TABLE 6 NC MACHINE TOOLS: TECHNOLOGY AND ECONOMIC CYCLE



Source: METALWORKING Engineering and Marketing, July 1987

TABLE 7

EXPORT OF METALCUTTING MACHINES TOOLS
% EXPORT / PRODUCTION

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
TOTAL	39.5	36.5	31.6	33.8	35.6	37.6	40.4	42.9	36.5	37.7	35.0	37.0
LATHES	53.7	55.3	40.4	45.1	41.5	46.9	53.6	51.0	43.7	46.5	43.5	47.4
DRILLING	48.1	37.0	60.6	79.2	60.4	61.6	114.3	92.8	51.1	60.1	52.8	65.3
BORING	40.0	37.4	34.2	37.9	38.7	55.7	38.6	71.2	21.9	17.1	29.2	38.3
MILLING	28.8	22.8	20.1	22.5	30.0	31.3	32.1	48.0	24.2	20.8	22.2	27.5
GRINDING	35.0	25.4	26.9	27.0	27.0	28.8	31.9	42.3	37.8	39.5	35.9	32.5
MACHINING CENTERS	N.A.	N.A.	45.2	47.2	48.9	49.7	52.1	49.2	40.1	39.2	35.1	37.0

Source: JMTBA, CECIMO, NTBA

TABLE 8

IMPORT OF METALCUTTING MACHINES TOOLS
% IMPORT / (PRODUCTION - EXPORT + IMPORT)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
TOTAL	8.5	6.7	7.5	6.5	4.9	5.1	5.8	5.3	6.2	6.7	7.5	6.4
LATHES	4.7	5.5	4.4	3.7	2.8	2.7	4.9	2.7	2.6	3.0	3.0	3.7
DRILLING	14.1	7.7	19.1	49.1	11.4	7.6	-27.8	46.7	5.4	9.7	10.5	14.0
BORING	6.7	7.2	6.8	4.2	8.5	6.0	8.0	9.9	7.5	4.8	7.4	7.0
MILLING	11.1	5.5	5.5	4.3	3.8	4.8	5.1	9.8	2.2	2.5	3.6	5.3
GRINDING	20.5	16.9	19.7	16.2	15.2	15.3	16.0	18.4	13.6	12.2	15.2	16.3
GEAR CUTTING	N.A.	N.A.	7.0	2.9	4.5	2.8	4.1	2.8	4.4	4.9	6.5	3.6
OTHERS	N.A.	N.A.	3.6	5.9	2.5	3.0	2.3	2.1	8.3	10.4	10.2	4.4

Source: JMTBA, CECIMO, NTBA

TABLE 9

EXPORT OF METALCUTTING MACHINES TOOLS
% distribution and million of Yen

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
Values (mln Y)	269577	310763	247576	237445	313503	395040	363660	296374	321500	428591	455809	
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100.0
LATHES	43.9	40.9	36.9	30.2	32.0	31.6	31.4	30.6	31.2	30.3	30.1	33.5
DRILLING	2.4	1.9	3.7	4.5	3.4	2.4	4.9	4.6	3.8	4.1	4.0	3.6
BORING	4.6	4.2	4.2	4.1	2.8	3.5	2.0	3.3	1.4	1.1	1.9	3.0
MILLING	6.3	5.5	6.1	6.2	6.5	5.8	4.6	6.1	3.7	3.2	3.3	5.2
GRINDING	9.8	7.9	10.0	8.3	8.6	9.9	10.2	11.4	12.4	12.8	12.4	10.3
MACHINING CENTERS	N.A.	N.A.	29.5	33.1	33.3	33.6	32.6	27.9	25.8	26.1	25.8	24.3

Source: JMTBA, CECIMO, NTBA

TABLE 10

EXPORTS OF METALWORKING MACHINES
% geographical distribution and million of Yen

	1984	1985	1986	1987	1988	1989
TOTAL	100	100	100	100	100	100
CECIMO	14.7	17.8	19.5	21.6	23.8	N.A.
EEC	12.6	15.2	16.9	18.7	20.8	N.A.
GERMANY	4.5	6.3	6.9	7.0	8.1	8.2
UNITED KINGDOM	3.5	3.2	2.9	3.8	3.9	4.7
FRANCE	0.8	1.2	1.2	1.2	3.7	2.0
ITALY	0.4	0.5	0.7	1.3	1.7	N.A.
SWITZERLAND	0.8	1.1	1.2	1.2	1.4	N.A.
US	42.6	52.5	42.7	36.1	33.9	35.2
Values (mln Y)	413526	519773	516252	438959	429685	542174

Source: JMTBA, CECIMO, NTBA

TABLE 11

EXPORTS OF METALFORMING MACHINES
% geographical distribution and million of Yen

	1984	1985	1986	1987	1988	1989
TOTAL	100	100	100	100	100	100
CECIMO	7.6	6.2	5.9	10.2	9.8	N.A.
EEC	6.9	5.8	5.5	8.6	9.6	N.A.
GERMANY	2.8	3.5	2.9	1.9	2.0	1.6
UNITED KINGDOM	2.0	1.3	1.1	4.4	3.0	4.6
FRANCE	0.1	0.4	0.7	0.9	9.6	3.2
ITALY	0.3	0.3	0.3	0.9	1.2	1.8
SWITZERLAND	0.1	0.2	0.1	0.2	0.1	0.4
US	33.1	25.2	49.6	42.9	35.0	30.9
Values (mln Y)	100022	124732	152646	142583	105464	113464

Source: JMTBA, CECIMO, NTBA

TABLE 12 EXPORTS OF METALCUTTING MACHINES

% geographical distribution and million of Yen

	1984	1985	1986	1987	1988	1989
TOTAL	100	100	100	100	100	100
CECIMO	17.0	21.4	25.2	27.1	28.4	N.A.
EEC	14.4	18.1	21.7	23.6	24.5	N.A.
GERMANY	5.0	7.2	8.5	9.4	10.0	9.9
UNITED KINGDOM	3.9	3.8	3.6	3.4	4.2	4.7
FRANCE	1.0	1.4	1.4	1.4	1.8	1.7
ITALY	0.4	0.5	0.8	1.4	1.9	N.A.
SWITZERLAND	1.0	1.4	1.7	1.7	1.9	N.A.
US	45.6	61.1	39.8	32.9	33.5	36.4
Values (mln Y)	313504	395041	363606	296376	324221	428711

Source: JMTBA, CECIMO, NTBA

TABLE 13

EXPORTS OF LATHES

% geographical distribution and million of Yen

	1984	1985	1986	1987	1988
TOTAL	100	100	100	100	100
CECIMO	21.7	30.1	33.7	34.4	36.2
EEC	18.1	25.0	28.5	29.1	29.9
GERMANY	5.3	9.0	10.2	9.7	11.6
UNITED KINGDOM	5.6	5.7	4.7	4.5	6.4
FRANCE	1.1	1.8	1.0	1.3	1.5
ITALY	0.4	0.5	1.2	1.4	2.6
SWITZERLAND	1.7	2.3	3.2	3.3	4.0
US	47.0	44.3	45.5	38.8	39.1
Values (mln Y)	100327	124713	114599	90736	100171

Source: JMTBA, CECIMO, NTBA

TABLE 14 EXPORTS OF MACHINING CENTERS

% geographical distribution and million of Yen

	1984	1985	1986	1987	1988
TOTAL	100	100	100	100	100
CECIMO	20.2	25.9	30.9	38.7	40.2
EEC	16.8	22.0	26.3	33.8	34.2
GERMANY	5.5	8.3	9.4	11.1	11.0
UNITED KINGDOM	3.6	3.7	3.9	4.8	4.4
FRANCE	1.4	1.9	2.1	2.4	2.8
ITALY	0.4	0.5	0.6	2.1	2.4
SWITZERLAND	1.1	1.7	1.6	1.9	2.2
US	58.0	56.7	51.6	42.0	38.5
Values (mln Y)	104286	132798	118614	82574	82936

Source: JMTBA, CECIMO, NTBA

TABLE 15

EXPORT OF METALCUTTING MACHINES TOOLS
INDEX OF SPECIALIZATION

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
LATHES	135.9	151.6	127.6	133.5	116.6	124.8	132.5	118.9	119.9	123.1	124.4	128.1
DRILLING	121.6	101.3	191.6	234.4	169.8	163.9	282.7	216.3	140.1	159.1	151.0	175.6
BORING	101.1	102.4	108.0	112.0	108.8	148.1	95.5	166.0	59.9	45.2	83.4	102.8
MILLING	72.9	62.6	63.7	66.6	84.4	83.3	79.5	112.0	66.2	55.0	63.5	73.6
GRINDING	88.5	69.7	85.2	79.8	75.9	76.7	78.8	98.6	103.7	104.7	102.7	87.7
MACHINING CENTERS	131.2	144.2	41.1	48.0	54.3	51.6	50.3	55.9	77.8	82.2	80.7	74.3

Source: JMTBA, CECIMO, NTBA

* Index > 100 means high weight within machine tool exports, in comparison with the weight within the machine tool production

TABLE 16

EXPORT OF METALCUTTING MACHINES TOOLS
% CONTENT OF NC MACHINES

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
TOTAL	64.1	70.5	66.0	65.5	71.7	72.1	71.8	69.3	79.7	81.3	81.6	72.1
LATHES	85.2	88.2	85.5	83.4	88.7	93.3	94.5	93.6	93.4	92.5	94.4	90.2
DRILLING	15.0	11.9	14.7	33.8	64.8	46.5	38.3	63.9	69.2	74.5	75.8	46.2
BORING	24.7	10.7	21.5	28.9	45.2	60.7	64.3	62.2	51.9	57.5	30.5	41.6
MILLING	35.5	52.2	43.3	55.1	74.0	72.3	72.8	73.1	65.2	68.3	58.5	60.9
GRINDING	1.6	3.6	8.3	13.1	20.7	15.4	28.5	29.6	33.6	41.1	40.7	21.5

Source: JMTBA, CECIMO, NTBA

TABLE 17

EXPORT OF METALCUTTING MACHINES TOOLS
INDEX OF NC SPECIALIZATION

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
TOTAL	128.8	138.2	122.4	107.8	107.1	107.7	105.8	98.6	112.8	111.2	107.9	113.5
LATHES	123.2	125.4	137.8	108.9	111.2	112.3	110.9	106.7	104.3	103.3	103.9	113.4
DRILLING	102.5	90.3	121.5	107.6	232.2	156.8	84.1	102.4	105.7	107.0	105.7	119.6
BORING	94.0	29.6	58.7	74.2	100.6	166.3	109.1	110.8	107.9	81.1	42.6	88.6
MILLING	111.2	126.6	96.4	106.8	143.5	151.1	134.3	109.4	104.7	107.2	91.5	116.6
GRINDING	34.6	81.5	128.6	162.9	177.0	111.8	149.6	124.8	124.6	116.9	100.3	119.3

Source: JMTBA, CECIMO, NTBA
* Index > 100 means high weight within nc exports, in comparison with the weight within nc production

TABLE 18

EXPORT OF METALCUTTING MACHINES TOOLS
% NC EXPORT / NC PRODUCTION

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
TOTAL	50.9	50.4	38.7	36.4	38.1	40.5	42.8	42.3	41.2	42.0	37.8	41.9
LATHES	66.1	69.4	55.6	49.1	46.1	52.7	59.4	54.4	45.6	48.0	45.2	53.8
DRILLING	49.3	33.4	73.7	85.3	140.2	96.6	96.1	95.0	54.0	64.3	55.9	76.7
BORING	37.6	11.1	20.0	28.1	39.0	92.6	42.2	78.9	23.6	13.8	12.4	36.3
MILLING	32.0	28.9	19.4	24.1	43.1	47.3	43.1	52.5	25.3	22.3	20.3	32.6
GRINDING	12.1	20.7	34.6	44.0	47.8	32.2	47.7	52.8	47.2	46.2	36.0	38.3

Source: JMTBA, CECIMO, NTBA

TABLE 19 EXPORTS OF MACHINING CENTERS

% geographical distribution and million of yen

	1983	1984	1985	1986	1987	1988	1989	1990
US	52	58	55	51	42	37	40	32
GERMANY	6	6	8	9	11	11	12	13
BELGIUM	7	5	5	7	10	9	10	13
UNITED KINGDOM	4	4	4	4	5	4	6	5
AUSTRALIA	1	3	2	2	*	*	**	**
URSS	6	3	*	*	1	2	**	**
SWEDEN	2	2	2	3	3	3	3	2
CANADA	1	2	2	1	2	2	2	**
CHINA	*	*	2	3	*	*	**	**
FRANCE	*	1	2	2	2	3	3	4
KOREA	*	1	2	2	*	*	2	2
SWITZERLAND	*	1	2	2	2	2	**	2
DENMARK	*	1	1	1	1	1	**	**
TAIWAN	*	*	*	1	3	3	5	3
ITALY	*	*	*	1	2	2	3	3
OTHERS	13	11	13	10	17	20	15	20
TOTAL	100	100	100	100	100	99	100	100
Values (mln Y)	78647	104286	136924	119982	82574	82574	112070	117483
CEE	N.A.	17	21	26	33	N.A.	N.A.	N.A.
CECIMO	N.A.	20	25	31	38	N.A.	N.A.	N.A.

Source: JMTBA, CECIMO, NTBA

* less than 1%

** less than 2%

TABLE 20 EXPORTS OF NC LATHES

% geographical distribution and million of yen

	1983	1984	1985	1986	1987	1988	1989	1990
US	46	51	47	48	41	41	41	28
GERMANY	6	6	10	11	10	12	12	15
BELGIUM	6	4	6	9	11	6	8	11
UNITED KINGDOM	7	6	6	5	5	7	6	5
AUSTRALIA	2	2	3	2	2	3	3	***
INDIA	1	2	2	2	*	**	**	***
SWEDEN	*	2	2	2	2	2	2	3
CANADA	*	2	2	*	2	2	**	***
KOREA	2	3	1	3	5	2	2	3
SWITZERLAND	2	2	2	3	3	4	5	***
DENMARK	*	1	1	2	*	**	**	***
TAIWAN	*	*	*	1	2	**	**	***
ITALY	*	*	1	*	1	3	3	4
THAILAND	*	*	*	*	*	**	2	3
OTHERS	18	14	13	14	14	19	18	27
TOTAL	100	100	100	100	100	101	102	100
Values (mln Y)	59677	90322	117059	108319	84911	93587	120070	129722

Source: JMTBA, CECIMO, NTBA

* less than 1%

** less than 2%

*** less than 3%

TABLE 21

IMPORT OF METALCUTTING MACHINES TOOLS
% distribution and million Yen

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
Values (mln Y)	38221	38623	43585	32517	29259	35186	33241	22073	36727	50511	68644	
TOTAL	100	100	100	100	100	100	100	100	100	100	100	
LATHES	13.3	15.6	14.4	10.4	13.9	11.1	15.4	11.2	9.4	9.1	8.1	10.9
DRILLING	3.0	2.2	3.2	8.3	3.0	1.4	1.5	4.2	1.8	2.5	2.8	3.1
BORING	3.5	4.4	3.4	2.2	4.5	2.0	3.0	2.0	3.5	2.2	2.4	3.0
MILLING	13.8	8.7	8.1	7.0	6.4	7.3	5.7	9.6	2.2	2.7	2.9	6.8
GRINDING	33.0	38.2	37.6	31.6	44.6	49.5	45.3	47.4	27.9	23.1	26.3	36.8

Source: JMTBA, CECIMO, NTBA

TABLE 22

IMPORT OF METALCUTTING MACHINES TOOLS
% CONTENT OF NC MACHINES

	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
TOTAL	19.5	18.1	24.0	32.5	42.2	46.3	39.3	38.1	42.8	33.6
LATHES	21.9	21.7	4.9	10.8	53.8	38.1	44.7	20.6	22.1	26.5
DRILLING	26.2	16.7	65.0	15.6	27.6	43.0	32.1	28.8	20.1	30.6
BORING	30.3	47.2	24.2	36.0	62.1	36.5	59.1	44.2	45.9	42.8
MILLING	39.4	4.7	25.9	30.3	35.6	69.1	30.7	31.7	41.4	34.3
GRINDING	17.2	15.3	22.5	30.0	42.3	42.1	34.0	45.3	52.6	33.5
GEAR CUTTING	4.7	87.9	15.7	18.2	58.0	26.4	62.0	62.8	72.3	45.3
OTHERS	28.5	2.7	43.8	60.5	14.2	67.9	34.6	32.8	32.4	35.3

Source: JMTBA, CECIMO, NTBA

TABLE 23

IMPORT OF METALCUTTING MACHINES TOOLS
% NC IMPORT / (NC PRODUCTION - NC EXPORT + NC IMPORT)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
TOTAL	3.2	2.1	1.9	2.7	3.9	3.5	3.8	3.8	4.6	3.3
LATHES	2.2	1.2	0.2	0.4	3.6	1.3	1.4	0.7	0.8	1.3
DRILLING	43.3	42.0	41.7	32.8	32.7	46.4	2.9	4.8	3.4	27.8
BORING	4.8	4.4	4.8	27.3	8.9	8.9	9.2	2.9	4.0	8.4
MILLING	4.8	0.4	2.4	4.0	4.0	11.0	1.1	1.3	2.3	3.5
GRINDING	42.1	32.3	32.4	29.3	35.5	32.9	18.9	16.7	18.9	28.8
GEAR CUTTING	3.9	13.9	1.8	1.3	6.5	2.1	7.7	9.9	10.1	6.4
OTHERS	1.9	0.3	1.8	2.9	0.6	2.5	4.3	4.5	4.2	2.6

Source: JMTBA, CECIMO, NTBA

TABLE 24

IMPORT OF METALCUTTING MACHINES TOOLS
INDEX OF NC SPECIALIZATION

	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
TOTAL	36.1	29.8	35.9	48.6	62.2	65.8	55.6	52.1	56.6	49.2
LATHES	35.3	28.3	6.2	13.0	63.2	43.4	49.9	23.0	24.3	31.8
DRILLING	216.1	53.3	233.0	52.8	60.7	68.9	49.0	41.4	28.1	89.2
BORING	82.7	121.3	53.8	98.7	105.4	65.1	122.9	62.4	64.0	86.3
MILLING	87.6	9.1	50.3	63.4	65.6	103.4	49.4	49.8	64.7	60.4
GRINDING	265.7	189.8	192.0	217.6	222.0	177.3	126.4	128.8	129.6	183.2
GEAR CUTTING	54.7	539.3	38.8	46.2	164.8	75.6	171.9	177.4	147.7	157.4
OTHERS	634.3	63.0	731.6	1535.2	447.7	247.5	103.1	66.7	65.0	432.7

Source: JMTBA, CECIMO, NTBA
* Index > 100 means high weight within nc imports, in comparison with the weight within nc production

TABLE 25

IMPORT OF NC METALCUTTING MACHINES TOOLS
% distribution and million Yen

	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
Values (mln Y)	8488	5879	7020	11452	14033	10219	14427	19250	29376	
TOTAL	100	100	100	100	100	100	100	100	100	
LATHES	16.2	12.4	2.8	3.7	19.6	9.2	10.7	4.9	4.2	9.3
DRILLING	4.4	7.7	8.2	0.7	1.0	3.9	1.5	1.9	1.3	3.4
BORING	5.3	5.7	4.5	2.2	4.4	1.6	5.2	2.5	2.6	3.8
MILLING	16.3	1.8	6.9	6.8	4.8	14.3	1.7	2.2	2.8	6.4
GRINDING	33.3	26.6	41.8	45.7	45.4	43.1	24.2	27.5	32.3	35.5
GEAR CUTTING	4.8	41.0	8.1	5.3	19.8	6.2	18.4	18.7	24.1	16.3
OTHERS	19.8	4.8	27.7	35.7	5.0	21.8	38.4	42.2	32.7	25.3

Source: JMTBA, CECIMO, NTBA

TABLE 26

JAPANESE GROUPS IN THE MACHINE TOOL INDUSTRY

	TOTAL SALES MLN US $		MACHINE TOOL SALES MLN US $		TOTAL EMPLOYEES		TOTAL R&D INVEST. MLN US $		TOTAL NET PROFITS MLN US $	
	1990	1989	1990	1989	1990	1989	1989	1988	1990	1989
AMADA	1341	1281	1207	1153	1594		42	37	134	92
YAMAZAKY MAZA	1150	1184	1150	1183	3524					
FANUC	1280	1241	1100	1079	2046				242	195
OKUMA	786	715	739	665	1884		17	17	33	28
MORI SEIKI	675	649	661	636	1803		8	6	81	72
KOMATSU	6276	6157	471	474	15097				195	130
TOYODA	1326	1261	464	466	4620				19	26
FUJI	436	392	436	392	931				48	40
TOSHIBA	1011	1058	374	359	3383				36	28
HITACHI SEIKI	405	377	365	346	1247		8	8	23	48
AMADASONOIKE	365	391	365	391	673				24	17
MAKINO MILLING	401	383	337	318	1085				32	19
AMADA WASINO	322	285	322	285	528				15	11
CITIZEN	2487	2257	298	339	3192				81	72
NIPPEI	303	242	267	211	1120				9	8
AIDA	284	302	253	268	895				31	24
MITSUBISHI	15540	15839	249	253	44624				485	575
OSAKA	282	285	236	230	1056				10	13
SODICK	232	227	223	220	795				8	8
OKUMA	209	196	209	196	716				12	10
MITSUI SEIKI	382	342	207	195	1164					
NIIGATA	1483	1546	178	170	3474				14	13
TSUGAMI	176	181	167	170	861				11	10
MAZDA	16950	15259	163	146	28831				163	141
TAKISAWA	156	136	156	136	522				7	5
OKAMOTO	159	144	146	139	642				9	7
HOWA	432	472	143	137	1395				12	13
BROTHER IND	1488	1614	134	113	5126				30	27
ENSHU	266	268	122	118	1089				7	7
HAMAI	84	81	72	69	344	330		1	4	2
HITACHI	2464	1796	66	52	5375				69	-119
KURAKI	82	71	64	58	346				2	2
IKEGAI	115	111	60	58	510				4	4
ASAHI	105	104	56	56	652				4	4
O-M	104	107	53	42	626				4	3
HITACHI	48586	49350	49	49	82473				1459	1465
TEIJIN SEIKI	437	457	48	50	1606				9	14
KURODA	165	176	46	25	923				4	5
SHOUN	46	36	46	36	235				-5	37
KOJIMA	24	24	23	22	139				1	1
KIRIU	168	146	22	15	888				3	
KOTOBUKI	27	26	20	16	180				0	-3
SANJO	125	136	7	12	624				4	4
FUJI SEIKO	82	81	2	2	510				7	7

Source: JMTBA, American Machinist

TABLE 27

JAPANESE TRANSPLANT ABROAD

COUNTRY	JAPANESE COMPANY	LOCAL COMPANY	LOCATION	YEAR	PRODUCTS
GERMANY	AMADA	PROMECAM MASCHINEN			
GERMANY	FANUC	GE FANUC			
GERMANY	CITIZEN WATCH	CITIZE MACHINERY EUROPE	STUTTGART	1989	NC LATHE
GERMANY	MAKINO MILLING	HEIDENREICH & HARBECK	HAMBURG	1980	MACHINING CENTER EDM
UK	KOMATSU				
UK	YAMAZAKI MAZAK	YAMAZAKI MACHINERY UK	WORCESTER	1985	NC LATHE MACHINING CENTER
FRANCE	AMADA	PROMECAM SISSON LEHMAN			
FRANCE	MITSUI SEIKI	MITSUI SEIKI EUROPE	CEDEX	1988	MACHINING CENTER
FRANCE	TOYODA MACHINE	ERNAULT-TOYODA AUTOMATION	CHOLET	1985	NC LATHE MACHING CENTER
AUSTRIA	AMADA	AMADA X		1986	PUNCHES AND DIES FOR PRESS BRAKES
LUXEMBOURG	FANUC	GE FANUC	LUXEMBOURG		
ITALY	AMADA	PRIMA INDUSTRIE (49%)	TURIN	1987	AUTOMATED EQUIP.
ITALY	AMADA	SAPIM SYSTEM		1990	
USA	AMADA	AMADA MFG AMERICA	LOS ANGELES		CNC TURRET PUNCH PRESSES, LASER CUTTING MACHINES
USA	FANUC	GM FANUC			
USA	FANUC	JV WITH CINCINNATI MILACRON			
USA	FANUC	MOORE SPECIAL TOOLS (40%)			JIG GRINDERS
USA	KOMATSU	DANLY-KOMATSU (30%)			HEAVY PRESSES
USA	HITACHI SEIKI	HITACHI SEIKI U.S.A.	HUNSVILLE, ALABAMA	1979	NC LATHE
USA	MAKINO MILLING	LEBLOND MAKINO MACHINE TOOL	MASON, OHIO	1982	MACHINING CENTER
USA	MITSUBISHI HEAVY	AMERICAN PRECISION MACHINERY	HOPKINSVILLE, KENTUCKY	1990	NC LATHE MACHINING CENTER
USA	MIYANO MACHINERY	MIYANO MACHINERY U.S.A.	WOOD DALE, ILLINOIS	1987	NC LATHE
USA	OKAMOTO MACHINE	OKAMOTO CORPORATION	BUFFALO GROVE, ILLINOIS	1987	SURFACE GRINDING MACHINE
USA	OKUMA MACHINERY	OKUMA MACHINE TOOLS	CHARLOTTE, NORTH CAROLINA	1987	NC LATHE
USA	TOYODA MACHINE	TOYODA MACHINERY U.S.A.	ARLINGTON HEIGHTS, ILLINOIS	1986	MACHINING CENTER, NC SPECIAL PURPOSE MACHINE
USA	YAMAZAKI MAZAK	MAZAK CORPORATION	FLORENCE, KENTUCKY	1974	NC LATHE MACHINING CENTER
USA	FANUC	GE FANUC AUTOMATION NORTH AMERICA	CHARLOTTESVILLE, VIRGINIA	1987	CNC, PLC
USA	MITSUBISHI ELECTRIC	MITSUBISHI ELECTRIC SALES AMERICA	MOUNT PROSPECT, ILLINOIS	1983	CNC
TAIWAN	AMADA	AMADA TAIWAN CO.	TAIWAN		CNC TURRET PUNCH PRESSES
TAIWAN	TAKISAWA MACHINE	TAIWAN TAKISAWA MACHINERY	PINGCHEN HSIANG, TAOYUAN HSIEN	1971	CENTER LATHE NC LATHE
BRASIL	KOMATSU				
BRASIL	TOYODA MACHINE	TOYODA KOKI DO BRAZIL	SAN PAULO	1975	CYLINDRICAL GRINDER SPECIAL PURPOSE MACHINE
SINGAPORE	KOMATSU				
SINGAPORE	MAKINO MILLING	LEBLOND MAKINO ASIA	JURONG TOWN	1981	MACHINING CENTER, NC MILLING MACHINE, NC LATHE
SINGAPORE	OKAMOTO MACHINE	OKAMOTO SINGAPORE	WOODLANDS NEWTOWN	1973	SURFACE GRINDING MACHINE
KOREA	DAINICHI KINZOKU	KOREA MACHINE TOOL	CHANGWON-SI, KYUNGNAM	1969	CENTER LATHE NC LATHE
KOREA	FANUC	FANUC KOREA CORPORATION	CHANGWON-SI, KYUNGNAM	1978	NC-EDM CNC
THAILAND	OKAMOTO MACHINE	OKAMOTO THAI	CHANGWAT AYUDHAYA	1987	SURFACE GRINDING MACHINE

Source: MEM, JMTBA

TABLE 28 DIVERSIFICATION IN THE TOP 10 MECHANICAL GROUPS

YEAR	TOTAL SALES	OF WHICH: MACHINE TOOLS		OTHERS	
	MLN YEN	MLN YEN	%		%
1984	13278	8450	64	4828	36
1985	18612	12230	65	6589	35
1986	23710	17265	73	6444	27
1987	20695	12125	59	8570	41
1988	24500	10500	43	14000	57

Source: METALWORKING Engineering and Marketing, July 1988

TABLE 29

COUNTRY	JAPANESE COMPANY	LOCAL COMPANY	YEAR	PRODUCTS	COOPERATION NATURE	NOTES
UK	AIDA ENGINEERING	DUCTILE	1982	ROBOTS	SALE LICENCE	
GERMANY	AIDA ENGINEERING	HOESEH	1982	CAO/FAO	MANUFACTURING/SALE LICENCE	
TAIWAN	ASAHI DIAMOND INDUSTRIAL	TAIWAN DIAMOND INDUSTRIAL	1977		MANUFACTURING/SALE LICENCE	
UK	DAINICHI	W.E. SYKES	1981	ROBOTS	SALE LICENCE	
USA	DAINICHI	CCA	1982	ROBOTS	SALE LICENCE	
USA	DAINICHI	CINCINNATI MILACRON	1982	ROBOTS	SALE LICENCE (OEM)	
SINGAPORE	DAINICHI	CHARTERED MACHINE TOOL	1982	ROBOTS	SALE LICENCE	
USA	DIJET INDUSTRIAL	GENERAL ELECTRIC	1979	METALLIC CARBIDES	MANUFACTURING/SALE LICENCE	
USA	DIJET INDUSTRIAL	KENNAMENTAL	1980	TOOLS	SALE LICENCE	RECIPROCAL EXCHANGE
GERMANY	E MACHINERY	G. ROLEY	1982	LITTLE LATHES, CN	SALE LICENCE	
BULGARIA	FANUC	MACHINOEXPORT	1980	CN/ROBOTS	MANUFACTURING/SALE LICENCE	
USA	FANUC	GETTY MANUFACTURING	1977	CONTROLS FOR ENGINEWITH MORE AXLES	MANUFACTURING/SALE LICENCE	KNOW-HOW
GERMANY	FANUC	SIEMENS	1975	NUMERICAL CONTROLS	R&D AGREEMENT	
CHINA	FANUC	OMEC	1980	CN/CONTROLS SERVO-ENGINE	MANUFACTURING/SALE LICENCE	
UK	FANUC	LE 600 GROUP	1982	ROBOTS	MANUFACTURING/SALE LICENCE/JOINT VENTURE	EST.DEC.1982
USA	FANUC	GENERAL MOTORS	1982	ROBOTS	JOINT VENTURE	GMR ROBOTICS EST.JUNE 1982
TAIWAN	FANUC	TATUNG	1982	ROBOTS	SALE LICENCE	
USA	HITACHI	GENERAL ELECTRIC	1980	ROBOTS	MANUFACTURING/SALE LICENCE	
USA	HITACHI	AUTOMATICS	1981	ROBOTS	MANUFACTURING/SALE LICENCE	
UK	HITACHI	GEC ELECTRICAL PROJECT	1982	ROBOTS	MANUFACTURING/SALE LICENCE	JOINT VENTURE GE
GERMANY	HITACHI	ZEPPELIN	1982	ROBOTS	SALE LICENCE	
CHINA	HITACHI SEIKI	CMEC	1981	MILLING MACHINE	MANUFACTURING/SALE LICENCE	
KOREA	HITACHI SEIKI	KIA MACHINE	1981	REPRODUCTION OF LATHES, MILLING MACHINES	MANUFACTURING/SALE LICENCE	
INDIA	HITACHI SEIKI	WALCHANDNAGAR INDUSTRIES	1982	WORKSHOPS	MANUFACTURING/SALE LICENCE	
KOREA	IKESAI	DAEWOO HEAVY	1977		MANUFACTURING/SALE LICENCE	
USA	IKESAI	ACROLOC	1982	CN, LATHES	SALE LICENCE	
SWITZERLAND	JAPAX	ATELIERS DES CHARMILLES	1982	PROCESSING MACHINE FOR ELECTRO-EROSION	TECHNICAL EXCHENGES, JOINT R&D	
GERMANY	KITAYAWA IRON WORK	PAUL FORKARDT	1982		SALE LICENCE	KNOW-HOW
KOREA	MAKINO MILLING MACHINES	DAEWOO HEAVY INDUSTRIES	1977	ROUGH-SHAPING TOOLS	MANUFACTURING/SALE LICENCE	
GERMANY	MAKINO MILLING MACHINES	HEIDENREICH & HARBECK	1978	LATHES, WORKSHOP	MANUFACTURING, SALE LICENCE, SHARING CAPITAL	
USA	MAKINO MILLING MACHINES	LEOLOND MAKINO	1981	LATHES, WORKSHOP	MANUFACTURING/SALE LICENCE	
ITALY	MATSUMOTO MACHINE	AUTOBLOCK-ARONZINO	1981		KNOW-HOW	RECIPROCAL EXCHANGE
KOREA	MITSUBISHI HEAVY INDUSTRIES	HYUNDAI MOTORS	1978	SPECIAL MACHINES	MANUFACTURING/SALE LICENCE	
USA	MITSUBISHI HEAVY INDUSTRIES	ACME-CLEVELAND	1982	WORKSHOPS	MANUFACTURING/SALE LICENCE	
GERMANY	MORI SEIKI	SCHIESS MOWEG	1982	WORKSHOPS	SALE LICENCE	
USA	OKAMURA	PLATT SACO LOWELL	1982	ROBOTS	MANUFACTURING/SALE LICENCE	
UK	OKUMA MACHINERY WORKS	T I MACHINES	1973	ROUGH-SHAPING TOOLS	MANUFACTURING/SALE LICENCE	KNOW-HOW
GERMANY	OKUMA MACHINERY WORKS	ALFRED H. SCHUETTE	1982	WORKSHOPS	MANUFACTURING/SALE LICENCE	KNOW-HOW
USA	OKUMA MACHINERY WORKS	DANLY MACHINE	1982	WORKSHOPS	MANUFACTURING/SALE LICENCE	
USA	OKUMA MACHINERY WORKS	DEVLIIEG MACHINE	1982	WORKSHOPS	MANUFACTURING/SALE LICENCE	
USA	OKURA YUSOKI	FMC	1982	ROBOTS	MANUFACTURING/SALE LICENCE	KNOW-HOW
USA	ORII	THE MINISTER MACHINE	1982	ROBOTS	SALE LICENCE	
USA	OSG MFG.	SOSSNER TAP & TOOL	1973	SHARP TOOLS	CAPITAL SHARING	
TAIWAN	OSG MFG.	TAIHO TOOL MFG.	1970	SHARP TOOLS	JOINT VENTURE	
USA	RICHMILL MANUFACTURE	JACOBS MANUFACTURING	1982		SALE LICENCE	
TAIWAN	TSUGAMI	TATUNG	1982	AUTOMATIC LATHES, GRINDING WHEEL		
USA	YAMADA DOBBY	ROCKFORD SAFETY EQUIPMEN	1982	SPEED PRESS	SALE LICENCE	
KOREA	YAMAZAKI MACHINERY WORKS	KOREA HEAVY MACHINERY IND.	1976	LATHES	MANUFACTURING/SALE LICENCE	
SINGAPORE	YAMAZAKI MACHINERY WORKS	PRODUCTION MACHINERY	1982	CN. LATHES	MANUFACTURING/SALE LICENCE	
USA	YASKAWA ELECTRONIC MFG	THE BENDIX	1982	CN, ROBOTS	SALE LICENCE (OEM)	
GERMANY	YASKAWA ELECTRONIC MFG	MESSER GRIESHEIM	1982	ROBOTS	SALE LICENCE (OEM)	
USA	YASKAWA ELECTRONIC MFG	MIC	1982	ROBOTS	JOINT VENTURE	
FRANCE	SANKYO SEIKI MFG	OGMS	1962	ROBOTS	MANUFACTURING/SALE LICENCE	
USA	SANKYO SEIKI MFG	IBM	1982	ROBOTS	MANUFACTURING/SALE LICENCE	
GERMANY	SEIBU ELECTRIC MFG	HERBERT WALTER	1982	TOOLS FOR PROCESSING MACHINE FOR ELECTRO-EROSIO	SHARING CAPITOL	
USA	SCHOUN MACHINE TOOL	THE OLOFASON		LATHES, NC,	R&D, MANUFACTURING, SALE LICENCE	TECHNICAL TRANSFER TOWARD JOINT VENTURE
GERMANY	SCHOUN MACHINE TOOL	ROBERT BOSCH		R&D		
UK	SODICK	A.A. JONES & SHIPMAN	1981	PROCESSING MACHINE FOR ELECTRO-EROSION	MANUFACTURING/SALE LICENCE	
KOREA	SUMITOMO ELECTRIC INDUSTRIES	HAN KOOK METALLURGY	1970	METALLIC CARBIDES	JOINT VENTURE	
GERMANY	TOKYO SEIMITAU	CARL ZWEIRE	1982	INSTRUMENTS OF TRIDIMENSIONAL MEASURE	SALE LICENCE	RECIPROCAL EXCHANGE
KOREA	TOSHIBA TUNGALOY	SINACO INDUSTRIAL	1970	SHARP TOOLS	JOINT VENTURE	
SPAIN	TOYODA MACHINE WORKS	DANOBAT	1975	ROUGH-SHAPING TOOLS	MANUFACTURING/SALE LICENCE	
FRANCE	TOYODA MACHINE WORKS	H.E.S. TOYODA	1980	WORKSHOPS	MANUFACTURING/SALE LICENCE	
USA	TOYODA MACHINE WORKS	THE MENDIX	1982	WORKSHOPS	SALE LICENCE	

Source: MEM, JMTBA, Leborgne

TABLE 30 SCALE OF MACHINE TOOLS INDUSTRY IN JAPAN CLASSIFIED BY NO. OF EMPLOYEES (1986 BASIS)

SCALE OF EMPLOYEES	NO. OF FACTORIES	TOTAL EMPLOYEES	PRODUCTION	DELIVERY
4-9	702	4080	-	33143
10-19	273	3751	-	47702
20-29	121	2975	-	42401
30-49	96	3725		62730
50-99	88	6060	108261	106914
100-199	63	8681	184134	184132
200-299	26	6346	142099	145090
300-499	11	4279	149016	148991
500-999	13	8174	268087	269934
Over 1000	6	9564	270878	277934
Total	1399	57731	1185204	1318589

Source: Jetro

TABLE 31 ACTUAL STYLE OF DISTRIBUTION STRUCTURE FOR DOMESTIC MACHINE TOOLS

A. Sole Agent Distribution System					
Machine tool maker	Sole agents			User	12%
Machine tool maker	Sole agents	Dealers/special exclusive dealers		User	1%
Total					13%
B. Dealer/Special Exclusive Dealer Distribution System					
Machine tool maker	Dealer/Special exclusive dealers			User	40%
Machine tool maker	Sole agent/Special exclusive dealer		Secondary dealer		31%
Total					71%
C. Other Distribution System					
Machine tool maker	Trading firms/Dealers			User	15%
Other					1%
Total					16%

Source: Jetro

FIGURE 1

MACHINE TOOL INDUSTRY

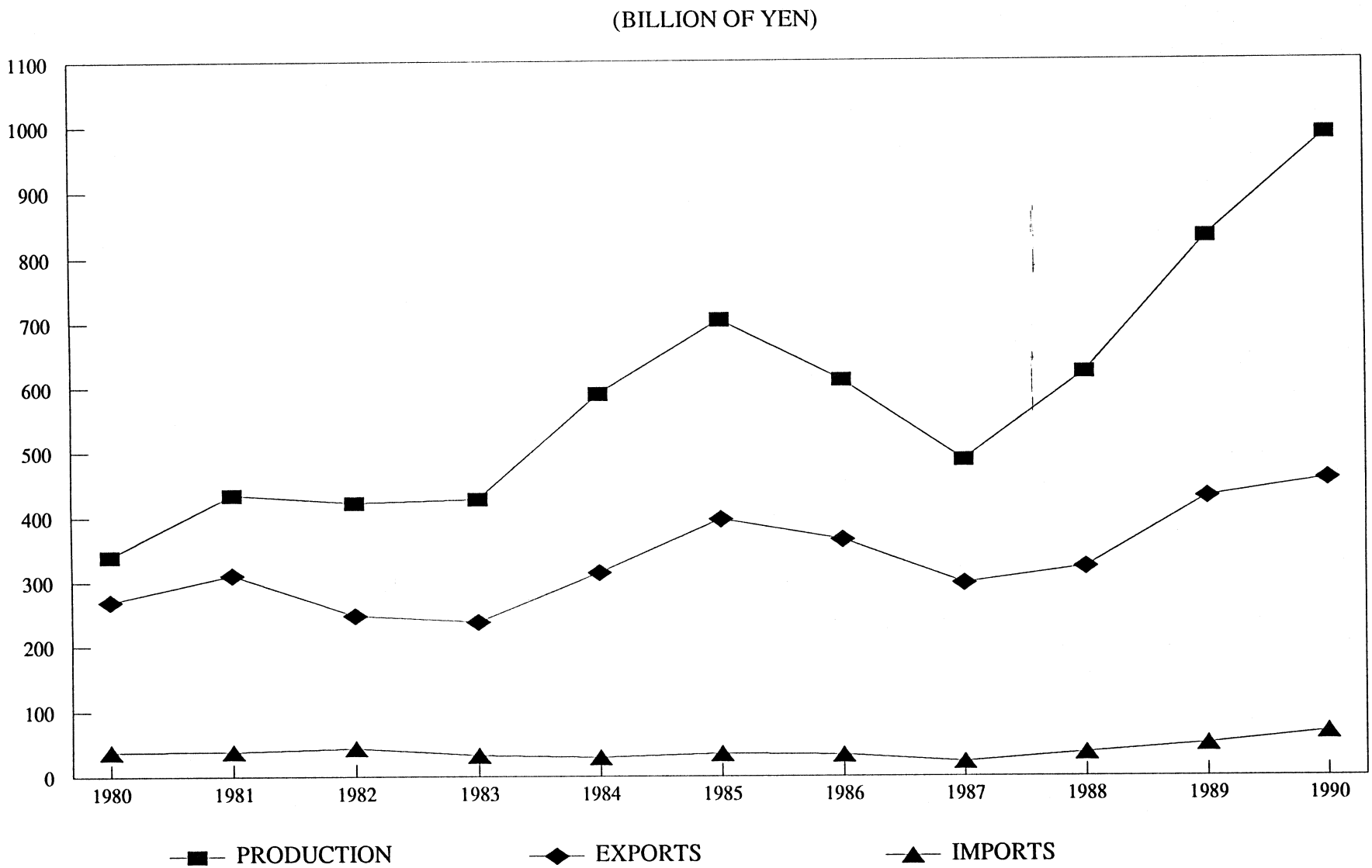


FIGURE 2

REAL EXCHANGE RATES

WHOLESALE PRICE INDEX DEFLATOR

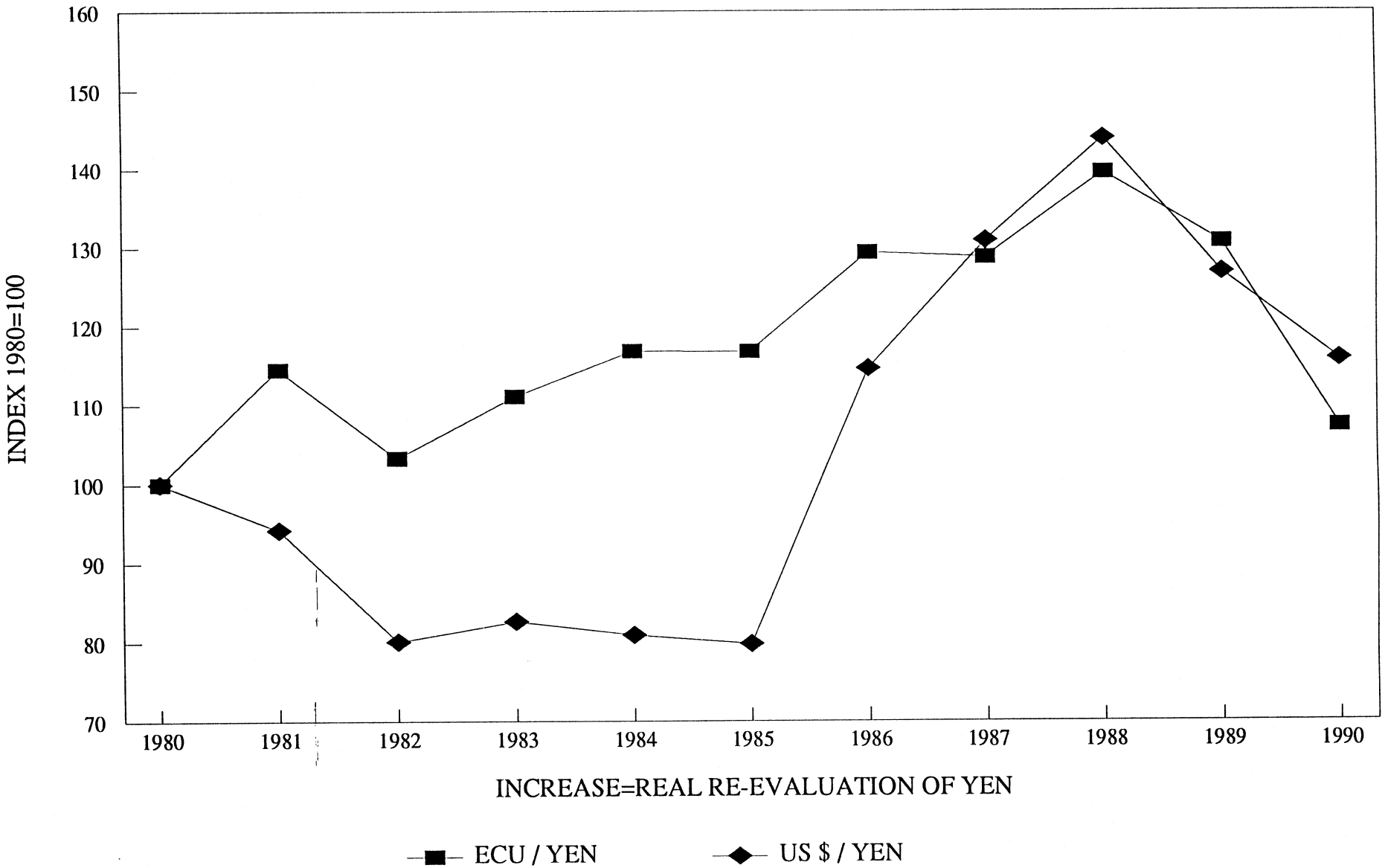


FIGURE 3

MACHINE TOOL INDUSTRY

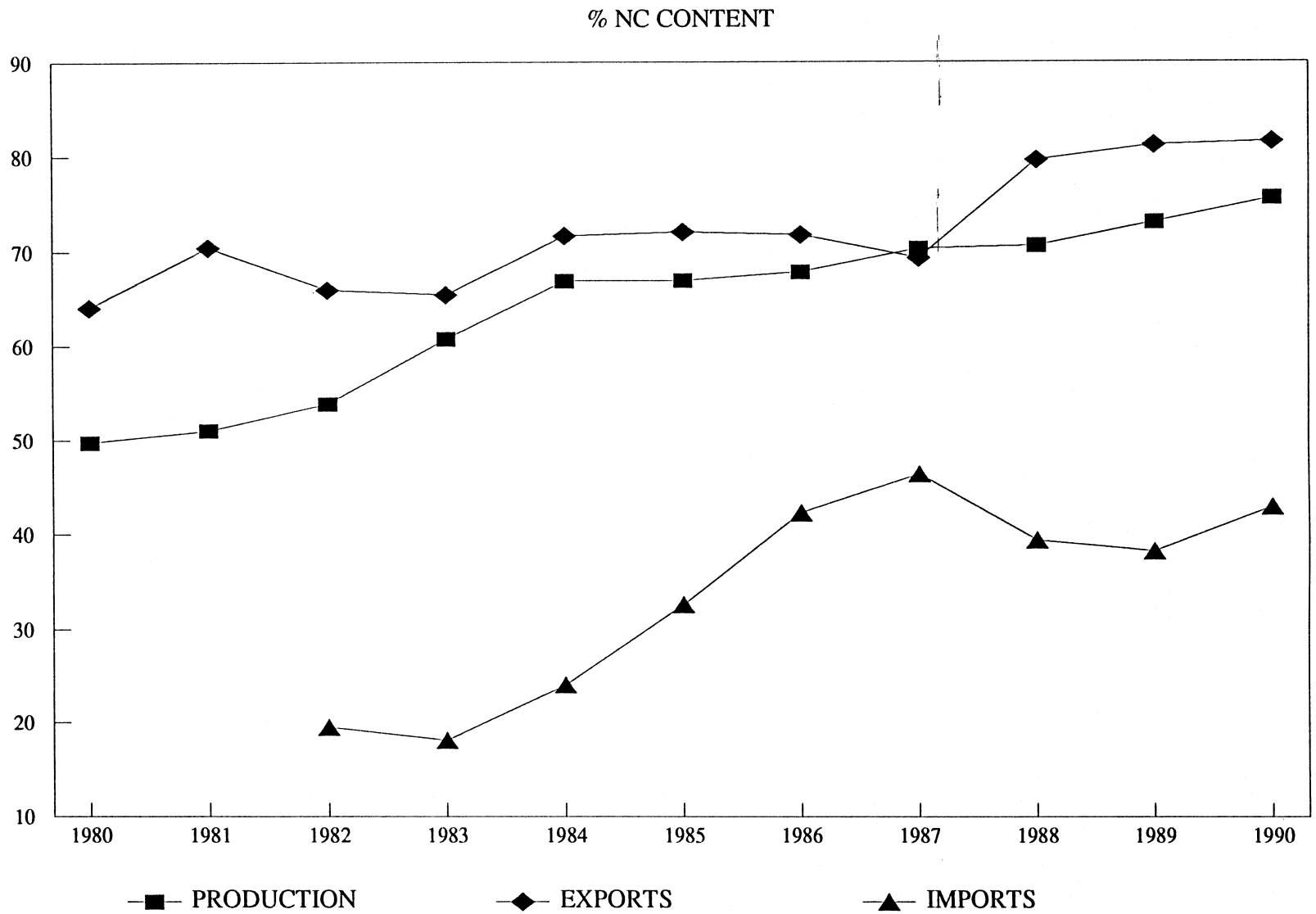
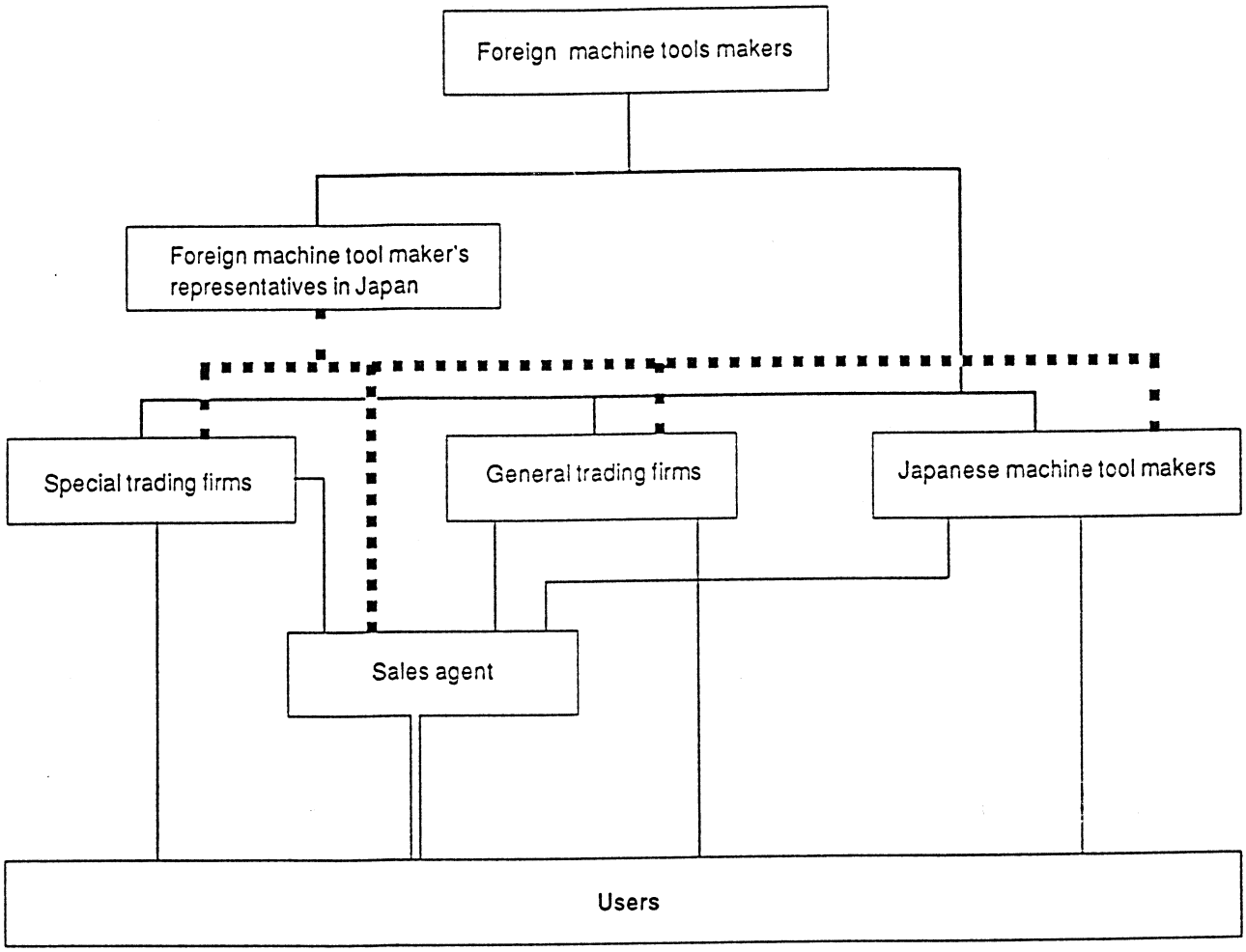


Figure 4: Distribution Structure for Imported Machine Tools



Source: JETRO 1990

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