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INTERNATIONAL TRENDS IN THE MACHINE TOOL INDUSTRY - IMPLICATIONS FOR ARGENTINA*

Prepared by the

Regional and Country Studies Branch

Division for Industrial Studies

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PREFACE

The Regional and Country Studies Branch is carrying out a series of analyses of the industrialization process in the developing countries in order to identify prospects and constraints and to outline the key issues for policymaking. In a period when past strategies and approaches for industrial development are being re-assessed, it seems essential to examine, inter alia, the options in terms of the resource base, structural policies, market orientation and support to the development of various forms of production. It is in this context that this paper was prepared. It attempts to highlight some current trends in an important industrial subsector and implications for developing countries, in particular for Argentina.

This paper was prepared by Mr. Staffan Jacobsson, Research Policy Institute of the University of Lund, Sweden, in co-operation with the staff of the Regional and Country Studies Branch.

INTRODUCTION[1/]

This paper provides an attempt to discuss some important trends in the international machine-tool industry and analyse some implications for the Argentinian machine-tool industry. Two main trends will be focused upon; (a) the substitution of computer numerically controlled (CNC) machine tools for conventional machine tools, (b) the growing importance of the NICs, in particular Taiwan, Province of China, and the Republic of Korea, in the world market. In section 1 we provide a short description of some features of the machine tool industry. In section 2 we discuss some recent trends in the industry. Three trends are discussed in some detail. These are: the changing output mix of the machine-tool industry; the growing importance of Japan in the world market; and rising barriers to entry into the industry. In section 3, we provide a more detailed analysis of firm strategies and barriers to entry in the international industry producing CNC lathes. Together with machining centres, which are combined milling, drilling and boring machines, these lathes constitute the bulk of the output of CNC machine tools. In section 4 we proceed to give an account of the experience of the Republic of Korea and Taiwan, Province of China. Finally, in section 5 we provide some thoughts on policy in Argentina.

1/ This paper draws heavily on a study undertaken by the author on adjustment problems in the NICs as a consequence of the growing importance of CNC machine tools in the global investment in machine tools. The project "Technical change and technology policy - the case of computer numerically controlled lathes in Argentina, the Republic of Korea and Taiwan, Province of China", was financed by SAREC. Their support is gratefully acknowledged. Some elements in the paper derive from a project undertaken by Dr. Charles Edquist and the author. This refers to parts of section 2.1 and chapter 4. Approximately 20 per cent of the entire paper is based upon our joint work. The joint project 'Technical Change and Patterns of Specialization in the Capital Goods Industries of India and the Republic of Korea' is in progress and is also financed by SAREC.

1. THE INTERNATIONAL MACHINE-TOOL INDUSTRY

1.1 The size and structure of the industry

A metalworking machine tool is "a powerdriven machine, not portable by hand while in operation, which works metal by cutting, forming, physico-chemical processing or a combination of these techniques" (MTTA 1983:2). It has been estimated that there are some 3,000 different types and sizes of machine tools ranging from less than one ton to over 60 tons and ranging in unit prices from less than one thousand pounds to over 400,000 pounds (MTTA 1983:2).

The machine-tool industry is therefore a very heterogeneous industry. Some products are, however, more important than others and in Table 1 we can see a list of the main categories of machine tools in the US, Japan and the UK. Grinding machines, turning machines or lathes, milling and drilling machines constitute the bulk of the stock of machine tools, although we would like to emphasize that there are a large number of different lathes and milling machines, etc. A broader classification would be to distinguish between metal-cutting and metal-forming machine tools. The former type accounted for 78 per cent of the stock of machine tools in the US in 1983 (American Machinist 1983).

Table 1. Stock of metalcutting machine tools in Japanese, US and UK engineering industries

	Japan (1981)		US (1983)		UK (1976)	
	Units	% of stock	Units	% of stock	Units	% of stock
Lathes	139,953	22.2	332,327	19.5	198,83[illegible]	27.0
Drilling machines	118,811	18.2	281,453	16.5	161,99[illegible]	22.0
Grinding machines	99,936	15.9	383,027	22.5	125,5[illegible]	17.0
Milling and planing machines	69,576	11.1	218,479	12.8	87,23[illegible]	11.8
Special machines	68,649	10.9	n.a.	n.a.	n.a	n.a.
NC machines (all kinds)	22,397	3.6	92,772	5.4	9,725	1.3
Others	109,366	17.4	394,775	23.2	153,471	20.8
Total	628,688	100.0	1,702,833	99.9	736,789	99.9

Source: Jacobsson 1984c.

The machine-tool industry is small in national terms. According to Jones (1983:1) it accounts for between one and three per cent of manufacturing employment in the developed countries, generally speaking. Historically, the machine-tool industry has been an important transmission mechanism whereby the latest machining technology - so important in societies based on metals - has been diffused throughout the economies. As MTTA (1983:2) puts it: "No modern product exists without machine tools, if not directly involved then certainly only one remove away". (In passing, we can note that electronics today has a similar function.)

Perhaps the most notable feature of the machine-tool industry is that the producers are usually relatively small. For example, in the UK about 80 per cent of the employees in the machine tool industry work in firms with less than 500 employees, and 28.8 per cent work in establishments with less than 100 employees (MTTA 1983a:22). In the US in 1977, there were 1,343 establishments in the machine-tool industry out of which only 9 had more than 1,000 employees. Altogether, these 9 firms had 16,600 out of a total of 83,100 employees, or only 1/5 of the total work force. Thus, the industry is very atomistic and furthermore, the average unit is very small. An illustrative example is a Japanese firm which is one of the world's leading producers of computer-controlled machine tools. The firm has 1,700 employees.

The case of Sweden can provide another illustrative example of the industry's smallness and atomistic structure as compared to other branches. In 1982, total production of the Swedish machine-tool industry was valued at US $180 million (American Machinist 1983:77). The number of firms in the industry amounted (in 1980) to 35 and employed 4,000 people. The average number of employees per firm was 115. In contrast, Ericsson, a major transnational firm in the telecommunication areas, had nearly 30,000 employees in Sweden and 38,000 abroad (in 1982). The volume of sales for the whole company was 3,115 million US dollars (Ericsson 1982). Thus, one firm in a branch dominated by MNCs is approximately 17 times as large as the whole industry producing machine tools in Sweden. Similarly, if the entire US machine-tool industry were combined in one firm, its sales would rank only 104th on the 1982 'Fortune 500' of America's largest manufacturing companies (NMTBA 1983/84:60).

1.2 Production and trade in machine tools

As can be seen in Table 2, which lists the 35 largest producers of machine tools in the world in 1983, Japan, the Soviet Union, West Germany, the United States and Italy were the five largest producers of machine tools in

Table 2. Estimated world machine tool production in 1983
(in millions of US dollars)

Country	Production
Japan	3,518.4
Soviet Union	3,019.8
West Germany	2,965.6
United States	1,870.0
Italy	975.7
East Germany	c835.2
Switzerland	734.0
United Kingdom	576.7
France	500.5
Romania	c487.7
People's Republic of China	c472.6
Czechoslovakia	382.3
Bulgaria	240.5
Canada	231.3
Republic of Korea	210.0
Yugoslavia	208.5
Taiwan, Province of China	193.6
Spain	184.8
India	174.7
Sweden	161.8
Austria	142.5
Hungary	131.0
Brazil	123.8
Poland	c120.8
Belgium	90.9
Israel	70.0
Australia	50.5
Denmark	48.7
Singapore	c36.7
Netherlands	32.6
Argentina	c31.8
Mexico	c21.0
South Africa	14.4
Portugal	c14.0
Hong Kong	c5.3
Total	18,877.8

Source: American Machinist 1984:77.

c = Rough estimate from fragmetary data.

the world. Among the developing countries, the People's Republic of China was the largest producer and ranked number 11 in the world. The Republic of Korea ranked as number 15, Taiwan, Province of China, as number 17, India as number 19 and Brazil as number 23. Several other developing countries including Argentina can also be found on this list. Although there are a number of problems associated with the valuation of output in economies which operate behind high tariff walls or where trade is restricted for other reasons, it is clear that the developing countries have progressed well in this industry.

In fact, the developing countries accounted for 6.7 per cent of the total production of machine tools of the 35 countries listed in Table 2, whereas in 1972 the developing countries listed in a similar table accounted for only 2.6 per cent of the world output (UNIDO 1975).

The industry is characterized by a fair amount of international trade. In 1982, about 40 per cent of the production of the 35 countries listed in Table 2 was exported. The export and import ratios differ of course between countries. Smaller countries generally have both higher export and import ratios than larger countries. For example, Sweden had an export ratio of 77 per cent, and an import ratio of 79 per cent in 1982 (American Machinist 1984:77). Similar figures apply to other small countries such as Austria, Hungary, Switzerland and Canada, whilst larger countries such as Japan, the US and the Soviet Union are less reliant on trade (Table 3). Although exact figures are not available, it would seem as if the trade dependency of the industry has increased in the past decades. For the developing countries, the main characteristic is that their export ratio is very low, with the exception of Taiwan, Province of China. The import ratio is also lower than for other smaller countries.

The industry is on the whole, however, fairly internationalized as far as trade is concerned. It is less so as far as direct foreign investment is concerned. Historically, there has been very little foreign investment. Some US firms have made investments in Europe, although Jones (1983) notes that several of these are now being withdrawn. Direct foreign investment in the developing countries is also very rare, the exceptions being some German firms in Brazil and the odd US firm in Asia. More recently, however, Japanese firms have started to make investments in the USA and in Europe as a means of overcoming potential trade restrictions.

Table 3. Trade in machine tools of some nations

(percentage)

Country	Export/Production	Import/Investment[a/]
Sweden	77	79
Austria	76	82
Switzerland	88	61
Canada	58	70
Japan	34	8
USA	15	27
Soviet Union	8	30
People's Republic of China	5	23
Republic of Korea	39	50
Taiwan, Province of China	67	57
India	11	35
Brazil	12	36

Source: Elaboration on American Machinist 1984:77.

a/ Production minus export plus import.

2. RECENT TRENDS IN THE INTERNATIONAL MACHINE-TOOL INDUSTRY

Today the industry is going through some important changes in terms of (a) the products it is producing, (b) its trade characteristics and (c) the barriers to entry into the industry.

2.1 The products it is producing

The most important technological development in the industry in the past decade has been the accelerating diffusion of computer numerically controlled machine tools (NCMTs). These machine tools are today becoming standard machine tools for a range of metal-cutting functions such as turning, milling, drilling and boring. Let us briefly describe the technology of NCMTs.

A number of different tasks can be identified in the operation of a machine tool:

(a) the workpiece is transported to the machine;
(b) the workpiece is fed into the machine and fastened;
(c) the right tool is selected and inserted into the machine;
(d) the machine is set, e.g. operation speed;
(e) the movement of the tool is controlled;
(f) the tool is changed;
(g) the workpiece is taken out of the machine;
(h) the workpiece is transported to another machine tool or to a warehouse or to assembly; and
(i) the whole process is overlooked in the case of tool breakages, etc.

In the 1950's, the first numerically controlled machine tool was developed. Instead of having a worker perform tasks (d) and (e), the information needed to produce a particular part was put on a medium, e.g. a tape, and fed into a numerical control unit. By simply changing the tape the NCMT could quickly be switched from the production of one part to the production of another. Flexibility and automation were combined. Because of the high costs of the NCMTs and the unreliability of the numerical control unit, the technology was not diffused widely until the early 1970s when the numerical control unit began to be based on mini-computers. A still more significant change in the technology was the introduction of micro-computers as the basis for the

numerical control unit, a process which began about 1975. The use of microelectronics was associated with an increase in reliability, a simplification in programming and the automation of other tasks, in addition to (a) and (e). Tool changing is normally automatic today (tasks (c) and (f)), and automatic material-handling equipment is supplied by the leading firms in the industry, automating tasks (b) and (g). Finally the essential task of overlooking the production process (task i) has begun to be automated through automatic diagnostics, etc.

In Table 4 we can see how the share of NCMTs has increased in the total investment in machine tools in some OECD countries. The extreme case is lathes where, in some countries, the share of NC lathes in total investment in lathes

Table 4. Share of NCMTs in total investment in machine tools in Sweden, UK, Japan and USA, 1978-1982

(percentage)

Year	Sweden[a/]	UK[a/]	Japan[a/]	USA
1978	26.0	19.0	15.6	n.a.
1979	31.1	22.5	27.2	n.a.
1980	28.6	30.9	28.3	27.8
1981	30.6	44.9	29.3	30.2
1982	31.4	40.8	38.8	n.a.

Source: Edquist and Jacobsson, 1984.

a/ Investment in metal-forming NCMTs are not included due to non-availability of data.

is close to 80 per cent (Table 5). In Table 6 we can see how the share of NCMTs in the total output of milling, drilling, boring machines, lathes and machining centres changed between 1976 and 1982. Thus, there is a strong substitution of NCMTs for conventional machine tools. This substitution process has been associated with a decline in the demand for some coventional machine tools, i.e. non-computer, numerically controlled machine tools. The decline is not only in relative terms but also in absolute terms. This effect can be illustrated by the examples of two of the most common machine tools, namely lathes and milling machines. For example in Japan the market for conventional lathes declined, in nominal terms, from Y 80 billion in 1974 to Y 44 billion in 1982. In contrast, in the same period, the market for CNC

Table 5. Investment in CNC lathes as percentage of all investment in lathes in a number of OECD countries

Year	France	FRG	Italy	Japan	Sweden	UK	US
1974	n.a.	n.a.	n.a.	22	34	n.a.	n.a.
1975	n.a.	17	n.a.	23	43	n.a.	n.a.
1976	26	n.a.	15	28	42	19	n.a.
1977	47	n.a.	n.a.	43	53	21	n.a.
1978	n.a.	n.a.	n.a.	41	70	31	n.a.
1979	n.a.	n.a.	n.a.	52	70	38	n.a.
1980	52	47	50	49	69	47	57
1981	n.a.	n.a.	n.a.	45	78	73	n.a.
1982	n.a.	n.a.	n.a.	58	77	79	60

Source: Jacobsson 1984d.

Table 6. Share of NCMTs in total output of milling, drilling and boring machines, lathes and machining centres in a number of OECD countries[a/], 1976 and 1982

	1976		1982	
	Millions of US dollars	Per cent	Millions of US dollars	Per cent
NCMT	1,145	36	3,658	66
Conventional	2,005	64	1,846	34
Total	3,150	100	5,504	100

Source: Edquist and Jacobsson 1984.

a/ USA, Japan, UK, France and Italy.

lathes grew from 25 billion yen to 65 billion yen (Jacobsson 1984a:3). In Table 7, we can see how demand for engine lathes, the most simple type of lathe which is also the most traditional lathe, declined in Japan between 1973 and 1980. It is noteworthy that the lathe, and in particular the engine lathe, is the most important single machine tool produced in most, if not all, NICs. In the Republic of Korea in 1982, 47 per cent (in value terms) of the metal-cutting machine tools produced were lathes, whilst 74 per cent of exports were lathes. In 1981 in Taiwan, Province of China, 38 per cent of the value of exports of machine tools consisted of lathes (Jacobsson 1984b). Similarly, as can be seen in Table 8, in the case of the UK, the demand for conventional milling machines declined in favour of NC milling machines and machining centres.

Table 7. Annual investment[a/] in various types of lathes in Japan, 1973-1980

(in millions of 1975 yen and percentage)

Year	NC		Automatic		Engine		Other lathes		Total value
	Value	Per cent	Value	Per cent	Value	Per cent	Value	Per cent	
1973	26,097	22.7	38,583	33.6	36,081	31.4	13,978	12.3	114,738
1974	25,324	24.1	35,251	33.5	28,153	26.8	16,314	15.6	105,042
1975	13,004	23.2	14,623	26.1	21,134	37.7	7,255	12.4	56,016
1976	14,455	29.3	19,494	39.6	10,991	22.3	4,247	8.7	49,187
1977	22,085	42.9	18,533	36.0	7,785	15.1	3,048	6.0	51,451
1978	21,132	41.9	17,250	34.2	8,887	17.6	3,150	6.3	50,419
1979	38,239	51.8	20,711	28.0	12,810	17.3	2,068	2.9	73,828
1980	50,227	48.5	30,959	29.9	15,804	15.3	6,522	6.3	103,512

Source: Jacobsson 1984c.

a/ Investment refers to apparent consumption, i.e. production minus exports plus imports.

Table 8. Investment in machining centres, NC milling machines and conventional milling machines in the UK, 1978 and 1982

(in thousands of pounds and percentage) a/

	Machining centres		NC-Milling machines		Conventional milling machines	
1978	13,151	(23.2)	26,024	(10.6)	37,493	(66.2)
1982	31,075	(49.6)	11,148	(17.8)	20,421	(32.6)

Source: Jacobsson 1984c.

a/ Percentage of investment in all machine tools performing a milling function, given in parentheses.

There is also a substantial diffusion of NCMTs in the NICs. In Table 9 we have listed available information on the stock of NCMTs in five NICs. In terms of actual numbers, among the NICs, the Republic of Korea is the greatest user of NCMTs. In terms of the share of NCMTs in the annual investment in machine tools, the NICs appear to be behind the OECD countries. In the Republic of Korea, for example, this percentage was around 10 in 1982 and in 1983, whilst the share in the OECD countries is in the order of 30-40 per cent. There is still, however, a significant diffusion of NCMTs in the NICs, and there is nothing which says that NCMTs will not continue to be diffused at a greater pace in the future.

Table 9. Approximate stock of NCMTs in Argentina, Brazil, India the Republic of Korea and Taiwan, Province of China

(units 1983)

Argentina	350
Brazil	1,000 a/
India	378
Republic of Korea	1,340
Taiwan, Province of China	374 b/

Source: Argentina: Chudnovsky 1984; Brazil: Rattner 1984; India and the Republic of Korea: Edquist and Jacobsson 1984; Taiwan, Province of China: ITRI.

a/ Imports 1972-1982 plus local production until August 1983.

b/ Apparent consumption of NC lathe and machining centres, 1977-1981.

2.2 Trends in trade

Two main trends can be observed as regards the geographical origin of trade in machine tools. Firstly, the Japanese share in world export of machine tools increased from 4.5 per cent in 1972 to 14 per cent in 1982. The German share declined from 32.2 per cent to 24.2 per cent, the US's from 8.2 per cent to 6.3 per cent, and the UK's from 6.2 per cent to 5.2 per cent. Hence, there was a clear shift of exports from Western Europe and the US to Japan. The rise in Japanese exports was chiefly due to their success with NCMTs. Secondly, the developing countries increased their share of world exports from 0.47 per cent in 1972 to 3.2 per cent in 1982. These countries had jointly 3 per cent of the US market for machine tools in 1980, although for the simpler lathes, engine lathes, they had reached a market share of 18 per cent (UNCTAD 1982). In 1982, US imports from Taiwan, Province of China, alone amounted to US $91 million which represented 2.1 per cent of the US market that year (NMTBA 1983/84). An analysis of the cases of the Republic of Korea and Taiwan, Province of China, is provided in chapter 4.

2.3 The barriers to entry

Although the size of the firms in the machine-tool industry is still small, for the industry-segment NCMTs there has been a trend towards larger firms in the past eight to nine years. The concentration ratio for, for example, NC lathes is fairly high; the largest five Japanese firms, which dominate the world industry, accounted for 76 per cent of the Japanese value of production in 1981. The situation is similar in Europe and the USA. Furthermore, a number of the firms have begun to diversify into the production of other NCMTs than those they originally produced. In particular, many producers of NC lathes are diversifying into the production of machining centres. These two NCMTs constitute the bulk of the output of NCMTs. Finally, a number of these firms have integrated backwards into the production of computers to steer their machine tools, that is, to the CNC unit. Thus, in the segment of NCMTs there is a trend towards larger-sized firms which master not only the more conventional mechanical technologies but also electronics technology.

We noted before that a recent trend in the industry is direct foreign investment by Japanese firms in Europe and the USA. This trend is accompanied by a large number of licence agreements between firms in Japan and in USA/Europe. Again, the main factor behind these developments is the threat of trade restrictions that face the successful Japanese firms. A consequence of these collaborations may, however, be that the structure of the industry will change towards an oligopolistic one. As one Japanese observer notes (Metalworking, Engineering and Marketing 1983:36):

> "Where will the new trend lead? The larger machine-tool builders of Japan, the United States and Europe will become allied, co-operating in technology, production capacity, marketing or capital. There will emerge some groups that can quicken oligopolistic competition... .... the technology, production capacity and capital that are required ... will exceed those of today's 'middle-class' machine-tool builders."

The barriers to entry for producing NCMTs are thus higher than for producing conventional machine tools, and furthermore, these barriers are increasing. Let us look a bit closer at three of the more important barriers to entry; the size of the firms and skill requirements. We will also briefly discuss the issue of integration backwards to the production of CNC units.

(i) The size of firms

As there are important economies of scale to be reaped in the production of both NC lathes and machining centres, the size of the leading firms in the global industry is of interest. In Table 10, we have indicated the size, in terms of units of output of NC lathes, of (a) the largest firm and (b) the average of the following 4 firms in Japan, Europe and USA.

In Table 11 we have indicated the same for machining centres but only for Japan. Two things can be noted: (i) the size of the leading firms have increased dramatically in the past ten years; and (ii) the Japanese firms are the largest ones in the world. This applies also in the case of machining centres although it is not shown in the Table. This can be derived from comparing firm-level output in Japan with the national output in some other OECD countries. Thus, whereas the leading five firms in Japan produced 3,600 units in 1982, the total production of machining centres in the UK was 629 units in 1981; in France 123 units in 1982; in Italy 455 units in 1982, and in the US it was 1,265 in 1982 (NMTBA 1983/84).

Table 10. Production of NC lathes in units by the leading firms in Europe, USA and Japan, 1975-1982 (selected years)

	Production of the top firm			Average of production of the following four firms		
	1975	1978	1981-82	1975	1978	1982
Europe	n.a.	250	1,000	n.a.	210	590
USA	n.a.	n.a.	520[a/]	n.a.	n.a.	n.a.[b/]
Japan	270	1,000	2,500	105	525	1,400

Source: Europe and Japan: Jacobsson 1984d:187 for 1975 and 1978. For 1982 firm interviews and data received from the Japan Machine Tool Builders' Association.

a/ 1980.

b/ Total production of NC lathes in the USA in units amounted to 2,739 in 1980, 2,021 in 1981 and 1,489 in 1982 (MTBA 83/84:100). As the leading firm produces about 500 units, the next four firms must produce substantially less per firm.

Table 11. Production of machining centres in units by the leading firms in Japan, 1975, 1978 and 1982

Production of machining centres	1975	1978	1982
The top firm	44	165	900
The average of the following four firms	39	76	675

Source: 1975 and 1978: Elaboration on Metalworking, Engineering and Marketing 1980:26. 1982: Elaboration on estimates from industry sources.

As a further indication of the size of the Japanese firms we can note that the total market for machining centres in the Republic of Korea is approximately 100 units per year and in Argentina the total stock is less than 100 (Chudnovsky 1984). Furthermore, whilst the average output of the 5 leading firms producing NC lathes in Japan was US $110 million in 1981, the whole Argentinian machine-tool production only amounted to a value of US $35 million.

(ii) Skill requirements

Parallel with the development of large-scale production of NCMTs, there has occurred a strengthening of the technological capabilities of the leading firms. Today, the larger Japanese firms employ between 150 and 250 design engineers. The leading European firms have between 50 and 115 design engineers. A large proportion of these are electronic engineers, between 30 and 50 per cent in the leading firms. NC lathes and machining centres are not designed anymore by an inventive mechanical engineer, but by a team with a multidisciplinary background. We can contrast the situation with the skill requirements necessary to compete in conventional machine tools. One Taiwanese firm, which is very successful in exporting engine lathes to the USA has only five design engineers, and an Argentinian firm became the technological leader in Argentina having less than 10 design engineers employed. Hence, firms attempting to compete in the market for NCMTs need a far greater number of design engineers than are required to compete in the market for conventional machine tools.

(iii) Backward integration[1/]

An issue related to skill requirements is the need, as perceived by some observers, to integrate backward into the production of the CNC unit (Antonelli 1983, Perspective Plan Committee 1983).

It has been mentioned that a considerable number of firms are integrating backwards into the production of CNC units. Forward integration from electronic firms is, however, less common. It is necessary, however, to be

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1/ This section is based on my Chapter (5) pp.221-222 in Chudnovsky et al. 1983.

cautious in interpreting what this integration means to producers of NCMTs in the developing countries.

The main reason for integrating backwards appears to be the benefits from the flow of knowledge between electronic designers and NCMT designers. However, this flow of knowledge is only of importance if the firm is pursuing a strategy which involves extending the technological frontier or which includes important elements of custom design. Extending the technological frontier mainly refers to adding different types of material-handling equipment to the NCMT so as to achieve unmanned production. The speed of the integration between, say, the CNC lathe and, say, the robot, should, however, not be exaggerated. The development is a very recent phenomenon and leading Japanese firms in this field stated in January 1983 that only about 10 per cent of their CNC lathes, produced now, are equipped with robots.1/

For a firm producing a standard NCMT and which intends to remain an imitator, there do not appear to be any disadvantages, from the point of view of the innovative process, in buying within the CNC unit from another firm. It is just another component. Clearly, this was not the case when the low-cost CNC unit had just been introduced in the mid-1970s, but the importance of the design links between the NCMT builders and the CNC suppliers has altered over time, as the sources of supply have multiplied. Hence, the role of the flow of knowledge between the CNC-unit producer and the NCMT builder has changed over time and varies according to the strategy pursued by the lathe builder.

For the NIC countries, there may be other reasons for establishing local production. It is being attempted in both the Republic of Korea and Taiwan, Province of China. The Republic of Korea has permitted Fanuc, which is the leading firm in the world, to establish a production unit there, which will probably result in a slight reduction in the cost of the CNC units due to lower local assembly costs. Taiwan, Province of China has a large government-sponsored programme for an exclusively locally made CNC unit. As

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1/ These robots are not proper industrial robots in the sense that they are dedicated to serving one particular machine tool only and cannot be transferred to other application areas.

there are important economies of scale involved in producing CNC units, mainly due to (fixed) software-development costs, the economic rationality for producing the CNC unit assumes that a substantial local production of NCMTs is envisaged. One Taiwanese source (Far East Trade Service Inc. 1982) suggests that local production of CNC lathes alone will amount to 1,000 units in 1986. Even though this is questionable, a scale of output of CNC units in the order of 500 units per annum would appear to be necessary to achieve a competitive cost. The present level of output of NCMTs in Taiwan, Province of China, is less than 200 units.

Likewise, local production of the CNC unit may be economically rational if the CNC-lathe producer includes a large element of custom design in its products. From limited evidence this would seem to be the case of a large Brazilian machine-tool producer who recently entered into a licensing agreement for the production of a kind of unit which can be used to control custom-designed CNC lathes.

Having discussed three of the main barriers to entry in a very broad way, let us look in more detail at the case of CNC lathes to find out how the size and nature of the barriers to entry vary depending on which firm strategy is chosen.

3. THE CASE OF CNC LATHES[1/]

The international industry producing CNC lathes operates in a market form characterized by monopolistic competition. This is also the case for machining centres. As Chamberlain (1960) noted, firms operating within such a market form neither sell identical products nor are homogeneous in their resources. The heterogeneity of CNC lathes is based on the fact that there exists a number of submarkets for CNC lathes. These submarkets differ in their demand in terms of the performance, size, and degree of standardization of the CNC lathes.

The customer can be anything from a large automobile firm which requires a very high performance and custom-designed CNC lathe served by a material-handling robot to a small workshop demanding a low-performance, standard CNC lathe. Satisfying the needs of different submarkets or niches requires various types of capabilities and organization among the CNC-lathe producers. Indeed, when products are differentiated, the sellers within an industry may vary systematically so that the industry contains groups of firms with different structural characteristics (Chamberlain 1960:81). Hence, firms behave differently from their competitors, as a way of surviving.

Caves and Porter (1977) take up this point in a paper which extends Bain's (1956) analysis of barriers to entry. The authors establish that "the conventional view implies that barriers to entry into the industry protect all incumbent firms as a group - a logical consequence of assuming that they are homogeneous" (Caves and Porter 1977:250). Instead, barriers to entry are moreover specific to the group rather than protecting all firms within an industry. The authors also make the important point that '... barriers to mobility between groups rest on the same structural features as barriers to entry into any group from outside the industry' (Caves and Porter 1977:250).

Two implications follow from this analysis. Firstly "each of the standard sources of entry barriers can vary with the characteristics that define industry groups. Entry can be easy into one group in an industry,

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1/ This section is based on Jacobsson 1984a.

blocked into another" (Caves and Porter 1977:254). Secondly, entry from outside of the industry is no longer a yes-no choice. Rather, the entry must be targeted to a particular group and "... each of the industry's groups faces its own queue of potential entrants because of the group-specific character of entry barriers and the differing initial resources of potential entrant firms" (Caves and Porter 1977:255).

One may identify three of these industrial, or strategic, groups among the CNC-lathe producers in the OECD countries. These groups all differ with respect to the choices the firms have made with six decision variables: product characteristics; target group or market niche; price level; marketing organization; R and D orientation; and production volume. The three strategies pursued by firms based in the OECD are: (1) the overall cost leadership strategy; (2) the focus strategy; and (3) the differentiation strategy (Porter 1980).

The nature of competition as well as the protecting barriers to entry are different for each strategic group. These characteristics are summarized in Table 12.

(1) The 'overall cost leadership' strategy began to be applied by a number of Japanese firms in the second half of the 1970s. Induced by the developments in microelectronics, these firms designed smaller, cheaper and lower-performance CNC lathes than those which hitherto had been produced by their OECD counterparts. Whilst these, very broadly speaking, took the production problems of larger firms as the point of departure in their design efforts, it was rather the requirements of the medium and smaller firms which guided the efforts of the Japanese firms.

Thus, these Japanese firms deliberately tried to open and succeeded in opening up the market of very price-sensitive small and medium firms, a market which until then had been largely unaffected by CNC lathes. As the lathes are standardized, the marketing can be done through a local dealer, and the R and D is oriented towards simplification and ease of using the technology. As there are large economies of scale to be reaped in the production and marketing of CNC lathes, firms pursuing this strategy require large volumes of output.

Table 12. Summary of the main characteristics of three strategies pursued by OECD-based CNC-lathe producers

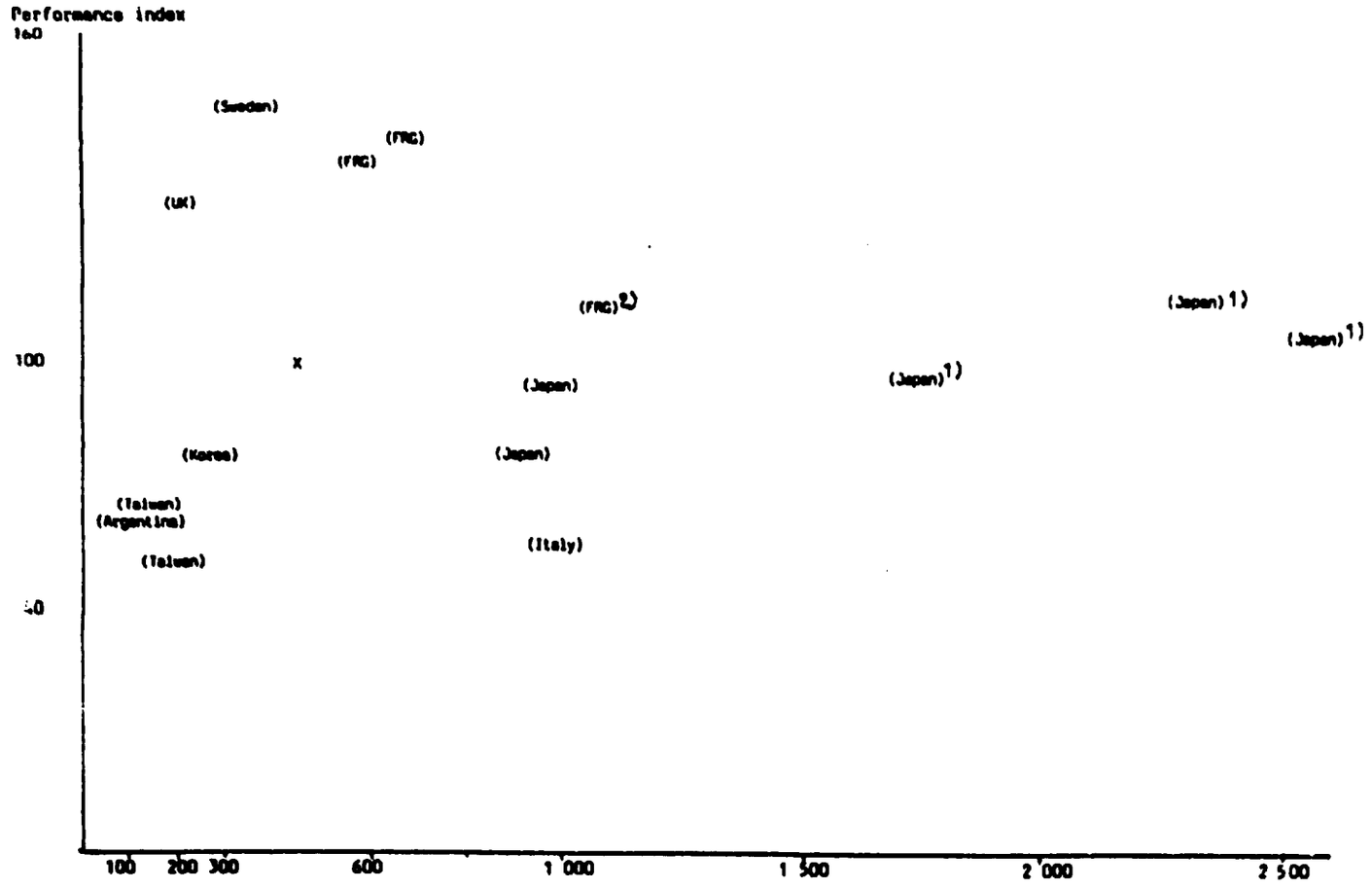
Characteristics	Overall cost leadership	Focus	Differentiation
Product			
Degree of standardization	standard	largely standard	important elements of custom design
Performance	low-medium	medium-high	high
Price	low	medium-high	high
Target groups	highly price-elastic, small-medium sized firms	medium-price, elastic small-large firms	leading edge firms
Marketing	through independent dealers	through independent dealers or direct with the customers	direct with the the customer
R and D	low-cost, easy to use product. Occasional CNC development	high performance coupled with standardization and modular design. Some special designs (software and hardware) developed. Sometimes CNC development	complex, system development sometimes including CNC development. Some special application areas developed
Volume	high	medium	low

Source: Jacobsson 1984a.

In Figure 1, we have drawn a strategic map over the industry where on the horizontal axis we have indicated the volume of output of the main Japanese and European producers in 1981. The firms pursuing the overall cost leadership strategy are found to produce between 900 and 2,500 units. On the vertical axis we have indicated the performance of the CNC lathes, as measured by their motor power.

(2) Whilst the firms pursuing this strategy sell CNC lathes with a low-medium performance, the firms pursuing the focus strategy produce high-performance CNC lathes. These lathes have a high cutting capability and very high precision and rigidity. The market is everything from small or large firms with a medium price elasticity of demand. The distribution is done both through a local dealer and directly with the buyer. Whilst these

Figure 1. A strategic map on the CNC-lathe industry



Source: Firm data.

1) These three firms show the highest profits ratios in the industry.

2) This firm contains three separate divisions out of which two follow differentiation and focus strategy. One division produces very simple CNC lathes. The performance index is an average of the firms models.

firms focus on the requirements of a particular segment, they are by no means isolated from price competition from the firms pursuing the overall cost leadership strategy. The price competition means that firms pursuing the focus strategy have had to standardize their products, but the frequent demand for custom design elements has meant that their R and D is often directed towards including elements of custom design, primarily in the form of modular elements. These firms have also had to increase their volume of output so as to gain from economies of scale. For example, two German firms (see Figure 1) had an output of between 500 and 600 units.

(3) A slightly different strategy is to continue to emphasize product development as the competitive strength of the firm. In the case of CNC lathes, firms pursuing this "differentiation" strategy often go for the development of flexible automation i.e. system development linking robots and/or other material-handling equipment to the CNC lathe(s). These systems contain large elements of custom design and the target group is large, leading edge firms, e.g. automobile firms. Sales are direct, as the communication between the buyer and the producer can be a key factor in the innovative process. Production volumes can be small, as the market is less price-sensitive. One Swedish and one U.K. firm which more or less follow this strategy produce 250 and 150 CNC lathes per annum, respectively. These firms can be found in Figure 1 in the north-west corner.

The entry into each of these groups involves overcoming different barriers to entry. The main ones are summarized in Table 13. For a firm, say, a medium-sized machine-tool producer from a developing country, desiring to enter the group following the overall cost leadership strategy, the main barriers to entry lie in achieving economies of scale and having access to a large marketing network. The main barriers for the focus strategy are in the form of design skills, including electronic design skills, as these firms often integrate backwards into the production of the numerical control unit. A good reputation for quality is also of particular importance to these firms. For firms desiring to pursue the differentiation strategy the main barriers lie in having a marketing network with direct links to a set of very advanced user firms, a brand image and design skills, again frequently in electronics.

Table 13. Ranking of the barriers to entry to the three different strategies pursued by OECD-based firms producing CNC lathes

Barriers to entry	Overall cost leadership	Focus	Differentiation
Economies of scale	1	3	
Access to large marketing network	2		
Design skills including electronic design skills	3	1	3
Direct links with trading edge firms			1
Brand image	4	2	2

Source: Jacobsson 1984a.

The overall cost leadership strategy is the dominant strategy. With the application of this strategy, mainly by some Japanese firms in the second half of the 1970s, the nature of competition changed in the industry. In particular, price competition became a much more important tool in competition than what had hitherto been the case. The pursuers of this strategy also dominate the industry quantitatively. This is illustrated in Table 14 which shows the share of the Japanese industry in world output. Similar changes have taken place in the industry of machining centres where the dominance of the Japanese industry is again reflected (Table 15).

Table 14. Production of CNC[a/] lathes in Japan, Europe[b/] and USA

(in units, millions of US dollars, and percentage share of total Japanese, European and US production)

	Japan				Europe[b/]				USA			
	Units	%	Value	%	Units	%	Value	%	Units	%	Value	%
1975	1,359	30.0	66.0	14.8	1,535	33.8	166.2[c/]	37.3	1,640	36.2	212.7	47.8
1976	2,073	41.0	88.7	17.8	1,656	32.8	203.2	40.8	1,321	26.1	205.9	41.3
1977	3,900	52.6	159.0	25.4	2,332	31.5	271.5	43.3	1,178	15.9	195.3	31.2
1978	4,986	49.8	274.9	29.3	3,551	35.5	425.8	45.3	1,464	14.6	237.2	25.2
1979	8,065	57.9	448.5	34.2	3,505	25.2	514.4	39.2	2,354	16.9	347.2	26.5
1980	12,036	60.4	673.0	35.3	5,137[d/]	25.8	751.7	39.4	2,751	13.8	481.0	25.2
1981	12,133	62.2	730.0	44.5	4,904	25.1	468.0	28.6	2,021	10.4	441.0	26.9

Source: Jacobsson 1984a.

a/ Some of the production can be NC lathes, i.e. non-computer based, numerically controlled. This applies particularly to the earlier years.

b/ UK, France, Italy, Federal Republic of Germany and Sweden.

c/ Excluding Italy.

d/ Estimated production of 300 units for Sweden.

Table 15. Production of machining centres in six leading OECD countries, 1982

(in units and millions of US dollars)

	Units	Value
Japan	6,936	649
USA	1,265	340
UK	629	84
Italy	455	93
Federal Republic of Germany	710	137
France	123	29

Source: NMTBA 1983/84, VDW, UCIMU.

4. THE MACHINE-TOOL INDUSTRIES OF TAIWAN, PROVINCE OF CHINA, AND THE REPUBLIC OF KOREA

The origin of the Taiwanese machine-tool industry is fairly recent. After the Second World War the development of the industry was retarded by the small size of the local market as well as by the low technical level of its customers (Amsden 1977). However, towards the middle or end of the 1960s, the industry began to grow in response to both greater local capital accumulation and, especially, to growing regional demand resulting particularly from the Vietnam war. The Taiwanese machine-tool industry took advantage of the demand for low-quality and low-performance machine tools by very price-sensitive customers.

The industry became export-oriented at an early stage, and by 1968 it achieved a 50 per cent export share. Initially, the exports were mainly for the regional market, but in the mid-1970s the main market for the Taiwanese machine-tool industry became the USA. In 1981, over 77 per cent of exports went to developed countries. Indeed, Taiwan, Province of China, is the fourth-largest exporter of machine tools to the US. By 1977 Taiwan, Province of China, became a net exporter of machine tools, the first newly industrializing country (NIC) to reach this position. The export orientation (in 1981 Taiwan, Province of China, exported 73 per cent of production) was conducive to a very rapid growth in the production of machine tools. The value of production rose from US $22 million in 1973 to US $242 million in 1981. Although the export market shifted to the developed countries, the strategy of focusing on the more sensitive segments of the market continued.

By all standards the Taiwanese machine-tool industry has been very successful. The perhaps surprising conclusion reached when studying the role of government policy is that there has been very little direct governmental influence on the industry. The nominal tariff rate has been very low, around 10 per cent, and the effective tariff has been about the same. Some subtle import controls on machine tools exist, but they are almost certainly less stringent than the Republic of Korea's. On the whole, quality and competitiveness of the machine-tool industry of Taiwan, Province of China, have increased gradually and 'autonomously' from an initial choice of product/market mix with low barriers to entry. The influence of government policy on this process has probably been greater than its direct influence.

Of particular importance to the export success has been the stability in the real exchange rate, ensuring stable relative prices of foreign and domestically made goods. This stability has, of course, had the effect of reducing the risks involved in investing in a marketing network abroad, and has allowed the entrepreneurs to base their strategies on expansion in foreign markets. Finally, growth in the domestic demand for machine tools has been constant, in contrast with many other economies where demand has fluctuated greatly.

As in the case of Taiwan, Province of China, the machine tool industry of the Republic of Korea originated in the period after the Second World War. The industry remained very small, however, until the mid-1970s. In terms of value of production it was only marginally smaller than the one of Taiwan, Province of China, but the GNP of the Republic of Korea is far larger than the one of Taiwan, Province of China. Furthermore, the export ratio was very low (only 12 per cent in 1974). In the second half of the 1970s the machine-tool industry of the Republic of Korea went through a period of explosive growth. Production rose from US $13 million in 1973 to US $178 million in 1981 (Table 16). Exports failed, however, to rise to a level comparable with Taiwan, Province of China; only 18 per cent was exported in 1981. The fast growth in the production of machine tools was instead based on a very rapidly growing home market. By 1979, the Republic of Korea had become the tenth-largest investor in machine tools in the world. The expansion of machine-tool production in the Republic of Korea has a large element of import substitution; the import share of machine-tool investment declined from 73 per cent in 1974 to 39 per cent in 1981. In contrast, the import share of Taiwan,

Table 16. Production of machine tools in the Republic of Korea and Taiwan, Province of China, 1971-81, selected years

(in millions of US dollars)

	Republic of Korea	Taiwan, Province of China
1971	5.2	12.8
1973	12.6	22.0
1977	73.7	67.8
1979	163.7	189.1
1981	178.0	242.3

Source: Jacobsson 1984b.

Province of China, is around 60 per cent - a difference related to the fact that in Taiwan, Province of China, it is a government agency which decides whether to allow imports or not, while in the Republic of Korea it is the machine-tool makers' association itself that has the power to decide. Unlike Taiwan, Province of China, the Republic of Korea is still, however, a net importer of machine tools. In 1981 the trade deficit amounted to around $100 million, a figure which can be compared to the total investment in machine tools in the same year of $331.3 million.

Apart from having promoted rapid growth in domestic demand, which indeed was a function of the major effort to build up a machinery industry in the Republic of Korea, the Korean Government has, unlike its Taiwanese counterpart, played a major role in the development of its machine-tool industry (Bendix et al. 1978). The central features of its policies were:

- the availability of long-term loans with subsidized interest rates;
- import prohibitions on items which could be produced locally;
- financial assistance to machinery firms of the Republic of Korea who bought Korean-made machine tools.

A condition, or possibly a preference, was, however, that the firms receiving such incentives should export a certain proportion of their output. There appears to be an understanding between the state and the firms that efforts to export machine tools should be made.

The Government's interest in the machine-tool industry and its readiness to intervene were further underlined in the 1981 "Basic Plan for the Advancement of the Machinery Industry". The instruments used by the Government were again import restrictions and credit policies. The import-substitution character of the development of the machine-tool industry also clearly suggests that the Government has been influential in its policies.

4.1 Entry into the production of NCMTs in the Republic of Korea and Taiwan, Province of China

Taiwan, Province of China, and the Republic of Korea have entered into the production of both CNC lathes and machining centres (Table 17). In

Table 17. Production of CNC lathes and machining centres in the Republic of Korea and Taiwan, Province of China

(units)

Year	Taiwan, Province of China		Republic of Korea	
	CNC lathes	Machining centres	CNC lathes	Machining centres
1977	14	-	-	
1978	40	-	-	not available, but probably zero
1979	78	7	1	
1980	106	24	9	
1981	174	18	87	
1982	163	53	222	75
1983	n.a.	n.a.	233	118

Source: Jacobsson 1984b and KMTMA 1984.

comparison, the Argentinian production of NC lathes amounted to 7 units in 1982 and 10 units in the first 11 months of 1983. Machining-centre production is at the prototype level (Chudnovsky 1984). While Taiwan, Province of China, entered earlier than the Republic of Korea, the latter has now overtaken Taiwan, Province of China, in the production of both CNC lathes and machining centres. In terms of value, production of the Republic of Korea of these two types of machine tools amounted to US $16.5 million in 1982 against Taiwanese production of only US $9 million.

Even if the Republic of Korea has overtaken Taiwan, Province of China, in spite of the latter country's earlier start, in terms of the requirements set by the international nature of competition, though, all firms in both countries produced below the minimum efficient scale of production. As mentioned earlier, scale is now very important and indeed, only one out of eight firms interviewed in these countries claimed that they made a profit on the production of CNC lathes. In both countries the machine-tool industry is very atomized. In the Republic of Korea, for example, 55 firms are listed by the Korean Machine Tool Manufacturers' Association. In Taiwan, Province of China, there are 30 producers of lathes. Out of this group, four firms in the Republic of Korea and two or three firms in Taiwan, Province of China, have emerged as leaders on the basis of scale of output and "mass" of technological capabilities. These six or seven firms produce nearly all of the NCMTs in these countries. These firms all have sales of between US $10 million and

US $20 million, and have a design staff of between 25 and 60 engineers. Other firms producing conventional machine tools survive only in a much smaller form.

In Table 18 we have listed some characteristics of these six leading firms. A number of points can be made. Firstly, all of them produce both machining centres and lathes, although the emphasis is on one of these two products. The production of both these products is, as was mentioned earlier, a general trend in the industry although not all firms are affected by this trend. Secondly, the firms export a high proportion of their output, if taken together. Thirdly, in the majority of cases, own design development, including copying, is the source of technology. The high export share and the importance of own design development are of course linked in that licensing normally includes export restrictions.

CNC lathe production is the more developed activity. Let us look a little closer at the position of these firms within the international CNC lathe-industry.

Even these two relatively successful countries are still small in terms of their share of the world production of CNC lathes. Whilst in 1982, the Republic of Korea and Taiwan, Province of China, had 3.3 per cent and 6.0 per cent, respectively, of the world[1/] production of conventional lathes, their share in the world production of CNC lathes was only 0.4 per cent and 0.7 per cent.[2/]

Firms in these two countries constitute a fourth strategic group within the international CNC lathe industry. The overall strategic position of the firms in these countries can be described as a low performance strategy,[3/] i.e. one focusing on the low-performance segment of the market. In the

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1/ The "world" is defined as the seven largest OECD countries plus the Republic of Korea and Taiwan, Province of China. The seven OECD countries accounted for 85 per cent of the non-socialist world's output of machine tools in 1981. American Machinist, February 1983.

2/ The share in world output of the Republic of Korea and of Taiwan, Province of China, was measured in value.

3/ The same applies to machining-centre production in Taiwan, Province of China.

Table 18. Some characteristics of the six leading NCMT producers in the Republic of Korea and Taiwan, Province of China, 1983

Firm	Country	Production of machining centres (units)	Export of machining centres (units)	Sales of NC lathes (units)	Export of NC lathes (units)	Source of technology	
						Machining centre	NC lathe
A	Rep. of Korea	110	60	14	n.a.	Own and licence	Own
B	Rep. of Korea	30[a/]	0[b/]	4	0	Both licence and own design	Licence
C	Rep. of Korea	25[a/]	0	150	139	Licence	Own
D	Rep. of Korea	1	0	62	approx. 30	Own	Own
E	Taiwan, Prov. of China [c/]	26	approx. 20	81	approx. 60	Own[d/]	Own
F	Taiwan, Prov. of China [c/]	0	0	55	28	-	Own
Total		192	80	366	257		

Source: Firm interviews and KMTBA 1984.

a/ First eight months of 1984.

b/ Will begin exporting end of 1984.

c/ 1982.

d/ In 1982 the firm developed its own design of a machining centre.

strategic map in Figure 1, three firms from these countries have also been plotted. These can be found in the south-west corner of the map. The strategy pursued by these firms involves focusing on users which do not require a high cutting capability or high precision and which are extremely price-sensitive. Typical users can be small subcontractors, first-time users of CNC lathes, schools and some metalworking plants in the NICs. The fact that the CNC lathes are of lower performance, given their size, means that they are cheaper to build. This is achieved, e.g., by using motors with a lower horse power and less rigid castings. The strategy is also less demanding in terms of design skills because of the nature of the product as well as the fact that these firms can, and very often do, copy other firms' models. Copying also implies lower R and D costs. Given the standardized nature of the product, independent distributors can be used. Access to a distribution network is facilitated as they can use a network which sells CNC lathes of firms pursuing a different strategy. For example, in Sweden the leading Taiwanese producer of CNC lathes uses a distributor which also sells high-performance CNC lathes produced by a German firm.

A number of problems still exist, however, for firms following this strategy. In terms of the requirements set by the international market, nearly all of the firms produce below the minimum efficient scale of production. The main sources of scale economies lie in the purchasing of components and in marketing and after-sales service. These scale economies also apply to firms pursuing the low-performance strategy. Indeed, as was mentioned above, only one of the eight firms interviewed in the Republic of Korea and Taiwan, Province of China, claimed that they made a profit on their production of CNC lathes. A contributing factor to these losses are the costs associated with creating a brand name for new entrants. A brand name involves not only large expenditure on promotion but also pursuing a low price profile for a long period of time. The present position of the firms is, however, untenable in the long run on account of the existence of economies of scale. It is also very questionable if the world market for such low performance CNC lathes is large enough to absorb the output of these firms even if they were to produce volumes large enough to reach a break-even point. A move to another strategy which involves not only larger volumes of production but also producing a technically somewhat upgraded product would therefore seem to be necessary. In spite of these problems, the low performance strategy is a way

for firms to enter the industry and gain experience. It should, however, be seen only as the first step in the longer process of the consolidation of their entry.

Comparing the resources of the leading NIC firms with the resources required to pursue the three different strategies, one concludes that the eventual shift to a strategy resembling the overall cost leadership strategy would involve overcoming the lowest barriers to entry. Although the minimum efficient scale of production, using Japanese cost data, is estimated to be around 800 units per year,[1/] the lower labour costs in the NICs can reduce this figure. Indeed, the leading firm of the Republic of Korea estimates that it will break even at an annual volume of production of 330 CNC lathes. This figure is, however, somewhat below the "normal" break-even point, as this firm has access to very cheap control systems which can constitute as much as 30 per cent of the cost of the CNC lathe. Shifting strategy to something close to the overall cost leadership strategy would also imply an upgrading of the technical performance of the CNC lathes as well as producing a larger number of models. This process has already been started by the two leading Asian NIC-based firms. However, these firms will probably need to double the number of designers in the medium term in order to succeed in this shift in strategy. All in all, doubling the number of designers and reaching a sales volume of, say, 500 units per year would be less difficult than to begin producing the high performance CNC lathes of the firms pursuing the other two strategies, not to speak of acquiring the marketing network and the brand image that these firms have. Thus, the leading NIC firms would need to move northeast in Figure 1 to a point very approximately indicated by X.

The exception to the rule, as regards choice of strategy, is one firm of the Republic of Korea which has a mixed strategy. On the one hand it follows the "low-performance strategy" on the international market. On the other hand, on the local market it appears to have the ambition to develop into a local "problem solver". It has developed a four-axes CNC lathe for the leading automobile manufacturer and sold a large number of units to that firm. It has also developed a simple material-handling device for CNC

1/ See my chapter (5) in Chudnovsky et al. 1983 for a detailed discussion of the issue of scale economies.

lathes. Recently, the firm developed a machining centre which according to firm sources, is aimed at the same market as the four-axes NC lathes, namely larger firms.

4.2 Government policy

What role then does the Government have in this industry? Before describing the actual policies in the Republic of Korea and Taiwan, Province of China, let us briefly discuss the theoretical justification for state intervention.

Whilst the production of conventional machine tools involves overcoming very low barriers to entry, the successful international sale of NCMTs involves overcoming very high barriers to entry. Indeed, the step from producing e.g. no lathes at all, or from producing, say, a textile machine, to producing engine lathes is smaller than the step from producing engine lathes to CNC lathes. Although external economies may be present ("the machine tool industry being a strategic industry in the capital goods sector"), the main argument for state intervention is the non-marginal changes in the barriers to entry in the industry. In the case of CNC lathes, these changes arise either as firms start to produce CNC lathes and begin to pursue the low-performance strategy, or when they shift from this strategy to the overall cost leadership strategy. For the NIC-based firms, the question is not to advance gradually into marginally stronger positions in terms of financial and technological capabilities. Radical changes are instead required. Design personnel and sales need to be doubled at least, and the production and marketing capacities need to be strengthened accordingly. Such radical changes in strategy certainly involve a great deal of risk, and there are good reasons for assuming that one corner stone of the infant industry argument, namely that of imperfections in the capital market, applies. It would apply to firms beginning to pursue the low-performance strategy, but also to firms shifting to the overall cost leadership strategy.

Of course, it is not self-evident that the NIC Governments should use their scarce resources to foster this particular industry instead of some other industry, but, for example, the Governments of the Republic of Korea and Taiwan, Province of China, have specified NCMTs as a strategic product. In

this context it should be mentioned that, although the barriers to entry into the production of CNC lathes are far higher than those for engine lathes, they are nevertheless rather low in comparison with other high-technology industries. For example, in telecommunications, which is another industry affected by microelectronics, the leading firms employ around 2,000 design engineers (Göransson 1984), which is about 10 times more than the number of engineers in the leading Japanese firms producing NCMTs. Thus, the opportunity costs involved in creating competitive, firm-specific resources in the machine-tool production should not be exaggerated.

Both Taiwan, Province of China, and the Republic of Korea have designed specific policies for the machine-tool industry. Whilst the policy of the Republic of Korea has been in operation for some time, the Taiwanese one was initiated as late as 1982. The three main elements are trade restrictions, credit policies, and R and D policies.

(i) Trade restrictions

In February 1983, the Taiwanese Government was contemplating a rise in the tariff rate to 20 per cent for some more advanced machine tools, including NCMTs. The Government of the Republic of Korea allows import restrictions to be applied for machine tools which can be produced domestically. The noteworthy aspect of this policy is that it is the Machine Tool Manufacturers' Association which in reality decides which machine tools can be produced locally, and therefore those which can be imported. In the case of CNC lathes in the Republic of Korea, the present rule is that all CNC lathes below a certain size must be supplied from domestic sources. As the size limit is set very high, the vast majority of CNC lathes cannot be imported. It is also the case that the import share of investment in CNC lathes dropped from 85 per cent in 1981 to 31 per cent in 1982 in value terms. Similar regulations apply to machining centres.

Of course, if the domestic supplying industry can produce the same range of NCMTs as are supplied by the international industry, at a price equal to the international price, the domestic buyers of machine tools would not suffer. However, leaving price differences aside, a fundamental feature of the machine-tool industry is the high degree of product differentiation, which

extends even to such a well-defined product as CNC lathes. In the case of CNC lathes the domestic industry in the Republic of Korea produces only low-performance machinery. In the OECD countries the buyers of such machine tools are generally very price-sensitive small firms. However, in the Republic of Korea, where import restrictions apply to all CNC lathes below a certain size, all machine-tool buyers will have to settle for the low-performance CNC lathes of the Republic of Korea.

(ii) Credit policies

The other main component in government policies concerns credits. In the Republic of Korea, the state channelled large amounts of capital into the machinery industry in the second half of the 1970s. The machine-tool industry also received credits with negative real interest rates. Furthermore, some firms received subsidies because they moved to the Changwon industrial complex in the south of the Republic of Korea in 1976-78. The most dramatic case of government intervention is the build-up of the firm which is now the largest producer of CNC lathes in the Republic of Korea, and indeed in the NICs. This firm, which is part of a larger conglomerate, started from scratch in 1977 with a loan of over US $40 million. Other firms also received credits, but not on the same scale, although they amounted to millions of US dollars in several cases.

In Taiwan, Province of China, the Government implemented a Strategic Industry Programme in 1982. The Programme has approximately US $250 million at its disposal and the money is allocated to individual firms for the production of about 115 types of products. It can be used to finance up to 65 per cent of the costs of a new project, including skill formation. The explicit purpose of the fund is to absorb some of the risks associated with the initiation of new and more advanced product lines. The second-largest CNC machine-tool producer in Taiwan, Province of China, is one of the firms which receives funding from this Programme. The firm is building a new plant for the production of a large number of NCMTs using very advanced production technology. Money is also available for the other leading firms as and when they wish to use it.

Hence, in terms of credit policies, both Governments have shown a willingness to design policies which assist the leading firms in the machine-tool industry to enter or consolidate an entry into the market for NCMTs. The magnitude of the intervention is, however, different. Whilst complete data are not available, the intervention of the Republic of Korea is much greater than the Taiwanese. In part, this stems from the different needs of the industry, the machine-tool industry of the Republic of Korea being younger than the Taiwanese. In part, however, the difference reflects greater overall state involvement in the Republic of Korea than in Taiwan, Province of China, an involvement which has contributed to the industry of the Republic of Korea overtaking the Taiwanese in the CNC machine-tool field.

(iii) R and D policies

The R and D institute KAIST, which is financed by the Government of the Republic of Korea, was instrumental in helping the second-largest producer of CNC lathes in the Republic of Korea to shift over to the production of CNC lathes by helping it with the basic design development of its first model. The R and D policy could be said to have been of some significance in that particular stage of the firm's development. Similarly, KAIST had the same catalytic function in the design of a machining centre by another firm.

The MIRL, in Taiwan, Province of China, which is partly financed by the Government and has 120 mechanical engineers and 60 electronic engineers, plays a similar role to that of KAIST in the Republic of Korea, although MIRL's section for machine tools is substantially larger. As part of its many activities, MIRL has designed two CNC lathes for smaller lathe producers who are just entering into the production of CNC lathes. Furthermore, it was recently announced that MIRL had entered into collaboration with the two leading firms for the development of a robot to be used for transferring components to and from CNC lathes. Again, the role of government R and D policy, in the form of a government-financed R and D institute, had a catalytic role in changing the firms' product strategies.

5. SOME THOUGHTS ON POLICY IN ARGENTINA

It is, of course, very difficult for an "outsider" with limited knowledge of the industrial and political context in Argentina to provide policy prescriptions. Some lesson can, however, be learnt from studying other countries. The following pages should be seen as attempt to contribute to the Argentinian policy discussion. The conclusions in this chapter are therefore only tentative and will need to be revised in the light of the present local context.

Before discussing in some detail the role of explicit government policies, let us briefly mention some implicit policies or rather basic factors which need to be dealt with if the explicit policies are to be effective. These basic factors are nearly self-evident, but may be worth-while mentioning anyway. Before continuing, we assume that the goal of the industrial policy is to create an internationally competitive industry. Firstly, a sufficient supply of human capital needs to be ensured. This refers to engineers, technicians and skilled workers. Secondly, the price of raw materials, e.g. steel, needs to be set at the international level or below it. Thirdly, the real exchange rate needs to be stable to ensure that the risk to entrepreneurs of building up a marketing network and reputation abroad is minimized. Fourthly, a generally stable environment, and fifthly, an "atmosphere" of export orientation need to be created. With this we refer to all social and cultural elements which make a nation look at itself as part of the global economy rather than as an isolated unit. The economic incentives for inducing firms to export are dealt with below.

5.1 Industrial policy for the NC machine-tool industry

As was shown in earlier sections, the production of NCMTs is normally restricted to a small number of firms. The same applies to Argentina where, to our knowledge, there are only two firms producing NCMTs. One of these produces CNC lathes and the other machining centres. Again, it is not self-evident that the Argentinian economy should foster these firms. It could equally well be argued that these firms should not be subsidized and that NCMTs will be imported instead. However, assuming that a machine-tool industry is judged to be vital for the economy, the very strong substitution

by NCMTs for conventional machine tools would clearly suggest that, from a market point of view, it is of strategic importance to move into the production of CNC lathes and machining centres. The substitution effect is strongest in the international market, but applies also to the Argentinian market, as was shown in section 2.1. Given the long time it may take to achieve international competitiveness in the NCMT industry, it would be of strategic importance, from the point of view of creating an industrial capability, to move into the production of these machine tools as rapidly as possible. In the following sections, we will first discuss the case of CNC lathes and then the case of machining centres.

(i) CNC-lathe production

Let us begin this section with a historical note on the experience of Argentina and Taiwan, Province of China, in lathe production.1/

Nearly all the NIC firms which are now trying to enter into the production of CNC lathes have as their main product engine lathes. The industry producing engine lathes is characterized by very low barriers to entry. The low barriers to entry have resulted in a fragmentation of the industry which is partly caused by a relatively weak technological basis, even among successful firms. With low barriers to entry, the learning time is short, which is illustrated by the fact that several Taiwanese firms which were established around 1970, became successful exporters only a few years later.

The leading Argentinian firm in the field of engine lathes is the only CNC lathe producer in the country. It operated for nearly 20 years in a context which made it relatively more profitable, and certainly a lot less risky, to sell on the local market than on the international market. The state policies of importance were high effective tariffs and an exchange-rate policy, or rather, lack of, which resulted in extremely fluctuating real exchange rates. A high export subsidy also existed, but was not sufficient to induce firms to export. Finally, the domestic market was small and somewhat fluctuating.

1/ The following three pages are based on Jacobsson 1984a.

The trade and exchange-rate policies meant that the firm mainly chose to limit itself to the local market. Given low barriers to entry and a small local market, it was rational for the firm to follow a strategy where it utilized its locally superior design skills to exploit a number ot niches. These consisted of firms demanding higher performance and more advanced types of lathes. In addition the Argentinian firm produced a set of standard engine lathes of relatively high quality. The erratic local market also meant that a broad range of products acted as a risk reducer against a sudden drop in demand (Castano et al. 1981).

In terms of the performance of the firm, this strategy had several effects. Firstly, the broad spectrum of lathes produced meant that the unit costs were high. The firm tried to rectify this problem at an early stage by introducing modular design, but this effort could not compensate for the initial high costs. Secondly, in terms of skill development, the strategy pursued meant that the firm required an excessive number of production planners in relation to designers. The firm had between 7 and 8 per cent of its employees in production planning, but only 3.6 per cent in design. In comparison, the three leading Asian NIC firms have between 1.3 per cent and 3.6 per cent in production planning and between 5 per cent and 9 per cent in design development. Thirdly, although the lathe industry is atomized in all countries, the reliance on the local market meant that the Argentinian firm remained very small, both in terms of financial and technological capabilities, even though it was the leading firm locally. For example, whilst the two leading Taiwanese firms have 35 and 25 designers, respectively, this firm had only 7. Fourthly, the firm had no incentive to follow closely the changes in the international frontier. When the first CNC lathe was put on the market in 1980, the design was already dated. Finally, the firm lacked experience in marketing as well as a developed marketing network and reputation abroad.

In the Taiwanese case, lathe producers operated within a context characterized by something close to free trade. The exchange rate policy pursued by the Government meant that there was a stability in the relative prices of domestic and foreign goods, which implied that exporting did not involve unduly high risks. The firms chose in this context to specialize in the low performance/low price segment of the international market. The

initial customers were price-sensitive customers in the region, but the products were gradually upgraded and the emphasis was shifted to the most price-sensitive, developed-country customers.

Although smaller than in Argentina, the local market grew steadily in contrast to the Argentinian case, which meant that the lathe producers took less risks when they specialized their production.

In terms of performance, the export-oriented Taiwanese growth differed from the Argentinian case in several respects. Firstly, whilst a similar fragmentation of the industry took place in Taiwan, Province of China, as in Argentina, the export orientation of the Taiwanese firms not only meant that production could be increased dramatically, as can be seen in Table 19, but also that a small number of larger firms was permitted to emerge. The emergence of these larger firms implied that firms with a substantial skill and financial base existed at the time when the 'electronic revolution' began to affect the industry. The proper response was therefore made much easier than for the leading Argentinian firm.

Table 19. Production of machine tools in Argentina, the Republic of Korea and Taiwan, Province of China, 1969-1981, selected years

(in millions of US dollars)

Year	Argentina	Republic of Korea	Taiwan, Province of China
1969	17.6	5.1[a/]	9.2
1971	22.2	5.2	12.8
1973	38.3	6.3	22.0
1974	n.a.	12.6	33.2
1977	60.0	73.7	67.8
1979	62.0	163.7	189.1
1981	35.0[b/]	178.0	242.3

Source: Jacobsson 1984d.

a/ Metalworking machinery.

b/ Preliminary.

Secondly, the prior export orientation meant that the firms continuously received information on the recent developments in the international market and that the firms understood the importance of learning to analyse the

conditions for success in the international market. Thus, in contrast to the Argentinian firm, the leading Taiwanese firm responded very quickly to the new design trends originating in Japan about 1979. The two leading Taiwanese firms also responded to the need for a larger number of design engineers as they began to emphasize CNC lathes in their production, and they have more than doubled their number of design engineers in the last four and seven years, respectively. Finally, the firms gained invaluable experience from exporting in the 1970s, which allowed them later to implement strategies which involved export ratios of 80 per cent of production.

The Taiwanese case suggests that the firms were able to finance internally the learning costs associated with the initiation of the production of engine lathes. This is what we would expect to happen in industries with low barriers to entry. Under the government policy the firms were able rapidly to gain the benefits from an international competitive edge and grow accordingly in their financial and skill base. Furthermore, the close contact with the international market provided the firms with very essential information and experience. In the Argentinian case, government policies did in fact restrict the growth potential of the more capable firm(s) and ensured that they did not have the incentives to keep up with the changes in the international market. The correct government policy in the case of engine lathes would therefore seem to have been such which enabled the firms to exploit their competitive advantage. Whilst the infant industry argument would apply, as it may to all new activities, the evidence suggests that the period of infancy did not need to be very long.

Coming back to the leading Argentinian firm, at the end of the 1970s it began developing a design for a CNC lathe of its own. Over the last four years the firm has sold a small number of these machine tools locally (Chudnovsky 1984). The design was, however, dated already when the first CNC lathe was marketed and the firm realized that they need a new design. In 1981 the management was also considering a change in its strategy and discussed the possibility of going for exports with CNC lathes. It was estimated that the firm needed to produce 360 NC lathes annually to break even in an international context. Given the limited local market, export orientation would be required within a context of "free trade", in the sense of absence of protective barriers. As was noted above, the firm did not, however, possess

the characteristics to make an export orientation a commercially interesting alternative. It was small, had no marketing network abroad and was very weak internationally speaking, not only in terms of design skills but also in financial strength. Furthermore, it was operating in a very hostile environment. Finally, it could not count on an active state policy of the kind we have seen performed in the Republic of Korea and to some extent in Taiwan, Province of China. The management then decided, rationally, that export orientation was not what it wanted and asked for and received tariff protection. With tariff protection it could continue its inward-oriented strategy. Such a strategy did not, however, necessitate a continued self-reliance in designs, and the firm became a licensee for the first time in its history.

Thus, implementing a protective barrier meant that the firm did not need to take the great risks and costs of developing its own designs for CNC lathes. Furthermore, it did not require the firm to produce CNC lathes in very large quantities so as to become price-competitive. Hence, the government policy of giving tariff protection had a result directly opposite to that of creating an internationally competitive industry. Of course, in the dismal economic and political conditions of the time, it could well be argued that granting protection to the firm gave it the necessary basis for survival. It could also be argued that protection made it possible for the firm to stay near the technological frontier instead of falling further behind. Indeed, it is almost a miracle that in Argentina two firms are producing NCMTs after the prolonged crisis. However, using only tariffs as the basis for a long-term policy vis-à-vis this industry would not be recommended. Indeed, if this policy continues, the policy will help to create a permanent infant industry. The contrast with the Asian NICs state policies is stark. As was noted in section 4.2, these Governments have used credit policies as their main policy element in fostering the CNC-lathe production. The Republic of Korea has also used trade restrictions of an absolute character. On the whole, however, the trade restrictions have not influenced the firms' objectives and strategies as they have done in Argentina, partly because of the importance of credit policies in enabling the firms to change their strategies radically, partly because the domestic market is greater in the Republic of Korea than in Argentina, and partly because of the atmosphere of export orientation in the Republic of Korea.

What should then a proper government policy in Argentina consist of? The firm needs to be induced to change its strategy to one, in our opinion, eventually being the overall cost leadership strategy.[1/] The explicit assumption is, as was stated in the beginning of this section, that the objective of government policy is to create an internationally competitive industry. There are many short steps to take, and the whole process may take many years to be completed. However, the firm must be induced to strengthen its technological capabilities and, subsequently, to export. In Figure 2 we located the firm (firm F) within a number of NIC-based firms. All the firms in the Figure follow the low-performance strategy. The firm needs (a) to become one of the leading firms within this strategy and (b) to shift subsequently into another strategy which is more viable in the long-term. The firm needs therefore to move north-east in the Figure which means both improving its design capabilities and producing a larger number of units per year. The latter involves exporting due to the limited local market.

Thus, the objective of government policy is to induce the firm to change strategic orientation. How this is done is of secondary importance, although the social cost of fostering an industry may vary depending on the tools used. This is well known, and the reasons need not be reiterated here. The first step for the firm in its long process of strategic reorientation and growth would be to start developing own designs for CNC lathes. It would also, over a period of time, employ perhaps five times as many design engineers as it employs at present. One way of forcing the firm to do so would be to limit the period of protection to, say, five years. After that period the firm would have had to have developed its own basic designs since (a) the supply of licenses would probably stop, as it would again be viable to export CNC lathes to Argentina; and (b) the inward-looking strategy would no longer be viable simply since the local market is not large enough to allow the firm to reap the benefits of economies of scale and thereby be price-competitive with imports. An export orientation would be needed. As exports are normally not allowed by the licensor, the firm would require to have its own designs. Of course, there are not always export restrictions

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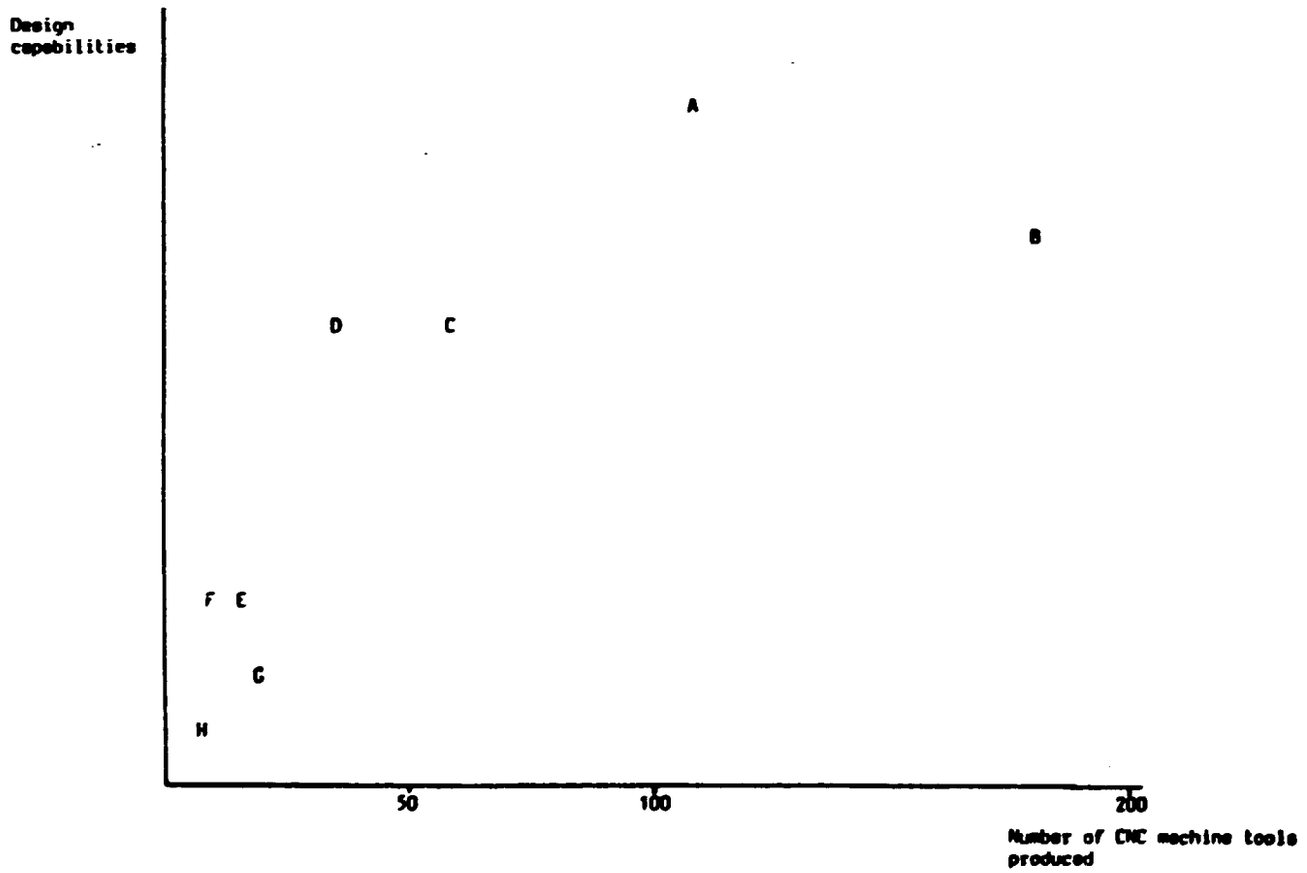
1/ CNC lathes are stable products today in the sense that the main technical developments take place in ancillary equipments. There are therefore less risks that a major shake-up in the international industry will take place in the 80s and early 90s.

Figure 2. Map on the position of eight NIC-based firms within the low-performance strategy



attached to license agreements, but in such cases the design is normally dated and the commercial value of the design in the international market is very low. It is of course for this reason that the licensor permits exports of the machine tool.

Another way of forcing the firm to start developing own designs would be to make tariff protection or other subsidies contingent upon own design development. Other alternatives may well exist. The State would, however, also need to provide the funds for and absorb some of the risks involved in choosing the strategic reorientation outlined above. Thus, a generous credit policy is called for. This credit policy and strategic reorientation need to start soon if the firm is to become internationally competitive by the end of this decade.

The exact configuration of policies pursued by the Government, though, would have to take into account the present local context. What needs to be underlined, however, is that the policy issue is certainly not a question only of whether tariffs should be erected or not and at what height such tariffs should be set. As we have seen in the case of the Republic of Korea, import restrictions of an absolute kind have been associated with a very successful expansion of NCMT production. It is rather the totality of pressures and incentives operating that is at stake and how that totality influences firm behaviour. Here we would again like to underline the importance of the basic factors mentioned in the beginning of this section. These would of course have to be solved before an offensive industrial policy is started, otherwise a strategy of "survival" will always be the rational one for the firm to pursue.

(ii) Machining centres

According to Chudnovsky (1984) there is one firm producing special machine tools which has begun to produce machining centres. The firm anticipates that it will follow the strategy of custom design for machining centres, too. This strategy is totally opposite to the low performance strategy and the overall cost leadership strategy anticipated to be the one for the CNC-lathe producer to follow. Custom-designed machinery is of course a lot less price-sensitive than standard machine tools, and geographical nearness and a common language may be decisive for the competitive strength of

the firm. With 30 designers (Chudnovsky 1984:50) the firm has developed a considerable "mass" of skills and it would seem likely that a gradual growth of the sales of custom-designed machining centres could be implemented without state intervention. The critical factor for a firm of this type is well developed marketing relationships with their customers, and given that the firm has developed such relationships on the basis of sales of other special machine tools, this should not be very problematical. On the other hand, if the firm desires to move into developing FMS, i.e. system development around a machining centre, there may be reasons for protecting the firm for a while and allowing it to develop such contacts with local users, similarly to the firm of the Republic of Korea discussed above. Again though, the protection should have a time limit.

(iii) Concluding remarks

A few concluding remarks can be made. Firstly, the R and D policy of the Republic of Korea and Taiwan, Province of China, includes design centres for NCMTs. A concentration of scarce design skills in a government R and D institute makes sense: (a) when there are many firms which want to move into the production of such machine tools; and (b) when there is no experience in designing NCMTs among local firms. This is not the situation in Argentina and it would make better sense for the Government to help directly in creating or strengthening the design teams in the firms in question than building up a design team in, say, INTI.

Secondly, one important benefit of licensing the design of a CNC lathe is that the licensee can get lower prices for the CNC unit and accessories from the licensor than from the producer of the CNC unit. As and when the firm producing CNC lathes shifts to own design development, it would be beneficial for that firm and the firm producing machining centres to buy these components together. Large cost reductions could eventually be made that way.

Thirdly, marketing abroad involves very large barriers to entry, not only in the sense of having to build up a good reputation, but also in the form of economies of scale. In order to strengthen their international marketing position, collaboration between the two Argentinian firms should be achieved by their sharing some of the fixed costs of marketing. The Government could also, as in the Taiwanese case, help by arranging permanent machine-tool exhibitions abroad.

Fourthly, as the situation seems to be today in Argentina, there is no firm producing standard machining centres. The CNC-lathe producer apparently plans to introduce machining centre models, but then under licence from the licensor of their CNC lathes. Given that the trend towards integration of CNC-lathe production and machining centre production is strong, and that there are sound economic reasons for such an integration,[1/] it would appear reasonable to think about the possibility of including the production of standard machining centres in a government plan to develop the NCMT sector. Several possibilities exist concerning the organization of such a production. Firstly, the CNC-lathe producer may try to design his own CNC lathes as well as his own machining centres. Given, however, the weak designing capacity of the firm, such an attempt would almost certainly be doomed to failure. For example, the leading producer of CNC lathes of the Republic of Korea, with 60 designers (as compared with less than 10 in the Argentinian firm), has gone for licensing of machining centres on account of the fact that it would not be able to keep up with the international development in CNC lathes if it diverted some of its designers to machining centres. Secondly, the CNC-lathe producer could strengthen its industrial capabilities through merging with another firm, which has a capability in milling-machine design (this being the basis for the design of machining centres). This enlarged firm could then, possibly, go for both CNC-lathe design and machining-centre design. Thirdly, the firm producing custom-designed machining centres could also produce standard machining centres for the international and local market. If so, it could collaborate with the CNC-lathe producer in terms of both joint marketing and joint acquisition of components.

5.2 Conventional machine tools

The second half of the 1970s was characterized by very successful exports of conventional machine tools partly from Taiwan, Province of China, and to some extent from the Republic of Korea, to the OECD countries. In the Taiwanese case, the export drive was associated with a fast growth in output of machine tools, whereas in the case of the Republic of Korea the home market

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1/ In terms of composition of components, CNC lathes and machining centres are very similar. This means that if a firm produces both, it can get cheaper components as it buys more. The two machines can also be produced in the same production apparatus and marketed jointly.

was more important. The main foreign market has been the US market, but the European market has also been penetrated. Judging from interviews with two of the leading Argentinian producers of lathes there appear to be no firm-specific reasons why these firms could not have done the same as the Asian NICs and gained a foothold in the US market. Given that the basic factors are taken care of as discussed in the beginning of this section, in particular the cost of raw materials and the fluctuating exchange rates, some of the time lost over the past ten years could well be recuperated. As could be seen in Table 19, Argentina was ahead of the Republic of Korea and Taiwan, Province of China, only 10 years ago in machine-tool production. Two problems may, however, warrant attention. Firstly, although up-to-date figures on the number of producers are not available to us, it was said in the mid-70s that there were 20 lathe producers in Argentina. In 1981 there were 30 lathe producers in Taiwan, Province of China. Given that Taiwan, Province of China, produces many more lathes than Argentina (in units 10 times the number), there may be reason for concentrating the industry somewhat in order to strengthen its technological and marketing capabilities. Secondly, the firms need to realize the importance of marketing development. In Taiwan, Province of China, this was chiefly taken care of initially by US machine-tool distributors going to Taiwan to seek low-cost producers. Subsequently, the firms invested in marketing facilities and took over some of the functions of the distributors. The Taiwanese Government also intervened and provided the starting-up money for an institute which collects and distributes marketing data and arranges for permanent exhibitions to be created. A great deal could be learned from studying the experience of Taiwan, Province of China, in this respect.

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