User industry and accumulation of technological capabilities of producers-Findings from the Korean machine tool industry

Keywords: East Asia, Korea, Industrialisation, Innovation Systems, Capital goods, Technological Capability

Summary

This study reveals that the user industry has a limited role as a source of technological capability in the case of the machine tools in Korea where the user industry is relatively more advanced than other capital goods industry. The study examined the sources of technological capability in terms of migration of workforces and flow of product design information. Although the capital goods sector is generally regarded as being the sector where the user producer interaction is important, the user industry failed to be the seed-bed of technological capability to develop machines. This study argues that this finding could have implications to the specificity of capital goods in a developing country.

INTRODUCTION

This study is aimed at finding an empirical basis for a deeper understanding of the users' role to producers in the accumulation of the technological capability of a capital goods industry in a developing country in its period of rapid "catching up."

The discussion on the user-producer relationship in the "catching up" period has been poorly developed, as Rosenberg's (1976) comments on the user-producer relationship show

> *From this perspective, some of my concerns about the prospects for poor countries which rely on the importation of foreign capital equipment are obvious. But if new techniques are regularly transferred from industrial countries, how will the learning process in the design and the production of capital goods take place? In the past, as I have argued, the appropriate skills were acquired through an intimate association between the user and the producer of capital goods. In the absence of these experiences, what substitute mechanisms or institutions can be established to provide the necessary skills?*
> Rosenberg (1976, 166)

The topic of this study is in line with Rosenberg's discussion. This study is interested in the 'association between the user and the producer of capital goods' in the dynamic accumulation of technological capability in a rapid catching up country.

In advanced countries, there has been increasing interest focused on the micro level and meso level dynamics of innovation in the studies of technical change. Lundvall (1985, 1988, 1992) emphasised the user-producer relationship as the basis of systems of innovation that span the micro and meso level dynamics of innovation. According to Lundvall (1992), the user-producer relationship includes communication of information, co-operation, power, hierarchy, loyalty and mutual respect and trust. The most basic function of the user-producer relationships is to communicate information both about technological opportunities and user needs (Lundvall 1992, 51).

To expand a little about user needs, such information can be more than 'apprehension of a need.' The study by von Hippel (1978; 255) of the active role of users in innovation, the *customer active paradigm*, argues that users' needs, or requests, that are passed to producers, include apprehension of a need, determination of a solution type, development of product functional specifications, development of product design specifications and complete product design.[1] Von Hippel's (1978) argument is different from that of Meadows (1969), Peplow (1960), Utterback (1971), Berger (1975) and Boyden (1976) in that in his view user needs include information on design: design specifications and complete product design. In the case of the most active role of users' innovation, user needs are expressed through the development of improved, sometimes radical, production equipment. Also he found that in the case of the semiconductor industry, 71% of the sixteen major process machinery innovations were made by users (von Hippel 1988, 22). These are mostly advanced users who have been active in innovation activities. Echoing von Hippel's work, there is other work on the users' role in innovation activities by Foxall (1986, 1989), von Hippel (1988), Cassiolato (1992), Leonard-Barton and Sinha (1993), Lee (1996) and Ogawa (1998).

To summarise the literature mentioned so far,[2] information on users' needs, passed to producers, not only includes 'apprehension of a need' but also product design.

If users are capable of product designing and transferring product design information to producers, users could be influential in supporting producers' learning to develop a product. If this happens in a developing country, this implies that users' information could be useful for enhancing technological capability of producers who are weak in their product development capability.

In addition, users could support producers' accumulation of technological capability in other aspect. User firms, which have accumulated experience of developing their own production equipment, could have nurtured workforces who are able to design and develop a new machine. If these workforces move to machine producers, producers' technological capability could be enhanced.

In relation to this aspect, there are a number of studies relevant to the flow of workforce in advanced countries. The study by Rosenberg (1976) shows that users developed original machine tools (MT) and entered into production of machine tools (MTs) by setting up MT companies through a process of *vertical disintegration*. Similar aspects were observed by Lee(1993) in his study on Japanese MTs. These are studies that show the migration of workforces from machine user firms to machine producer firms through user entry.[3]

In developing countries, there are a number of studies that discusses the role of users as a seed-bed of technological capability. The following literature indicates that user firms nurture the technological capability to produce capital goods and enter into production of capital goods either by widening their business area[4] or by setting up a spin-off company. Berlinski (1982, 27) said that 'As a rule, the domestic firms began their activities in metal-working by copying simple models of imported products which frequently were at hand in their own plants and with which they are familiar due to its use in the production.' This shows that user factories nurture the technological capability to produce production equipment Leff (1968, 10) mentions the entry of a repair shop into machine production. Chudnovsky and Nagao (1983, 39) mention

the metal working shop which entered into machinery equipment production from its experience of using the machinery. Albin and Katz (1987, 460) show the entry of a baking firm into production of a baking machine. Dahlman et al. (1987, 766) mention the glass-making machinery firm which grew out of a machine shop producing spares. Lall (1987, 63) gives an example of a cement producer who set up a cement equipment production firm from its experience in maintaining cement plants. Dahlman and Fonseca (Dahlman & Fonseca 1987, 164-5) cite the spin-off case of USIMEC, which is the subsidiary capital goods producer from USIMINA's steel plant.

In addition to the above mentioned literature, literature on industrial growth in the developing country provides hints at the role of users as firms nurturing the technological capability to produce machines. The existing literature reveals that the user in the developing country accumulates technological capability through experience of operating, modifying and assimilating imported technology (Lall 1980; Kim 1980; Dahlman and Westphal 1981; Lee et al. 1988). These stage models describe stages of assimilation of imported technology. Imported technology not only includes the technology of final products but also the technology of capital goods. Therefore, to be more specific about the accumulation of technological capability of the capital goods in developing countries, the stage of assimilation of foreign technology can be described as: importation of capital goods, learning to operate the imported capital goods, learning to modify them and, finally, learning to produce the original capital goods. If similar stages were implemented in the user industry, user firms would reach the stage of producing production equipment through learning by using. Therefore, it can be conjectured that the user industry could be a seedbed of technological capability.

Based on the discussions in the literature discussed, this study is designed to look at the role of users of a capital goods industry in transferring technological capability which includes migration of workforce and transfer of product design information.

This study is going to investigate the role of users in the context of a country where user industries have been revealing fast growth of production and have been accumulating technological capability dynamically. In comparison with other Asian NICs, Korea has relatively well-developed related industries in the capital goods sector, including user industries. (see the following section). Over the past two decades, Korea has achieved a substantial accumulation of technological capabilities in the capital goods sector. According to US patent data, the number of the application of Korean application in 'machinery, except electrical (SIC 35)' was 4 in 1983 and the number of all applications before 1983 was 25. In 1994, it goes up to 235 (US Department of Commerce 1998).

The following section discusses the research method for examining the role of users in relation to producers for empirical analysis.

2 RESEARCH SETTING

This study selected the MT industry, for a case study, which is presumed to have been close to the user industries that have been driving industrial growth. The MT is crucially important for improving productivity in the machining processes in the export sector. The Korean MT industry's user industries are key export sectors, such as automobiles, electronics and the shipbuilding industry. Export from automobile and electronics industries in Korea have been rapidly growing and therefore driving industrial growth and, since the 1980s, have occupied a place on the world market.[5]

In examining the user-producer relationship, this research is designed to answer the role of the user industry in supporting producers' accumulation of technological capability in the period of rapid growth of the producer industry in a situation where the producer industry has grown alongside the growth of the user industry. Figure 1 depicts the rapid growth in domestic demand from the user industry.

This study is mainly directed towards the period between 1976 and 1994. In the Korean MT industry, this is the period

when the domestic MT industry accumulated technological capability dynamically. In this period, accelerating growth of export and production a ong the logistic curve (see Figure 1)[6] and the accumulation of technological capability in terms of patent grants with a similar trend (Figure 2) were recorded. It also demonstrated its ability to produce more expensive machines and gained a higher domestic market share (see Figure 3).[7]

This stage is also the stage of the 'emergence of the capital goods sector and transformation into a key sector'[8] from the stage of the 'transition from primary and light-industry sectors to large-scale processing industries' according to Teubal's category of industrial growth.[9] In this period, the large-scale processing industries such as steel, automobiles, textiles and electronics emerged as 'important' industries. In the manufacturing sector (The Bank of Korea, 1997), the textile and leather industries occupy 10.5% of the whole manufacturing production in 1993, transport equipment accounts for 11.2%, the electronics industry 12.9% and the chemical industry 13.8%.

Theoretically this is the period when the Korean economy was in 'take off' stage and demonstrating an early 'drive to maturity' stage, when the gain of 'leading sectors' spread around the economy through forward and backward linkages. In the general machinery industry, domestic producers met 35.5% of domestic demand in 1980 and 58.8% of domestic demand in 1993 (KOSAMI 1995, 83) through backward linkages according to Rostow's terminology (Rostow 1960).[10] In this period, from the end of the 1980s, the capital goods and the components industry developed with the growth of the leading sectors such as steel, footwear, textile, automobile and electronics industries. In that period, GDP per capita grew from 802 $ (1976) to 8,508 $ (1994). This period overlaps with the period of Koreas' 'emergence as a Newly Industrialised Country' which is 1985-1995. (Krueger 1997)

In this period Korean cap tal goods sector emerged as a manufacturing sector which occupied a substantial proportion of the production of manufacturing sector. The production amount of the capital goods (except for automobiles and

shipbuilding) in 1993 occupies 7.8% of the manufacturing sector (Park 1997. 457) The proportion of production of the capital goods sector in the manufacturing sector is similar to that of advanced countries.[11]

In understanding the accumulation of technological capability of producers. the following conjecture is possible with respect to their relationship with users. In Korea, the machine user industry might have led the dynamic industrial growth of Korea through technological capability flows. The reasons to support this are that (i) Korea has advanced user industries such as automobiles and electronics; (ii) users have been active[12] in innovation activities (Lee 1993); (iii) If von Hippel's argument (1978, 1988) is true for the developing country, the user industry could have accumulated the capability to develop capital goods. In Korea, product development capability is the weakest when compared to the capability to set up, expand and operate a factory (Amsden 1983). If the user provided product designs including prototypes to producers, they would be an important source of information for the product development of producers. For all these reasons it can be conjectured that users might have filled the role of stimulating the accumulation of technological capability of producers by providing sources of information for enhancing technological capability needed to develop a machine.

In examining the technological capability flow, the focus is on the following points. First, this study examines the flow of design information in terms of the flow of information embodied in prototypes and disembodied in blue-prints and patents and the flow of information measured by the help received from the employees of user firms in the form of technical assistance. This flow of design information reveals spill-overs of technological capability which has been accumulated in user firms. Second, this study examines the flow of labour. The workforce embodies technological capability. The migration of the workforce from users to producers reflects the spill-over of technological capability accumulated in user firms. Firm level data were mainly collected from interviews and surveys of firms, which covered the major proportion of the industry. The survey questionnaire was mailed to those firms belonging to the trade association, the Korean Machine

Tool Manufacturer's Association (KOMMA 1994). They were sent to key engineers in the development of new products, after these individuals had been identified through telephone calls to the companies concerned. The key engineer is the engineer regarded as being central to the process of development of a new MT. It is usually the director of a development team or research laboratory or someone holding a position with main responsibility for product development process. The interviews covered 10 MT producers, including 5 major producers and 2 automobile producers. The interviews were planned to cover major large producers (5 out of 6 of the major producers) of MTs, and some small MT makers. The unit of analysis of technical change at firm level is product model change. In analysing firms, the unit of analysis of firm organisation was the division of a firm confined to MT production because firms[13] normally produce a range of various products. Industry level data were collected from literature surveys and statistical directories.

The response rate to the mailed out questionnaire was 38.1% (37 out of 97 firms). This sample covered 4 largest firms which produced 62.7 % of metal cutting MTs in 1993.[14] Metal cutting is the predominant industry in the MTs and occupies 80% of the production of the MTs according to 1992 statistics. Among small firms, 33 out of 91 belonging to the machine tool trade association responded to the questionnaire with a response rate of 36.7%. Therefore, these firms are presumed to be responsible for more than half of the total production of the MT industry.

Literature and documentary information were used to supplement the information collected at firm or industry level.

3 MAIN FINDINGS

This study examines the role of users in providing sources of technological capability to producers. The positive role of users can be expected where both users and producers are innovative. If domestic firms were not sufficiently innovative, this research would not be worth embarking on. As a starting point to the empirical investigation, this study examined whether domestic firms are sufficiently innovative.

Korean MT firms recorded a rapid growth in patents (see Figure 2). As a result of this rapid accumulation of technological capability, Korean MTs have been increasing their position in the domestic market, from 18.1% (1976) to 49.8% (1994) over 15 years. Korean MT makers are also capable of making original models.[15]

Although Korean MT firms are innovative, if user firms are not aggressive in innovation activities, the poor role of users can be expected. There have been innovative performances in user sectors in Korea. For example, the automobile industry, which ranked 14th in the total of U.S. patent applications (106) until 1996 for motor vehicles and motor vehicle equipment. This industry also occupied 3.2% of world market (1995). Korean automobile makers are capable of producing original car models and engines. They have the capability to manage the planning and establishment of production lines.[16] They are also capable of developing some production equipment. For example, Hyundai Automobiles developed its own transfer machine [the transfer machine for machining bearing caps] for the first time in 1983 (The Committee of Editing the 25 History of Hyundai Automobile 1992). It also developed various MTs.[17] All of this shows that both users and producers are innovative.

This study examines two aspects of the flow of technological capability, accumulated in users, to producers: the flow of labour and the flow of design information

A. FLOW of LABOUR

This section examines the flow of technological capability in terms of the flow of labour embodying knowledge. With accumulated knowledge to produce machines from their experience of use, users either transform themselves into producers or they permit their workforce to move to producers. This study regards both of these cases as exemplifying the flow of technological capability from users to producers because, from the perspective of industrial classification, they are movement of labour from the industrial sector, where machine is used, to the industrial sector, where machine is

produced.[18] With this influx of labour, the technological capability of the machine producing sector is enhanced.

This study examines the migration of the workforce from users to producers from four points of view: (i) the migration of the workforce of the automobile makers to producers; (ii) the migration of the workforce of users to all the surveyed user entry firms; (iii) the migration of the users' workforce to the major new entry firms in the 1980s and the 1990s ; (iv) the migration of key engineers from users to producers.

This study examines the migration of the workforce from the automobile industry because the automobile industry is one of the advanced user industries. The conjecture behind this examination is that the advanced user industry would have rich opportunities to accumulate knowledge to produce machines from their experience of use, repair and modification of imported advanced machines. The automobile industry is an advanced user industry because they employ the most sophisticated MTs and robots for metal working. The examination of the flow of the workforce of the automobile makers revealed that automobile makers are poor nurturers of knowledge to develop and produce machines.

In Korea, there are three large automobile makers, all of which have MT producers within their conglomerate group: *Chaebol*. These MT producers are among the five largest MT producers in Korea. This study examined whether these automobile makers provided MT producers with the workforce which accumulated knowledge to develop MTs from their experience of use, repair and modifications of machines. These are represented as A, B and C company in Table 1.

Table 1 shows that in general these automobile affiliated firms did not rely on the workforce with accumulated knowledge from the experience in the automobile makers. Of these three firms, only one, company (B), relied on the recruitment of workforce which had experience of use of MTs in user firms. However the proportion of this recruitment is very small (5%). In the case of other two companies, although there was migration of the workforce from users, this workforce did not have knowledge of using machine tools.

As shown in Table 1, it is difficult to argue that automobile affiliated MT makers emerged as a result of accumulated knowledge in the automobile makers. In other words, advanced users played a limited role in providing producers with a workforce with accumulated knowledge.

The following paragraphs discuss the migration of the workforce from users to producers in the surveyed user entry firms. This study examined sources of recruitment to see whether user entry firms relied on the 'internal workforce' which could have had accumulated knowledge from experience of use when they entered. This study examined whether there are user firms. There were 11 user entry firms[19] , among the surveyed firms, that entered into MT production in the period between 1976-1994. Here, 'user entry firms' refers to those firms from the industrial sector which does not produce machines, that entered into the production of MTs. According to the survey result, over half (6 firms) of the 11 user entry firms[20] in the period between 1976-1994 relied on 'internal workforce with experience of use' i.e., less than 40% of recruitment. This shows that majority of recruited skilled labour does not come from user firms because more than 60% of recruitment came from other external workforces, such as other MT makers, new recruitment from education institutions, internal workforce without experience of use, and others. From this study, a pattern of user entry could be observed. This study examined the characteristics of user entry firms. Users' entry pattern can be explained into three different groups. Group 1 include those firms which entered into machine tool production by mainly relying on internally accumulated technological capability from the experience of use of machines. These firms relied on the internally recruited workforce either around half (40-60%) or more than half. Those firms belong to this group are 4 firms. Group 2 include those firms which entered into machine tool production by recruiting workforces from other machine tool makers. Group 3 include those firms which did not rely on neither internally recruited workforce embodying accumulated technological capability nor workforce from other machine tool makers. The majority of entry firms, 7firms, belong to group3(see Table 2). Consequently, it is not

reasonable to argue that user entry firms are mainly the result of the spill-overs of technological workforce that had accumulated technological capability in user firms.

This finding is consistent with the study of the major entry firms in the 1980s and 1990s. Whether new entry firms in the 1980s and 1990s have relied on users' experience of utilising machines was investigated. As there had been rapid development of the mass-production system in the automobile and electronics and the shipbuilding and other manufacturing sectors in this period, the user sector could have nurtured the capability to produce machines out of utilising such machines. However, Table3 does not provide evidence in support of this.

This study examined the migration of the workforce that embodied knowledge to design machines from users to the surveyed producers. Empirically, it is impossible to measure this precisely. Instead, this study examined the origins of the key engineers in charge of R&D or production, in the producer firms. The results showed that in roughly half (48.6%) of the surveyed firms key engineers were originally from other MT producers of surveyed firms while 5.4% came from machine users, such as automobile makers, automobile component makers, electronics product producers and electronics component makers.

In conclusion, the migration of workforce from users to producers implies that users are a limited source of technological capability to develop a machine. Instead, the workforce from other machine tool producers is a more important source. 38.2% of the surveyed firms replied that more than 40% of recruitment of the workforce are from other MT producers. Interviewed engineers regarded the spill-overs of workforce from other MT producers as an important source of the recruited workforce of entry firms. According to one interviewee from a MT producer that for the last 20 years has been one of the biggest companies and is a non-*Chaebol* company, many of its engineers have moved on to new MT producers.[21] In another large company, one of the biggest in the 70s and 80s, with more than a 20 year history the

interviewees were proud of the fact that their colleagues had moved to other firms and had contributed to the growth of new companies, although at the same time complaining about the problems that the loss of skilled engineers brought.[22]

User entry is presumed to have contributed to intensifying competition and therefore enhancing competitiveness (Lee 1993). User entry can result in *vertical disintegration* of user firms. However, this should not be interpreted as the result of spill-overs of knowledge which has been accumulated from experience of use, repair and modification of MTs in the user factory. From the analysis so far, it can be concluded that users are a limited source of technological capability to producers in terms of the transfer of workforces which accumulated technological capability.

B. The FLOW of DESIGN INFORMATION through VARIOUS MEDIA

The following section examines the flow of design information by means of prototypes, blue-prints and patents, and through staff called upon for technical assistance. This section examines (i) cases that advanced users helped producers in the process of developing a new product through the transfer of designs: prototypes, blue prints, patents or through staffs seconded to give technical assistance (ii) survey result on whether users generally are regarded as important by producers as providers of blue-prints, patents and staffs seconded to give technical assistance.

Firstly, the examination of the flow of designs from users was carried out to see whether the most active form of a *customer active paradigm*, where users develop designs for production equipment and sometimes users transfer them to producers, can be found in the Korean MT industry. This examination was carried out in the context of those discussions in the literature of user active innovation which stresses the importance of advanced users in developing a new product (Rothwell 1976; Rothwell, Gardiner, and Schott 1983; Glete 1984; Pavitt 1984; von Hippel 1976,1977, 1978 & 1988; Shaw et al. 1989; Foxall 1989).

This study found that automobile makers, as advanced users, do not provide designs through the flow of prototypes.

blue-prints or patents or technical assistance to producers in the process of product development. This study examines the flow of the design information from automobile makers, as advanced users. The interviews included four MT producers who are affiliates of the conglomerate group (*Chaebol* group): these firms' closest relationships are with the automobile companies in the same conglomerate group. The interviews were also conducted with engineers in the two major automobile companies. The interviews[23] revealed that no case of design transfer from the producer to the user was found in the machines designed for common groups of users, standard MTs, which are the dominant type of machines produced in Korea. In specialised MTs, there is the flow of specifications, which includes drawings and rough descriptions of the machines to be developed, but the design process is carried out by producers, not by users. This finding reveals that even in the most favourable circumstance where users and producers have close relationship, the transfer of completed design is rare.[24] This result implies that in general, the design transfer from the advanced user to the MT producer is unlikely to occur because the transfer of the design is lacking even in the most favourable circumstances. Therefore we could find that other interviewed MT producers[25] that do not belong to the same conglomerate producing automobiles, did not reveal any experience of technological transfer of designs from the automobile makers either.

Secondly, this study examined, by means of a survey, whether users generally are regarded as an important source of design information through the transfer of blue-prints, patents and technical assistance. Approximately one-fifth (20.6%) of the surveyed firms responded that users are 'important' or 'very important' in standard MTs. These machines represent 92% of all of MT production in 1993.[26] The discussion so far has revealed the limited importance of the flow of design information of users to producers in the MT industry.

4. CONCLUSION

The users' role to producers is limited as an element that has an influence on producers' accumulation of technological capability to develop a product. The findings reveal that Rosenberg's (1976) *vertical disintegration* (which belongs to spin-offs from users) and von Hippel's *customer active paradigm* (users' transfer of design information) (von Hippel 1978 and 1988) are not the major aspects contributing to the accumulation of technological capability of domestic producers in that: (i) there was only a minor migration of workforce from user firms to producer firms ; (ii) in respect to the transfer of design information, most advanced users did not transfer design information to producers (iii) according to the survey result the majority of producers do not regard users as an important source of design information.

This study's finding reveals that although the machine tool industry, as part of the machine industry, is generally regarded as being the sector where the user producer interaction is important (Pavitt 1984; Malerba and Breschi 1995), the user industry failed to be the seed-bed of technological capability to develop machines.

This study's finding reveals that Korean machine tool case is different from those cases mentioned in the studies on the capital goods in developing countries (Berlinski 1982; Fransman 1985 ; Leff 1968; Chudnovsky and Nagao 1983; Albin and Katz 1987; Dahlman et Al. 1987; Lall 1987; Dahlman and Fonseca 1987). The difference could be derived from the fact that this study's finding is an extensive study on the machine tool industry in a country which has an experience of rapid industrialisation. None of the cases mentioned above are those in Asian NICs. Korea's past experience in the early period of industrialisation has some similarity with the literature mentioned above. In the early period of industrialisation, cases of users as the seedbed of technological capability could be observed. Korean producers seem to have had more opportunity to accumulate knowledge of production from their experience of using machines in the past. This might be because the technology and skills employed in the user sector, metal working sector, are similar to those needed to produce 'relatively simple' machines (Fransman 1985, 604).

According to the Korean railway arsenal, which 20 years ago used to make MTs for its own machining work, it stopped production of MTs for in-house use in the 1980s because the technological capabilities of in-house development of MTs lagged behind those of many producers (KOMMA 1991, 147-148).[27]

The story of the founder of the MT industry, which accumulated technological capability in a machining shop (KOMMA 1991, 138-140) in the 1940s, supports this conjecture. He had mastered repair and modification to existing machines after 3 years' experience in metalworking. Then after one year working on development he accomplished the manufacture of a new machine. Thus with only four year experience of learning, a machine user was able to complete the transformation into a machine producer. According to Lee (1993, 199), the proportion of users' patents is much higher (66.6%) in 1975-9 than in the period post 1985 (39.2%) in the Korean MT technology. All this implies that machine users had more opportunities in the past to accumulate the technological capability to produce. This means that there was a lower gap of technological capability between users and producers in the past.

The bigger gap between producers and users in the current period could be explained by the fact that from the middle of the 1970s, modern production plant started to be established, equipped with imported machinery in Korea.[28] From then machines were produced no longer by craft-type traditional production. If a machine is made by craft-type traditional production, it will not be competitive. Some machine models were introduced with technological licensing from foreign firms. After initiation of production of numerical control (NC) machine tools[29] in the late 1970s and early 1980s, the producer need to have an understanding of interfaces between mechanical and electronic components. All of these require extensive capability of machine producers. Because of these aspects, it is conjectured that the gap between the machine users and producers in the capability to produce machines has been widened.

A further conjecture could be that this study's finding could suggest the specificity of capital goods industry in Korea. This

study is about a machine tool industry of which user firm workers are most skill intensive. The MT industry is one of the most skill-intensive industries where the workforce has a crucial role in enhancing productivity of machine use and in the repair and modification of machines. Users of MTs carry out machining work for components and assembly. Some users design mechanical components. These skills can also be utilised in the development and production of a machine. Therefore users of machine tools have the highest possibility of accumulating technological capability to produce machines from their experience of use. In many other industries, the skills required to operate a machine are much lower than those to produce a machine. For example, users of textile and wood and paper mill machines do not have skills for machining or designing mechanical components. The capability accumulated by the workforce in the user firm is of more limited significance in the initiation of machine making. There is a evidence that in the textile machine industry there is a poorer role of users' involvement in the producers' innovation process in Korea than in Japan (Sugiura, 1994). Amsden (1989) mentions the failure of the textile industry as a basis of further sophisticated development of technology. Therefore, we could conclude a more limited role of users in the other industry.

This paper conjectures that the Korean machine tool case could reflect the specificity of the developing country in the catching up process. Korea is a country that has most advanced users of machine tools among developing countries such as automobile industry and electronics industry among developing countries. The fact that even in Korea users' role is limited implies that in other developing countries users' role would be limited. However, this conjecture needs to be validated by further research.

This study has a limit in that it has been confined to examining the role of users in providing sources of *technological capability needed to develop a new machine*. However there are other possible areas of users' contribution to producers in provision of technological capability. For example, it was observed from interviews that users have almost equal or better

technological capability in designing automated production line through linking various unit machines or adding optional components to the unit machines. Therefore users' role could be more important in providing design information to producers in making automated production line than in providing unit product design information. Further illumination of users' role with respect to this aspect is required for further understanding of the user-producer linkage.

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<Table>

Table 1 Sources of workforce in the entry of the 5 main MT producers

Firms	Proportion of internal recruits	The characteristic of the internal recruits	Other sources of recruitment
A	10% from automobile maker*	No previous experience of making MTs	90% new recruitment
B	5% from B automobile maker**	Experience of use, designing and making MTs	40% other MT producers, 45% new recruitment
C	10% from other firm in the same *Chaebol* group	No experience of making or using MTs	90% new recruitment
D	20-40% from internal recruits with machine use experience, 20-40 internal with no use experience.		New recruitment 20-40%, 0-20% from other MT producers.
E	no data available****		

Note: 1. Entry year: three firms (1976), one firm (1952) and one firm (1991).

2. * At the time of entry in 1976, A auto mobile maker produced automobiles by assembling imported *foreign model components.*

3. ** They are from the MT division. This automobile company was registered as the comprehensive MT maker in 1980 (Data from the company)

4. This company started the MT production from 1952. Therefore, it was impossible for the interviewee to answer.

5. Because of confidentiality, the company's name was randomly given.

Source : Interviews in 1994.

Table 2 Characteristics of Different Groups of User entry Firms

Groups	Main source of recruitment	Number of Firms	Entry year	Products produced before entry	Establishment Year
Group1: Entry on the basis of internal technological capability	About half or more than half: internal recruitment of workforce with an experience of use	4	*78*,86,86,91	*bearing*, tools, ship engine, mould &forging	*53*, 61, *79*, 84
Group2: Entry by relying on external technological capability	About half or more than half: recruitment of workforce from other machine tool makers	2	*85*,86	*car component*, casting	*62*,67
Group3 Entry by investment in creating technological capability	About half or more than half: recruitment of new graduates from school, internal recruitment without experience of use	5	78,77,*85*,80, *78*, 89	mould work, armament, *car component*, gear & reducer, *bearing*, sheet mould	68,76,*62*,71, *53*, 82
	Without any major source of recruitment	1	76	engine	37

Note: There are two firms (Italicised) which belong to both of the groups: One firm belongs to both Group 2&3. The other firm belongs to both group 1&3.

Table 3 Analysis by company of the percentage of employees recruited to the six main user entry firms that were established during the 80s and the 90s

Company	Sources of recruitment
B *	5% from an automobile maker 50% from other MT producers
G	no response to survey
S **	70% from other MT producers and machine producers. 30% from internal recruits
SS	no response to survey
M ***	40-60% from other MT producer 40-60% new recruitment
K	no response to survey

Note: * This company is the only company in this table which appeared in the Table 1
**The entry into the MT industry by one of the Korean's biggest three *Chaebol Groups*
***The entry by one of the biggest automobile component makers
Source : survey and interview

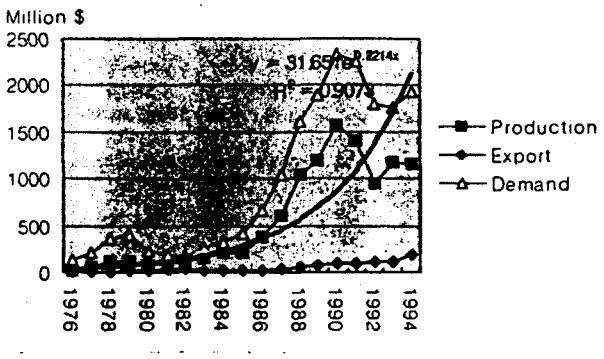
Table 4 Major source of recruitment in the entry into the MT production

Major source	% to the total respondents
Other MT producer	38.2
Internal recruit-use experience	29.4
New recruitment of graduates or school leavers	29.4
Internal recruit- no use experience	5.9
Other	5.9

Notes: 1. Number of respondents are counted by those firms who recruited more than 40% of work forces from the source of technological capability
2. Total number of respondents is not the sum of the numbers above the row of total number
Source: Survey result

<Figure>

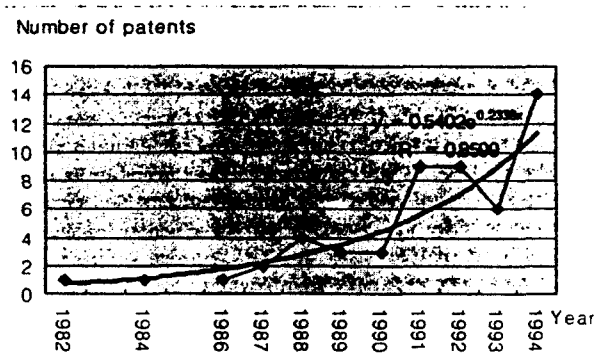
Figure 1 Production, export and demand of domestic machine tools



Note: 1. Current price
2. Output is based on shipment statistic.
3. Output was calculated by using exchange rates from National Statistical Office (1990; 1994)

Source: KOMMA (1985;1993;1996)

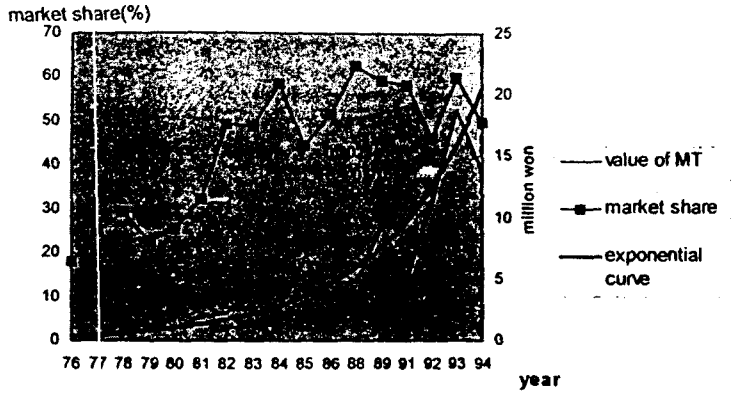
Figure 2 Patent grants of metal working machinery, elements, mechanisms by Korean Korean companies and private applicants in the USA



Note: Number of patents in 1983 =0. number of patents in 1985=0
Number of patents in the pre 1982 =4

Source: US Patent Office (1996. 97)

Figure 3 The value per machine and market share of domestic MTs



Note: 1. Shipment based
2. Value of MT : constant price at 1990
3. * Domestic market share of domestic producers : (output-export) / (output + import-export)

Source: KOMMA (1985; 1996)

<End Note>

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[1] See von Hippel (1978, 255)

[2] These discussions on the user-producer relationship literature need to be re-interpreted. The discussion on the user-producer relationship is focused on knowledge generation in product innovation in advanced countries (Lundvall 1985, 1988, 1992). The concept of 'product innovation' needs to be modified in the case of the developing country. Developing country firms are not capable of carrying out original product innovations. However, the definition of innovation could be widened beyond "the first application of science and technology in a new way with a commercial success" (OECD 1971, 11). If we accept that the concept of innovation in broad terms, which "encompass the processes by which firms master and get into practice product designs and manufacturing processes that are new to them, if not to the universe or even to the nation" (Nelson 1993, 4), innovation activities can take place in a developing country. Therefore, in developing countries, what is meant by product innovation is product development activities that are new to the firm, rather than new to the world. These product development activities are oriented to learning to understand foreign technology and applying this foreign technology to the development of a new product rather than to knowledge generation. Therefore product development activities include not only activities of developing a new product but also of learning from external sources of knowledge.

[3] If a machine user firm enters into machine production for commercial purpose, a machine user firm is also a machine producer firm.

[4] By entering into production of the production equipment, the machine user becomes both the machine producer and the machine user.

[5] In 1995, passenger car 3.2% (Korean shares in the world export according to International Trade Statistics Yearbook 1995). In 1995, D-Ram 29.0% (Korean shares in the world export International Trade Statistics Yearbook 1995).

[6] Usually the logistic curve is used to describe the general trend of the growth of any "population" (Johnston, 1984; de Solla Price 1963).

[7] Domestic market protection has been loosened in the period. In the Korean case, gaining market share was made possible in the economic environment in which market protection measures had been relaxed. For example, the nominal protection ratio, as the measure of market protection, was decreased substantially in 1980-1990 (for further detail see 'Policy for promoting an industrial sector' in B in section 4.2.4 in Lim (1997))

[8] In the general machinery industry, domestic producers met 35.5% of domestic demand in 1980 and 58.8% of domestic demand in 1993. (KOSAMI 1995, 83).

[9] Justman and Teubal (1991, 1171) understands the process of industrialisation in the context of structural changes : (i) the transition from primary and light industry sectors to large-scale processing industries such as steel, cement, and petrochemicals(LP) (ii) the emergence of the capital-goods sector and its transformation into a key sector (CG) (iii) the emergence of high-technology industry (HT) This study's main interest is the period of (ii)

[10] In the 1970s 1980s, the leading sector such as textile, automobile, footwear, shipbuilding industries emerged as 'leading sectors' (take off stage). Rostow contends that the rate of investment rises to 10 percent level in the take-off stage. The rate of investment in 1976 was 26.5% and in 1992 36.8% in 1993 34.4% (Potential) (Korea, 1994)

[11] In the advanced country, the proportion of the machine industry (ISIC 382 code : machinery except electrical) is 7.9% in Japan

(1994) and 10.8% in Germany (1994)(OECD. 1996).

[12] In 1975-1979, 66.6% of patents in the machine tool sector were made by users. In 1980-1984, 29.4% of patents were made by users. Post 1985, 38.0% of patents were made by users.

[13] Especially large firms are multi-business firms.

[14] Data from KOMMA in 1995.

[15] According to the survey, 23 % of the models from the firms surveyed are original models and 54% of the models are either original models or models which modified foreign models. See cases of Korean firms in Lim (1997).

[16] Interview of B division manager of H automobile on 7 Nov. 1994

[17] Firm data, 1994

[18] As this study is mainly interested in explaining the dynamism of accumulation of technological capability of the machine producing industrial sector, this study uses this approach. Any way, the machine user which enter into machine production is also a machine producer.

[19] 27% of the surveyed firms.

[20] User entry firms are those firms who entered into MT production from producing automobile components, electronics products and electronics components .

[21] According to an interviewee who had worked for more than 20 years. 90 engineers and technicians under his command had moved to other MT producers. 60% of them had been head-hunted by the other new MT producers. 40% had moved to other MT producers or other companies or into the service sector or had founded new firms in unrelated areas. Usually a workforce with over-five-years' experience moved to other big MT producers. Roughly two engineers per year moved to other companies. 10 workforces under his command had founded new MT producers or component makers. (Interview on 10 Nov. 1994).

[22] Interviews on 11 April, 1995.

[23] Interviews on 7 November 1994, 6 April 1995.

[24] In Korea, the transfer of complete product design is an important source of knowledge in accumulating technological capability. Technological licensing from foreign firms, which has been an important source of knowledge, usually includes the transfer of blue prints which embody complete product design.

[25] Two biggest MT producers and three small MT producer firms.

[26] 30 % in specialised MTs made the same response. Specialised MTs fall into two categories. One is specialised MTs which are made special by adding automatic equipment to a standard main body of a MT. The other is special purpose MTs in which the main body is specially designed.

[27] *"Until 20 years ago, we could provide almost every machine by ourselves. We made ...lathes... But the development of technological capability of firms outside was so rapid that in-house made products lost competitiveness..."*(KOMMA 1991, 148)

[28] According to Barrow (1989, 353), *'In the mid-1980s, a few of the large manufacturers visited were anxious to improve the quality of their output. In part, this move was in anticipation of an increase in domestic demand for higher quality machines, but it was also a response to increasing competition in this product area on international markets from other NICs. In order to improve quality levels, a few firms had imported new machinery. This included large sophisticated machine tools from West Germany and Japan, very high-precision machinery(e.g., jig borers) from Switzerland and the US, and co-ordinate measuring machines from the UK.'*

[29] machine tools controlled by a computer