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THE ENGINEERING INDUSTRY IN THE REPUBLIC OF KOREA

A SUCCESS STORY IN CRITICAL PERSPECTIVE*

Prepared by the

Regional and Country Studies Branch

Division for Industrial Studies

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PREFACE

The Regional and Country Studies Branch, Division for Industrial Studies, is regularly preparing working papers focussing on selected issues of the process of industrial development at the country level. These issue oriented studies are primarily undertaken with a view to serve as analytical input to UNIDO's technical assistance programming in the industrial sector as well as to improve the information basis for industrial policy measures to be taken by concerned authorities at the national level.

The study presented here concentrates on the engineering industry of the Republic of Korea, in particular on the production of non-electrical machinery as the nucleus for the establishment of a viable domestic capital goods sector. Being highly selective in its coverage of branches and topics the study is not presenting an in-depth analysis of the country's engineering industries nor can it claim to give a full-fledged picture of all the essentially dynamic processes, constraints and challenges encountered in its various branches. Rather it throws light on some of the crucial bottlenecks which should be paid attention to in trying to enhance the sector's international competitiveness in the medium and long run.

It is essential to note, however, that the study presented here is focussing on constraints and weaknesses within the framework of a success story. There can be no doubt that the engineering sector of the Republic of Korea is among the most technologically advanced, diversified and efficient of all developing countries. Hence what the study basically demonstrates is that even in a clear cut case of successful, well-planned development unforeseen constraints have emerged requiring specific policy responses. As the problems that have actually emerged in the case of the Republic of Korea are related to general issues of industrial development (such as the importance of parts and components production and the related role of small and medium enterprises), it is hoped that the analysis presented in this study will prove to be useful

for policy-makers in other developing countries as well. In particular it may provide valuable information for some of the more advanced Third World countries.

The study was prepared by staff of the Regional and Country Studies Branch together with Charles Edquist and Staffan Jacobsson, Research Policy Institute, University of Lund, Sweden, as UNIDO consultants.

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I. OVERALL STRUCTURE OF THE REPUBLIC OF KOREA'S ENGINEERING INDUSTRY

This chapter starts with some general background information on the Republic of Korea's manufacturing sector as a whole before turning to a closer look at the engineering industry proper. Table 1 presents data on the number of establishments and workers as well as on manufacturing value-added (MVA) at the two-digit ISIC-level. It can be seen that within the period studied (1975-1983) manufacturing employment increased by almost 50 per cent and the number of establishments by some 70 per cent whereas MVA went up by 350 per cent (in current US$).

At the same time the structure of manufacturing production underwent radical changes. In terms of absolute employment, the textile industry was the largest manufacturing sector in 1975 as well as in 1983, but it increased by only 34 per cent between these years. Employment in the paper industry etc. increased by 40 per cent. For chemicals the figure was 54 per cent, for non-metallic minerals 67 per cent and for basic metals 98 per cent. However, the largest growth in employment was experienced in the engineering industry where employment increased from 295,000 to 626,000, i.e. by 112 per cent.

Looking at MVA figures, the three largest manufacturing sectors in 1975 were food etc., textile etc., and chemicals etc. Each of these accounted for more than 20 per cent of MVA. Thereafter came the engineering sector with 16 per cent. All other manufacturing industries remained small as compared to the four mentioned above.

By 1983 the engineering industry had surpassed the other three, however, and accounted for more than one fourth of total MVA. Hence, it is by now the largest industrial sector and it is still experiencing rapid above-average growth.

The structure of the engineering industry proper is reflected in table 2. At the three digit ISIC-level the engineering sector is composed of five different segments which can be briefly characterized as:

- Fabricated metal products (ISIC 381) consisting of a very large number of relatively simple products, e.g. tools, knives, valves, and metal structures;

Table 1. Structure of the manufacturing sector in the Republic of Korea, 1975 and 1983

	No. of establishments		No. of workers Thousands		Value added 1975		1983	
	1975	1983	1975	1983	million US$	percentage shares	million US$	percentage shares
Food, beverages and tobacco	3,891	4,465	150	188	1,237	21.2	4,165	15.8
Textile, wearing apparel and leather industries	6,280	10,260	505	676	1,288	22.0	4,380	16.6
Wood and wood products	1,797	2,579	52	65	153	2.6	472	1.8
Paper and paper products, printing and publishing	1,844	3,045	70	98	229	3.9	1,286	4.9
Chemicals and plastics	1,985	3,848	183	281	1,273	21.8	4,866	18.5
Non-metallic mineral products	1,689	2,809	60	100	324	5.5	1,286	4.9
Basic metals	523	1,055	48	95	277	4.7	2,133	8.1
Fabricated metal products, machinery and equipment	4,152	9,473	295	626	950	16.3	7,220	27.4
Other manufacturing	626	1,709	57	86	110	1.9	529	2.0
Total manufacturing	22,787	39,243	1,420	2,215	5,843	100.0	26,337	100.0

Sources: Report on Mining and Manufacturing Survey 1977 and 1983.

- Non-electrical machinery (ISIC 382), including the production of parts for and the assembly of mechanical machines;

- Electrical machinery (ISIC 383), involving the production of parts for and the assembly of basically electrical and electronic products such as generators, radios or integrated circuits;

- Transport equipment (ISIC 384), encompassing the production of ships, cars, trucks and other machinery used for transport purposes;

- Medical, optical, scientific, measuring and controlling equipment (ISIC 385).

As demonstrated by table 2, electrical machinery and transport equipment are the dominant engineering branches both in terms of employment and MVA. The most important product categories are radio, television and other communication equipment (ISIC 3832) on the one hand, accounting for 50 per cent of MVA in electrical machinery, and shipbuilding and repair (ISIC 3841) and motor vehicles (ISIC 3843) on the other hand, being responsible for 49 per cent and 44 per cent, respectively, of MVA in transport equipment.[1/]

Compared to the standard pattern of engineering industries in typical OECD countries, the Republic of Korea has a relatively strong ISIC 383 (based on its success in e.g. integrated circuits and TVs) whilst its share of ISIC 382 has remained relatively small. However, it is just this segment of engineering industries, i.e. non-electrical machinery, that must be regarded as the true machine building sector including typical product groups such as agricultural machinery, construction machinery, machine tools, textile machinery, pumps etc.. In what follows this study will therefore concentrate on selected aspects of the non-electrical machinery sector, with special emphasis on machine tools.[2/] The machine tool industry which as industrial

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1/ Cf. Report on Mining and Manufacturing Survey 1983.

2/ This restriction implies that such important sectors as electronics and automobile industry are excluded. For short summary articles the interested reader is referred to: The Electronics Industry in Korea, Monthly Review (Korea Exchange Bank), 10/1983; The Vehicle Industry in Korea, Monthly Review, 11/1984; The Machinery Industry in Korea, Korean Business Review, No.74, January 1985. Cf. also Annex Tables A-1 to A-3 of this study.

Table 2. Structure of the engineering industry in the Republic of Korea, 1983

	No. of establishments	No. of workers (thousands)	Value added million US$	Value added percentage shares
Fabricated metal products except machinery and equipment (381)	2,975	117	1,081	15.0
Machinery except electrical (382)	2,532	101	1,081	15.0
Electrical machinery, apparatus, appliances and supplies (383)	2,292	236	2,649	36.7
Transport equipment (384)	1,193	143	2,206	30.5
Professional and scientific equipment (385)	481	29	202	2.8

Source: Report on Mining and Manufacturing Survey 1982.

nucleus establishes the capability to produce machines, occupies a certain "spider in the web" position[1/] and can legitimately be considered as the "key industry in the capital goods sector .... crucial to a country's technological development."[2/]

Technological weaknesses or deficiencies in the production of machine tools thus are of special importance as determinants of a country's future industrial progress and should be taken seriously in particular in the case of more advanced developing countries like the Republic of Korea.

The data presented in table 3 lend further support to the hypothesis of a relatively weak position of non-electrical machinery within the country's engineering industries (excluding ISIC 385). It is noteworthy that this branch in 1982

- generated only 13.4 per cent of engineering gross output thus being lowest at the 3-digit level,
- had a negative trade balance and was responsible for the highest share in total engineering imports (39.3 per cent),
- accounted for only 7.2 per cent of total engineering exports and with 25.8 per cent had the lowest export/production ratio and
- with 62.6 per cent showed by far the highest import/apparent consumption-ratio.

What has just been said applies a forteriori to the machine tool industry proper which - although having made rapid progress in the seventies still is only capable of serving about one quarter of domestic demand with export figures having remained rather low (US $38 million in 1982).[3/]

A closer look at capacity utilization rates achieved in the recent past (table 4) confirms the below-average performance of general machinery[4/] as

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1/ Jacobsson 1984, p. 44.

2/ Cf. Singh 1985, p. 13.

3/ Average annual export growth has reached, however, remarkable 77 per cent between 1971-1982. Cf. Korean Business Review, January 1985, p. 34.

4/ Note that the terms non-electrical machinery, general machinery and industrial machinery are used as synonyms unless otherwise stated

Table 3. Production and trade in engineering products in the Republic of Korea 1982

	Gross output		Imports		Exports		Apparent consumption[a/]		Import/apparent consumption (per cent)	Export/production (per cent)	Self-sufficiency[b/] ratio (per cent)
	US$ million	per cent	US$ million	per cent	US$ million	per cent	US$ million	per cent			
Fabricated metal products (381)	2,277	15.2	321	5.1	1,109	15.5	1,489	10.5	21.6	48.7	78.4
Non-electrical machinery (382)	2,003	13.4	2,489	39.3	515	7.2	3,977	28.1	62.6	25.7	37.4
Electrical machinery (383)	5,484	36.6	2,112	33.4	2,162	30.2	5,434	38.4	38.9	39.4	61.6
Transport equipment (384)	5,214	34.8	1,407	22.2	3,364	47.0	3,257	23.0	43.2	64.5	56.8
Total	14,978	100.0	6,329	100.0	7,150	100.0	14,157	100.0	44.7	47.7	55.3

a/ Production minus export plus import.

b/ Production minus export divided by apparent consumption.

Sources: Report on Mining and Manufacturing Survey 1982; Economic Statistics Yearbook 1983.

compared to total machinery which in turn has used installed production capacity to a considerably lower degree than total manufacturing. It is interesting to note, however, that in 1983 the capacity utilization differences narrowed down to a rather small margin. In that particular year general machinery reachieved its 1978 level of 69 per cent and came close to the 71 per cent average figure for total machinery.

Table 4. Trend of capacity utilization rates in the Republic of Korea's engineering industry, 1978-1983

	1978	1979	1980	1981	1982	1983
General machinery	68.9	74.9	46.8	51.4	52.4	69.0
Electrical machinery	71.1	74.9	65.3	69.0	65.2	76.3
Transport equipment	45.0	43.1	41.9	58.2	61.5	68.1
Total machinery	63.5	66.2	53.1	61.0	60.9	71.2
Total manufacturing	88.1	81.9	69.5	70.3	69.8	76.7

Source: Economic Planning Board.

The relatively low capacity utilization rates of the country's machinery industry were the logical consequence of a 'big push' policy adopted by the Government in the early seventies vis-à-vis the heavy industries.[1/] The combined impact of financial incentives (long-term loans at subsidized interest rates), fiscal incentives (tax exemptions, accelerated depreciation allowances), protective measures (import prohibitions on domestically produced items) and direct Government investment in industrial estates resulted in building up massive overcapacities in the country's machinery (and chemical) industries. This in turn led to a preemptying of resources available to light industries and to imbalances between investment in physical production

1/ Cf. World Bank 1984, p. 69; Asian Development Bank 1985, p. 5.

Table 5. Size distribution of engineering enterprises (ISIC 38) in the Republic of Korea, 1982

Size classes of employment	Establishments Number	Per cent	Employment Number	Per cent	Value added US$ million	Per cent	Investment US$ million	Per cent
5- 9	2,558	29.3	17,517	3.1	76.9	1.3	11.0	0.7
10- 19	2,767	31.7	38,736	6.9	193.8	3.3	27.0	1.8
20- 49	1,721	19.7	55,301	9.8	232.8	5.5	47.8	3.1
50- 99	807	9.3	56,026	9.9	407.4	7.0	85.6	5.6
100-199	427	4.9	58,728	10.4	455.2	7.8	71.7	4.7
200-299	173	2.0	43,449	7.7	365.3	6.3	90.8	5.9
300-499	103	1.2	38,910	6.9	376.7	6.4	71.1	4.6
500 and above	160	1.8	254,796	45.2	3,640.2	62.3	1,133.0	73.7
Total	8,716	100.0	563,463	100.0	5,748.2	100.0	1,538	100.0

Source: Report on Mining and Manufacturing Survey 1982.

facilities on the one hand and lagging human resource and technology development on the other hand. Moreover, it caused the discrepancies between powerful large industrial conglomerates (chaebol) and weak and neglected small enterprises to further increase.

Table 5 throws some light on the size distribution of engineering enterprises in 1982 which is unlikely to have changed very much since then. It can be observed that those 160 establishments employing more than 500 workers, i.e. only 1.8 per cent of all engineering establishments, are strongly dominating the whole sector. They accounted for as much as 45.2 per cent of employment, 62.3 per cent of MVA and 73.7 per cent of capital investment which seems to be a quite unbalanced pattern.

However, this pattern cannot be adequately evaluated unless it is put in relation to some other country. Figures exist e.g. for Japan, a country after which the Republic of Korea has patterned much of its development strategy. As the Japanese figures are organized in a different manner various size groups of firms have been clustered in order to make comparisons possible.

Table 6. MVA in the engineering industry (ISIC 38) in Japan, 1981, and the Republic of Korea, 1982, by size of establishments

Size classes of employment	Share of total engineering MVA	
	Japan	Rep. of Korea
5- 99	31.6	17.1
100-299	13.9	14.1
300 and above	54.5	68.7
Total	100.0	100.0

Sources: For Japan: Japan Statistical Yearbook 1983;
For Rep. of Korea: Report on Mining and Manufacturing Survey 1982.

Table 6 clearly demonstrates that small-scale enterprises employing up to 100 workers generate a distinctly smaller part of MVA in the Republic of Korea's engineering industry than is the case in Japan while the opposite is evidently true for larger firms with a workforce of 300 and above. This rather dualistic size pattern has created a number of concomitant functional weaknesses. Only recently has the Government become aware of the precariousness of this industrial structure and has, accordingly, given priority policy attention to strengthening the small and medium industrial establishments. This central issue of 'chaebols versus small firms' will be taken up again in chapter III.

Before chapter III. turns to major policy issues, the following chapter II. will go down to the product group level and will provide rather detailed analyses of competitive structures, strength and weaknesses in selected engineering sub-branches.

II. SELECTED ANALYSES AT THE PRODUCT GROUP LEVEL

1. Hydraulic excavators[1/]

Hydraulic excavators were developed in Europe in the 1950s and gradually replaced by line excavators because of their higher efficiency. In 1980, in the OECD countries, 65,000 units were produced and it was the 20 largest firms that accounted for 91 per cent of these. Nine of these producers were Japanese including the three largest ones which each produced between 6,000 and 8,000 units. All Japanese producers except one (Hitachi) started as licensees.

In the Republic of Korea hydraulic excavators are currently produced by two companies: Samsung Shipbuilding and Heavy Industries (SHI) and Daewoo Heavy Industries (DHI). Both firms are parts of large private conglomerates (Chaebols). SHI produces under a license from Poclain of France and DHI produces under a license from Hitachi of Japan.

The first license was taken by SHI in 1974 and production got off the ground in 1977-78. SHI sales were very low until 1982 when they increased to 115 units. It was 955 units in 1984 and was expected to exceed 1,200 in 1985. Hence production volume is quickly growing and is approaching the size of the smallest among the 20 largest producers in the world in 1980. The price of Poclain excavators produced by SHI is approximately 25 per cent higher than those produced by Poclain in France. Exports have been negligible so far.

About 10-15 engineers work with excavator design at SHI - a rather low figure. Two own models have been developed but they are not produced on a large scale since performance is not yet satisfactory. SHI would have to significantly increase the size of the design staff today if the company was to achieve the marketing of an own model in 1990.

In the production of licensed excavator models, SHI has been confronted by many problems and constraints, such as limitations in localization ratio owing to a weak structure of vendors, lack of design capability, frequent

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1/ Cf. Edquist/Jacobsson, 1985a.

change of licensed products, inferior brand image in international markets etc. The localization ratio (or local content ratio) refers to the percentage of value added of the end-product which is produced domestically in the Republic of Korea.

When a new model is introduced, the localization ratio normally is around 30-40 per cent and it often increases by 8-10 per cent annually. In the case of SHI excavators, however, the import ratio has remained at 40-60 per cent depending on the model partly because the license contract requires some imports of components from Poclain. Another important obstacle to an increased localization ratio has been insufficient production capability and/or product quality on the part of subcontractors in the Republic of Korea.

DHI produces forklift trucks, excavators, cranes, etc. The firm entered production of excavators in 1977. By 1984 the production volume was 1,500 units. The selling price in Europe of Japanese produced Hitachi excavators in 1984 was 60-70 per cent of the DHI price on the Korean market. Exports are small and mainly go to Korean contractors abroad.

About 25 designers work with excavators and cranes. Most of the design staff are used in order to understand and digest the licenses. This means, inter alia, increasing the local content ratio, which includes assistance to domestic subcontractors. In 1984 the local content ratio for excavators was as high as 85-90 per cent and DHI as a whole has 250 domestic sub-contractors.[1/] However, according to the contract with Hitachi certain components still have to be imported from Japan. This includes items like hydraulic control valves which are very expensive. This was mentioned as part of the reason why DHI is a high cost producer of excavators.

The picture outlined above indicates that the performance of excavator production in the Republic of Korea has been quite good, taking into account that the industry is less than a decade old.

However, from the point of view of international competitiveness the main problems of producers in the Republic of Korea are:

1/ A partial explanation for the high localization ratio - as compared to the case of DHI discussed above - may be the much larger production volume of SHI.

- complete license dependency,
- high production costs,
- product quality deficits (magnitude of this problem is difficult to estimate),
- an extremely low export ratio as a combined result of the above mentioned problems.

The case of hydraulic excavators above all demonstrates that the domestic producers have to increase their basic design efforts in order to become independent of foreign licenses. This is a long term process of 5 10 years. However, it is also clear that the firms are also dependent upon foreign firms with regard to hydraulic components. The hydraulic system is the very heart of the machine. Hence, in order to master designing the machines as a whole, producers must also master hydraulics which is a difficult engineering sub-discipline. (For a discussion of hydraulics, see also pp. 34-35). In particular the production of hydraulics requires very high precision and low tolerances. The manufacturing of hydraulic components therefore is increasingly based on advanced production technology like e.g. computer numerically controlled machine tools. Their role within the engineering industry of the Republic of Korea is discussed in section 2.3.

2. Machining Centres[1/]

2.1. The technology and its diffusion

The most important technological development in the machine tool, and one may even argue in the engineering, industry in the past decade has been the accelerating diffusion of computer numerically controlled machine tools (NCMTs). These machine tools are today becoming standard machine tools for a wide range of metalcutting functions such as turning, milling,, drilling and boring. The basic technology of NCMTs will be briefly described below.

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

(a) the workpiece is transported to the machine,
(b) the workpiece is fed into the machine and fastened,

1/ Cf. Edquist/Jacobsson 1985a.

(c) the right tool is selected and inserted into the machine,

(d) the machine is set, e.g. operation speed,

(e) the movement of the tool is controlled,

(f) the tool is changed,

(g) the workpiece is taken out of the machine,

(h) the workpiece is transported to another machine tool or to a warehouse or to assembly,

(j) the whole process is supervised for tool breakages, etc.

In the 1950s, the first numerically controlled machine tool was developed. This was an NC milling machine developed in the USA. The first machining centre was developed in 1959, again in the USA. A machining centre is a combined milling, drilling and boring machine. It is thus a materialization of system thinking in that cubic components, e.g. engine blocks, can be completely machined in one setting. Machining centres are one of the more important types of NCMTs and in 1982 they accounted for 30 per cent of the production value of NCMTs in the leading OECD countries.

For all NCMTs, instead of having a worker perform tasks (d) and (e), the information needed to produce a particular part is put on a medium, e.g. a tape, and fed into a numerical control unit. By simply changing the tape the NCMT can quickly be switched from the production of one part to the production of another, i.e. flexibility and automation are being combined. Because of the high costs of the NCMTs and the unreliability of the numerical control unit, the technology was not diffused widely until the early 1970s when the numerical control unit began to be based on mini-computers. A still more significant change in the technology was the introduction of micro-computers as the basis for the numerical control unit, a process which began about 1975. The use of microelectronics subsequently led to an increase in reliability, a simplification in programming and the automation of further tasks, in addition to (d) and (e). Tool changing is normally automatic today <tasks (c) and (f)> and a machining centre has between 25 and 125 tools. Automatic material handling equipment is supplied by the leading firms in the industry, automating tasks (b) and (g). Finally, the essential task of overlooking the production process <task (j)> has begun to be automated through automatic diagnostics etc.

Machining centres (MCs) are now being diffused widely, at the expense of other machine tools performing milling, drilling and boring functions. In table 7 the substitution process for the case of the UK is illustrated. Whilst machining centres accounted for 23 per cent of investment in all types of machine tools performing a milling function in 1978, the share grew to 50 per cent in 1982.

Table 7. Investment in machining centres, NC milling machines and conventional milling machines 1978 and 1982 in the UK (in 1000 pounds and percentage of investment in all machine tools performing a milling function)

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

Source: Edquist/Jacobsson 1985a.

In the Republic of Korea NCMTs have recently also received wide diffusion. The country has a stock which is in the order of 1,500-1,600 units already.

Until recently, the sale of NCMTs was almost completely confined to stand-alone machines. The trend in the market today, however, is that the NCMTs are fitted into a whole production system. These systems range from small, e.g. a CNC lathe attached to a material handling robot, to large, e.g. a totally automated system consisting of 10 machines controlled by a superior computer. The term for this development is normally FMS (Flexible Manufacturing Systems). On the supply side, FMS demand capabilities very different from those requested for stand-alone NCMTs. Integration capabilities and software development are key features of the suppliers of FMS, apart from knowledge in machine tool manufacturing. Another feature of the FMS market is that a close interaction between the supplier and the user is a prerequisite for a successful project. The ability to supply and to use

smaller as well as larger systems (as opposed to stand-alone NCMTs) is very often looked upon as being a critical factor in determining industrial competitiveness in the years to come.

2.2. Structure of world machining centre production

For reasons mentioned above the production of MCs was very limited in the 1960s. Of the five leading OECD countries in the machine tool area, the USA took the lead in the production of machining centres. A significant change in the world industry producing MCs began, however, to take place in the second half of the 1970s.

Firstly, the Japanese caught up with the US producers in terms of the number of units produced in 1978. Japan dominates the world industry today with a production of 7,000 units in 1982. The USA are the second largest producer with a production of 1,300 units in 1982. The European producers lie far behind these two nations. The largest European producer is the Federal Republic of Germany with a production of 849 units in 1983. The United Kingdom had a production of 170 units in 1982 and Italy produced 455 units in 1982.

Secondly, in the latter half of the 1970s the Japanese began exporting MCs on a large scale, thereby internationalizing an industry which hitherto had been characterized by, at most, regional trade. In 1982 Japan exported 1,728 MCs to the USA which represents 54 per cent of the US investment of MCs in unit terms in that year. In terms of value the Japanese market share was 34 per cent. The Japanese firms also export substantial numbers to the European countries. For example in England in 1982, Japan reached a share of 53 per cent and 35 per cent of the apparent consumption of MCs in units and value respectively.

Thirdly, there is a trend towards the diversification of firms producing CNC lathes into the production of MCs. Examples are Okuma and Ikegai in Japan. A number of other firms have produced both types of NCMTs for some time. Through joint production, advantages are gained in reducing the cost of (1) components bought (or produced inhouse) as the important parts are used for both products; (2) production as the same machine tools can be used to

produce some of the mechanical components for both MCs and CNC lathes; (3) marketing where the same marketing channels can be used for both products.

Fourthly, there is a trend towards direct foreign investment by Japanese firms in Europe and the USA. This trend is accompanied by a large number of licence agreements and other forms of collaboration between firms in Japan and in USA/Europe. The main factor behind these developments is the threat of trade restrictions that the successful Japanese firms are facing. A consequence of these collaborations may, however, be that the structure of the industry will become more concentrated.

Fifthly, the size of the leading international firms increased dramatically after 1975. Whilst the top firm in Japan produced 44 and 165 units in 1975 and 1978 respectively, it produced 900 units in 1982. The firms following behind the leader in Japan experienced a similar growth in size. Thus, the average production of the next four firms rose from 39 units in 1975 to 76 in 1978 and 675 in 1982. The largest US firm produces in the order of 400 units annually and an Italian firm within the 200 units range. The industry is, however, not homogenous and evidently also firms producing substantially smaller numbers of MCs annually than the leading Japanese firms are able to survive.

There are two major firm strategies in the MC industry. A number of firms, both in Japan and in other OECD countries, produce a very small number of advanced, high precision and high performance MCs often with large elements of custom design of the machining centre and/or the peripheral equipment. Often, these firms supply systems rather than stand-alone, manually operated NCMTs. This differentiation strategy involves producing a very limited number of units per annum. Scale economies are therefore not important. In terms of technological capabilities this strategy presupposes the ability to stay at the frontier or even to extend it. A Swedish firm evidently manages to do so with only some 20 designers. It may also involve living purely on custom design without extending the frontier. In the case of a small Japanese firm, 22 designers suffice to be a top builder in the Japanese context. Selling custom designed MC also presupposes a direct marketing link with those firms demanding their products. A flow of information between the buyer of the MC and the producer is critical for a successful sale. Such marketing links create a formidable barrier to entry for new firms in any given market.

For the firms following the mass production strategy, i.e. that followed by the largest Japanese firms, economies of scale are essential to achieve and price is a much more important competitive instrument than in the prior strategy. Normally the firms pursuing this strategy also have a much broader range of products. This implies that they need to have a lot more design engineers than the firms pursuing the custom design strategy. The leading Japanese firms employ design engineers in the order of 200-300.

2.3 The production of machining centres in the Republic of Korea

Machining centre production began in the Republic of Korea in the early 1980s. The number of units produced in 1983 amounted to 118, a fairly high figure given that production began only in 1981. In terms of units the country's production is higher than, for example, the Swedish production. Production in 1984 is expected to further increase. Exports are a high proportion of production and it is interesting to note that Tong-il, which is the leading firm in the Republic of Korea, sells to Japan.

There are at present four firms in the Republic of Korea producing MCs. These are Tong-il, which produced 110 units in 1983, Daewoo which produced 5 units, Kia 2 units and Whacheon 1 unit. The structure of the industry is, however, fluid and it can be expected that further changes will already have occurred in 1984. For example, Kia increased its production from 2 units in 1983 to 30 units in the first 8 months of 1984 and Daewoo's production rose from 5 to 25 in the same period. In table 8 some of the more important characteristics of these firms are summarized. It can be seen that Tong-il dominates both sales and export performance. The sources of technology are divided between own design development and licence. The technology used, however, is predominantly of domestic origin. 82 per cent of the MC units in table 8 were produced with own designs. For CNC lathes, the ratio is 98 per cent. It can also be seen that Daewoo and Whacheon are relatively large in CNC lathes. As was discussed above, this gives them additional strength in the machining centre market.

The performance of the machine tool industry in the Republic of Korea is on the whole very good. Given that the industry was virtually non-existent in the early and even the mid 1970s, the production performance is very

Table 8. Selected characteristics of machining centre producers in the Republic of Korea

Firm	Sales 1983 (million US-$)	Employees (1984)	Ownership	Number of designers (1984)	Origin of design for MCs	Output of MCs	Export of MCs	Output of CNC lathes	Export of CNC lathes[a/]
Tong-il	20	1,500-1,800	private firm	n.a.	own design and "license"	110 (1983)	60 (1983)	14 (1983)	n.a.
Daewoo	16	700	private conglom.	60	1) licence 2) assembly agreement for the Korean market with Toshiba	25 (8 months in 1984)	- -	150 (1983)	n.a.
Kia	4	n.a.	private conglom.	50	licence and own design	30 (8 months in 1984)	to be initiated in Nov. 84	4 (1983)	0
Whacheon	18	800	private firm	30	own design	1 (1983)	- -	62 (1983)	approx. 30 (1983)

a/ Total export of NC lathes from the Republic of Korea in 1983 was 65 units. In 1982 it was 138 units.

Source: Edquist/Jacobsson 1985a.

impressive. In terms of its production of NCMTs, the country is the leader among the newly industrializing countries. It is strong in both MCs and in CNC lathes, products which mutually support each other in many ways. In terms of export performance, the machine tool industry as a whole - as already mentioned above - is less impressive although for MCs and for CNC lathes the export share is very high indeed. This may well partly be explained by the very limited local market for these products in contrast to conventional machine tools. In terms of design capabilities, the four leading firms have all invested considerably in the generation of design engineers. Whacheon is fully self-reliant in terms of design. Daewoo has its own CNC lathe designs but has for good strategic reasons decided to wait some time with own design development in the MC field. The firm realizes that it does not yet have sufficient design capabilities to be able to make competitive designs for both MCs and CNC lathes. Given the dynamics of the firm, it may be expected, however, that it will in the medium term go for own design development in the field of MCs too. KIA mainly emphasizes own design development for MCs and has also started to design their own CNC lathe. Finally, although it is not entirely clear that the model that Tong-il has successfully sold overseas is of own design, a number of factors point in that direction.

Although the performance in the field of MCs has been very impressive in the Republic of Korea in terms of both volume of production and technological maturity, that development has to be put into the perspective of the nature of competition in the international industry and the resulting requirements for participating firms. From that point of view, a number of weaknesses can be found in the country's MC industry. Four such weaknesses will be discussed in more detail below.

(1) Two different types of strategies pursued by firms in the developed countries were distinguished above, namely the differentiation and the mass production strategy. The firms in the Republic of Korea having their own design development have not clearly opted, however, for either of these strategies. Tong-il which has two models of MCs of own design, produces MCs with a high motor-power indicating that high performance MCs are being produced. The German firm Wanderer, with which Tong-il is linked, follows the differentiation strategy and produces large and very heavy MCs which Tong-il is also producing. To our knowledge Tong-il supplies, however, only

standard machines at the moment. It does not seem, therefore, to follow either of the strategies; it does not have the sales volume to be profitable in the mass production strategy nor the design skills and product features to pursue the differentiation strategy. A choice of strategy is evidently required.

Whacheon has only one MC model and does not yet offer custom designed features. The company's MC is also of a lower performance than most equivalent models, in that its motor strength is low. In terms of the product characteristics, Whacheon would fit into the mass production strategy. However, it has only just begun production. It is though an important producer of CNC lathes in Korea, and the problem of scale economies is, therefore, somewhat reduced. The same will apply to Daewoo as and when the firm designs its own MC. KIA has only one own model of an MC, although they are currently developing more models. The present model is very small and of low performance in terms of motor strength. The firm does not at present supply custom designed features and their collaborator for another MC is a firm following the mass production strategy. KIA would seem to aim at following the same strategy but both volume and design capabilities are insufficient at present. The firm claims that one or two models can be added to the range every year which means that it will take between 4 and 9 years to reach 10 models, a number frequently found in the large Japanese firms. Thus, although the industry has a very good performance, the step to joining the world industry as equal competitor seems large, with the possible exception of Tong-il.

(2) It is clear that there is a growing integration globally between firms producing MCs and firms producing CNC lathes. Although there are still specialized MC producers and specialized CNC lathe producers, the economics of integration would suggest that more and more producers will produce both of these products which is what actually is being attempted by all firms in the Republic of Korea. Two are, however, stronger in MCs and two in CNC lathes. Given the still limited size of these firms in relation to the large Japanese firms and some others, it is not at all clear that these firms have the strength, both technologically and financially, to expand with both technologies simultaneously. What could be explored in this situation, is the

potential of mergers or less dramatically, at least of collaboration in design and marketing.

(3) The present export orientation needs to be continued in the light of the fairly small domestic market in the Republic of Korea. The four firms do have export organizations but even such a large firm as Daewoo complains about its poor service and maintenance as well as its sales network. As there are large fixed costs involved in building up a reputation and important economies of scale in marketing, assistance to the firms to consolidate and improve their marketing structure could well be envisaged.

(4) None of the producers have an FMS capability at the moment, that is a capability to supply fully automated production systems as distinct from stand alone machine tools. This is a weakness from the point of view of the using industry which will have to go overseas for the supply of such custom designed machinery. Custom designed machinery is normally easier and less costly if it is supplied locally by a local 'problem solver' or by a firm following the differentiation strategy. The possibilities of fostering a supplier of this kind could be looked into. Of course, the management of firms following the differentiation strategy design their firms in a very different way than the managers of firms following the mass production strategy. It can, therefore, be expected that different policy instruments need to be applied in order to foster firms following these two strategies. In particular, an intimate relationship with local large user firms and a high class design team mastering various aspects of flexible automation technology needs to be created.

3. Plate heat exchangers[1/]

The processes where heat exchange is of importance range from the pasteurization of milk to the cooling of water within nuclear power stations. With rising energy costs, the industrial world has been emphasizing the regeneration of energy from various industrial processes. Heat exchangers are one tool by which this is done. The more important kinds of heat exchangers are tube and plate heat exchangers.

1/ Cf. Edquist/Jacobsson 1985b.

Tube heat exchangers are an old technology and still dominate the market for heat exchangers. Plate heat exchangers (PHEX) were first produced in the 1930s to meet the hygienic demands of the dairy industry and until around 1970, the application of PHEX was mainly restricted to the dairy industry. Since then, the chemical industry, the nuclear industry, other process industries and the shipping industry have become large users of PHEX.

The total market for PHEX in the non-socialist countries is in the order of 175 million US$. In 1980 three firms accounted for roughly 80 per cent of the value of production in the OECD markets with one single firm (Alfa Laval) alone accounting for 50 per cent of production. A very limited number of firms - 7 to 8 - exist in this business in Europe and only a few in the USA and Japan. Hence the global PHEX industry is extremely concentrated. However, different firms specialize in different market segments in terms of size and area of application. Smaller firms are more specialized than the dominant ones.

The production technology is dominated by the pressing of the plates. Alfa-Laval has four large presses, the largest having a capacity of 40,000 tons. A press for large PHEX costs in the order of 2.5 million US$. The material pressed is mainly titanium or stainless steel. In the case of a titanium based PHEX the share of raw material in total cost is 70 per cent. Although no patents or technical secrets seem to exist in the industry, the number of engineers needed is large, since marketing involves a great deal of design and engineering work.

The market for PHEX in the Republic of Korea is in the order of 2.5 million US$ annually, out of which roughly one half goes to the marine sector. PHEX has in the order of 20 per cent of the total market for heat exchangers in the country. There is no Korean firm with the capability to supply PHEXs, although several firms produce tube heat exchanters.

There is now a strong wish by the Government that a local production base of PHEX should be established in the Republic of Korea. A number of times, in the past six years, Korean firms have visited the internationally leading firms, i.e. Alfa Laval of Sweden and APV of the United Kingdom and asked for collaboration. Recently, a firm belonging to the Daewoo Chaebol

(Daewoo Precision Industries Ltd) visited Alfa Laval and tried to reach a collaboration agreement which would involve local pressing of the plates. However, Alfa Laval did not accept local pressing of the plates as such an agreement would facilitate copying.

Daewoo subsequently contacted the smaller Danish firm Paserlak and has today a memorandum agreement for local production of PHEXs. In the first phase Paserlak will provide plates and drawings. In a later stage, Paserlak has agreed to transfer plate manufacturing technology upon the request of Daewoo. Paserlak having agreed to what Alfa Laval refused, it may be concluded that it is easier to get technology from a smaller firm than from the dominant one. However, the Daewoo-Paserlak arrangement is not yet working, partly because the prices of the plate heat exchanger offered are higher than those of the leading firms in the industry.

This example calls for a thorough analysis of the global industry manufacturing the product in question as well as for the possibility of Korean firms to enter and, if so, which should be the most appropriate route of entry. Such a feasibility study should include an analysis of the basic characteristics of the industry as well as of the barriers to entry in terms of product technology, production technology, R & D requirements, marketing arrangements, etc. The conclusion of such a feasibility study may well be that the Republic of Korea should continue to import PHEXs.

However, if it is concluded that production of PHEXs should be initiated in the Republic of Korea, it is important to specify how such an entry should be made. In the short run, it seems to be out of question that a Korean firm could be a full range supplier like Alfa Laval. A specialization strategy seems to be necessary. Hence a certain size range or application field should be identified in such a way that barriers to entry can be overcome within a reasonable time period and at limited cost. This would probably lead in the direction of the strategies of some of the smaller European PHEX producers. If sales are restricted to a (protected) local market, the firm entering can team up with some foreign producer through, e.g. a license agreement. If the Korean firm is also aiming at selling on the export market the main barrier to entry would probably be in generating a design team which can provide optimum designs for the particular product range chosen. A marketing network abroad

would also be needed which may be very costly if the producer is not a part of a conglomerate whose marketing facilities can be used.

4. Submersible pumps[1/]

The international pump industry is divided into a number of segments. A submersible pump (SPs) is a pump where also the motor is submerged into the liquid which the pump is to transport. SPs are produced by, on the whole, larger firms than what is the case for pumps generally.

The international industry producing submersible pumps (SP) is dominated by the Swedish firm Flygt AB, which is a subsidiary of the US firm ITT. In 1983 the sales value of Flygt was 194 million US$ and the firm is specializing in SP. The second largest firm is the Japanese Tsurumi which produced SPs to a value of around 65 million US$. The firm produces also other types of products but their sales value is not known. Flygt produces in the order of 60,000 pumps annually whilst Tsurumi produces 250,000 (mainly smaller) SPs. Another Japanese firm, Ebara, which has a total sales value of 650 million US$ produces SPs to a value of 30 million US$. On the European market, the FRG firm KSB (Klein, Schanzlin and Becker), with a sales value of 460 million US$ produces SPs to a value of 10 million US$ and the firm ABS-Pumpen, which is also FRG-based, produced SPs to a value of 32 million US$. This firm seems to be specializing in SPs. Another firm specialized in SPs is the Swedish firm Weda with a sales value of around 5 million US$. These firms accounted in 1983 for around two thirds of the world output with Flygt in the lead with a market share of 35-40 per cent. Other firms in the industry are mainly UK and US firms.

The industry can be characterized as one which has a mature product technology and which experiences a very rapid technological change in the production process. With a technically relatively simple product, which is easy to copy, the leading firms have to meet very strict price and delivery time conditions in order not to loose market shares. In turn, the very activity of reducing costs of production and shortening delivery times by these relatively large firms determine the conditions under which new entrants can survive.

1/ Cf. Edquist/Jacobsson, 1985c.

The globally leading firms emphasize the introduction of computer technology and organizational changes as very important tools in their competitive strategy. Computer aided design, including links to parts programming of numerically controlled machine tools are being developed; the machining process is on the whole undertaken with NCMTs; the inventory and material flow within the firms are controlled by a computer; warehouses are automatized and computer-controlled; computer links are made to subsidiaries abroad in order to minimize the stock of parts and complete pumps. The subsystems are connected to a central computer.

In 1982 the pump industry in the Republic of Korea produced 618,000 units to a value of 54 million US$. 47,000 of these were industrial pumps which due to their very high unit costs accounted for a production value of 27 million US$, i.e. 50 per cent of the total. The KOSAMI Handbook lists at least 29 firms as pump producers most of which are small. Six firms are listed as producers of SPs. Table 9 reveals some characteristics of these firms.

Table 9. Producers of submersible pumps in the Republic of Korea

Name	Sales value total in 1982 (million US$)	No. of Employees	Sales value of SPs (million US$)
Dong Ah	33[a/]	1,010	1.6
Chungwoo	5.8[a/]	240	n.a.
Samzin Ind. Co.	1	37	n.a.
Hajie Ind. Co.	1.2	90	n.a.
Manyoung Machinery	0.9	30	n.a.
Hyupsun Ind. Co.	0.7	60	n.a.

a/ 1983.

Source: Edquist/Jacobsson 1985c.

The two largest firms are Dong Ah and Chungwoo. The latter produces, however, very few SPs although it is one of the largest pump producers in the Republic of Korea. It is rather a small firm (240 employees) and has typically received very little assistance from the Government. This is in sharp contrast to e.g. the case of the larger firms producing excavators and machine tools. Dong Ah has had a licence from Tsurumi and according to Dong Ah, their main domestic competitors are smaller firms set up by former engineers from Dong Ah using Tsurumi technology. There is thus a great deal of competition which, however, has taken the form of a downgrading of product quality rather than price reductions due to cost reductions. Total production by Dong Ah was 3,000 units in 1983. The total domestic market was estimated at around 7 million US$.

On the whole, the submersible pump industry in the Republic of Korea can be characterized by:

- an atomistic structure,
- very small volume production,
- poor quality/highly priced products,
- technological stagnancy. This is particularly so in the case of Dong Ah which after having had a Tsurumi license now is looking for yet another licensor in this relatively simple technology. Furthermore Dong Ah does not have a single numerically controlled machine tool, whereas Chungwoo has at least two Korean-made CNC lathes.

Given the wide discrepanices in both volumes of production and technological dynamics between the international industry and the Korean industry, it is very questionable if this industry should be fostered at all in the Republic of Korea.

However, to the extent that one sees a future of this industry in the country the following areas need to be emphasized:

- Greater efforts in design development as well as in process technologies. Considerable expertise is now being developed in this field in the developed countries parallel with the development of more complex process technology. At least part of these skills need to be duplicated in the Republic of Korea.

- Precision engineering skills need to be developed.
- Given the small local market it is highly probable that exports need to be promoted in order to become cost-efficient.

All these points involve considerable investments in indivisibilities. To the extent that this industry is to be fostered at all in the Republic of Korea, a merger between the leading firms could be taken into consideration before the more functional support is dealt with.

5. Summary for priority areas

The above discussion clearly shows how the development constraints vary within the selected product groups of the engineering sector. Consequently, the priority areas for potential support measures differ. Table 10 summarizes the priority areas for support depending on the type of product considered. For each product, a ranking of the most important development constraints is made. The type of actions to be taken would then of course reflect this ranking.

Table 10. Ranking of main development constraints

	Product group			
Development constraint	Excavators	Machining Centres	Submersible Pumps	Heat Exchangers
Technology variables				
- product	(1)	(3)	(2)	(2)
- process			(3)	
Marketing	(2)	(1)	(4)	
Merger		(2)	(1)	
Feasibility study - bargaining strategy				(1)

For excavators, problem one is the ability to master hydraulics technology and develop own basic designs. Marketing abroad is the second most important problem. For machining centers, marketing networks abroad are the most critical area followed by the need to merge lathe and machining centre producers. The development of an FMS supplying capability ranks third. For submersible pumps, a merger is a prerequisite for success. Product and advanced process technology are also badly needed as well as a foreign marketing network. Finally, for plate heat exchangers, a feasibility study including a strategic analysis should receive top priority.

III. ISSUES IN ORGANIZING A COMPETITIVE ENGINEERING INDUSTRY

1. Changing attitudes towards small and medium sized firms

During the Park Chung Hee Government - until 1980 - the large business conglomerates (chaebols) were growing very rapidly in the Republic of Korea in accordance with the prevailing Government plans, which, at times, outweighed (static) economic principles. The Government provided a wide range of support measures from restrictions on imports to subsidized bank loans and generous export financing. It has even been argued that "the chaebols' spectacular expansion was made not through rational management or innovation but through close connection with the Government."[1/]

A typical Chaebol in the Republic of Korea encompasses a variety of companies and activities, from as many as 28 in one case to somewhere between 10 and 20 in most other cases. One example is the Samsung Group of companies. It spans over business lines from food seasonings to building aircraft engines and state-of-the-art 256K DRAM semiconductor chips.

For two decades these giant business groups were allowed to penetrate into sectors traditionally characterized by small firms and to swallow up firms that could not compete. The logic was 'the bigger the better'. These companies certainly contributed substantially to the phenomenal growth in the Republic of Korea's GNP during the last decade. These days, it is argued by many, however, that they are not flexible enough to adapt to rapid changes in the international markets. Also the Government has reached the conclusion that the chaebols do not work efficiently any more, given the present global economic situation (others point, however, to the superior risk taking ability of the Chaebols).

Some reasons for this alleged inefficiency are:

- that ownership of the chaebols often is concentrated in a handful of family members and that there should be a separation of capital and management to increase operational efficiency,
- that the giant firms are heavily dependent upon bank lending,

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1/ Business Korea, December 1984, p. 24.

- that the chaebols are too diversified,
- that small business cannot grow under the shadow of the few large groups as the allocation of investment funds and bank lending as well as general economic policies tend to be biased in favour of the chaebols.

The other side of the coin is that the small- and medium-sized firms have remained rather weak in the Republic of Korea. They have not really got a chance to emerge and become efficient and they are often plagued with sluggish sales, backward technology, insecurity and poor access to credits. The Korea Times reported, for example, that in 1984, 30 of the largest business conglomerates accounted for 48 per cent of outstanding bank credits whereas their share of value added in GNP was only 16 per cent.[1/]

During the last few years the Government has tried to end priveleges exclusively enjoyed by big business and to restrict further growth and diversification of the chaebols. The Government also plans to more strongly promote small firms since it is believed that small business can play the role of a safety net in times of recession and that they are capable of quickly innovating new technologies.[2/]

The Ministry of Trade and Industry (MTI) announced in 1984 a plan for intensive support of 1,000 small companies. Since much of the country's trade deficit stems from imports of parts for electronics, machinery, shipbuilding and automobiles, MTI has begun to put emphasis on small companies becoming involved in parts and components production. In a move to stimulate the development of the parts industry, MTI has launched a plan to integrate the parts manufacturers and large-size prime manufacturers into closely-knit production units. The plan is known as the industrial systematization project. It calls for financial support and tax priveleges to companies which join the project.

Tax privileges include e.g. a reduction of tax payments by 10 per cent in the case of domestically purchased and by 8 per cent in the case of

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1/ Cf. Korea Times, August 23, 1984, p.2.

2/ For a detailed treatment of recently established small industry promotion schemes in the Republic of Korea, in particular concerning the activities of the Small and Medium Industry Promotion Corporation (SMIPC), cf. UNIDO (1986).

imported machinery and equipment for laboratory and inspection purposes.[1/] Furthermore, expenses on required technical guidance are tax deductable.

Most of the items covered by the systemization project are related to automobiles, machinery and electronics. However, a number of problems exist. Prime manufacturers are inclined to demand price cuts from their parts makers, payments are often delayed by several months and prime makers sometimes suddenly reduce or stop orders. Hence many problems remain for the producers of parts and components and various kinds of functional support are called for. A Systematization Promotion Council has already been established within the Korean Federation of Small Business, which, inter alia, has the task to regularly (on a quarterly basis) examine business transactions and to initiate suitable measures to deal with and eventually to avoid disputes between large firms and their suppliers.

It is in particular in the light of the Republic of Korea's mounting foreign debt and the country's chronic trade deficit that the building-up of a viable domestic parts end components industry is called for. In 1984 US $10 billion was paid for machinery imports equalling one third of the total import bill. Moreover, machinery imports grew at an average annual rate of 18.7 per cent over the past seven years, thus exceeding the average growth rate of total imports. In the light of this development, concerned industrial policy-makers have again come up with the idea of reducing imports of foreign machines by raising the local content ratio of domestically produced machinery.

On the whole it seems that the country's machinery industry has a much better capability with regard to the assembly of machines than for the production of parts and components. This may be illustrated by the recent agreement between the US firm Caterpillar and Daewoo Heavy Industries. Under this agreement Daewoo produces forklifts according to Caterpillar design. These forklifts are then shipped to Caterpillar in the USA and distributed to its worldwide dealers. Hence, in this way, the Republic of Korea's machinery manufacturing capability is combined with foreign engineering and marketing expertise. Several other machinery makers are also already involved with US aircraft makers in the co-production of some aircraft parts and components.

1/ Cf. UNIDO (1985), pp. 26-28.

At this point their major task is to assemble parts imported from the US maker using technology transferred to them. Also some machine tool makers are supplying machine tools to Japanese companies on an Original Equipment Manufacturing (OEM) basis. From the point of view of the Republic of Korea, such arrangements are a way for the country to establish itself as a world supplier of a wide spectrum of machinery.

However, deals of the kind described above are open mainly to large companies and more for assemblers than for manufacturers of parts and components. As the quality of locally made components often is low, many exporting companies feel that their purchase on the domestic market is risky and may jeopardize their export competitiveness.

The relative backwardness of parts manufacturing in the Republic of Korea is often seen as being linked directly to government industrial policy during the 1970s which stressed production of finished machines, putting the assembly sector far ahead of parts manufacturing. While it is evident that this policy facilitated remarkable progress in assembly capability, by now it is equally clear that previous policies have to be balanced by a policy supporting capability generation in (small and medium-sized) firms producing parts and components.

The strong bias towards the production of final consumer goods is to be found not only in the non-electrical machinery branches but more or less applies to the whole engineering sector. Electronics for long was a case in point showing both a high dependence on imported parts/components and when it came to domestically produced parts/components a heavy reliance on imported materials. Import-substitution efforts in the early 1980s have, however, changed the situation in electronics to some degree.

It may be noted that in Taiwan Province of China priorities were different from the beginning. Initially stress was placed on establishing a parts and components industry. The assembly sector then grew out of the development of parts manufacturing. Today, the country's export of parts and components far exceeds that of the Republic of Korea, though the latter leads in the export of automobiles and some finished machinery products. Some observers believe that Taiwan Province of China is sooner or later to run

ahead of the Republic of Korea even in the field of finished machines, thanks to its firmer basis with regard to the production of parts and components.

As mentioned above state policy is now geared to increase the support of (small) firms producing parts and components, by means of the so-called systematization, which involves a kind of subcontracting network integrating assemblers and parts suppliers. It may be argued that it is in the long term interest of large companies to support the development of a stronger structure of subcontractors, although they often, in the short run, tend to neglect this aspect. Therefore, parts makers still operate under unstable conditions including possible change of contractors.

Thus the fact remains that the structure of suppliers of parts and components is rather weak in the Republic of Korea and that the strengthening of this structure may be considered to be of strategic importance for the coming decade. Some of the more obvious points of intervention in supporting existing small and medium producers of parts and components are:

- to assist in identifying foreign licensors in order to upgrade their product technology. (Since the licensees are very small it may be an advantage if the licensors identified are small but with a high technological capability. The licensors will still generally be larger than the licensees. For obvious reasons it is also an advantage if the potential licensors have not been previously exporting to Korea);
- to assist in negotiations with the licensors and with technical advice during the process of digesting and indigenization of the license;
- to assist in starting efforts to make more comprehensive adaptive design changes - for example upon the request of contractors - and on this basis help them to initiate own basic design activities;
- to assist with technical advice with regard to modernizing production technology;
- to assist in quality control;
- to assist in export marketing;
- to assist with risk absorbing credits.

It may also be important to support small- and medium-sized firms in their efforts to initiate production of parts and components which have not previously been produced in Korea. In this context assistance in selecting

suitable new products may be provided. Obvious criteria in this regard are that a sufficient internal or external market exists and that the technological capability required to produce them is within the reach of the firms concerned.

2. Requirements for specialization

As a case in point, it was suggested during the previous analysis of the production of hydraulic excavators that the production of hydraulic components is a critical technical element to achieve competitiveness within this industry. This seems to apply to the Republic of Korea as well as to many other relatively advanced developing countries.

It could therefore be argued that the domestic design and production of hydraulic components should receive priority attention in the Republic of Korea. If this was to be achieved inside the large assembly firms, they would be likely to need some external assistance to be successful sin hydraulic components are quite complex to produce and require a specific technical capability. However, it would probably be a waste of resources if both the firms producing hydraulic components as well as all other firms using them, entered into production of these components. This would largely prevent the capturing of economies of scale thus leading to higher production costs. (In a country with a weak structure of subcontractors there is always a risk that assembly firms start producing the components themselves, pressed by government requirements with regard to domestic content.) A much more efficient solution from the national point of view would be that a limited number of specialized producers of hydraulic components be created and supported in ways indicated above.

There is one further example supporting the view that hydraulics is a strategic field for many relatively advanced developing countries. In Cuba around 1970 the mechanization of sugarcane harvesting was a strongly prioritized issue. The Cuban engineers managed to design a sugarcane harvester in 1969 which was a technological breakthrough. It is still the most efficient harvester in green (unburnt) cane harvesting and this machine is exported to at least 30 countries. However, although the machine was designed in Cuba it was never produced on a large scale there due to deficiencies in the Cuban mechanical industry. In particular, Cuba did not possess an adequate technical capability in the field of hydraulic components, which the production of this machine - called Libertadora 1400 - required.

This was the main reason why the Cubans relinquished their patent rights and practically gave away their sophisticated design to a developed country producer of grain harvesters[1/].

A general issue which seems to be neglected in the Republic of Korea, both with regards to machinery and to component production, is the question of how the final structure of the industry should look like. As the goal of Government policy is to create an internationally competitive industry in the years to come, the structural characteristics of this industry will need to be specified already now.

In this context it is noteworthy that an increasing degree of specialization is among the salient features of the capital goods industry in the developed countries. This is manifested by, for example, the rapid increase in intrabranch trade. It can be shown[2/] that a substantial increase in the export ratio and import ratio took place in the early 1970s for large countries such as the Federal Republic of Germany, France and the United Kingdom, whereas an analysis of Sweden as a smaller country reveals that between 1960 and 1970, 25 out of 35 branches experienced growing export and import ratios. This trend continued in the 1970s. These trends imply that each producer of capital goods, machine or component, puts greater emphasis on an increasingly narrow range of products. In small economies, this means that a large share of their production is exported and a high proportion of their investment needs are met by imports. A case in point is the trend for pulp and paper machinery in Sweden. In 1960, the export ratio for such machinery in Sweden was 71 per cent while the import ratio was 51 per cent. Only ten years later these ratios had increased to 86 per cent and 70 per cent respectively.

A further manifestation of the growing specialization of capital goods production is the very high import content of engineering products, particularly in smaller economies. Table 11 shows to which degree some smaller economies in Europe (Sweden, the Netherlands, Belgium) have become dependent on imports of components and other goods in various parts of the capital goods sector. There is also evidence that the international specialization in components is growing.

1/ Cf. for further details Edquist 1985, chapters 4 and 7.

2/ Cf. Saunders 1978.

Table 11. Import content of engineering production for selected countries (imported inputs as a percentage of total inputs)

	FRG	UK	Italy	Sweden	Nether-lands	Belgium
Metal products	6	9	9	10	25	31
Non-electrical machinery	19	17	39	39	68	72
Electrical goods	19	16	29	42	67	59
Motor vehicles	11	7	21	33	75	81
Other transport equipment	39	25	26	30[a/]	46	75

a/ Shipbuilding only.

Source: The Boston Consulting Group, A framework for Sweden's Industrial Policy, Liber Foerlag, 1979.

The reasons behind such a trend evidently lie in the exploitation of the benefits of specialization and economies of scale. This means that firms in a given country concentrate their production and export on certain products within the range covered by the branch, leaving other products to be imported. These can be either final products or components. As Saunders explains: "Many analysts have stressed the importance of this form of specialization in the growth of international trade in manufactures between industrial countries. Extensive intrabranch trade is one of the most important ways by which specialization can be achieved and economies of scale reaped."[1/]

The implication of this development for component producers in the Republic of Korea is of course that they also will have to specialize if they really are to become internationally competitive. This means that some products need to be selected for domestic production while the rest will have to be imported. The products to be produced domestically will, on the other hand, need substantial support not only in terms of technology but also, in the years to come, in export marketing.

1/ Saunders 1978, p. 37.

IV. CONCLUDING REMARKS

Throughout this paper the emphasis has been more on weaknesses than on strengths, more on bottlenecks and constraints than on existing capacities and their development contributions. This in itself has been a clearly biased way of looking at the study's subject to be justified only by its focus on measures geared to the removal of existing obstacles to the realization of the industry's full potential. There can be absolutely no doubt, on the other hand, that the Republic of Korea's engineering industry has in the recent past been in a leading position in the developing world, including the handful of so-called newly industrializing countries. Moreover, it is even seen as an emerging threat by many developed country producers of engineering goods which are increasingly facing import competition also with regard to technologically advanced products.

Once the prevailing weaknesses in the industry's structure - a lop-sided size pattern in favour of large industrial conglomerates, a biased processing pattern in favour of final products, and a lack of horizontal specialization - will have been successfully overcome, engineering can for long be expected to remain among the leading growth sectors of the Republic of Korea's economy.

In this context it is noteworthy that the non-electrical machinery branches - in contrast to e.g. chemicals or electronics - have only to a minor degree relied on direct foreign investment as source of technology transfer.[1/] Rather licensing in selected technological areas has been used to build up domestic technological competence. In the long run, just like in the case of the country's automobile industry[2/], this may prove to be the right approach to achieve domestic mastery of technologically advanced production processes without, at the same time, becoming too dependent on foreign companies.

1/ Between 1977-1983, only 9 per cent of total direct foreign investment went into non-electrical machinery, as compared to 17 per cent for electric and electronic machinery and 27 per cent for chemicals. Cf. Lee 1985.

2/ Cf. Westphal/Rhee/Pursell 1984.

Table A-1. Indices of engineering production in the Republic of Korea, 1976-1984, (1980 = 100)

Year	Total industry	Total manufacturing	Total engineering (ISIC 38)	Metal parts (ISIC 381)	Industrial machinery (ISIC 382)	Electr. machinery (ISIC 383)	Transp. equipment (ISIC 384)	Precision instruments (ISIC 385)
1976	61.9	61.0	58.8	55.2	82.3	56.3	53.4	61.0
1977	74.1	73.4	74.4	75.6	87.3	71.2	74.2	71.4
1978	91.1	90.9	104.9	99.9	133.2	99.0	110.7	91.7
1979	101.8	101.9	117.2	99.8	133.4	117.2	127.7	97.7
1980	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1981	112.8	113.4	126.3	121.6	125.7	121.1	148.7	100.2
1982	117.7	118.7	134.0	133.6	137.5	123.6	163.0	91.4
1983	135.6	137.6	164.7	162.1	193.5	167.7	158.1	98.4
1984[a/]	158.9	160.8	217.3	173.0	189.7	217.7	306.9	105.5

a/ As of August 1984.

Source: Economic Planning Board.

Table A-2. Value of engineering exports of the Republic of Korea, 1976-1984, (in US$ million)

Year	Total industry	Total engineering (ISIC 38)	Metal parts (ISIC 381)	Industrial machinery (ISIC 382)	Electr. machinery (ISIC 383)	Transp. equipment (ISIC 384)	Precision instruments (ISIC 385)
1976	7,715	1,784	233	129	941	344	138
1977	10,046	2,616	589	155	1,071	658	144
1978	12,711	3,390	550	204	1,404	1,049	182
1979	15,055	4,154	648	297	1,887	1,101	221
1980	17,505	4,699	791	358	2,096	1,155	299
1981	21,254	6,396	1,153	450	2,390	2,066	338
1982	21,853	7,654	1,164	470	2,392	3,366	261
1983	24,445	9,766	1,507	529	3,239	4,191	299
1984[a/]	13,899	5,463	715	243	1,787	2,566	151

a/ January to June 1984.

Source: Economic Planning Board.

Table A-3. Value of engineering imports of the Republic of Korea, 1976-1984, (in US$ million)

Year	Total industry	Total engineering (ISIC 38)	Metal parts (ISIC 381)	Industrial machinery (ISIC 382)	Electr. machinery (ISIC 383)	Transp. equipment (ISIC 384)	Precision instruments (ISIC 385)
1976	8,774	2,682	94	1,153	777	542	117
1977	10,811	3,311	231	1,424	985	512	158
1978	14,972	5,404	238	2,441	1,418	1,056	251
1979	20,339	6,906	567	3,137	1,824	1,063	316
1980	22,292	5,636	392	2,146	1,739	1,055	304
1981	26,131	6,722	440	2,331	2,074	1,549	327
1982	24,251	6,865	582	2,242	2,300	1,417	325
1983	26,192	8,499	643	2,220	3,011	2,214	411
1984[a/]	15,488	5,449	373	1,305	1,604	1,940	227

a/ January to June 1984.

Source: Economic Planning Board.

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