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# TECHNICAL CHANGE AND TECHNOLOGY POLICY

## THE CASE OF NUMERICALLY CONTROLLED LATHES IN ARGENTINA

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Table of contents

List of Tables



Appendix

## 1. Introduction

The machine tool industry constitutes a very small part of the metal working sector in all countries. For example, in Sweden in 1977, it accounted for only 2.6% of the value added in the engineering sector.[1] It is nevertheless a critical branch as it produces the machinery which produces all other machinery; both for the capital and consumer goods sectors. This characteristic of the machine tool industry means that any productivity increase in machine tools, both product and process, will have repercussions throughout the whole economy. Furthermore, the machine tool industry is, historically as well as at present, an important centre of innovative activity. This has been analysed historically by Rosenberg,[2] and today the machine tool industry is once again a locus of innovative activity with the diffusion of electronic control systems to machine tools. The role of the machine tool sector in generating and diffusing innovations has made it of central concern to many governments in the advanced countries as well as in some developing countries. Several Newly Industrializing Countries (NICs) have also achieved high levels of production of machine tools. In 1979, Brazil was the 13th largest producer of machine tools in the world, Taiwan was the 18th largest and Argentina was the 23rd largest, ahead of such countries as Australia, Portugal and South Africa.[3]

The general problem which will be addressed in this chapter is - under what conditions will the recent rapid technical change in products in the machine tool sector increase the technological gap between the developed countries and the NICs? The technical change referred to is the trend towards the substitution of standard machine tools by numerically controlled (NC) machine tools. The specific task will be to analyse the conditions under which the leading Argentinian lathe producer will be able to move from the design and production of standard lathes to numerically controlled lathes.

NC lathes is today synonymous with computer controlled lathes and like many computer controlled technologies it has distinct advantages over its manually operated counterparts. Without going into details, it is clear that the NC lathe is a technology which saves both capital and labour when used in many applications now, and the number is increasing. It saves most on skilled labour.[4] This is very advantageous to investors

in the developed countries where skilled labour usually do not work shifts and where hence, capital is not fully utilized. The skill saving character of NC lathes could also be said to be advantageous to investors in the NICs, where skilled labour often is very scarce.

The advantages associated with NC lathes has led to the fast penetration of them in the developed country markets. In table 1 we can see how the value of production of standard and NC lathes have altered in the main non-socialist producing countries. The countries account for 84% of the non-socialist world's production of machine tools[5]. We can note that in 1975, when the first microelectronically controlled NC unit was introduced, the share of NC lathes in the total production of lathes was only 27.9% whilst it had grown to 54% in 1980. We can furthermore note that the annual rate of growth in the production of NC lathes since 1977 has been in the order of 40%, while the rate of growth of standard lathes has been much below.

Table 2 reveals how the growing importance of the production of NC lathes is reflected in the share of NC lathes in the total investment in lathes in a number of developed countries. The share of NC lathes is generally above 50% of the investment in lathes in these developed countries. Whilst it is not likely to reach 100%, everthing points to a continued decline in the importance of standard lathes. Hence, there is at the world level a substitution of NC lathes for standard lathes.

Realizing what is happening, a number of lathe producers in the NICs - in Argentina, Brazil, Taiwan and South Korea, are attempting to switch their production over from standard lathes to NC lathes. We will in this paper, analyse under what conditions the leading Argentinian lathe producer will able to successfully make the switch.

We will analyse three factors determining the answer to this question. The first factor of importance is how the international competitive situation has altered with the growth of importance of NC lathes. The second factor is the size of the Argentinian market for NC lathes. The third factor is the structure and capabilities of the firm. These factors will be dealt with in sections 2 - 4. In section 5 we will draw out the strategic implications and discuss policy at the level of the firm and at the level of the state. Finally, in section 6 we will summarize the main conclusions.

Table 1 World* Production of Lathes (million U.S. current dollars)

| Year | Standard | % Growth | NC | % Growth | NC/Total |
|---|---|---|---|---|---|
| 1975 | 1 145 | | 445 | | 27.9 |
| 1976 | 1 057 | - 7.7 | 498 | 11.8 | 32.0 |
| 1977 | 1 132 | 7.0 | 626 | 25.7 | 35.6 |
| 1978 | na | na | 938 | 49.8 | na |
| 1979 | 1 515 | na | 1 310 | 39.7 | 46.4 |
| 1980 | 1 625 | 7.2 | 1 906 | 45.4 | 54.0 |

* Japan, US, West Germany, France, UK, Italy and Sweden.

Sources: Elaboration on data supplied by CECIMO and national Machine Tool Builders Associations.

Table 2 Investment in NC Lathes as % of Investment in All Lathes

| Year | US | JAPAN | UK | FRANCE | SWEDEN |
|---|---|---|---|---|---|
| 1974 | na | na | na | na | 34.4 |
| 1975 | na | 23.4 | na | na | 42.6 |
| 1976 | na | 28.2 | 18.6 | 26.4 | 41.6 |
| 1977 | na | 40.8 | 21.3 | 46.7 | 52.6 |
| 1978 | na | 40.1 | na | na | 69.9 |
| 1979 | na | 50.8 | 38.4 | 73.8 | 69.5 |
| 1980 | 56.5 | na | 47.3 | na | na |

Sources: Elaboration on data supplied by CECIMO and national Machine Tool Builders Associations

## 2. The international structure of the NC lathe branch

The most important single factor determining the viability of NC lathe production in a NIC, or in any other country for that matter, is the recent Japanese expansion. Since 1975, the Japanese have drastically increased their share of the worlds production. The 'world' is defined as U.S., Japan, West Germany, France, Italy, U.K. and Sweden. Table 3 shows that in value terms, the Japanese increased their share of world production from about 15% in 1975 to between 32 to 35% in 1980. As the Japanese yen has increased significantly in value in relation to the dollar, we have used both current and 1976 years exchange rates in calculating the value of production.

In terms of units, table 4 shows that Japan increased its share of world production from 31.7% in 1975 to 60.4% in 1980. The large increase in production in Japan has been associated with an export drive and Japan's share of the world market (as defined above) excluding Japan's internal market, rose from less than 6% in 1975 to between 21 and 26% in 1980 in value terms. In terms of units it rose from 12.6% in 1975 to 45.5% in 1980. Hence, in 1980, nearly half of the NC lathes sold in the non Japanese western market was made in Japan. This can be seen in table 5. In other words, there has been an exceptionally rapid shift in world production to Japan.

The rise of the Japanese has taken place in a period of very rapid growth in world production of NC lathes. Both in terms of units and value (not deflated) the yearly increases has been in the order of 40%. To a large extent, this increase has been due to the Japanese growth. In terms of units, the growth in Japanese production accounted for about 70% of the world growth of production, whilst in terms of value Japanese growth accounted for about 40% of the world growth.

Table 3 The production of NC lathes in Japan, Europe* and the U.S. (U.S. dollars and % of world production)

| | Japan | | | | Europe | | | | U.S. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (%) | (2) | (%) | (1) | (%) | (2) | (%) | | (1) | (2) |
| 1975 | 66.0 | 15.2 | 66.0 | 14.8 | 156.4 | 35.9 | 166.2* | 37.3 | 212,7 | 48.8 | 47.8 |
| 1976 | 88.7 | 17.8 | 88.7 | 17.8 | 203.2 | 40.8 | 203.2 | 40.8 | 205.9 | 41.3 | 41.3 |
| 1977 | 143.7 | 23.8 | 159.0 | 25.4 | 263.3 | 43.7 | 271.5 | 43.3 | 195,3 | 32.4 | 31.2 |
| 1978 | 194.8 | 24.1 | 274.9 | 29.3 | 373.4 | 46.3 | 425.8 | 45.3 | 237.2 | 29.4 | 25.2 |
| 1979 | 331.0 | 29.9 | 448.5 | 34.2 | 427.4 | 38.6 | 514.4 | 39.2 | 347.2 | 31.4 | 26.5 |
| 1980 | 513.7 | 31.8 | 673.0 | 35.3 | 619.9 | 38.3 | 751.7 | 39.4 | 481.0 | 39.8 | 25.2 |

(1) 1976 exchange rates

(2) Current exchange rates

* excluding Italy

** West Germany, France, Italy, U.K. and Sweden

Sources: elaboration of data supplied by the various countries' machine tool producers associations

Table 4 The production of NC lathes in Japan, Europe and the U.S. (units)

| Year | Japan | | Europe** | | U.S. | | Total |
|---|---|---|---|---|---|---|---|
| | no | % | no | % | no | % | |
| 1975 | 1,359 | 30,0 | 1,535 | 33,8 | 1,640 | 36.2 | 4,534 |
| 1976 | 2,073 | 41,0 | 1,656 | 32.8 | 1,321 | 26.1 | 5,050 |
| 1977 | 3,900 | 52,6 | 2,332 | 31.5 | 1,178 | 15.9 | 7,410 |
| 1978 | 4,986 | 49,8 | 3,551 | 35.5 | 1,464 | 14.6 | 10,001 |
| 1979 | 8,065 | 57,9 | 3,505 | 25.2 | 2,354 | 16.9 | 13,924 |
| 1980 | 12,036 | 60.4 | 5,137* | 25.8 | 2,751 | 13.8 | 19,924 |

* assumed a production of 300 units in Sweden

** West Germany, France, Italy, the UK and Sweden

Sources as in Table 5

Table 5. Japanese share of non-Japanese world market

| Year | Units | Value | |
|---|---|---|---|
| | | (1) | (2) |
| 1975 | 12.6 | 5.7 | 5.6 |
| 1976 | 22.1 | 9.0 | 9.0 |
| 1977 | 29.0 | 13.2 | 14.2 |
| 1978 | 34.8 | 16.9 | 21.0 |
| 1979 | 41.7 | 20.9 | 24.3 |
| 1980 | 45.5 | 23.6 | 26.5 |

(1) 1976 years exchange rates
(2) Current exchange rates

Sources: as in Table 5

How can we explain the success of the Japanese? There are four sets of factors which are important to understand if we are to analyse the implications of this expansion for a NIC. These are: firm size, new design concepts, pricing policy and the size of the Japanese home market.

## 2.1. Firm size

The discussion of the size of firms will be divided between the production of the machine tools proper and the NC units, as the micro computers are generally produced by separate firms.

### 2.1.1. The production of the machine tools proper

Let us begin by stating that the cost structures of production change over time, changing the requirements for successful competition. To maintain a defensible long term business position, it is important to anticipate and be ready to respond to, or to initiate these changes. For example, when electromechanical switch gear for the telecommunication industry were replaced by electronic ones, manufacturing costs, for example labour costs, were replaced by the ability to purchase materials at a low cost as the prime element defining overall production cost.[6]

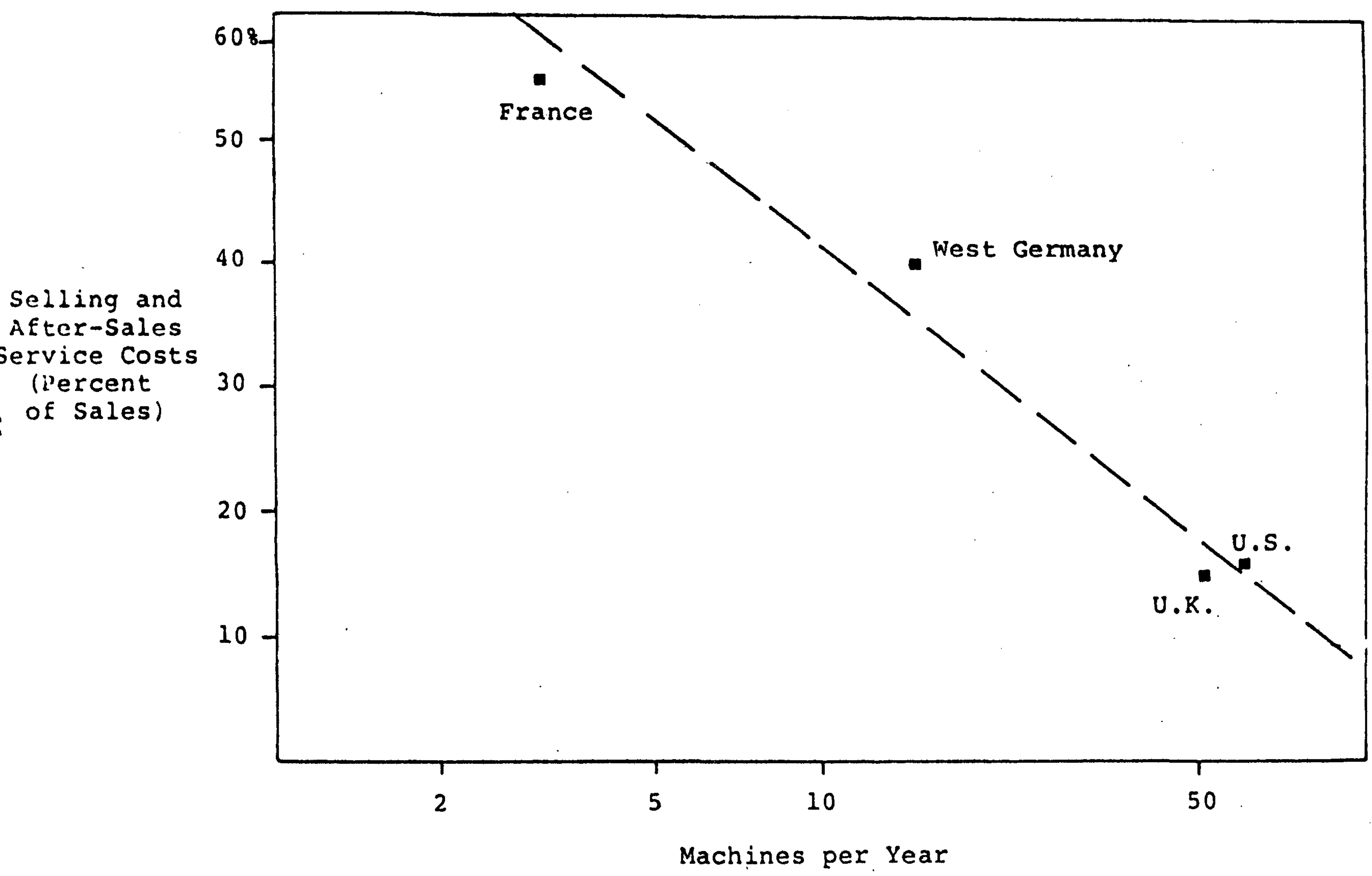
Similarly, the cost structure alters when we move from the production of standard lathes to NC lathes. As table 6 shows, the main element in the production cost for NC lathes is bought-in materials, as in the case of electronic switch gear. The content of the material also changes from primarily domestically produced and with high labour content such as foundry items, to standard items bought from internationally specialized firms which produce very long series. Given that these firms achieve high scale advantages in production, they give very high discounts to the firms buying large numbers of units. Hence, there are large scale advantages in the acquisition of materials which accounts for the largest share of production costs. It is not uncommon for large machine tool producers to get up to 30 - 35% discount when they buy their components such as the numerical control unit, the electrical motors and the ballscrew. Furthermore, the direct labour content is reduced considerably when production is switched to NC lathes. Hence, wage costs have lost a lot of their significance in defining overall production costs, instead, acquiring components at a low price is of great importance.

Table 6 Structure of production costs of one firm's CNC lathe when produced in very small batches

| | | |
|---|---|---|
| | Materials | 64% |
| out of which | a) imported | 46 |
| | domestic | 18 |
| | Capital cost | 17% |
| out of which | a) fixed capital | 14 |
| | b) work in progress and inventories | 3 |
| | Labour costs | 17% |
| out of which | a) white collar | 8 |
| | b) operators | 7 |
| | c) administration | 2 |
| | Miscellaneous | 2% |

Source: Interview with firm representative

Table 7 DISTRIBUTION SCALE AND SALES AND SERVICE COSTS




Source: Boston Consulting Group: A framework for a Swedish Industrial Policy, Appendix 8.

Other sources of scale advantages which have become of greater importance with the shift to NC lathes and the rapid growth of that market is the increased need for R & D and for a marketing and distribution network. Whilst the former needs no explanation in times of fast changes in product technology and the introduction of new technical elements, electronics, into the product, the latter deserves some comments. In general, we can say that the machine tool business is characterized by a fragmented customer base with significant requirements for information and after sales services such as repair and maintenance. With the shift to NC lathes, the requirements for both information and repair and maintenance have increased substantially. This is mainly due to the fact that for most customers the electronic unit is like a black box and that the skill requirements for service and maintenance have increased. Consequently, the users tend to rely more upon the service network of the supplier.[7] Table 7 illustrates the magnitude of the costs of sales as a percent of total costs. The table shows that this percentage may reach 50% when only a few units are sold in a market and that it still accounts for 17 - 18% when 50 units are sold. Hence, the scale economies are very substantial.

To summarize, the key word to achieve a strong competitive position in the NC lathe business is scale advantages. A general explanation of the success of the Japanese is that they anticipated and took advantage of the growing scale advantages. This is reflected in table 8 where we can see the difference in the structure of the NC lathe sector in the U.K., France, West Germany, Italy and Japan. There are several points to note: Firstly, the largest Japanese firm in 1978 produced four times the number of units as the largest firm in the four countries mentioned above, whilst three years before that (1975) the largest Japanese firm was at the same level as the largest European firms. Furthermore, the four following Japanese firms had an average production of 525 NC lathes in 1978 whilst the European firms ranged between 35 and 210. In fact, the 16 largest firms in the four European countries produced 1,815 NC lathes in 1978 whilst the five largest Japanese firms produced 3,100 units in the same year. Hence, there is a great difference in the structure of the European branch and the Japanese. Whilst the data in the table is from 1978, at least two Japanese firms, Yamazaki and Mori Seiki have plants capable of producing between 2 and 3,000 NC lathes p.a. As the scale advantages are significant, this increase in the size of the production units has raised the minimum efficient scale of production of NC lathes. We will later come back to what this implies for the NICs.

Table 8 Some comparative data on NC lathe production in Japan and Europe

| Country | Production of NC lathes | Concentration: Largest firm % | Largest firm No | 4 largest % | 4 largest No | Average of the next to leader firms |
|---|---|---|---|---|---|---|
| UK (1977) | 270 | 31 | 80 | 83 | 225 | 50 |
| France (1978) | 330 | 45 | 150 | 80 | 265 | 35 |
| BRD (1978) | 1255 | 20 | 250 | 70 | 875 | 210 |
| Italy (1978) | 709 | 20 | 140* | 64 | 450 | 103 |
| Japan (1978)** | 4986 | 19 | 1000 | 64* | 3100 | 525 |
| Japan (1975) | 1359 | 19 | 270 | 60 | 700 | 105 |
| Japan (1970) | 660 | 40 | 250 | 92 | 610 | 90 |

* Based on 1977 years concentration data ** five largest firms

Sources: For Europe: Elaboration on Planning Research + Systems Limited: A market study of numerically controlled machine tools in the United Kingdom, France, Italy and West Germany, October 1979. For Japan: Elaboration on data in Metalworking, Engineering and Marketing, March 1980,p.26, Today's Machine Tool Industry: The Recent Technical Trends in NC Lathes, 1977 and Progressive Development of Numerically Controlled Machine Tools in Japan, 1977.

### 2.1.2. The production of the NC units

The NC unit accounts for between 15 and 25% of the cost of the NC lathe. As the largest item of cost in the NC unit is depreciation for development costs, the scale advantages are very substantial.Hence, the structure of this sector in Japan and elsewhere is important to analyse.

There are a minimum of seven Japanese NC producers.[8] By far the most important one, Fujitsu Fanuc, has however between 60 and 70% of the market. In table 9 we can see that the spectacular growth of NC lathes post 1975 is matched by an equivalently spectacular growth of NC units.The largest European producer is Siemens, which sold, according to one source,[9]

Table 9 Annual production of NC units by Fujitsu Fanuc

| year | no |
|---|---|
| 1975 | 2,000 |
| 1976 | 3,544 |
| 1977 | 6,662 |
| 1978 | 9,519 |
| 1979 | 14,182 |
| 1980 | 21,000 |

Source: Sou 1981:10 Datoriseringen inom verkstadsindustrin

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3,200 units in Europe in 1979. However, only 1,500 units of these were their own, the remaining were Fanuc units for which Siemens have the right to distribute in Europe. As Siemens and Fanuc have a joint firm, General Numeric, which markets their products in the U.S. (15% market share), the total production level of Siemens ought not to be higher than 3.000 p.a. Other European firms have a substantially lower production. For example SMT and Kongsberg in Scandinavia do not reach 500 units p.a. Hence, Fanuc's production is six to seven times that of Siemens' and forty times that of the Scandinavian makers.Other major firms, such as General Electric and Olivetti produce substantially less than Fanuc.

Of course, this difference in structure may explain the success of Fanuc but should not, in a competitive environment, explain the success of the Japanese machine tool builders. There are however three important considerations to bear in mind. Firstly, the exceptionally rapid changes in the technology. In four years the world market underwent dramatic changes and that is a very short time, especially for an atomised industry like the machine tool industry. This is manifested in the fact that smaller European machine tool builders still buy NC units from a national and more expensive supplier, e.g. ASEA in Sweden. In other words, small firms take some time to adjust and acquire information etc.

Secondly, the simultaneous increase in production of NC lathes among a small number of firms and the production of NC units have allowed the Japanese machine tool builders to reap substantial benefits. For a firm buying about 1,000 units p.a., the rebate can be as large as 35%.

It would conceivably have been possible for the Japanese machine tool builders to buy, say, General Electric's NC units with a rebate. The point is however that in times of substantial and rapid changes in technology, like the introduction of microprocessors in NC, the geographical nearness and the historically strong design links between NC producers and machine tool builders in Japan have probably speeded up the diffusion process and hence rebate possibilities. The nearness and history of collaboration was also exceptionally important due to the fact that the Japanese NC producers initiated the development of simpler NC units which could be applied to more simple machine tools, like smaller lathes.[10] A very important part of the Japanese machine tool builders' success lies in the development of new design concepts for which the availability of cheap NC units was a prerequisite. Hence, there were strong complementarities in design developments between NC units and NC lathes. Of course, today, any machine tool builder can buy a Japanese NC unit but we again want to emphasize the time element in the diffusion of knowledge in explaining the rapid success of the Japanese post 1975.

### 2.1.3 Design concepts

NC lathes are not an homogeneous product. In fact, the price ranges today between 80,000 and 250,000 dollars. This has not always been the case though. An important factor in explaining the Japanese success has been the introduction of new design concepts. The first important point to keep in mind is that the development of cheap NC units was a prerequisite for the diversification of NC lathes into the less complex part of the spectrum. As the Japanese themselves said already in 1977:[11]

> "...the tendency of diversification in turned parts in the middle and small lot sizes became notable while the cost reduction in NCs has been realized owing to electronic technique innovations, thus making it possible to develop inexpensive NC machine tools."

Two main types of cheap NC lathes may be identified. First, a production type NC lathe which is small and developed for turning smaller parts for automobiles, electric appliances etc. Second, a low cost type of NC lathe which has been especially designed so that small and medium size firms can afford to buy them. It is these low cost NC lathes which have played the most important role in the success of the Japanese NC lathe industry.[12]

The validity of this partial explanation of the Japanese success is indi-

of both quality and performance. Out of a list of all NC lathes made in Japan,[13] 38% had a motor power of less than 15kw, another 38% had a motor power between 15 and 30kw and only 24% had more than 30kw. In comparison, the largest Swedish NC lathe producer, which is one of the leading non Japanese ones, has no model with a motor power of less than 35 kw. Secondly, the different strategy of the Japanese is indicated by the weight per unit of NC lathes. In 1979, the average weight of Japanese exports to European and U.S. markets ranged between 4 and 4.7 tons per unit. In comparison, the Swedish firm's lightest NC lathe weighs 6.6 tons. Hence, the Japanese have gained some of their market strength via changing design philosophy.

The basis for this change in philosophy is well illustrated in the following paragraph from a Japanese journal:[14]

> "At the first stage, these low cost NC lathes could not be introduced smoothly due to the prejudice that NC lathes should be machine tools of high quality equipped with luxurious functions. Though NC lathes of high grade with luxurious functions were really required for some turning operations, it is also true that all the valuable functions are not required for all the turning operations. In many fields, NC lathes of simplified functions can sufficiently turn the parts, and many low-cost NC lathes are now widely accepted positively."

In other words, using a performance/cost ratio, we can say that the Japanese have emphasized reduction in costs whilst traditionally the philosophy of European machine tool builders has been to emphasize performance. This widening of the spectrum of choice of NC lathes has clearly had the effect of opening up new markets and, hence, permitted a move to mass production which was illustrated in the previous section. Hence, there are very clear links between types of customers, design of the machine tool and the scale of production of the machine tool.

### 2.1.4 Pricing policies

Traditionally, Japanese leaders of industry have put a very heavy emphasis on gaining large market shares in their objective function. Hence, a philosophy of long term gains instead of short term profits pervades the Japanese industry. It is very difficult to substantiate the argument that this also applies to the NC lathe industry. There exists however some information which tends to indicate that this is the case.

Firstly, it appears to be widely known in industry that the Japanese

are offering very substantial discounts on their NC lathes. Secondly, one source suggests that in the U.K. market, they are now raising their prices after an initial heavy penetration of the market.[15] Thirdly, the Japanese Economic Journal [16] reports the existence of a Japanese export cartel which pursues a price differentiation policy. Fourthly, the Committee of the European Coorporation of Industries of Machine Tools sent its leaders to Japan to "...urge it to learn orderly exporting."[17] The disorderly conduct of the Japanese was their pricing policies. Hence, it seems very probable that the general pattern of emphasizing large market shares in Japanese industry also applies to the NC lathe industry. The price competitiveness arising from low markups per sold NC lathe could thus partly explain the Japanese success.

2. 1.5 Domestic market size

The size of the market for NC lathes is roughly the same in Europe, the US and Japan. However, whilst the US and the European markets are heavily penetrated by external competition, the Japanese home market is captive. In 1979, the Japanese imported only 3 NC lathes while they exported 4 196.[18] Whilst one possible explanation to this phenomenon could be an extreme specialization and superiority of the Japanese lathes, it is clear that Japan never imported a large number of NC lathes. The maximum was 24 in 1971. [19] With a captive home market of the Japanese size, the risks involved in a large expansion in production are of course considerably reduced.

2.1.6 Conclusions

There are two basic questions to answer. How did the Japanese do it and what are the implications for a NIC trying to move into production of NC lathes?

To begin with the first question, there are several points to be made. Firstly, there has been a lot of discussion over the advantages of having an electronic sector in the same country for the downstream industries. It appears to be clear that this has been the case in this particular branch in Japan. This is based on the fact that it was the Japanese NC firms

who initiated the diversification of NC units to the cheaper, Read Only Memory types which have their software 'build into' the hardware. Secondly, there has been a long history of design links between Fanuc and the Japanese machine tool builders. However, it is equally important to stress that this first advantage of the Japanese machine tool builders has now been eroded via a world wide availability of these cheaper NC units. Hence, there seem to be no serious technological disadvantage for a NIC based firm trying to produce the low cost type NC lathe to buy in the NC units from a geographical and business distance. The situation is however different for a firm in the more advanced part of the spectrum. For these firms, who rely on complex product developments such as the combination of robotics and machine tools, it is vital to have an in-house electronic R&D section or very good design links with an electronic firm.

Secondly, the Japanese domestic market is captive. In combination with the high level of concentration, five out of twenty five firms account for 64% of the production, this dramatically reduces the risks of an expansion.

Thirdly, somebody external, but not necessarily the state, to the machine tool builders must have taken some of the risks inherent in this exceptionally rapid expansion. It is sufficient to note that two firms have factories producing between 2 and 3,000 NC lathes per annum.[20] This means that a decision was taken to build factories whose output would be sufficiently large to cover the entire domestic market of Japan at the time the decision was taken. In other words, the market justifying such a spectacular investment was not there but had to be created. The risks are of course very large. It would seem implausible that the machine tool builders themselves could take these risks. Some external institution would be required. It is of course difficult to know exactly which, but again, generally speaking, the banks' take a large part of the risks in Japan, which is indicated by a very low ratio of owners capital to total capital.

Concerning the implications for the NICs which want to enter into the production of NC lathes, there are two diverging forces at work. Firstly, the Japanese have initiated a diversification in design of NC lathes towards the less complex end of the spectrum. This is clearly advantageous for the NICs. However, any NIC firm in a free trade environment would have to compete with the Japanese who have very low prices, short delivery times and good service and maintenance network. This is the most important single factor in analysing

the viability of NC lathe production in the NICs and we will return to discuss it in more detail after examining the other determinants. These are a) the size of the home markets, b) the Argentinian firm producing NC lathes and c) government policy in Argentina.

## 3 The size of the home market in Argentina

In the previous section we argued that the very large and captive home market in Japan reduced the risks inherent in some of the Japanese firms' very rapid expansion of production of NC lathes. The size of the domestic market in relation to the minimum efficient scale of production is a very important factor determining the long term viability of NC lathe production in any country. This is simply so since it is much easier and less costly to sell to the home market than to export. Furthermore, it is usually very important for product developments to have a stable set of customers who demand new technologies and try them out when they are first produced. Most advanced countries have a national champion in the machine tool industry which is the leading technology developer for a range of national firms.

The existence of a relatively large home market is of course also important for NC lathe firms in the NICs. An important task is then to describe the past rate of diffusion of NC lathes and, in particular, estimate the future size of the market for NC lathes in the NICs.

In the case of Argentina, a leading North American NC lathe firm claims that it will be able to sell 100 units per annum during the next few years.[21] The total market would then be higher as it is unlikely that one firm could monopolize the market. In another study, the Argentinian Electronic Commission, in collaboration with Siemens,[22] suggested that the annual market for NC units would be 990 for the next few years. As between 40 and 50% of the installed NCMTs usually are NC lathes, this would mean an annual market of at least 400 units. In the following section we will suggest that these estimates are far too optimistic and that a more realistic estimate implies difficult problems for technology policy.

### 3.1. The present and potential size of the market for NC lathes in Argentina

In a survey, the diffusion pattern in the past was found to be as in Table 10. The total number of NC lathes identified amounted to 189. To this it is reasonable to add 15% as some units, particularly the older ones, were surely overlooked in the survey. Hence, we estimate that there were, in April 1981, 215 NC lathes in Argentina. From 1976, there has been a steady growth in the number of installed units per annum; from 5 in 1976 to 45 in 1980.

Table 10 The installment year of 79% of the known NC lathes

| year | no |
|---|---|
| 1976 | 5 |
| 1977 | 17 |
| 1978 | 30 |
| 1979 | 33 |
| 1980 | 45 |
| 1981* | 21 |

* only to May

Source: survey by the author

We also estimated the potential yearly demand for NC lathes for the next five year period. Table 11 shows that the expected yearly market will not be above 100 units. For an account of the method see Appendix.

Table 11 An estimate of yearly demand for NC lathes in Argentina 1981-1985.

| Year | Number |
|---|---|
| 1981 | 81 |
| 1982 | 81 |
| 1983 | 82 |
| 1984 | 85 |
| 1985 | 91 |

Whether the potential will be realized is another matter which primarily depends on a) the availability of skills required to maintain and service the NC lathes as well as knowledge of the NC technology among the firms in Argentina, and b) the rate of investment. Concerning the first factor, it seems probable that the present growth rate of installed NC lathes will go some way to establishing a service and maintenance structure. Furthermore, it will diffuse information about NC lathes and allow for an accumulation of experience in using NC lathes.

Concerning the latter factor, the Argentinian economy is today(April 1981) in an exceptionally severe crisis. The level of capacity utilization in the machine tool industry is close to a mere 30% and several capital goods industries have a capacity utilization of less than 50%. The crisis is, at the econommic level, a function of a) the high interest rates; 30 % real interest rates during the past two years, b) the overvalued peso which made imports cheap (the overvaluation was discontinued in Spring 1981) and c) the fast reduction in the historically very high tariffs, causing tremendous adjustment problems. It seems futile to even speculate on the outcome of this policy. One possibility could however be a restructuring of the industrial sector to serve the exploitation of the 'natural' comparative advantage of Argentina; agriculture and energy. There is today a heavy investment in the energy field. A minimum of 41% of the installed NC lathes serve the oil exploitation industry. If such a specialization were to come about,[23] the agricultural machinery sector would also be a large market for NC lathes[24] as well as the transport sector, which already today constitutes a fair market.[25]

3.2. Conclusions

A very important conclusion of this exercise is that even if we assume a growth rate of 5,9% in the relevant eight branches ( a very optimistic assumption), the size of the local market is so limited that a hypothetical firm producing NC lathes in Argentina, in a free trade context, would have to base its production on sales on export markets. In relationship to the size of the production units in Europe and particularly Japan, the domestic

market in Argentina is only marginal. The same applies also to other NICs. For example, the Republic of Korea's import of NC lathes, which is roughly the same as investment in NC lathes due to very low domestic production levels, was 50 units in 1978, 115 units in 1979 and 45 units in 1980.[26] The limited local markets has very important implications for technology policy and we will turn to that later in the essay. First we will discuss the history of the leading Argentinian lathe producer and analyse how the structure it has built up during twenty years of growth affects its possiblity to produce NC lathes successfully.

## 4. The Argentinian firm producing NC lathes

The third factor determining the viablity of NC lathe production in Argentina is the capabilities and the structure of the firm producing NC lathes. Ar gentina has about 100 machine tool firms. The majority of these are very small and are still at a quite rudimentary stage in their technological development. However, there are a limited number of firms which have taken the step into more advanced production. According to Cortez,[27] on ly eight firms have reached a stage where the design is not done by copying imported equipment, but where qualified engineers are included in the design team and where fabrication of prototypes is a systematic activity. Only one of these firms has moved into production of a NCMT, a NC lathe.

We will in this section look at some aspects of the history of the firm producing the NC lathe, as well as the relationship between government policy and the level of skills and structure of the firm.

### 4.1. Some aspects of the history of the firm[28]

Since the early 1960s, when the firm initiated its first prototype development, the firm has placed very heavy emphasis on product design in its long term strategy. This means that already by the mid or late 1960s it had gained a position as a market and technological leader in the highly protected Argentinian market. The firm's share of the local lathe market reached 41% in 1966 and has thereafter varied between 30% and 49% (in value). During the past 20 years, it has gradually created a product design capability which is the result of a high degree of 'self-reliance' in design. The range of products designed and produced included not only a series of parallel lathes but also copying, revolver and semi-automatic lathes as well as a milling machine and finally, two NC lathes. It is important to note here that the firm has gradually increased the complexity of the pro-

ducts; from the first parallel lathe, through copying lathes and finally the NC lathes. It was clear from interviews that there was a gradual increase in design capability and that the step taken to the NC lathes would not have been possible if the copying lathes had not been designed previously. Hence, the chief of the design team was quite clear that it would have been impossible to go straight from the design of parallel lathes to CNC lathes.

Before we continue, let us elaborate a bit on the relationship between the use of electronic control units and the design and production of the lathe. One may identify three effects:

a) the mechanical content has been reduced in favour of electronic and electrical solutions. For example, in the main spindle drives, large mechanical gear-boxes with hundreds of parts have been replaced by a variable speed motor.

b) The demand for high quality on the remaining parts is much higher, in particular in relation to the frictional behaviour of the parts and the servomechanism as well as the demand for reliability and durability. As a result, the design of the mechanical parts has been very much influenced by developments in the control units. As one report states [29]

> "In the early days of numerical control, it was not uncommon to fit existing machine tools as distinct from machine tools designed and made for use with NC. Retrofitting, as this is called, did produce some successful NC machines but it also produced many unsatisfactory ones. The mechanical characterictics of conventional machine tools made prior to 1955-60 - stiffness, frictional characteristics of slideways and feed drive systems - were often unsuitable for use with NC and retrofitting of this kind is now unusual except for some of the simpler and cheaper NC systems"

c) the design process has become more complex.[30] Other disciplines than mechanical engineering have entered the design task such as: electrical engineering, electronic and lately small computer techniques and servo techniques. As a result, machine tools are no longer designed by inventive engineers but require a team with a multidisciplinary approach.

The transition of this particular firm into design and production of NC lathes began four years ago and has been very gradual. The first step taker was to buy a NCMT and to study it and learn how to use it. During this time, the firm also sent people abroad to learn programming.

In the actual product development work, one may separate the mechanical parts from the electro/electronic parts. For the former, which are all, except for the ballscrew, produced inhouse, there were little or no problems during the development work. (All in all four man years were spent on design work) This may seem rather surprising since only 40% of the value of the mechanical parts are the same in their NC lathes as in their conventional lathes. The relative ease of solving the problems was due to three factors: (a) the two people responsible for the mechanical parts both had between 20 and 25 years of design experience (b) the firm had already produced very high quality machine tools and (c) the firm developed a relatively simple type of NC lathe and, furthermore, created a design which, if not a retrofit, was more of an adapted copying lathe than a fully redesigned machine.

The electro/electronic parts of the NC lathe, i.e. the control unit, the motor and the electronic parts of the spindle, are brought in from abroad. The design work here was undertaken by an engineer with only three to four years of experience. His competence was created through a gradual process. Firstly, he was responsible for the electrical parts of a copying lathe. These are more complex than in a parallel lathe, which is the main output of the firm. Secondly, he designed and produced a simple form of electronic control unit. The last phase was the NC lathe where he, among other things, designed the whole interface between the CNC unit and the machine tool.

However, the continued government policy of a high level of protection across the board did not give the firm the stimulus to take the risks associated with a specialization strategy. An option for the government would have been to reduce the tariffs for the less complex products, i.e. the parallel lathes, which were suited for mass production and specialization, whilst keeping the high protection for the more complex products whose production was a vital step in the continuous accumulation of skills. The non-selective intervention helped to create instead a firm which, in spite of being a local leader and one of the best lathe produceres in Latin America, is cursed by five major problems:

a) a very diversified production which consists of parallel lathes and products which satisfies the demand from small niches of advanced users. The niche mentality applies also to minor variations in the size etc of the parallel lathes. This results in an absence of scale economies as well as an absence of specialization in the design efforts. Of course, the problems associated with this diversification are also partly a function of the limited local market; with larger markets, some specialization could take place within the firm such as in the case of the leading Brazilian machine tool firm.

b) a skill structure which is probably different from the one which would be required in the context of a specialization strategy based on export markets. This is particularly evident in the very large number of production planners which are needed to cope with the production of a wide range of products. Also, whilst the design skills are advanced in the local context, they are weak in an international context. The design process is still characterized too much by the 'inventive mechanical engineer' rather than by a multidisciplinary team. It is, of course, questionable if this is due to protection but in an international competitive environment the firm would have needed to have spent much more on R&D.

c) interrelated with the governmental policy of protection was the creation of a philosophy of short term gains and high risk aversion. This is particularly evident in the length of time, three years, required to develop the CNC lathes. The length of time needed to develop the CNC lathes also

shows the lack of specialization in the design efforts. In Europe, the design of a totally new concept takes 1.5 years whilst the Japanese develop adaptations in only three months. The risk aversion mentality is also reflected in the design of the CNC lathes. These were made on a modular basis with the conventional machines and so simple that they can be produced with the existing layout and machinery, implying a gradual growth of the CNC share of production rather than a specialization. However, it is important to stress that the description of the firm as a 'low risk taker' refers only to a comparison of what would have been required in the context of international competition; in a context of the national and regional scene, the firm is a progressive one.

d) a lack of specialization and exports to the technologically advanced markets has led to a lack of information on the technological frontier. It is clear that the design concept was old already when the first CNC lathe left the factory.

e) finally and perhaps most importantly, the lack of exports to other countries than Brazil and Mexico means that today the firm has no developed marketing network in the U.S. and Europe. Such a network is an absolute prerequisite for exports of advanced machinery. The importance of a network is reflected in the fact that a leading CNC lathe builder in Europe claims that its marketing network constitutes its greatest source of scale advantage today. Clearly, with an earlier specialization, such a network could have been gradually created during the past decade.

To sum up: the past government's history of indiscriminate tariff protection has, in combination with a small local market, been conducive to creating a firm with characteristics which make it less well prepared to switch over to the production of a large number of CNC lathes. [32]

## 5. Technology Policy

In the past sections we have discussed the changing international structure of the NC lathe branch, the size of the local market in Argentina and, finally, the structure of the leading Argentinian lathe producer. We will against this background discuss two future scenarios. We will, furthermore, attempt to discuss the conditions which would need to be fullfilled for each scenario to be realized. This includes a discussion of which of the scenarios is likely to be realized. We will place particular emphasis on the role of government policies. The first scenario involves an expansion into the world market, i.e. a full export oriented strategy. The second scenario involves a much more limited production of CNC lathes and is aimed primarily at the regional markets.

### 5.1. The full export oriented strategy

We will first discuss three basic conditions for a successful move into the production of CNC lathes for this particular firm. The three conditions are partly determined by the international market and can thus be generalized to other NICs.

#### 5.1.1. Scale of operation and specialization

As was noted in section 2, the scale of operation of the largest Japanese firms has increased drastically during the past five years. Hence, also in this traditionally batch producing branch, there is now a move towards mass production principles. In order to assess the scale and specialization advantages involved in the manufacturing of CNC lathes, and hence assess this barrier to entry for a new firm, an analysis was made together with a representative from the Argentinian firm. [33]

Table 12 gives an account of an estimation of a) advantages from speciali-

zation and b) scale advantages in the firm. The table shows that if production is increased from a few CNC lathes per month to about thirty per month, production costs could be reduced by 25% per unit of output. A little more than a quarter of this reduction reflects the advantages from specialization.

Table 12 An estimation of advantages from specialization and scale in an Argentinian firm producing CNC lathes %

| | (1) | (2) | (3) |
|---|---|---|---|
| Materials | 100 | 100 | 85 |
| Capital | 100 | 82 | 51 |
| Labour | 100 | 76 | 60 |
| Other | 100 | 100 | 75 |
| Total | 100 | 93 | 75 |

(1) Mixed output including a few CNC lathes per month.
(2) Specialization in CNC lathes. The data reveals only specialization effects.
(3) Specialized production of 30 CNC lathes per month. The data includes both advantages from specialization and scale advantages.

Source: Elaboration on data supplied by the firm

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Advantages from specialization only arise from a) as, since a CNC lathe contains less moving parts than a conventional lathe, the light machinery section in the firm could be reduced. This is particularly important in a developing country which does not have an adequate component industry. This

lack of 'back up industry' has meant that the firm itself has had to produce a range of components which an European firm would have bought from a specialized producer. The result in Argentina has been a low machine utilization and therefore high costs. Most of this section can now be eliminated. b) A reduction in the cost of some special equipment related to the large number of models can now be reduced to half. c) A reduction in the large number of production engineering staff who plan a very diversified production mix. d) a reduction in the number of workers.

The sources of scale advantages are as follows: discounts for materials, fixed costs for buildings and inventories as well as increased machine utilization via shift work, fixed costs for design and development as well as for production engineering, fixed costs in administration and some fixed costs for electricity etc. We can see their relative importance in table 13.

Table 13 Sources of scale advantages with a production of 30 CNC lathes per month in an Argentinian firm

| Source | % |
|---|---|
| Materials | 53 |
| Capital | 30 |
| White collar workers | 14 |
| Other | 3 |
| | 100 |

Source: as in table 6

Discounts for materials is by far the most important source of scale advantages (53%) and it should be remembered that only a 15% discount was

assumed to exist when 30 units are produced per month. This is reflected in the cost structure with a production of 30 units per month. In table 14, we can see that materials now constitute 72% of the costs. Any further reduction of the price of these would be far more important than any marginal changes in the other sources of costs, e.g. through the introduction of group technology in metal cutting. The second most important source of

Table 14 Cost structure (estimated) with a production of 30 CNC lathes per month in an Argentinian firm

| Item | % |
|---|---|
| Materials | 72 |
| Capital | 13 |
| Labour | 13 |
| Other | 2 |
| | 100 |

Source: as in table 6

scale advantage is the use of fixed capital (30%) and interestingly, scale advantages arising from indivisibilities in R&D and production planning constitutes only 14%.

The first conclusion to be drawn from this is that a basic requirement for a newcomer into the CNC lathe field is to acquire good relations with component suppliers, in particular the suppliers of the NC unit and the electrical parts, which constitute the lions share of the materials bought in.

The second conclusion is that the scale advantages are so great that it is now no longer possible for an entrant in a free trade economy to initiate production in small quantitites and gradually increase the share of CNC lathes in the total production, as has been the policy of this particular firm. Specialization and large scale production is now a must. It should be stressed that the scale advantages indicated in table 18 do not end at a production of 25 to 30 units per month. For example, obtaining a 30% discount for the materials would reduce production costs to 65% instead of 75% of the production costs in the case of very small scale production. In terms of prices we can also see that attaining the scale advantages which are possible with a production of 30 units per month is indispensible for market success. Whilst a detailed account of the prices is not possible for reasons of confidentiality, it

was estimated that, given a government export rebate of 25% of the FoB price, a selling price in Europe or the U.S. of around 85,000 dollars is not unrealistic. This should be compared with Japanese prices of around 100,000 dollars and Taiwanese prices of around 75,000 dollars. Hence, the firm should be well below the Japanese prices, even though the product would be of inferior standard. An indispensible condition for success is to be able to compete pricewise with the Japanese.

5.1.2. Pricing policy

As noted in section 4.2., the firm today has a structure of skills and production which reflects a strategy of diversification of production, aimed primarily at the local market. In a climate of free trade, the firm would have to specialize production and associated with this, change the structure of skills. This means, for example, to increase the number of skilled assembly workers. In the production of CNC lathes, assembly is relatively more important than metal cutting whilst the opposite is the case in the production of standard lathes. The readjustment will take a minimum of 2 to three years,as, for example, skilled assembly workers in this particular field do not exist in Argentina. Hence, it will take a minimum of two years before the level of production can be increased to 30 units per month. Meanwhile, the firm has to compete with the Japanese and others. As the firm is a newcomer in the market, low price will have to be the base of its competitive strength. This means that the CNC lathes will need to be priced somewhere near to their long run average cost, which means an initial loss until full scale advantages can be reaped.

5.1.3. Design concept

In section 2.1.3 we suggested that a part of the explanation for the sucess of the Japanese is that they have widened the spectrum of CNC lathes in terms of size, performance and quality. A new entrant, which does not have the capability to produce very complex and/or custom designed machines, will have to, so to speak, follow in the breach that the Japanese have opened. This means producing a CNC lathe which is very simple and cheap. To compete via licensing of an 'old' design originating in, say Northern Europe, would be fruitless.

To sum up; there are three basic conditions which will have to be ful-

filled if the firm is to have a chance of succeeding. These are: achieving a high level of production through specialization, pricing close to long run average costs and acquiring 'low cost' designs.

### 5.1.4. Effects on the structure of the firm

The fulfillment of a strategy which satisfies these three basic conditions would require a dramatic shift in the types of markets the firm would penetrate, the size of its operations and the type of products it would produce.

a) With the recent Argentinian policy of tariff reduction in most of the engineering sector, the firm's position has changed from being the leader in a closed home market to being a very small firm facing international competition. The requirement of obtaining scale advantages in order to survive international competition means that the firm cannot continue its diversification strategy but has to specialize and produce on a large scale. In section 3.1. , we estimated the maximum potential market in Argentina to be 90 CNC lathes per annum. This limited home market, in relation to the mininum efficient scale of production , means that the firm will have to sell the vast majority of its production on the external markets.

b) The firm therefore needs an established marketing and service network abroad. This is exceptionally important in the machine tool industry.

c) To produce on a large scale, a lot of capital is needed. The capital for work in progress alone would perhaps amount to seven million dollars per year (were the firm to produce 30 units per month) which is roughly the size of its annual sales today. The firm will therefore need capital which it cannot get in Argentina at the moment due to the exceptionally high interest rates.

d) The firm also needs technical information due to its, internationally speaking, weak design department.

e) Due to the present Argentinian economic crisis, the firm will have to initiate an export oriented production very quickly in order to survive. Hence, time is a very important variable.

The magnitude of this transformation and the speed at which it would have to take place suggests that the firm cannot do it alone. One option for the firm would be to collaborate with a firm based in a developed country. Such collaborations are common in other branches where foreign firms provide designs and capital. Another possibility would be that the firm restructures within the framework of an Argentinian industrial policy programme. A transformation of the kind indicated above is frequently associated with government interventions in the developed countries.

### 5.1.5. Collaboration with a foreign firm

We shall below deal first with the option of collaborating with a firm based in a developed country. Then we will briefly review some common reasons for state intervention and thereafter discuss the particular case of the Argentinian government.

The reasons for collaborating with a foreign firm would be threefold: the need for risk capital, technical information and a marketing network. One possible strategy for the firm would then be, at least in the short term to acquire a licence and with it some risk capital and access to a marketing network. In other words, it would involve a relocation of production to a peripheral country (seen from the point of view of the developed country firm) under the control of the foreign firm. The central element would be the licence. Let us elaborate on the possibility of such an agreement.

For a licensor, there are two reasons for being interested in selling a licence to the Argentinian firm. Firstly, to get access to the Argentinian and the Brazilian markets. The Argentinian and Brazilian governments agreed recently on a Brazilian reduction in tariffs to 5% on CNC lathes; it is far higher for imports from other countries. As the Brazilian intensity in use of CNC lathes is far behind that of Argentina,[34] a low cost lathe, imported from Argentina should have a substantial Brazilian market, apart from the more marginal local market. This could of course be a sufficient motive for a foreign firm to sell a licence as Pontiggia, the largest Italian lathe producer which is one of the few successful European competitors to the Japanese, has done to a Brazilian firm. However, the limited size of the local markets would seem insufficient to justify the relatively large input of capital that would be needed for the reorganisation and running of the firm. Hence, a possible

licence from a foreign firm would have to be combined with another source of finance.

The second reason for a foreign firm to be interested in a collaboration would be that it believes that the Argentinian firm could produce at a lower cost than the licensor. There does seem to exist a view in some firms [35] that a localization of production in a peripheral country could have this effect. However, the data on the cost structure in table 6 makes it difficult to understand such a view. The only sources of a comparative advantage that a peripheral firm would have would be a) lower direct labour costs, which account for about 11% of the production costs in an advanced country like Sweden, b) a skilled labour force which is willing to work shifts, i.e. increase machine utilization and c) government incentives, e.g. the 25% export rebate.

To base a long term investment decision on these three factors would however seem very unlikely. Firstly, technical change is now on the verge of allowing for a 24 hour run of the capital stock with the aid of very few direct workers.This involves the development of different automatic feeding mechanisms and material handling systems. Secondly, the export rebate could easily be scrapped. Hence, that leaves lower direct labour costs and a risky rebate as reasons for a large scale capital investment. On the negative side there are all the risks of investing in a peripheral country as well as high prices of domestically produced materials (at least in the Argentinian case) and the need to have larger stocks due to uncertain deliveries of imported components. All in all, whilst the production costs would probably be slightly lower in Argentina than in an advanced country, the cost reduction would not justify the magnitude of the investment required. This is all the more clear when we realize that a decision to locate production in a peripheral country would be part of a strategy to combat the Japanese.The maximum cost reductions attainable in Argentina would not go very far in breaching the gap to the Japanese.In this particular branch there is not such a simple solution to the problems faced by the European and U.S. producers. We would therefore suggest that the possibility that a foreign firm would participate in financing a strategy based on exports to the industrialized world is very small.

What about the possibility of reorganising within the framework of an Argentinian industrial policy? First we will discuss some common reasons for

state intervention.

### 5.1.6. Intervention and the role of the Argentinian government

In the literature, we may find a whole set of suggestions as to the correctness of some form of government intervention in a market economy for the purpose of generating technological capabilities. Some relevant ones are summarized as follows.

(1) Externalities pose a general problem in the allocation of resources to in-house R&D activities in a market economy. Firstly, the increasing social division of labour may mean that the benefits in the form of 'learning by doing' resulting from investment activity accrues in the form of externalities.[36] For example, the increased social division of labour in the capital goods sector has led to the emergence of specialised engineering forms for the design, construction and commission of plants. The benefits from the increased efficiency in the operation of these firms, due to accumulated working experience do not accrue to the investing firm but to the future customers of the engineering firm. The investing firm will though have to pay for the costs of the learning in terms of less proficient designs etc. This suboptimality problem did also exist in the developed countries as they industrialized, as it does in any market economy, but the point is that today's developing countries do have an alternative to the development of indigeneous skills, namely experienced firms from the developed countries. The products and services of these firms are then rationally chosen by an investing firm in a develping country. This means that engineering firms, as well as capital goods producers in the developing countries which participate in the international market economy, will face a less than socially optimal demand, if any, for their products and services. In our particular case, the experience acquired in designing and producing copying lathes, behind tariff barriers, was fundamental in the process of generating the competence required to design and produce the CNC lathes. It is thus a very good example of this general thesis.

Secondly, technical solutions arising from investment in R&D may be difficult to appropriate.

Thirdly, people are mobile and as skills are human embodied, the increased capabilities which arise as a by-product of design activities may benefit other firms.

Fourthly, as was suggested in section 2.1.2. , there may be important inter industry links in the innovative process, indicating that externalities may be central to some innovative processes.

(2) In-house R&D activities in locally owned or managed firms in developing countries may be smaller than socially desirable for several other reasons. Firstly, we have the common reason that the private discount rate is higher than the social. This is accentuated by the inherently very long learning times in the capital goods sector. Secondly, these reasons may be enhanced by the existence of multinational companies whose often strong competitive power may induce local firms to discount future benefits still more heavily. A perceived very rapid technical change may have the same effect. This implies that the generation of both the technical solutions and the increased capability to provide further solutions, which arise as a by-product of design activities, will be suboptimal from the point of view of the society.

For our particular case, historically speaking, an externality of important dimension has been that associated with a gradual creation of design skills via the gradual increase in complexity of the products designed and produced, i.e. the demand from one firm, e.g. a motor car company for a revolver lathe, helped the firm to generate the skills needed to design the CNC lathe which is sold to a range of firms other than the motor car firm.

When we discuss future strategies, externalities are however of less importance. The only type of importance is the correlation between the existence of local firms producing CNC lathes and the speed of diffusion of this technique. The basis for such an externality would be that the local firm would have a greater incentive to diffuse information to the local market than would a foreign based firm.

The biggest issue for the firm today is however the availability of capital. The firm needs capital to finance a) the transition to large scale and specialized production, b) a price policy enabling it to gain market shares abroad, c) work in progress which will be dramatically higher than before and d) a long term improvement in its design skills. Some of this capital would be risk capital as (i) an export oriented strategy would imply exporting close to 90% of the production, which is exceptionally high, (ii) the penetration of external markets would require a very long term view, and therefore risky, of profits, and (iii) the firm perceives very high risks in continuing

its self reliance strategy in design due to the recent fast technical change in CNC lathes. For it to design a long term strategy of self reliance, some form of risk capital is clearly required.

It would therefore be theoretically correct to say that a governement intervention to provide various types of capital is justified. However, the main factor affecting the future of the firm is the exorbitant interest rates which are the deliberate creation of several monetarist governments in Argentina. Concerning risk capital, the argument for intervention rests on the assumption that the state's discount rate is lower than the firm's, i.e. that the state has a longer term view of technological development than the firm. It is however very difficult in this particular circumstance to claim that this is the case. Of course, one could argue that a government should have a long term view of capability generation. However, the implicit discount rate revealed by the government's industrial policy is clearly higher than the firm's. In other words, recent governments' policies reveal such an exceptional bias against the local production of capital goods that, assuming reasonably informed officials, one cannot but conclude that the state sees no value in establishing a long term creation of technological capabilities.

For governments,though, that are interested in such positive interventions, it is justified to discuss how an intervention should be carried out.

The debate on infant industries has centered on the issues as to whether protectionist policies are required and if so, to what extent and for how long. Concerning the former question, there are, as we have seen, many causes for sub-optimality. However, it is very difficult to conclude from those that tariff protection and not other means should be applied to correct the discrepancies between private and social profitability. The problem with tariff protection is that there is no direct link between the intervention and the type of result that one wants to achieve, e.g. improved design skills. Indeed, whilst there is no doubt that protection has been associated with capability generation, there is really nothing to indicate that it is the best way to create these capabilities.

The only argument that one can suggest in favour of tariff protection is that during an initial period of industrialization, the perceived risks of establishing new activities may be so great that nobody starts any even if there are long term benefits associated with the activity.

Concerning the problem of the design of a protectionist policy, Corden, amongst others, writes:[37]

> "The essential idea of uniformity is that the same rates of protection be provided for all investment activites in manufacturing so that there is no discimination other than which comes naturally out of the price system. Thus, as far as possible, the principle of comparative advantage is applied" (our emphasis)

Hence, a 'neutral' protection is favoured. However, the question is; neutral in relation to what? As the basis for protection is that it takes time to learn the basis of an industrial activity, the reference point in designing a protectionist system must be the 'learning time' required in different industries. That is, if we compare the learning time in the production (assembly) of home electronics with the production of machine tools, we will most certainly find that the latter is far longer. Hence, a uniform protection policy which would constitute some form of average between the two would be very disciminating against machine tools. Hence, branch or product specific intervention is clearly to be preferred.

Given that differential rates of protection are required, the next question is how long should it continue? In this particular case, roughly ten years would have been an appropriate period of protection. We saw however in section 4.2. that the protectionist policy was not discontinued thereafter and the consequences it had for the firm. Today, there is a strong pressure from Argentinian industry to go back to the pre 1976 very high levels of protection and the firm has applied for, and will probably receive, a 35% nominal rate of protection on CNC lathes. For the firm, such protection would practically make it a monopolist on the market for the less complex CNC lathes, and it would be able to acquire profits to finance an export drive. For exactly this reason, it would seem tempting to recommend protection. However, as we are now talking about the development of specific skills and a specific reorganisation of the firm instead of the creation of general skills, it would be more appropriate to directly subsidize these activities by providing capital with low interest rate.

There are two reasons for choosing a subsidy instead of protection. Firstly, a tariff would perhaps result in a reorganisation of the firm, but would not necessarily have this effect. This could though be secured by including a clause ensuring that the tariff was linked to the firm's achievement of

specific goals. The most important reason for choosing a subsidy though, is that any tariff on CNC lathes would increase the cost of capital and hence reduce the rate of diffusion of new technology in the whole engineering sector. As machine tools are the bearers of much of the new technology in metal working, it is dangerous for any economy to impede the flow of imports. In other words, it is better to pay subsidies directly to the local firm producing CNC lathes than let the metal working sector pay for all the CNC lathes the firm does not sell.

To conclude, the most important factor determining the firm's continuity in building technological capabilities through taking the step into the specialized production of CNC lathes is the availability of capital at a reasonable cost as well as a large amount of risk capital. We have also argued that there is no basis for state intervention judging from the present and recent Argentinian governments' revealed objective function.

The government is however not a logical entity as it continues with its predecessor's policy of paying a 25% rebate on the FoB price of exported machine tools. This rebate is fundamental in creating price competitiveness for the firm in export markets, in both the short and medium term . Some of the rebate can be seen as a compensation for the high domestic costs of materials, such as steel, but the greater part of it is a pure export subsidy. The subsidy would, in the case of a production of 30 units per month, amount to an equivalent of half the local content of production costs (excluding profits of the firm). This is, of course, a very large subsidy. However, if we compare it with the magnitude of the scale economies in materials alone, the attainment of maximum (30%) discounts would imply a sum equivalent to half of this very large rebate. Hence, the export subsidy compensates for the high domestic raw material prices and most importantly, as there are large scale advantages, it permits a pricing of the CNC lathes which is closer to its long run average costs. This effect is, however, created more by chance than by design. Hence, the state finances roughly the difference between the production costs today and the longrun average production costs.

To some extent, the export subsidy takes care of the problem of risk capital; that is the capital associated with pursuing a marketing policy with a very long term view on profits. However, it is conducive only to <u>production</u> of CNC lathes and not to the local development of designs. Furthermore, it is not sufficient to solve the problem of working capital which is bound to

increase as production is specialized to CNC lathes and expanded to gain scale advantages. Hence, risk capital specifically supplied to ease these problems is required in addition to the export subsidy.

The firm cannot however count on an active government policy. It cannot either count on any large scale collaboration with a foreign firm. This means that the firm's option of an export oriented growth strategy is not a valid one. With a proper government policy since the early 1970s, a firm would have been created which would have penetrated foreign markets with parallel lathes and had close contact with product developments on the world market. The obstacles to a transformation would then have been much smaller. A large amount of capital would still have been needed though, so everything cannot be blaimed on inproper government policies. A large part of the problem has been caused by changes in the international structure of the CNC lathe branch. Unfortunately for the firm, both these factors work against its possibilities for success. Let us therefore turn to the second scenario; involving a penetration of the regional markets only.

5.2. The regional market strategy

As noted above, the Argentinian and Brazilian Governments agreed recently to reduce the tariffs on NCMTs to 5%, amongst other products. This is very important as the Brazilian tariff for other countries is prohibitive and Brazil's engineering sector is 3-4 times the size of Argentina's. In the absence of any large scale local producer in Brazil, the Brazilian market would seem to be very important for an Argentinian firm producing CNC lathes. The size of the market is however today rather limited - only about 200 CNC lathes are installed in Brazil.[38] Even though one would expect the size of the market to increase with the introduction of a CNC lathe priced not far above the international price, the total market of Argentina and Brazil would be below the required minimum level of production for one firm, given free trade.

However, with the Brazilian tariff policy, which is not likely to be changed due to Brazil's severe balance of payment problem, and the likelihood of an Argentinian tariff of 35% on CNC lathes, the price of imported CNC lathes will be much higher than the international price. This means that for domestic producers, the minimum efficient scale of production will decrease substantially. Hence, in a world of tariffs, 300 units per year can be substantially reduced.

A strategy aiming at mainly penetrating the local markets would therefore put less pressure on the firm to drastically increase the volume of output. This implies that the capital requirements would also be reduced as less capital for work in progress would be required. Furthermore, as the firm has sold a fair number of conventional lathes to Brazil, the problem of a marketing network would not be so great. This means that the need for collaborating with a foreign firm would be less than in the case of the full scale export strategy. However, given that no capital will be available from the Argentinian side, and that a fast drive to exploit the dormant Brazilian market would require some extra capital, a collaboration agreement would still be of interest to the Argentinian firm. This would be strengthened by the need for technical information even though this too would be less accentuated if it were to compete on the relatively unsophisticated Brazilian market.

A further reason in favour of licensing, in this scenario, is that it may reduce the price of the components. In one case, a firm who has a licence from a large Italian firm receives a 20% discount on all the electrical and electronic components which it is forced to buy from the Italian firm. This firm, in turn, has a 30% discount from the producer of the components and makes a nice profit from the 10% differential. For a firm beginning to produce CNC lathes, an agreement of this kind is most advantageous as an important source of scale advantages, and thus barrier to entry, lies precisely in the discount on components. Hence, the need for a large scale production is considerably reduced with such an agreement.

The correct, and perhaps the only possible strategy for the firm would therefore be to pursue a short term strategy of licensing with its marketing efforts directed towards the regional markets. This would appear to be a viable alternative also as it seem reasonable to think that a foreign firm would be interested in supplying a design and limited financial assistance for the exploitation of the regional markets in Latin America. However, we should keep in mind that we are not dealing with a free trade world and that the success of a strategy aimed at exploiting only the regional markets is profoundly dependent on the existence of tariffs or other trade barriers.

Given that licensing ought to be a part of the firm's short term strategy, the question remain to be answered is licence from whom? Two conditions must be met by the licensor; firstly, it has to have a production of CNC lathes which is so large that they receive the maximum discount possible. This will , in turn, permit the licensee to receive some of that discount. Secondly, it has to produce a smaller and cheaper CNC lathe which is designed for mass markets. Only producers from two countries fulfill these conditions; Japan and Italy. As the largest Brazilian firm of machine tools, which is now entering into production of CNC lathes, has reached a licence agreement with the most successful Italian producer, it appears as a competitor ought to go for the Japanese. As is evidenced by the Taiwanese experience, there are Japanese firms which are quite prepared to license their designs for the exploitiation of local markets. [39]

5.3. The long run case

What about in the long run? Should the firm limit itself to producing for the regional markets and should it depend on the availability of foreign licences for its technical achievements?

The most important question to answer is whether or not they will be able to compete with the Japanese. In the short run, we would say no, but in the long run there are a number of relevant observations to be made. Firstly, the market for CNC lathes is expanding rapidly and there is no reason why it should be saturated within the next five to ten years. Particularly not if the diversification process of CNC lathes designs continues, creating cheaper and simpler designs. Conversely, the market for standard lathes is expected to decrease even more. Secondly, the Japanese are likely to move into the production of more sophisticated products since they have penetrated large parts of the markets for the cheaper CNC lathes, rather than designing even simpler CNC lathes. They are also more likely to move into the development of production systems. Today, they are in fact putting a lot of emphasis into developing a) robotics b) a production capacity in machining centers which is a combined milling, drilling and boring machine. Together with CNC lathes and robotics, they will then have the key parts of automated production systems in their hands.

Thirdly, technical change in terms of new low cost designs is probably slowing down and we will see a series of responses to the Japanese challenge which, if not copies, will be very similar in design concepts.

With relatively cheap and good engineers, a firm like the Argentinian one would be able to break into the market on the basis of good designs. A good design in this context is one which follows in the breach that the Japanese have opened and which puts at least as much emphasis on low cost and simplicity as the Japanese do. This would be particularly important for penetrating third world markets where users often do not have large amounts of capital and certainly less knowledge of advanced metalcutting techniques.

This takes us into the long run comparative advantage of the Argentinian firm. As we saw in earlier sections, its cheaper direct labour will provide only a marginal cost advantage which anyway may be swamped by other factors such as high material costs. Its only long run source of comparative advantage can be in a strong design team and not a dramatically lower cost of production.

Of course, a discussion of a long term comparative advantage assumes a free trade context. If we assume the continuation of tariff protection and access to the Brazilian markets, the firm would perceive much less need to continue to develop its own designs. Especially if a licence agreement was associated with access to low priced components. However, if the firm wants to move out of the regional context and penetrate the world market, it will need to continue to strengthen its design skills. Today, it has discontinued its design efforts and changed its philosophy to licensing. If this continues, the firm's strategies in the future will be limited to the regional markets and, hence, the future of CNC lathe production in Argentina will be dependent upon tariff protection of the Brazilian market. This is an unhappy decision for the Argentinian economy, but a reasonably rational one for the firm under the present circumstances. A proper government policy would include the support for a short term policy of licensing by the firm but a medium and long term policy of it developing its own designs. However, as we have seen , this is only a theoretical alternative.

6. Conclusions

At the global level, there is a strong trend towards substituting standard lathes by CNC lathes. Given the central role of the machine tool industry in the capital goods sector, we asked the question under what conditions a NIC based firm would be able to switch from the design and production of standard lathes to CNC lathes.

From the above, it is clear that very drastic changes have occurred since 1975/76 when micro electronic control units were introduced. The most important single factor is that the barriers to entry in the form of minimum efficient scale of production have increased dramatically. This is partly a reflection of the maturity of the product; it is now going into the mass production stage. Associated with the move towards mass production is a widening of the spectrum of designs as well as a standardization of the electronic control units so that any producer of a standard CNC lathe can buy in that component without any large problems. Both these aspects benefit firms in the NICs. However, the large minimum efficient scale of production as well as increased design skill requirements means that for individual small firms to take the step into design and production of CNC lathes, some sort of active government policy is acutely needed. The purpose of goverment intervention would basically be to reduce the risks involved in a larger transition.

The developed countries' governments are very much involved in such intervention programmes and if the NIC Governments do not respond, the possibilities for a successful production of CNC lathes in the NICs will be greatly reduced. In other words, if the technological gap is not to increase in the production of machine tools, specific government involvement is needed in the NICs.

In the case of Argentina, the government has not been willing to provide this support. The possibilities for the leading Argentinian lathe producer to successfully take the step into the design and production of CNC lathes has been further reduced by inappropriate government policies of indiscriminate

protection over the past ten years. This has, in combination with a small local market, created a structure of the firm which is not conducive to a rapid shift to CNC lathes. Future CNC lathe production in Argentina is therefore dependent on the existence of low tariff barriers for export to the Brazilian market from Argentina, but high tariffs for exports from other countries. This is, of course, an exceptionally feeble basis for the future. Without government intervention, one could then conclude that the substitution of CNC lathes for standard lathes at the world level, combined with the trade and industrial policies of recent and present Argentinian governments will probably lead to the destruction of its best firm in the metal cutting machine tool area, as well as a waste of 20 years of capability generation, for which the Argentinian metal working sector has paid very dearly.

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33. I am most grateful to Ingeniero A Castaño for all the time he devoted to discussions as well as for the interest he took in my project.

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## APPENDIX

### Method in estimating the potential for NC lathes in Argentina

The size of the market for NC lathes in any economy is a function of a) the economic profitability of the technology in comparison with conventional machine tools and b) the number of times this choice is made, i.e. the size of the industrial branches which can use NC lathes as a part of their production process. It has been shown that NC technology reflects a technical change which is at least as advantageous to the NICs as to the developed countries. This was based on the assumption that metal working skills are scarcer in the NICs than in the developed countries. Given that a greater scarcity does not always mean a higher salary, it is relevant to ask if the micro economic choice of technique would be the same in a NIC as in, say, Sweden. An analysis of the Argentinian case, using Argentinian cost data suggests that for all non extreme situations, such as 30% real interest rate, the micro economic choice of technique is very similar for Sweden, an advanced country, and Argentina, which may be said to represent a NIC.

The size of the market depends then on the magnitude of the relevant branches which can use NC lathes in their production process. Hence, when discussing the size of the market in any country, it is vital to analyse the structure of the engineering sector

To understand the differences in use of NC lathes by branch, the diffusion pattern in Sweden was studied at the four and five digit level. The data refer to 1976. It was found that eight subsectors contained 85% of the NC lathes. These are: Tools and Implements (3811); Engines & Turbines (3821); Agricultural Machinery (3822); Metal and Wood Working Machinery (3823); Special Industrial Machinery (3824); Other non-Electrical Machinery (3829); Electrical Machinery (3831) and Automobile Parts (38432). Hence, it is the size and growth pattern of these eight branches which are of interest to us in determining the relationship between industrial structure and the market for NC lathes.

In the Argentinian case, data from INDEC shows that, using a moving average, the importance of these eight branches grew from 26.7% to 37.6% of the value of production in the engineering sector during the 1970's. The data also shows that three of the fastest growing branches were; special industrial machinery (3823), other non electrical machinery (38299), and car components (38432). These three branches contained 61% of the NC lathes in Sweden in 1976. Furthermore, they show the highest intensity in use of NC lathes in Sweden in 1976. Hence, there has been a change in the structure of the Argentinian engineering sector which appears to be conducive to the demand for NC lathes. We have to still keep in mind though the relatively small absolute level of production in Argentina. It was estimated that the value of output in the eight relevant branches amounted to only 2.5 billion dollars in 1977/78 whilst in the case of Sweden, the equivalent figure was over seven billions in the same year.

The method used to estimate the potential demand for NC lathes is a simple one. It is assumed that the variations in intensity in use of NC lathes between branches reflect their different technical characteristics of production. For example, special industrial machinery, which has one of the highest intensities in the use of NC lathes, contains more batch production and more metal cutting than the production of office machinery. We furthermore assume that the content of production at the four and five digit levels is roughly the same in Sweden and Argentina. This is a much more difficult assumption to make as the heterogeneity of products is very large in the metal working sector. There is however no way that this assumption can be tested with the poor data base in Argentina.

After calculating the estimated sales value in Argentina in 1977/78, we multiply this at four and five digit level with the intensity figures of NC lathes in Sweden in mid 1976. This '1976 potential' can be seen in table 1.

The eight branches in table 1 accounted for 85% of the NC lathes in Sweden in 1976. Hence, we need to add 15% if we are to get a correct estimate. The total potential would then be 227 NC lathes. However, the total stock of NCMTs increased from 2,100 in mid 1976 to 3,900 in 1979. Today, it is surely more than 4,200. Hence, if we assume that the proportion of NC lathes to all NCMTs is the same as in 1976, we need to double the 1976 potential in order to acquire a correct estimate of the '1981' potential for Argentina. This would be around 454 NC lathes.

Table 1 The '1976 potential' for NC lathes in Argentina

| Branch (ISIC) | '1976 potential' | Actual stock** |
|---|---|---|
| 3811 | 3 | 31 |
| 3821* | 6 | 7 |
| 3822 | 28 | 1 |
| 3823/4 | 54 | 23 |
| 38299 | 23 | 46 |
| 3831 | 13 | 1 |
| 38432 | 72 | 43 |
| Total | 193 | 152 |

* U.K. data

** I have assumed that the NC lathes for which I have no information on branch distribution are distributed in the same way as the ones for which I have information.

Source: Survey by the author and elaboration on H. Sten: Rapporter från Sveriges Mekanförbund 10.8.76, 21.10.76, 8.9.77

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Hence, in order to reach the same intensity in use of NC lathes as in Sweden in 1981, the total number of NC lathes would need to be 454. In this exercise we have used the level of sales in 1977/78 in Argentina as the denominator. If the economy expands, we would need to add a given number of new NC lathes to the potential. In table 2 we can see one way of estimating the demand for NC lathes during the following five year period. We differentiate between NC lathes sold to realize the given potential and new potential as a result from an expansion of the sales in these eight branches. We assume in this example that the realization potential is reached in five years and that there is a continuation of the historical growth rate of 5.9% in the eight branches concerned.

The limitations of such a mechanistic analysis are many. First of all we need to remember the assumptions made. Secondly, the peculiarities of the Argentinian situation should be borne in mind. For example, the economy is very erratic, in addition to being a very small market. There is therefore