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SCOPE FOR THE USE OF NEW INFORMATION TECHNOLOGIES BY SMALL- AND MEDIUM-SCALE METALWORKING AND ENGINEERING INDUSTRY

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SECTORAL WORKING PAPERS

In the course of the work on major sectoral studies carried out by UNIDO, Studies and Research Division, several working papers are produced by the Secretariat and by outside experts. Selected papers that are believed to be of interest to a wider audience are presented in the Sectoral Working Papers series. These papers are more exploratory and tentative than the sectoral studies. They are therefore subject to revision and modification before being incorporated into the sectoral studies.

This paper was prepared in co-operation with UNIDO consultant K. H. Plätzer (Federal Republic of Germany). The views expressed do not necessarily reflect the views of the UNIDO Secretariat.

Preface

The rapid implementation of computer-aided design (CAD) and computer-aided manufacturing (CAM) in industrialized countries will have repercussions in the future on international trade, particularly North-South. Progress in low-price, high-performance microcomputers, together with appropriate software, has facilitated the introduction of CAD and CAM systems based on microcomputers and their expanding use in medium-scale and small-scale industry in industrialized countries.

This study deals with the potential and basic requirements for the introduction of these instruments in developing countries. After a brief analysis of the capital goods sector in the industrialized countries and in selected developing countries, focusing on the role of medium-scale and small-scale industry, there is a description of the new computer-aided (CA) techniques at enterprise level. This is followed by an analysis of the impact of these new technologies on medium-scale and small-scale industry in developing countries and their application potential.

The next chapter analyses the political and institutional prerequisites for the introduction of these new technologies in developing countries. There is a brief description of the systems for promotion of medium-scale and small-scale industry in India and the Republic of Korea. It is shown that a specific industrial policy for medium-scale and small-scale industry, including the promotion of sub-contracting and the technological specialization of small and medium-sized enterprises for promotion, above all the establishment of enterprises in advanced technology areas, are essential conditions for any expansion of the industrial base in the capital goods sector. Considering the specific conditions of each country and bearing in mind the objective of technological progress, it is recommended that one should analyse whether industrial policies, industrial support institutions and promotion programmes are adequate to permit utilization of the potential represented by the application of data-processing systems in medium-scale and small-scale enterprises in developing countries.

This study was used as a discussion document at the Meeting of the UNIDO/JUNAC (Board of the Cartagena Agreement) Technical Working Group for the Formulation of a Work Programme on Micro-electronics in the Capital Goods Industries of the Andean Group Countries (project UC/RLA/86/230), held at Paipa and Bogota from 8 to 12 March 1987. The final report of this meeting was issued as document UNIDO/PPD.36.

The present paper was prepared in co-operation with K. H. Plätzer (Federal Republic of Germany), acting as UNIDO consultant. Tables and diagrams for which no source is mentioned were produced by the consultant.

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References to dollars ($) are United States dollars, unless otherwise stated.

A comma (,) is used to distinguish thousands and millions.

A full stop (.) is used to indicate decimals.

A slash (/) between dates (e.g., 1980/1981) indicates a crop year, financial year or academic year.

Use of a hyphen between dates (e.g., 1960-1965) indicates the full period involved, including the beginning and end years.

The term "billion" signifies a thousand million.

Metric tons have been used throughout.

The following symbols have been used in tables:

Three dots (...) indicate that data are not available or are not separately reported.

A dash (-) indicates that the amount is nil or negligible.

A blank indicates that the item is not applicable.

Totals may not add precisely because of rounding.

ABBREVIATIONS

CAA	Computer-aided assembly
CAD	Computer-aided design
CAE	Computer-aided engineering
CAM	Computer-aided manufacturing
CAP	Computer-aided planning
CAPP	Computer-aided process planning
CAQ	Computer-aided quality assurance
CAR	Computer-aided robotics
CAT	Computer-aided testing
CIM	Computer-integrated manufacturing
CNCMT	Computerized numerically controlled machine tools

1. INTRODUCTION

The purpose of this study is to analyse the desirability of and need for introducing the new enterprise-level computerized-system technologies, commonly referred to as "computer-aided" (CA), in the medium-scale and small-scale industry of developing countries. The study also seeks to assess the potential for their applications and the impact on the expansion of the industrial base.

Chapter 2 gives a brief description of the capital goods industry in the industrialized countries and of structural and trade characteristics. It also deals with aspects of this industrial sector in some developing countries, placing greatest emphasis on the selected examples: India and the Republic of Korea. The countries dealt with are compared in order to identify the political and promotional prerequisites for the expansion of medium-scale and small-scale industry in developing countries.

Chapter 3 presents a schematic system of the CA technologies and describes specific applications in the different technical areas of an enterprise. It then goes on to analyse the impact of these technologies on medium-scale and small-scale industry in developing countries.

The strategy options and the industrial policy and industrial promotion framework needed to encourage medium-scale and small-scale industry in the developing countries are discussed in chapter 4. The examples of India and the Republic of Korea are again used for an analysis of the impact of political, promotional and technological support measures on progress in medium-scale and small-scale industry. This provides the basis for directly deducing recommendations in specific areas for the expansion of the industrial base in the capital goods sector. Chapter 5 contains the basic conclusions and recommendations.

2. THE ROLE OF SMALL- AND MEDIUM-SCALE ENTERPRISES IN THE CAPITAL GOODS SECTOR OF DEVELOPING COUNTRIES

2.1 Definitions

2.1.1 Classification of enterprises

The criteria for classifying enterprises into micro-, small-scale and large-scale enterprises vary from country to country. In the context of the present study, for practical reasons, the number of employees per establishment is used as being the most common international parameter. This gives the following classification for developing countries: 1/

Micro-enterprise: up to four employees;
Small-scale enterprise: from 5 to 19 employees;
Medium-scale enterprise: from 20 to 99 employees;
Large-scale enterprise: over 100 employees.

The study focuses on medium-scale and small-scale enterprises which, in Latin America, represent globally between 80 and 90 per cent of the total number of industrial establishments and provide employment for between 40 and 70 per cent of the labour force. As far as added value per worker is concerned, the statistics normally show that it is lower for this group of enterprises than for large-scale enterprises or industry as a whole. The same applies to the level of investment per worker. Both ratios indicate that, overall, the operations of this group of enterprises are more intensive in terms of labour and less intensive in terms of capital requirements.

2.1.2 Capital goods

Until now there has been no single definition of capital goods, which are characterized by great diversity and heterogeneity. It is estimated that the number of different products that could be classified as capital goods is close to 4 million. Some products may have a dual character, e.g. telephones for domestic use or for use in businesses. If we consider the end use of capital goods, the following differentiation can be made:

- Capital goods for the production of capital goods, i.e. machinery and equipment used for the production of goods within the capital goods sector itself; this means above all machine tools and corresponding automation systems and, in a broader context, also construction machinery and equipment;

- Capital goods for the production of intermediate goods, e.g. electric power production and distribution equipment, installations for the production of iron and steel, fertilizers and other chemical products, and mining equipment;

1/ In industrialized countries, a small-scale enterprise may have up to 99 employees and a medium-scale enterprise from 100 to 499 employees.

- Capital goods for the production of consumer goods and services, e.g. agricultural machinery and implements, and equipment for food processing and footwear, textile and electrical consumer goods industries. 2/

In regard to industrial classification, capital goods together with consumer durables form group 38 of the International Standard Industrial Classification (ISIC) made up of industries concerned with metalworking and engineering, non-electrical machinery, electrical, electronic and telecommunications machinery and equipment, transport equipment and scientific and measuring equipment. There are other industrial branches manufacturing products that may be regarded as capital goods, e.g. wooden office furniture (ISIC group 33) or lorry tyres (group 35). However, such products represent a tiny proportion compared with the volume of production and sales of those in group 38 and are therefore generally not considered in the relevant literature or in global analyses under the heading "capital goods". The distinctive feature of all these products is that they cause the reproduction and expansion of the stock of economic wealth and the flow of income through their contribution to gross fixed capital formation.

2.2 Some characteristics of the capital goods industry in industrialized countries

2.2.1 Structural aspects of the sector

The most important countries internationally in the capital goods sector are the market-economy industrialized countries which, in 1970, accounted for approximately 74 per cent of total world production, a figure which had dropped to approximately 63 per cent by 1980. In the same period the Eastern European countries increased their share from 20 per cent (1970) to 29 per cent (1980) and the developing countries from 6 per cent (1970) to 8 per cent (1980). 3/

With regard to the market-economy countries, six countries (United States of America, Japan, Federal Republic of Germany, United Kingdom, France and Italy) account for over 80 per cent of these countries' exports. Although their economic structures differ in many aspects, as regards their capital goods industry they have in common the fact that small- and medium-scale enterprises (with up to 499 employees) predominate. Table 1 summarizes this industrial structure for the United States, the Federal Republic of Germany and Japan; the United Kingdom, France and Italy have the same characteristics. In the three countries considered, enterprises with up to 49 employees represent the largest proportion of all industrial establishments in the sector (it is worth mentioning that, in the Federal Republic of Germany, some of the small-scale enterprises are considered to be craft enterprises, which may have an impact on the percentage figure for enterprises of this size), whereas enterprises with 500 or more employees represent a mere 10 per cent. Enterprises with up to 499 employees account for 48 per cent of annual sales in the United States, 55 per cent in Japan and 42 per cent in the Federal Republic of Germany. This analysis appears to confirm that small- and medium-scale production units offer economic advantages in the production of machinery and equipment, where the bulk of production is in small batches.

2/ "Capital goods industry in developing countries: a second world-wide study", UNIDO/IS.530, Vienna, May 1985.

3/ UNCTAD, "The capital goods sector in developing countries: technology issues and policy options", New York, 1985 (United Nations publication, Sales No. E.85.II.D.4).

Table 1. Structure of the capital goods industry in the United States, Japan and the Federal Republic of Germany, 1985

	Percentage within the total number of enterprises		
Number of employees	United States	Japan	Federal Republic of Germany
20-49	51	58	38
50-99	22	20	23
100-499	21	18	30
500 and over	6	4	9
Total	100	100	100

Source: Verband Deutscher Maschinen- und Anlagenbau e.V. (VDMA): Maschinen- und Anlagenbau im Zentrum des Investierens, Frankfurt, 1986.

The capital goods sector is closely linked to all the other economic sectors, as indicated in general by input-output tables. As far as the machinery industry in the Federal Republic of Germany is concerned, the resulting interdependence is shown in table 2.

Table 2. Machinery industry in the Federal Republic of Germany

Suppliers of parts, components and services	Percentage	Purchasers of machinery and equipment	Percentage
Metalworking and engineering	32.0	Metalworking and engineering	26.5
Services	13.5	Transport	7.0
Electrical and electronics industries	10.1	Agriculture	5.3
Foundries	6.0	Electrical and electronics industries	5.2
Rolling and wire drawing	5.5	Chemicals	5.1
Iron and steel	4.5	Construction	4.5
Others	28.4	Others	46.4

This interdependence also demonstrates the very important role of sub-contracting for parts and services (e.g. engineering) in an industrialized country. Whereas it is estimated that sub-contracting amounts to approximately 40 per cent of the final value of capital goods in industrialized countries, in India the proportion is a mere 10 per cent. 4/

4/ Jorge M. Katz and collaborators, "Desarrollo y crisis de la capacidad tecnológica latinoamericana: el caso de la industria metalmecánica", Buenos Aires, 1986.

An important feature of the capital goods industries of the market-economy industrialized countries is the large volume of international trade. To take the example of the Federal Republic of Germany, approximately two thirds of the production of machinery is for export, while in 1985 imports of these products represented 43 per cent of annual sales in the Federal Republic of Germany (in 1975 machinery imports constituted only 28 per cent). This evolution clearly indicates the advance made in production specialization and emphasis on products where enterprises have technological or price advantages over competitors. In 1985 the developing countries already accounted for over three per cent of machinery imports into the Federal Republic of Germany, above all machines for general use since these were produced under better price conditions than in the industrialized countries. As regards the production costs of capital goods, in all countries labour represents about one third of the total cost, approximately 10 per cent more than in the industrial sector in general. This indicates the labour intensity of the capital goods sector and also reflects the high proportion of qualified personnel receiving wages above the industrial average level. In all the countries considered, enterprises spent approximately three per cent of their annual expenditure on research and development and four per cent on new investments.

2.2.2 Recent technological developments

An outstanding feature of this sector, above all in industrialized countries, is the high degree of specialization of individual enterprises, with an ensuing high level of sub-contracting. Furthermore, in industrialized countries the small-scale and, to a certain extent, medium-scale enterprises concentrate on the production of intermediate products and parts and components, whereas the large-scale enterprises focus on the production and/or assembly of end products. In developing countries there are relatively more small-scale enterprises offering end products. This indicates that specialization of production, concentration of individual efforts by enterprises and sub-contracting and complementation of production are at initial stages. It is to be expected that some of these small-scale enterprises will become medium-scale enterprises by purchasing other similar enterprises, perhaps large ones, and continuing to manufacture end products, while others will be able to manufacture intermediate products and/or components or will simply disappear because they do not have the necessary entrepreneurial flexibility to adjust to the new market conditions. This process will lead to an increase in productivity and capacity for technological development.

This specialization process, combined with sub-contracting and/or complementation, took place in Europe over the past 30 or so years, principally owing to two very different factors: the introduction of value added tax in the period 1950-1960 which neutralized the tax burden on production inputs and the application of numerically controlled machine tools in the 1960s. This automation gave rise to mass production of machined parts and reduced the manpower requirement on the production lines and product rejects due to human error. This trend continued with the introduction of gradual automation in other areas of the production process, specifically product quality control, product storage and raw material and intermediate material inspection.

This automation phase had the serious drawback that it required relatively large production batches in order to be competitive in price because machine retooling required rather a long time and caused idle time in production. Furthermore, numerically controlled machine tools normally carried out only one operation (e.g. drilling or turning). This automation played a large part in the increase in the rationalization index of the production process, which reached nearly 5.5 per cent per annum in the Federal Republic of Germany in the 1960s.

As a result of a slowing down of technological development and other factors, particularly economic factors, leading to a considerable reduction in industrial earnings, this index diminished during the 1970s to 4 per cent per annum and was a mere 2 per cent in the first four years of this decade.

The lack of electronic equipment at acceptable prices to deal with data in the production process was one of the most important factors in the slowdown in technological development. Large-scale enterprises introduced computing systems in production and assembly, e.g. the automotive industry, but these systems were not economically viable and did not offer adequate production capacity for small- and medium-scale industry. This situation was paralleled by the development of multifunctional machine tools with automatic retooling, thus reducing idle time and the transport between machines of products in the process of manufacture. Numerical control systems began to generate computerized multifunctional machine systems with automatic retooling and three-dimensional working capacity. At the same time, multifunctional machine tools were grouped to form computerized machine centres, producing a reduction in product manufacturing time. Depending on the type of part involved, the machines receive operating commands from a central computer which draws the necessary data from its memory. This advance was made possible by the reduction in price and, alongside this, by the increase in micro-electronic computing system capacity. Mini-computers and microcomputers are currently used in areas which previously required large computers, thus bringing production system prices within the reach of small- and medium-scale enterprises (machine centres cost in the region of $50,000-150,000, depending on the size of the centre and the work functions involved). The high degree of flexibility of these production systems also makes it possible to manufacture parts and pieces in small batches, thus providing a basis for increased productivity and reduced costs in the area of greatest industrial production importance, i.e. batch production.

The effects on manpower are considerable: production lines merely require supervisors and a few workers and there is a need for more production and computing experts in the enterprises - e.g. to write the program for the computers (it is estimated that the ratio between hardware and software is currently 70:30 but that, at the end of the next decade, software will account for 90 per cent of costs). Although automation has an impact on manpower in each enterprise and also in each industrial sector, it is estimated that, in the Federal Republic of Germany, the effect on unemployment is relatively slight: approximately 3 per cent of the labour force is put out of work because of the introduction of automated systems, 2 per cent of these people find work in other areas within the enterprise and 1 per cent are not re-employed in the same enterprise. This means that there is a need for vocational reorientation programmes for the labour force, both in the enterprise and nationally.

These changes require a high degree of flexibility in the enterprises, particularly small-scale enterprises, with regard to their future business opportunities for expanding their areas of operation. This process will also begin in the near future in developing countries, where automated production of batch-manufactured products can open up fresh fields of industrial activity. In the past, these products were not manufactured in developing countries because of the lack of qualified production labour. In future it could be the lack of technicians and engineers that is the obstacle to the manufacture of these products.

2.2.3 Some comments on the production system

With reference to production systems, it is possible to distinguish between continuous processes, generally mass production, and batch (discontinuous) processes, for the production of individual batches and in response to customer orders. According to an analysis by the Economist Intelligence Unit, approximately

80 per cent of all products manufactured in tne world are produced in batches of between 10 and 50 pieces. The unit production cost is between five and 20 times higher than it would be if those products were mass-produced. 5/

Against this background it is interesting to compare the production systems of industry in the United States and the United Kingdom, as an example of a European country. The value added depending on the production system is as follows:

Table 3. Distribution of value added depending on the production system (percentage)

Production type	United States	United Kingdom
Mass production	48	12
Batch production	40	30
Production to order a/	12	58
Total	100	100

a/ Including aircraft, special machinery and special regulation systems.

It is estimated that the Japanese structure of production systems (no exact figures are available) includes even more mass production than the United States, while the Federal Republic of Germany falls between the United Kingdom and the United States, but closer to the United Kingdom.

The difference in unit production cost (i.e. products manufactured in batches are five to 20 times dearer than products which are mass-produced) indicates the greater productivity of mass production compared with other systems, such as the iron and steel and the automotive industries, which have very different characteristics. In the iron and steel industry the only product being manufactured is steel (albeit in various forms) which is produced in a variety of dimensions (plates, bars, sections, etc.) in the final stages. The investment per industrial unit is one of the highest of all industrial technologies, resulting in an extremely high cost per job. The high level of automation in this sector is characterized by the tailoring of each production stage to the preceding and/or succeeding one.

The question of automation in the automotive industry is quite different. In this case it is a matter of producing components, parts and pieces in such a way that there is no interruption in the complex end product assembly process (leaving aside, in this context, component production). To a greater extent than in the iron and steel industry, automation has taken over from humans on the production lines, contributing to the introduction of the industrial robot.

Recently there has been a change in the automotive production structure, particularly in Sweden, moving away from the rigid production line towards production groups in which the human contribution once again has more opportunity to determine the work rhythm.

This change has reduced the psychological pressure on workers and absences due to work-induced illnesses. In other words, flexibility in the production process has been increased in order to have more human work stations and higher productivity. This increased flexibility was made possible by the introduction of

5/ Economist Intelligence Unit, "Chips in Industry", London, 1986.

micro-electronic systems in production and assembly processes for components and end products. In a way, we see here an increase in productivity through the use of batch (discontinuous) production methods surpassing the cost of continuous production.

2.3 The small- and medium-scale metalworking and engineering industry in developing countries

The small-scale industries in the capital goods sector in industrialized countries are mainly suppliers of intermediate products, parts and components to other enterprises which are generally larger (medium- and large-scale enterprises). The small-scale enterprises normally have relatively close connections with their customers and co-operate with them on specific tasks, such as technological research and development of new products. They specialize in the production of a few products using advanced technology (high technology in the production process or high-technology products).

The corresponding small-scale enterprises in developing countries are predominantly involved in end product manufacture and thus compete with medium-scale enterprises and sometimes large-scale enterprises on the same sales market. The specialization of such enterprises is comparatively far less marked and a direct link with the customer and inter-industry co-operation are relatively rare. These enterprises generally try to increase their sales figures by expanding their production range, rather than by specializing in a few well-designed products and achieving deeper sales market penetration with those products, often with less competition. This change in approach will also bring about an appreciable increase in enterprise productivity and, generally, an increase in product quality.

There are many reasons for these differences between small-scale enterprises in the two groups of countries considered. One of the bases of these differences lies in the relatively short industrial history of developing countries. In the first stages of industrialization, it is physical production which tends to play a predominant part. As advances are made in industrialization other enterprise functions become more important, e.g. marketing, organization and technological innovation. This leads to a transition of entrepreneurial efforts to the areas of planning, analysis and control of operations and functions within enterprises or enterprise departments, research and technological development and manpower specialization. If a small-scale enterprise is to progress, it is extremely important for it to possess an innovative business management approach, as can be seen in the industrialized countries and in some "nearly industrialized countries" (NICs) such as Singapore, the Republic of Korea and Taiwan Province, as well as, in specific instances, Colombia.

This indicates that the developing countries can hope to progress gradually towards production specialization, i.e. the focusing of efforts within enterprises on specific engineering tasks, broader use of sub-contracting and production complementarity between enterprises. At the same time, there must be external promotional efforts to give impetus to this process of change which will be discussed in chapter 4.

Since not all existing and future enterprises will adapt to these situational changes and, moreover, since the market structures will not change abruptly (with the exception of the high-technology market), there is reason to believe that the small-scale enterprises in the metalworking and engineering sector in countries with strong industrial development will fluctuate between two extremes:

- The traditional labour-intensive small-scale enterprise with relatively low levels of investment per worker, manufacturing products of relatively low selling price, low technological complexity and relatively low quality for a broad market;

- The modern small-scale enterprise, relatively intensive as regards physical and human capital investment, technologically advanced and operating with considerable flexibility, manufacturing very specific high-technology products for a clearly-defined market with a selected circle of customers.

These two categories of enterprises will have different machinery and equipment, as well as different production operations, personnel with greatly contrasting skills and unequal market conditions. The promotion of these two groups will obviously require different strategies: whereas the first category requires technical assistance to improve its economic and technical situation, the second category requires, in particular, support in the pre-investment phase, a favourable environment in terms of legal and fiscal services for businesses and a promotion strategy to attract human and financial (sometimes risk) resources to these new enterprises. They will also benefit from the additional creation of service enterprises in the computing sector, enterprises providing both hardware and software and systems analysis and engineering enterprises, with particular reference to production control and planning systems.

2.3.1 Importance of the capital goods sector

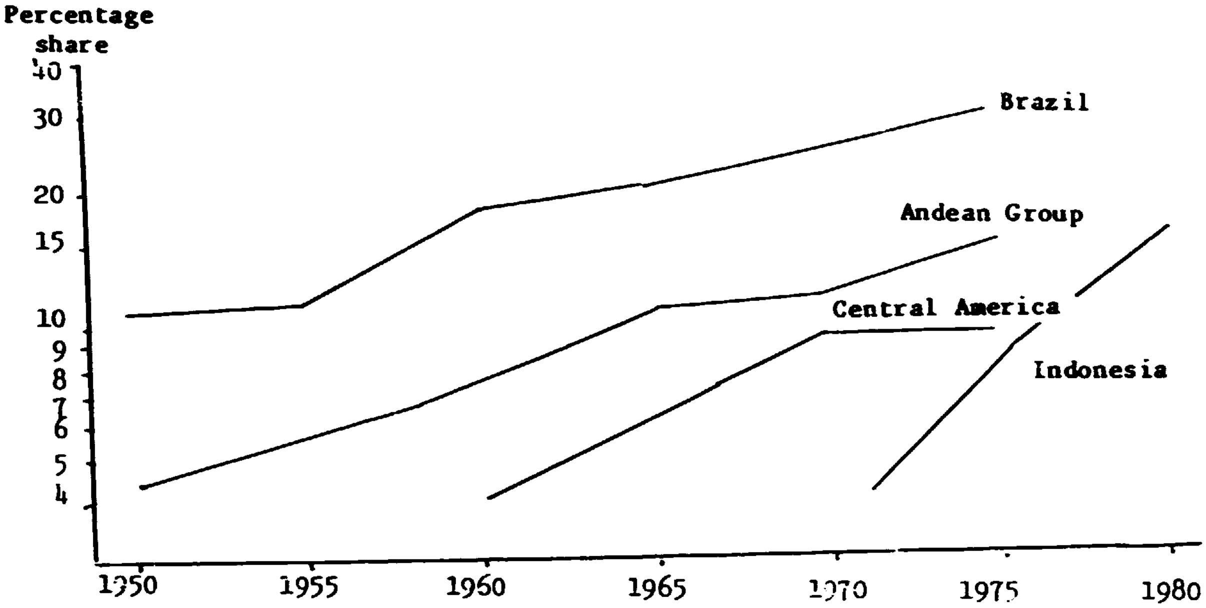
The importance of the capital goods sector increases as industrialization progresses (see figure 1), while the consumer product sector becomes less important (see table 4). In Latin America, the share of the capital goods sector in manufacturing sector value added amounts to approximately 25 per cent, but there has been little growth in the last decade. In the Republic of Korea, the capital goods sector accounted for 16.3 per cent of value added in 1975, rising to 27.4 per cent in 1983, an indication of the strong industrial growth in that country.

Tables 5 and 6 show the composition of the capital goods sector in various groups of countries. It can be seen that fabricated metal products (ISIC 381) decline in importance as industrial development takes place, while electrical machinery and equipment (ISIC 383) account for an increasing proportion of the capital goods sector, reflecting the transition from the production of relatively simple products of low technological complexity to that of products of high technological complexity, above all the telecommunications and micro-electronics products included in ISIC 383. This again indicates the strong basis of the capital goods industry in the Republic of Korea, where this group dominates the capital goods sector.

The development prospects for the capital goods sector in Latin America are indicated in table 7. The greatest growth is anticipated in the transport equipment and scientific equipment groups (bearing in mind that the 1980 base for the latter is relatively low).

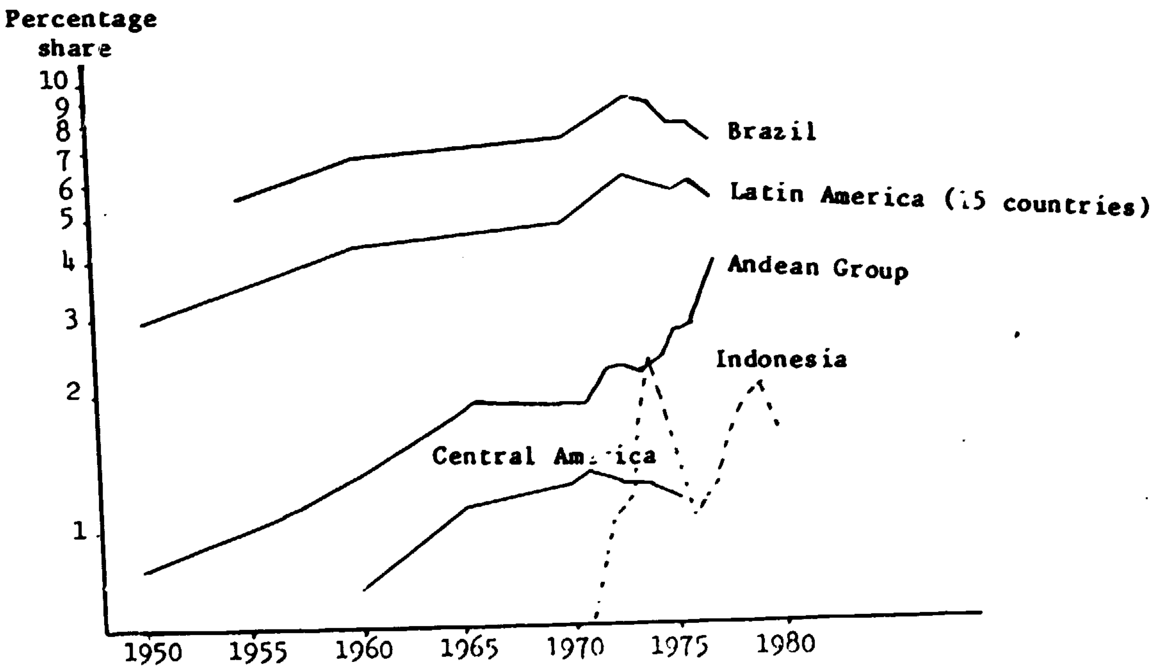
This development, based on past group growth patterns, will give a capital goods sector of the kind set out in table 8. The past trends will give particular emphasis to the transport equipment group, while those groups which are very important for balanced development of the sector will lose ground, i.e. non-electrical machinery and electrical machinery and equipment. Furthermore, table 8 clearly shows that there will be growth in the group which is most largely made up of large-scale enterprises, while the other four groups, in which there is an international numerical predominance of small- and medium-scale enterprises, will lose a considerable part of their importance. To conclude: Latin America needs another strategy to promote small- and medium-scale enterprises if it is to develop an internally balanced and externally competitive capital goods industry. If not, the transport equipment group will have to meet its requirements for parts and components generally supplied by other capital goods groups outside the region.

Figure 1. Share of the engineering industry in total manufacturing value added, 1950-1980



Source: "Prospects for industrial development and for a capital goods industry in Indonesia", Vienna, 20 July 1984 (UNIDO/IS.479 and Add.1 and 2).

Figure 2. Share of non-electrical machinery (ISIC 382) in total manufacturing value added, 1950-1980



Source: "Prospects for industrial development and for a capital goods industry in Indonesia", Vienna, 20 July 1984.

Table 4. Structure of manufacturing industry in Latin America (15 countries), a/ 1950-1977 (percentage of value added)

ISIC	Industry	1950 b/	1955 b/	1960 c/	1965	1970	1975	1976 d/	1977 d/ e/
311-312 313-314	Food, beverages and tobacco	31.0	28.6	26.7	24.4	23.0	20.7	19.8	18.9
321	Textiles	15.9	14.7	11.9	10.2	8.8	8.2	7.9	7.8
322-324	Footwear	8.1	7.1	5.5	4.5	3.6	3.5	3.2	3.0
323	Leather	1.0	0.9	0.7	0.6	0.8	0.4	0.4	0.3
332	Furniture	2.2	1.9	1.7	1.5	1.3	1.3	1.3	1.5
342	Printing and publishing	4.2	4.0	3.5	3.3	3.2	2.6	2.7	2.8
390	Other manufactures	1.0	0.9	0.9	0.9	1.1	0.9	0.9	0.9
	Subtotal Group A	63.4	58.1	50.9	45.5	41.8	37.6	36.2	35.1
331	Wood and cork products	2.9	2.4	2.3	2.1	1.8	1.7	1.8	2.1
341	Paper and paper products	2.2	2.4	2.1	2.5	2.6	2.3	2.4	2.4
351-352 356	Industrial chemicals, other chemicals and plastic products	5.4	7.3	8.8	10.0	11.3	12.6	13.5	14.7
353-354	Petroleum refineries and products of petroleum and coal	4.8	5.6	6.0	6.6	6.3	5.6	5.8	4.3
355	Rubber products	1.5	1.8	1.8	1.9	2.0	2.2	2.3	2.3
361-362 369	Non-metallic mineral products	5.3	5.6	4.9	4.6	5.1	5.4	5.4	6.1
371-372	Iron and steel and non-ferrous metals	3.6	4.6	5.7	7.0	7.3	7.6	7.4	8.5
	Subtotal Group B	25.7	29.7	31.7	34.6	36.4	37.4	38.6	40.4
381	Metal products	4.3	4.6	4.6	5.6	5.8	5.6	5.4	5.0
382	Non-electrical machinery	2.9	3.5	4.2	4.4	4.5	5.4	5.8	5.1
383	Electrical machinery	0.9	1.1	3.0	3.8	4.3	4.7	5.0	5.7
384	Transport equipment	2.4	2.6	5.1	5.5	6.7	8.7	8.3	7.9
385	Professional equipment	0.4	0.4	0.5	0.6	0.4	0.6	0.6	0.8
	Subtotal Group C	10.9	12.2	17.4	19.9	21.8	25.0	25.3	24.5
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

a/ Argentina, Bolivia, Brazil, Colombia, Costa Rica, Chile, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Paraguay, Peru and Venezuela.

b/ Excluding Bolivia, Chile, Paraguay and member countries of the Central American Common Market (Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua).

c/ Excluding Paraguay

d/ Excluding member countries of the Central American Common Market.

e/ Excluding Argentina.

Source: ECLA, based on official statistics.

Table 5. Composition of the capital goods sector
(percentage)

	ISIC	Market-economy developed countries 1963	1980	Developing countries 1963	1980	Republic of Korea 1983
38	Capital goods	100.0	100.0	100.0	100.0	100.0
381	Metal products	19.8	17.0	25.6	20.1	15.0
382	Non-electrical machinery	28.6	28.1	17.3	22.6	15.0
383	Electrical machinery and equipment	18.4	24.4	19.9	23.5	36.7
384	Transport equipment	28.4	24.4	34.6	32.1	30.5
385	Scientific and measuring equipment	4.8	6.1	2.6	1.7	2.8

Table 6. Structure of the engineering industry in Latin America and selected subregions, 1950-1977 (percentages of value added)

ISIC	Product group	1950	1955	1960	1965	1970	1971	1972	1973	1974	1975	1976	1977
Latin America													
381	Fabricated metal products	4.3	4.6	4.6	5.6	5.8	5.7	5.8	5.7	5.4	5.6	5.4	5.0
382	Non-electrical machinery	2.9	3.5	4.2	4.4	4.5	5.0	5.4	5.9	5.6	5.4	5.8	5.1
383	Electrical machinery	0.9	1.1	3.0	3.8	4.3	4.4	4.6	4.9	4.5	4.7	5.0	5.7
384	Transport equipment	2.4	2.6	5.1	5.5	6.7	7.2	7.5	8.2	8.9	8.7	8.3	7.9
385	Professional equipment	0.4	0.4	0.5	0.6	0.4	0.6	0.7	0.7	0.6	0.6	0.6	0.8
	Subtotal	10.9	12.2	17.4	19.9	21.8	23.0	24.0	25.4	25.0	25.0	25.2	24.5
Brazil													
381	Fabricated metal products	-	2.9	3.4	3.9	4.3	4.7	5.0	5.4	5.2	5.2	5.2	5.0
382	Non-electrical machinery		5.5	6.4	6.8	7.0	7.6	8.1	8.8	8.4	7.4	7.5	6.9
383	Electrical machinery	10.9	1.2	3.2	4.3	5.3	5.7	6.0	6.5	5.4	5.6	5.9	5.9
384	Transport equipment		1.2	5.2	5.1	8.0	8.9	9.6	10.3	11.7	11.5	10.9	10.4
385	Professional equipment		0.2	0.4	0.5	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	Subtotal	10.9	11.1	18.6	20.6	25.2	27.6	29.4	31.7	31.3	30.5	30.2	28.9
Andean Group a/													
381	Fabricated metal products	1.2	1.6	2.8	3.5	3.7	3.8	3.8	3.8	3.6	4.4	4.1	4.8
382	Non-electrical machinery	0.8	0.9	1.3	1.9	1.8	1.9	2.2	2.2	2.1	2.6	2.7	3.6
383	Electrical machinery	1.0	1.0	1.3	2.1	2.6	2.7	2.9	2.9	3.0	3.7	3.7	4.1
384	Transport equipment	1.4	2.0	2.0	3.3	3.0	3.1	3.3	3.5	3.2	3.9	3.6	2.8
385	Professional equipment		0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.4	0.2	0.3
	Subtotal	4.4	5.6	7.5	10.9	11.3	11.7	12.4	12.6	12.2	15.0	14.3	15.7
Central America b/													
381	Fabricated metal products			1.2	3.1	4.8	4.8	4.9	5.0	5.0	4.6		
382	Non-electrical machinery			0.7	1.1	1.2	1.3	1.2	1.2	1.2	1.1		
383	Electrical machinery			0.3	0.7	1.7	1.7	1.7	1.8	1.9	1.8		
384	Transport equipment			1.8	1.5	1.6	1.7	1.6	1.5	1.6	1.7		
	Subtotal			4.0	6.3	9.3	9.5	9.4	9.5	9.7	9.2		

a/ Bolivia, Colombia, Ecuador, Peru and Venezuela.

b/ Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua.

Source: "The capital goods industry in Latin America: present situation and prospects", UNIDO/IS.478.

Table 7. Development prospects for the capital goods sector, 1985-1990 (value-added index: 1980 = 100)

		1980	1985	1990
		(in millions of constant 1975 dollars)		
381	Metal products	6 173	136	212
382	Non-electrical machinery	7 503	155	234
383	Electrical machinery and equipment	6 215	121	226
384	Transport equipment	10 604	206	493
385	Scientific equipment	146	185	463

Source: UNIDO, "Capital goods industry in developing countries: a second world-wide study", UNIDO/IS.530, Vienna, 9 May 1985.

Table 8. Future composition of the capital goods sector in Latin America (percentage)

		1980 (Actual)	1985 (Projection)	1990 (Projection)
38	Capital goods	100.0	100.0	100.0
381	Metal products	20.1	16.9	13.4
382	Non-electrical machinery	24.5	23.4	18.0
383	Electrical machinery and equipment	20.3	15.1	14.4
384	Transport equipment	34.6	44.0	53.5
385	Scientific equipment	0.5	0.6	0.7

2.4 An example of capital goods sector development: Republic of Korea

2.4.1 Some sectoral aspects

The Korean engineering industry 6/ clearly demonstrates the importance of this sector in the development of a country's manufacturing sector. Between 1975 and 1983 the share of ISIC 38 in manufacturing added value grew from 16.3 per cent (1975) to 24.7 per cent (1983), making it the major industrial sector in 1983. In the same period, the share relating to textiles, wearing apparel and leather (the most important sector in 1975) decreased from 22 per cent (1975) to 16.6 per cent (1983) and there was a similar pattern in the food industry - from 21.2 per cent in 1975 down to 15.8 per cent in 1983. Total manufacturing sector employment increased in this period by 56 per cent, compared with a mere 20 per cent in the textiles sector and 25 per cent in the food sector, but in the basic metals sector (ISIC 37) the increase was 98 per cent and in the engineering industry 112 per cent.

6/ ISIC division 38, consisting of capital goods and consumer durables.

As regards the structure of the engineering industry, the electrical machinery and equipment branch (ISIC 383) and the transport equipment branch (ISIC 384) are dominant (see table 6). Approximately 50 per cent of value added in the electrical machinery and equipment subsector is accounted for by telecommunications products and consumer durables (e.g. radios, television sets). In the transport equipment subsector the same percentage is accounted for by shipbuilding, while vehicles are responsible for 44 per cent. In comparison with the industrialized countries, the non-electrical machinery subsector is less strong (15 per cent of the sector's value added). With reference to capital goods, this subsector must be regarded as of central importance. The nucleus of this subsector is represented by machine tools since this industry establishes the capability to produce other capital goods. If there are deficiencies in machine tool production, these will have a direct impact on the other branches of the capital goods sector. The share of subsector 382 in the coverage of national demand is less than one third, and exports are very limited. At the same time, the utilization of installed capacity nationwide is less than in the other subgroups considered, which indicates that the push given to the development of the machinery sector in the past decade did not have the desired success.

The composition of the engineering sector by enterprise size is shown together with that for Japan in table 9. It can be observed that large concerns in Korea (1.8 per cent of all establishments in the sector) clearly dominate the capital goods sector, whereas small-scale enterprises play a very small role in comparison with Japan and, as we have already seen, with other industrialized countries. This structure means that technological specialization of enterprises is little developed, as is sub-contracting of parts and components.

Table 9. Value added in the engineering industry in Japan (1981) and the Republic of Korea (1982), by size of establishments

Size (in terms of employment)	Share of value added (percentage) Japan	Republic of Korea
5-99	31.6	17.1
100-299	13.9	14.1
300 and above	54.5	68.8
Total	100.0	100.0

Source: "The engineering industry in the Republic of Korea", UNIDO, Vienna, 8 May 1986 (UNIDO/IS/R.43).

In the past few years, the Government of the Republic of Korea has taken steps to reduce this imbalance by the introduction of special programmes for the promotion of small- and medium-scale enterprises. These measures are set out, among others, in section 4.1.1.

2.4.2 Some aspects of the electronics subsector

In the last decade, production in the electronics branch has grown at an annual rate of 40 per cent. This branch's share in manufacturing value added was 2.4 per cent in 1970 and 5.7 per cent in 1980. In 1980 approximately 70 per cent of production was exported. The value of production rose from $0.2 billion in 1972 to $1.4 billion in 1976 and $3 billion in 1980. 7/

Table 10 gives a comparison of the structure of electronics production in the United States and Japan, as industrialized countries, and India and the Republic of Korea, as developing countries. The table shows that, in the United States and India, more importance is given to professional electronic products, whereas in Japan and the Republic of Korea consumer electronic products and components predominate. Output of professional electronic products, which are strictly capital goods, is still very low in the Republic of Korea (11 per cent), while "off-shore" manufacturing plays an important role in that country. Statistically this type of production is not significant in India.

Table 10. Comparison of the structure of electronics production in the United States, India, the Republic of Korea and Japan (percentage)

Area	United States	India	Republic of Korea	Japan
Consumer electronics	15	26	38	38
Components	17	18	33	30
Professional electronics	68	56	11	32
Total	100	100	100	100

Source: UNIDO, "Small-scale electronics industry as sub-contractor in Asia and the Pacific region", UNIDO, Vienna, August 1985.

With regard to enterprise size in the Republic of Korea there is again a predominance of large-scale enterprises (see table 11). The number of large-scale enterprises with more than 500 employees also grew more quickly than the number of smaller enterprises between 1970 and 1978. Of the approximately 700 companies in 1978, 103 were joint ventures and 44 were foreign, the remainder being domestic enterprises.

In the first years of this decade, the Government began to promote small-scale enterprises more than before (see section 4.1.1). This has led to a considerable increase in new small enterprises. According to information from the Electronic Industry Association of Korea, in 1985 it had as members 136 companies with less than 50 employees, of which 36 had been in existence for less than two years, 58 for less than four years and 75 for less than six years. These new enterprises are found mainly in the high-technology area. Currently, the Government is envisaging a considerable increase in the contribution of small-scale industry to value added, exports and employment up to 1991 (see section 4.1.1).

7/ UNIDO, "Small-scale electronics industry as sub-contractor in Asia and the Pacific region", Vienna, August 1985 (UNIDO/IS.549).

Table 11. Republic of Korea: Structure of the electronics industry by size of enterprise, 1970 and 1978

Employees	Number of establishments 1970 Number	1970 Percentage	1978 Number	1978 Percentage	Production in 1978 (Percentage)
Over 2,000	4	3	17	2	39
1,000-2,000	3	2	30	4	16
500-1,000	9	5	62	9	11
100-500	41	23	294	42	25
Below 100	118	67	307	43	9
Total	175	100	707	100	100

Source: World Bank, Korea Electronics Technology Project, 1980.

2.5 An example of an electronics industry: the case of India

The annual turnover of the Indian electronics industry is of the order of $1 billion. While many Asian countries focus their electronics production on export markets (with a predominance of free zone production in, for example, Malaysia, Thailand and Singapore), the electronics industry in India is directed towards achieving self-reliance in electronics. As a result, India has the most complete production range of electronic products of the developing countries in Asia. However, owing to the extremely rapid international technological development and the legal and fiscal restrictions on the import of advanced technologies and products in recent years, the electronics industry has not always been able to keep pace with the rapid technological changes, even though it has a good scientific and technological research infrastructure. In many product areas India does not therefore have the most modern technologies. In view of these deficiences, the Government has in the last two years introduced technology transfer measures including the purchase of technology and products, licensing and joint venture agreements with foreign companies.

Manufacture of electronic products grew between 1971 and 1981 by a factor of 2.6 (compared with a factor of approximately 40 in the Republic of Korea). The highest growth (a factor of 7.3) was in the computers and industrial and control equipment branch, reflecting the political importance assigned to the capital goods sector in India. Small-scale industry has a share of about one third in the value of electronics production (see table 12), achieving two thirds in the area of consumer electronics and playing no part in the areas of telecommunications equipment and aerospace and defence equipment, which are dominated by State enterprises.

Table 12. Electronics production by type of enterprise, 1981

Sector	Total production (millions of rupees)	Share of public sector units (percentage)	Share of private sector units (percentage)	Share of medium-scale units (percentage)
1. Consumer electronics	2 460	9.02	24.56	66.42
2. Communication and broadcasting equipment	1 540	95.17	4.83	-
3. Aerospace and defence equipment	690	99.49	0.51	-
4. Instrumentation control and industrial electronics equipment	1 560	35.39	28.49	36.12
5. Computers and office equipment	325	30.15	42.16	27.69
Total equipment	6 575	47.15	18.88	32.97
6. Electronics components	1 730	28.03	39.15	32.82
Total	8 305	43.25	23.02	33.73

Note: Excluding production worth 255 million rupees in the Santacruz Electronics Export Processing Zone.

Source: UNIDO, "Small-scale electronics industry as subcontractor in Asia and the Pacific region", Vienna, August 1985.

The high share of small-scale industry in the production of computers and office equipment, as well as professional electronic products, indicates the relative strength of small-scale industry in the high-technology area.

In general, the importance of small-scale industry, above all in consumer electrical product manufacture, is due to the fact that these products are reserved for small-scale industry by the country's authorities (see section 4.1.1). India has for a long time considered the production of electronic components to be a production area for small- and medium-scale enterprises. In the period between 1950 and 1960 it granted production licences and put up barriers to imports. With an assured market, the enterprises made no great technological efforts and in 1982 average production capacities per production unit in India and internationally for selected products were as follows:

Table 13. Production capacity per unit (millions of pieces)

		In India	Internationally
Integrated circuits:	Digital	1.0	50.0
	Linear	0.5	5.0
Transistors and diodes		20.0	500.0
Power transistors		0.2	3.0
TV tubes		0.1	1.5
Capacitors:	Electrolytic	10.0	50.0
	Ceramic	50.0	50.0
	Plastic	10.0	50.0
Carbon resistors		50.0	1 000.0
Relays and switches		0.2	2.0
Reed switches		3.0	20.0

Neither production capacity nor production and product technology could keep pace with international development. Moreover, selling prices were far above the world level and the electronic end products including those components were not competitive internationally. Faced with this serious situation, the Department of Electronics of the Indian Government decided that component production should no longer be reserved for small- and medium-scale industry and allowed the import of foreign technology. This drastic change in industrial policy in India demonstrates that small-scale industry, whether in India or in industrialized countries, can no longer be competitive in this field because of innovative production technologies and innovative product developments based on high levels of previous investment in research and development.

India's electronics exports amounted to only $56 million in 1981. The production of software for export has been called India's "billion dollar hope" because of the availability of large numbers of well-trained engineers and scientists. However, software exports amounted to only $10 million in 1980. National and international experts 8/ have explained the disappointing situation by saying that, among other factors, the software producers did not have access to the newest generations of computers because of the ban on their import, whereas such access is an essential prerequisite for successful competition for software contracts in industrialized countries where such equipment is used. It is also mentioned that administrative barriers, both with regard to high-technology imports and with regard to scientific and technological research and development, are a cause for the widening gap between the electronics sectors in India and in the developed countries. The example of the electronics industry in India demonstrates that the capital goods sector needs international technology if it is to be able to compete, in specific areas, on sales markets. An excessively high tariff barrier or any other exaggerated protectionist measure for the sector under consideration gives rise to a situation in which the investment inputs for the entire economy are above the international level, with repercussions on a country's competitiveness and a negative cost and benefit imbalance at micro- and macro-economic level.

8/ UNIDO, "Small-scale electronics industry as subcontractor in Asia and the Pacific region", Vienna, August 1985.

2.6 Possible areas of activity for small- and medium-scale industry in developing countries

2.6.1 Global aspects

The development of automation in areas of the enterprise's production sector, i.e. the production process, handling of product flow, storage, quality control, etc., has gradually led to the human being's increasing separation from the processing of the product. During this development it was also found important to "humanize" the workstation, to which particular attention has been paid in Sweden, and to eliminate extraneous physical and psychological burdens caused by heavy work. Although this has already been planned, it has not been possible to integrate these partial computerization systems into a global system because of the high cost of computing equipment and the lack of software and working tools (e.g. the "light pen").

The first integral systems were installed in the early 1970s for a cost of around $3 million per unit in high-technology companies in the United States (aviation and electronics), and the first enterprises were established, specializing in two information technology areas which would have a great impact in the next 10 years on engineering industries and other branches of industry. These areas are CAD and CAM, combined with the introduction of mini-computers and, most recently, microcomputers with a high capacity-to-cost ratio. These integral systems are capable of rapid application advances in the engineering industries in industrialized countries, both in large-scale enterprises and, with a time-lag of 2-4 years, in medium- and small-scale enterprises. It is estimated that, by 1988, approximately 50 per cent of process plants (capital goods) will be designed by these systems and that, by 1995, 50 per cent of machinery components will be produced using CAD and CAM. This will result in product life-cycles that are even shorter than those at present and more pronounced technological competence. Moreover, the door will be opened for new production potential in developing countries once they have access to the information bases and can participate in this technological advance.

2.6.2 A new type of small-scale enterprise

Some observers say that the introduction of the new technologies discussed earlier should be easier in developing countries than in industrialized countries because the traditional social and industrial structures which may hinder technological innovation are less developed. Such observers quote Taiwan Province, the Hong Kong area, Singapore and the Republic of Korea as examples. However, in other countries technological advance provides far less support for this theory.

Empirically, the industrial growth potential for developing countries in the field of advanced technologies of a different kind seems to lie above all in the area of new and technologically specialized small-scale enterprises. As said previously, the future of the small-scale enterprise in developing countries will lie between two extremes:

- The traditional labour-intensive small-scale enterprise (employing highly qualified staff) manufacturing products of relatively low price, quality and technological complexity;

- The modern small-scale enterprise, more intensive as regards capital and physical installations, less intensive as regards labour with low qualifications (but more intensive as regards highly qualified manpower), technologically advanced and operating with considerable flexibility, manufacturing products of high price, quality and technological complexity by the application of CAD and CAM systems.

In basic terms, the minimum size of a small-scale enterprise producing components is one machine centre. Nevertheless, in order to increase operating flexibility it is advisable to install two machine centres. The investments in machinery and basic hardware and software for CAM are of an order of magnitude of $80,000 (for one centre) to $120,000 (for two centres). Such an enterprise will employ approximately 8-12 persons (including office staff), i.e. an investment amounting to $10,000 per employee. Such enterprises will need other enterprises specializing in software production. It is thought that a software enterprise employing about six highly qualified persons will be able to serve six production enterprises.

This type of enterprise will need a CAD system which, in view of its diversified and multiple use, should be installed in an institution which allows access to other enterprises and to selected post-graduate students. CAD systems with acceptable working capacity and efficiency will have to be of the mini-computer type at a price of approximately $200,000-300,000, including basic software. This system can also be used by other branches, e.g. the food products industry and engineering and construction companies. None the less, the most recent software development advances make it possible to install simple CAD systems in individual enterprises at a cost of $10,000-30,000, depending on the software type.

2.6.3 Micro-electronics

A previous section has already touched on the example of the electronics industry in India. The extremely rapid technological change is altering the production system of the electronics industry. Nowadays, the production of electronic components is concentrated in a few factories in some countries of the world, including the Republic of Korea and Taiwan Province. The economies of scale achieved by these factories have permitted a considerable reduction in selling prices which will most probably be kept low by excess capacity.

Similar technological developments are occurring in the production of micro-electronic components: integrated circuits. Whereas the first generations were produced on a highly labour-intensive basis and production thus tended to take place in free zones, particularly in Asian countries (Thailand, Malaysia, Singapore, Taiwan Province, Republic of Korea), recent production installations for very large-scale integrated circuits are highly automated and use, among other things, CAD and CAM systems. These production units require high levels of investment which to date have only been within the reach of large companies in a few countries. The automation of integrated circuit production caused the minimum investment per production unit to jump from around $1 million to $40-50 million.

A newcomer in this area is the Republic of Korea which, according to estimates, invested around $1 billion. The ebbing of investments in this field, particularly in the United States, Japan and the Republic of Korea, and the high installed capacities in 1985 caused a considerable reduction in selling prices and the closure of some factories in the United States because they were not profitable. In Europe, only two companies (Siemens and Philips) are undertaking large-scale preparations for participating co-operatively in the development of the next generation of 1 megabyte microchips. For this development they are receiving financial support from the Governments of the Netherlands and the Federal Republic of Germany, as well as the European Economic Community.

The risk involved in this area and the high human resources requirements (for example, the Republic of Korea is relying heavily on Korean scientists returning from universities and research centres in the United States) and the high investment, both in research and production units, make the micro-electronics sector a dangerous one for newcomers. However, as shown by the examples of Singapore and the Republic of Korea, there is broad scope for small-scale enterprises specializing in the manufacture of complementary products. In both countries, small-scale enterprises produce disc drives for large-scale enterprises which include them in their end products. Other production areas may be computer peripherals and micro-electronic systems application, such as industrial process control equipment, electric motor control and software for industrial applications (e.g. CAD/CAM systems) and other applications.

In all these cases, a high priority aspect is the capacity for technological and engineering development. The countries of Europe and some Asian developing countries have support programmes for young scientists and engineers who are attempting to develop products and applications in the high-technology field. These programmes have already led to the establishment of new enterprises and the creation of new jobs.

2.6.4. Aspects of the range of future production

The application of CAD and CAM systems in small-scale industry requires a concentration of business efforts on specific high-technology products because of the necessary investments and the need to handle this new technology. As we have seen, small-scale industry in the industrialized countries produces, above all, special parts and components under sub-contracting arrangements for inclusion in a more complex end product. This applies to both sections of engineering products, i.e. capital goods and engineering goods.

A small- and medium-scale enterprise entering this area of production thus must follow the path of technological specialization. The product range suited to small-batch manufacture is extremely broad and enumeration of those products goes beyond the scope of the present study. The product combination and selection parameters will be, above all, market potential and the configuration of machine centres and available software. This means that, before machinery is purchased, it is necessary to determine the envisaged production range and to choose the products on the basis of the weight, geometry and type of machinery needed.

2.6.5. Software

Some 30 years ago, the hardware in a computing system represented approximately 90 per cent and the software 10 per cent of the total investment. Nowadays the investment is approximately 30 per cent hardware and 70 per cent software and it is thought that, by the beginning of the next decade, the ratio will be 10:90.

As an extension of the present process, the introduction of CAD and CAM systems will go further in changing the weight of investment in tangible items (machinery, equipment, etc.) to give more emphasis to intangible items. In this context, intangible items can be described as the investment in planning, organization and human resources which are not quantified when the investment is made, but rather at future production stages. In other words, intangible items are investments in technology.

The most important group of intangible items for the development of the engineering goods industry comprises:

- Planning of production operations;
- Engineering design;
- Product design;
- Software for the manufacturing process.

In future these areas will be as important for large-scale enterprises as for small-scale ones. In the industrialized countries and in the developing countries it is doubtful whether small-scale enterprises will generally be capable of putting together the necessary capital for such investments. In order to ensure their future participation in an industrial sector that has demonstrated its great importance for our economies, it will be necessary to organize external systems of finance and new systems of business co-operation or other systems of access to technologies in the intangible items group, i.e. access to software. In many industrialized and developing countries (e.g. Republic of Korea, Singapore and Thailand) this access is supported by public agencies.

2.6.6. Aspects of employment

As a result of the ongoing automation of engineering goods production, it is highly unlikely that the sector will continue to absorb manpower with low skill levels at the same rate as in the past. However, the employment potential for technical and academic personnel is increasing with the level of industrial automation. This very probably means an increase in value added per employee which will in turn normally increase State revenue from taxation. The decision regarding whether this alternative, i.e. to increase tax revenue rather than to make a direct and massive increase in manpower, is a viable path to follow will be a political one. Some countries have opted to take this path by using part of the additional value added for educational programmes in technological innovation and employment in infrastructure and other non-industrial fields.

3. IMPACT OF NEW TECHNOLOGIES ON SMALL- AND MEDIUM-SCALE INDUSTRY IN THE CAPITAL GOODS SECTOR

3.1 Overview of CA techniques

3.1.1 General remarks

The use of computers in specific applications within the enterprise is already commonplace. Examples of traditional application are finance control, strategy planning, work preparation, stock control and, with regard to production, numerically controlled machine tools, etc. All these applications generally made use of special case-specific programs without much interrelation (with the exception of large-scale enterprises). The development of micro-electronics and the introduction of microcomputers on the market caused a considerable reduction in computer prices - by a factor of more than 20 in a period of approximately 8 years. This price reduction had a strong impact on the profitability of computer application and, as a result of the relatively low investment, caused a rapid dissemination of such systems in small- and medium-scale industry in the industrialized countries and in the more advanced developing countries.

Alongside this was the need to link up the various computer programs and systems within the enterprise concerned. This brought about a rapid development of communication link software. In the technical and technological area of the enterprises people saw the need to combine complementary programs. The lack of technical standards and the multitude of different programs presented systems software and hardware compatibility problems which have gradually been reduced.

3.1.2 CA techniques

This software development gave rise to a series of new expressions using the initial letters of "computer-aided" (CA) related to specific applications. Table 14 lists the most widely used abbreviations.

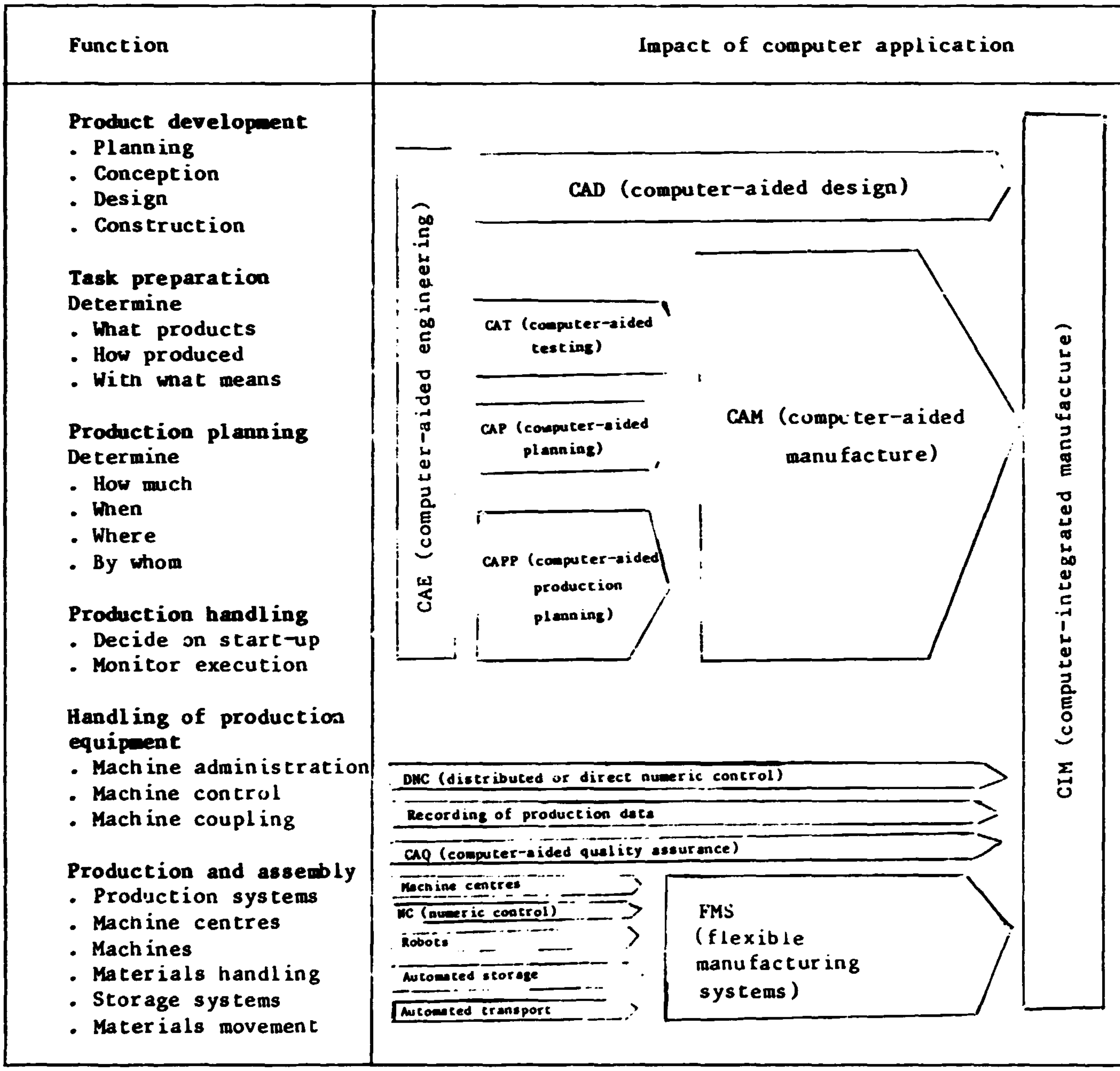
The interrelation of these computer application systems within the enterprise and the corresponding functions are set out in figure 3. It must be noted that the use of CA-type techniques is designed to support the execution of the task corresponding to each concept and not to take full responsibility for complete tasks, and that the operating system is interactive, that is to say that the computer user is in dialogue with them and has the possibility of intervening, making changes and proposing alternative solutions. At the same time, it is worth mentioning that the outline given is designed to demonstrate the interrelation of CA techniques and does not set out to represent the specific case of an enterprise. The introduction of CA techniques in an enterprise must be gradual, with the management of the enterprise itself deciding where to begin.

In industrialized countries, CAD and CAM use in production takes place in areas where those systems help to increase operating flexibility (by reducing delivery times and providing customers with better service) and/or to increase productivity and thus generate a reduction in production costs. Isolated systems are still most frequent, but there has recently been a rapid advance in integrated systems. The isolated systems use different data banks set up according to the enterprise's requirements, whereas integrated systems make use of a central data bank in a large computer. Small- and medium-scale industry in developing countries also has to take account of another decisive factor for the application of CAD/CAM systems: they make it possible to manufacture products of high technological complexity and high quality using imported CAD and CAM software and then permit the construction by the enterprise itself of new products using the installed computing bases. It seems highly advisable for the majority of enterprises in developing countries to begin with machine centres using specific software for the selected production range, before going on to use CAD systems to introduce their own new products.

Table 14. Most common abbreviations in the "computer-aided" sector

Abbreviation	Name	Explanation
CAE	Computer-aided engineering	Basic term for computer application in pre-production areas.
CAD	Computer-aided design	Design and calculation of product construction.
CAM	Computer-aided manufacturing	Planning and execution of production with computer assistance.
CIM	Computer-integrated manufacturing	Basic term for computer application in all the technical areas of an enterprise.
CAP	Computer-aided planning	Planning in the technical area of an enterprise.
CAPP	Computer-aided production planning	Planning and handling of production.
CAT	Computer-aided testing	Execution of technical tests with computer application (e.g. new products).
CAQ	Computer-aided quality assurance	Product quality control and assurance.
CAR	Computer-aided robotics	Computer handling of production robots.
CAA	Computer-aided assembly	Assembly assisted by computers.

Figure 3. Outline of computer application interrelations in the technical part of an enterprise



Source: W. Poths and R. Löw, "CAD/CAM: Entscheidungshilfe für das Management", Frankfurt, 1985.

3.1.3 Possible practical applications

The first model is the isolated application of CAD or CAM. The basic models of combinations of different CAM techniques are represented in figure 4 and have the following characteristics:

Model 2. When CAP is combined with CAM, CAP normally also has graphic functions, e.g. in tool movement. Computer programs for the implementation of computer-aided production (e.g. CNCMT) are drafted in the unit of the enterprise responsible for work preparation. The data are transmitted to the machines by paper tape, magnetic tape, diskette or direct connection (cable). CAP also requires inputs to provide the geometric data of the parts to be produced, as well as the technological data.

Model 3. The previous combination is supplemented by CAD. CAD is now responsible for the determination of geometric data, apart from computer assistance in product design and construction. When supplementing an existing model 2 it is necessary to ensure that the new CAD system is compatible with the existing CAP and CAM. Data transmission is normally by disc.

Model 4. The existing system is expanded by a CAQ system, i.e. the production output is controlled by a computer-aided technique.

Model 5. With the introduction of CAPP to model 4, the CAD data are used to administer the CAPP production inputs and the CAP data are used to manage the CAPP "work stations" (machines). There is also CAQ feedback to the CAPP on possible differences between the actual state of the end product and the desired state so that changes may be made in the CAM system control data.

In small-scale enterprises in industrialized countries use is still generally made of isolated systems, particularly CAM systems, without combining them with CAP, CAQ or CAPP. When combined systems are used, model 2 predominates. Expansion of the use of CAD and CAM and also other models would require a larger investment in CNC machine tools, necessitating relatively large investments for those enterprises and, possibly, a readjustment of the manufactured products.

3.2 Computer-aided design

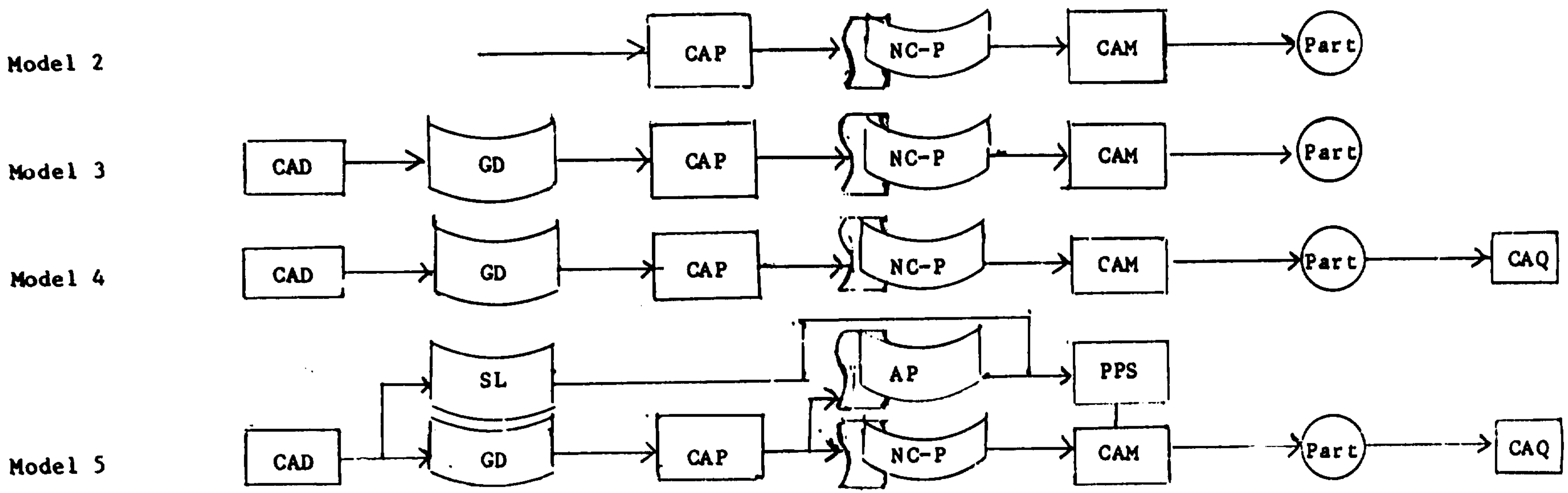
CAD has been used since the middle of the 1960s, particularly in large-scale enterprises in the electronics industry (e.g. for the design of printed circuits and, later, integrated circuits - "chips"), in the aircraft industry and in the automotive industry. The wide application of CAD began in the first years of the 1980s with the drastic reduction in the prices of computers and peripherals (e.g. graphic hardware), and CAD is currently extending to small- and medium-scale enterprises in industrialized countries.

There are various definitions of CAD which are not always consistent. One may sum up CAD as including all computer-aided activities needed to produce all the technical documents required for product manufacture and testing or inspection. These documents may be written or in a form that is legible to the machines used in production and testing.

The operator (construction technician or engineer) works with two direct dialogue television sets (alphanumeric or graphic dialogue) with the CAD system. The operator then has the possibility of intervening directly in the system operation process, making changes (e.g. in the design), seeing the results of his intervention and deciding whether intervention is appropriate and advisable. Whereas the alphanumeric dialogue is carried out with texts and figures, the graphic dialogue uses design instruments.

Figure 4. Combination models for CA techniques

NC-P = NC-program GD = geometric data SL = parts list AP = work plan



Basic CA system models

The construction process using CAD is represented in figure 5. CAD systems may be used to produce tenders, design and construct products, calculate technical parameters and print out calculations, designs, parts lists (for CAP), work plans (for CAPP) and operating programs for CNCMT.

CAD offers considerable economic advantages, particularly to enterprises whose products are produced in small batches in response to specific customer orders. The advantages can be seen above all in the construction of variants of products already constructed and manufactured or the construction of products similar to existing products. It considerably cuts down the time needed for technological innovation and the time between receipt of an order and supply of a finished product. An analysis of systems recently installed gives an amortization period for the investment of between two and three years. The economic benefits are greater, however, when CAD is used with the other CA techniques.

In the early 1980s it was estimated that CAD could not be used with microcomputers. Since 1983, however, there have been rapid advances in applications of PCs for CAD because of the high working capacity of these computer systems, the great versatility of the peripherals and the extremely rapid development of appropriate software (in the Federal Republic of Germany, for instance, there are more than 200 software firms offering programs for CAD). The costs of PC hardware are of the order of $3,000 to $12,000, depending on the configuration, and the cost of basic software for CAD is in the region of $3,000 to $8,000. It is thought that the introduction of 16 bit processors (in place of the current 8 bit PC processors) will open up further areas for their use in CAD, given their greater internal data storage capacity. The most important software components are:

- Graphic programs;
- Geometry programs;
- Mathematics programs;
- Applications programs;
- Operating systems;
- Data banks;
- "Menu" techniques.

Small CAD systems (for example, PCs) have two-dimensional geometric programs, whereas the large systems are three-dimensional. Software selection is very important for the effectiveness of the CAD system.

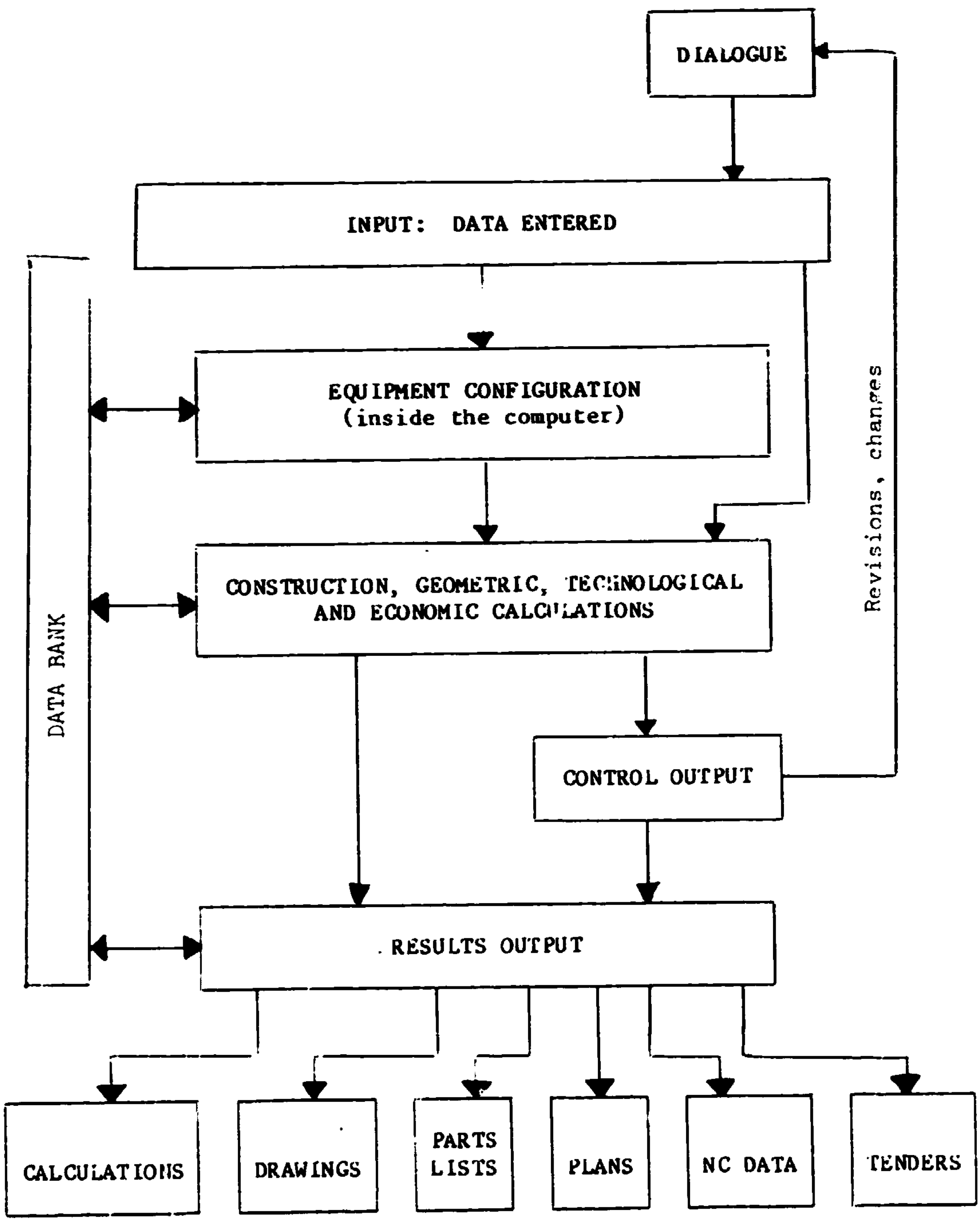
Different microcomputers have recently been coupled to a central computer with extensive data bank storage capacity.

3.3 Computer-aided production planning

CAPP is designed to reduce the time required for single production systems or small-batch production. Approximately 80 per cent of the time it takes an enterprise to complete an order is idle time, storage time or waiting time, during which the product is not being manufactured.

The 20 per cent production time can also be subdivided into 20 per cent machine time and 80 per cent retooling time, and time for movement between machines or other preparatory or similar tasks. It is therefore very important to enhance the organization of production.

Figure 5. Construction process with a CAD system



Source: Peter Sokolowski, "CAD mit Personal-Computern", Frankfurt, October 1985.

The functions for which CAPP is used and the corresponding sub-areas are:

Production planning:

- Production programme planning;
- Production quantity planning;
- Planning of production capacity and production time use.

Better production handling:

- Organizing the start of order production;
- Monitoring of the order during production.

CAPP application is designed to:

- Improve installed production capacity use;
- Reduce working capital;
- Reduce delivery periods;
- Improve small-batch production profitability;
- Improve productivity.

The competitive situation means that CAPP is receiving considerable attention in small- and medium-scale industry in industrialized countries, where it was introduced before CAD and CAM in many cases. Moreover, in the area of CAPP, which is considered relatively complex, microcomputers are being introduced.

The CAPP systems needed by small- and medium-scale industry are generally of low complexity and can therefore be carried out using a microcomputer and be partially integrated with CAD.

3.4 Use of computers in metalworking and engineering production

The use of computers in the metalworking and engineering industry started with the use of numerically controlled machine tools. These machines made it possible, during automated production, to retool rapidly in order to have the desired flexibility in the production process (the same applies to assembly robots). The functions of numerically controlled machine tools are nowadays determined and controlled by microcomputers (CNC - computerized numerical control). Larger-scale enterprises adopted DNC (direct numerical control) systems using a computer to store the programs and distribute them to the relevant production machines. Flexible manufacturing systems (FMS) are the result of combining one or more DNC systems with automated manufactured and semi-manufactured products and production input transport and handling, as well as automatic machine retooling.

A survey of Japanese enterprises using FMS gave the following results:

- The number of machines per system varies between 2 and 22 (6 on average);
- Use is predominantly made of machine centres;
- The number of manufactured products varies between four and 1,500 per FMS;

- The production batches vary between three and 300 products;

- The investment cost fluctuates between $150,000 and $7.5 million;

- The software cost represents 10 per cent of the hardware cost. 9/

These results indicate that not only machine centres but also their combination in an FMS are feasible for small-scale enterprises and that the production budgets may be small and within the product absorption capacity levels of developing countries' markets.

CNCMT may be controlled directly by a CAD system with the corresponding interface and software. The software must be capable of transferring the geometric data into control data for the production machines.

3.5 Aspects of productivity and profitability of the application of computerized techniques

Enterprises in industrialized countries which have decided to use the CAE techniques described previously report a considerable productivity increase. In the Federal Republic of Germany this increase is more pronounced in the production of integrated circuits, with a factor of 10-20, whereas the construction of metal products and machinery has increased by a factor of between two and six, in general terms, and by as much as a factor of 30 in one instance. In the preparation of control data for CNCMT with a CAD system a factor of 20 was achieved in one case and in the design of variants of existing products a factor of 25 was achieved. 10/

The findings of a survey on productivity increases in the United States and the United Kingdom are summarized in table 15. These increases are of the same order as those achieved in the Federal Republic of Germany.

In virtually all instances of CAD and CAM use, apart from badly planned ones, there has been a considerable improvement in the enterprises' economic and financial situation. It is difficult to quantify some aspects of their use (e.g. enhancing the image of the enterprise in the eyes of customers as a result of very short delivery periods), and therefore it is difficult to calculate the total impact of the use of such systems. In most cases in which CAD/CAM systems have been used, the return on investment took 2-3 years, and less than one year in special cases (above all when the systems are used with more than one working shift). The most widely heard observation by systems users concerns increased production flexibility and enhanced quality. The overall benefits of using CA techniques are represented in figure 6. Costs and delivery times are reduced and production flexibility and product quality are improved.

9/ H. Grabowski, "Die automatisierte Fabrik", Karlsruhe, 1985.

10/ W. Poths and R. Löw, "CAD/CAM: Entscheidungshilfen für das Management", Frankfurt, 1985.

Table 15. Examples of CAD productivity

Sector of activity	Location	Primary use of CAD	Average productivity ratio	Range of PR between different types of drawings
Integrated circuits	USA	Design	2:1 after 6 months	NI
Car components	UK	Design	3:1 after 12 months	NI
Plant design	UK	Draughting	3:1	1:1 - 20:1
Process plant	UK	Design	NI	1:1 - 50:1
Electric motors	UK	Draughting	6.6:1	NI
Printing machinery	UK	Design/ draughting	2:1	NI
Architecture	UK	Design	3.5:1	NI
Cars	UK	Design	3:1	NI
Personal computers	UK	Design/ draughting	2:1	NI
Process plant	UK	Design/ draughting	4:1	NI
Petroleum exploration	UK	Design	2:1	NI
Cars	UK	Design/ draughting	2.78:1 after 6 months	NI
Aircraft	USA	Design	2.5:1 in 1979 3.32:1 in 1980	NI
Instruments for personal computers	UK	Design/ draughting	3:1	NI
Public utility	USA	Draughting	3:1	NI

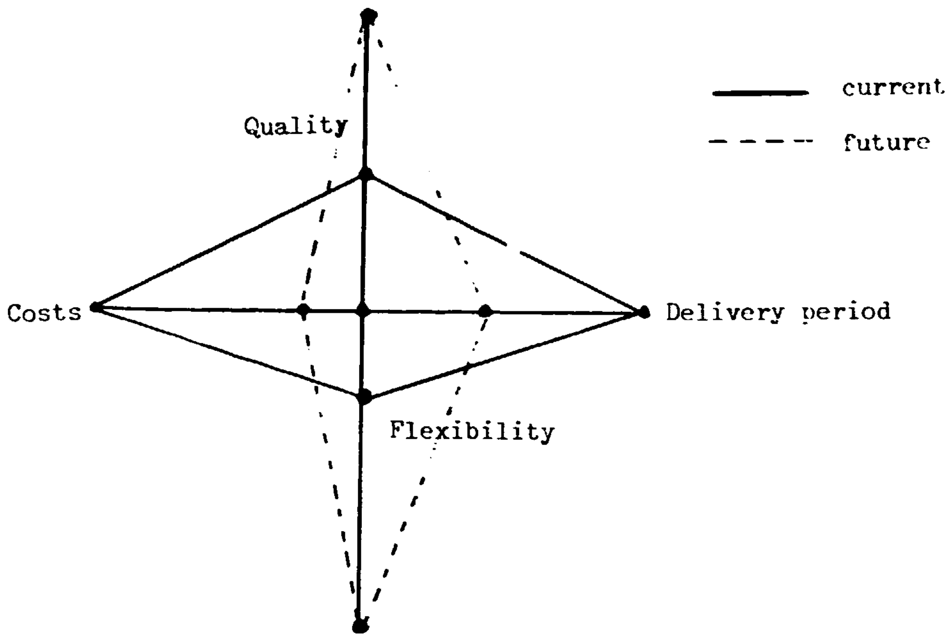
NI: No information.

Source: Interviews with users. "The impact of electronics on the international economic setting - the case of computer-aided-design", UNIDO, Vienna, March 1982 (UNIDO/IS.297).

3.6 Data processing as a factor of enterprise integration

Data processing has become the fourth production factor, along with capital, labour and the most traditional one, land. Since data processing is the last of these factors it is logical that this factor should be bringing about basic reappraisals of business systems, particularly as regards enterprise organization. The increasing importance of data processing will bring about a profound change in the way in which enterprises are organized and the way in which management functions are delegated to lower levels in the enterprise. Alongside this, there will be change in the work-force from relatively low-paid posts (workers) to relatively highly-remunerated posts (engineers, data processing experts).

Figure 6. Impact of CA techniques on the objectives of the enterprise



Source: O.H. Schiele, "CAD/CAM/CIM - 2D/3D, Was braucht der Maschinenbau", Frankfurt, 1984.

4. STRATEGY OPTIONS AND PROMOTIONAL POLICY REQUIREMENTS OF SMALL- AND MEDIUM-SCALE INDUSTRY

4.1 Two examples of promotion strategies: Republic of Korea and India

4.1.1 Republic of Korea: systematization of sub-contracting and strengthening of self-management

Faced with the imbalance between large-scale and small- and medium-scale enterprises (see section 2.4 and tables 9 and 11), the Government of the Republic of Korea promulgated the "Small Business Systematization Promotion Act" in 1975. This act includes clauses prohibiting delays in payment by a large-scale firm to a sub-contracting small-scale enterprise and sets out to promote sub-contracting by specialized small-scale enterprises in general. The act puts great stress on the technological innovation of small-scale enterprises and their specialization. Promotional and financial technical assistance through public institutions and specific programmes is also envisaged. A fund provides financing for investment, working capital and sales. Access to credit guarantee funds is also permitted. As regards new investments, small-scale enterprises receive a 10 per cent tax rebate on production machinery and quality control and laboratory equipment (only 8 per cent if the machinery is imported). Technical assistance expenses are tax-deductible as losses.

To deal with inter-industrial linkages, the "Systematization Promotion Council" has been established within the Korean Federation of Small Business. The purpose of this Council is to co-ordinate between large-scale and small-scale enterprises, resolve differences and disputes between the parties, examine business transactions every quarter and investigate, and propose solutions for, problems concerning the systematization of co-operation between industries. At the same time, it makes a list of the products suited to sub-contracting and reserved for small-scale enterprises. Industry plays an active role in this work.

The results in the first four years of operation have been impressive (see table 16). In the four years in question, the number of products reserved for small-scale industry increased 25 times, the number of purchasing companies nine times and the number of sub-contracting companies 12 times. Comparison between the last two factors indicates that sub-contracting by small-scale enterprises increased even more than the number of purchasing companies participating in the systematization efforts. In 1979, moreover, 157 small-scale enterprises were able to sell 41 products, i.e. approximately 1.9 companies per product. This indicates, _inter alia_, that specialization brought about a reduction in competition.

Table 16. Republic of Korea: results of the industrial systematization efforts (in figures)

	1979	1980	1981	1982
Subsectors considered	5	6	24	34
Products reserved for sub-contracting	41	71	426	1 038
Purchasing companies	37	64	220	345
Sub-contracting companies	157	263	1 141	1 940

At the beginning of the 1980s, when the Republic of Korea was also undergoing economic problems because of the world economic situation, the Government increased support and promotion for small-scale industry. After making a thorough analysis of the situation in 1972, it began to readjust all small-scale industry programmes to achieve an additional economic growth which large-scale industry was at the time unable to guarantee. All the revised and new programmes were brought together under the central theme "Technological advancement". The policy measures adopted in this context to benefit small- and medium-scale industry were focused principally on the following areas: 11/

Improvement of competitiveness:

- Identification and development of small- and medium-scale industries with high growth potential;
- Special programmes to improve the quality of the products manufactured;
- Expansion of co-operative programmes.

Expansion of the industrial base:

- Development of parts and components production programmes;
- Strengthening of the systematization of sub-contracting;
- Strengthening of support systems for small-scale industry.

Promotion of internationalization:

- Expansion of exports;
- Strengthening of international co-operation;
- Improvement of industrial design.

Promotion of technical innovation capacity:

- Increased support for technology development and commercial application of new technologies;
- Expansion of training and management support programmes.

Stabilization of business prospects:

- Strengthening of the functions of co-operative associations of enterprises;
- Encouragement of programmes for co-operation between small-scale enterprises and mutual assistance;
- Promotion of regional dissemination of industries.

Increased investments and, simultaneously, expanded tax rebates:

- Economic assistance;
- Financial support;
- Tax incentives.

11/ UNIDO, "Small-scale electronics industry as subcontractor in Asia and the Pacific region", Vienna, August 1985.

In addition to these political measures, the Government has arranged for lendings by the country's banks so that 35 per cent of total industrial lendings must be for small-scale and medium-scale industry. In 1981 the Government set development targets for small-scale industry, with the aim of increasing value added by 9.4 per cent, employment by 6.6 per cent and exports by 12.5 per cent annually up to 1991.

Among the agencies to assist and service small-scale industry, mention must again be made of the Korean Federation of Small Business. There are three salient aspects of the structure and work of this Association: firstly, self-help and the active participation of the members in the work; secondly, continuous dialogue between government agencies resulting in laws and decrees to promote small-scale industry and the expansion of sub-contracting, as we have already seen; thirdly, an annual government contribution to the Federation's budget. At the beginning of the 1980s, this contribution was over 60 per cent of the total budget and it is currently around 45 per cent, with a continuing gradual downward trend agreed by the two sides.

4.1.2 India: "ancillarization" and social responsibility of the purchasing enterprise

During the establishment of the industrial base in India, especially heavy industry, local production of spare parts became a fundamental requirement. These spare parts were often manufactured by a few small-scale enterprises which soon became known as "ancillaries" to the large purchasing enterprises. 12/

Soon after the authorities had formalized the role of these small-scale enterprises, "ancillary committees" were established at federal state level and in large enterprises. Here ancillaries predominate, whereas the system is far less widespread in the private industry sector.

An ancillary is defined as an undertaking having investment in plant and machinery not exceeding 2.5 million rupees, engaged in the manufacture of parts, components, tools or sub-assembly intermediates or in the rendering of services, and depending for at least half the value of its activities on a single large enterprise, selling the remainder of its production or services to other customers.

The ancillarization system consists in a close relationship between a large enterprise and a small enterprise which, in practice, functions almost as a department of the enterprise which also supplies the product designs. Co-operation agreements are generally long-term, covering, for instance, five years. During this time the small-scale enterprise has guaranteed sales, giving rise in practice to some negligence in developing other markets (permitted under the system for up to 50 per cent of sales) or enhancing product quality. In reality, the system applies in particular to parts and components of low technological complexity. Nevertheless, the large enterprise is generally called upon to provide substantial technical assistance. 13/

12/ UNIDO, "Small-scale electronics industry as subcontractor in Asia and the Pacific region", Vienna, August 1985.

13/ UNIDO, "Small-scale electronics industry as subcontractor in Asia and the Pacific region", Vienna, August 1985.

An ancillary is technically distinguished from a small-scale enterprise in India as follows:

- Provision of technical and managerial assistance;
- Supply of critical raw materials or components where necessary;
- Guaranteed sales market for at least half of production;
- Fixing of selling prices to allow reasonable margins on capital employed.

Owing to this protection as regards sales guaranteed by the large enterprise, the ancillary's product development and marketing activities are very limited. The ancillary is thus completely dependent on the large enterprise and is unprepared for technological change. In fact, there are few examples of the well-functioning ancillarization schemes in production sectors subject to rapid technological change. 14/

4.2 Some basic considerations

Advances in micro-electronics use in industrialized countries will bring down production costs and have considerable impact on trade with developing countries which do not react to this development; this impact will particularly affect the more advanced developing countries. Tariff protection of the necessary magnitude seems unrealistic. At the same time, it is unrealistic to expect the more advanced developing countries (with the exception of the Republic of Korea) to possess the financial and human capability to keep abreast of technological advance in the next 10 years. The high cost of the investment involved (in absolute terms and per job) and the existing world production capacity surplus will make it economically difficult to justify the production of chips with a high level of integration in most countries. It should also be mentioned that chips represent approximately 5 per cent of the value of computer systems.

It seems more advisable and, to some extent, necessary to become involved in the design and production of micro-electronics application systems. In this field, as in that of capital goods production, above all large parts, pieces and components, there is scope for developing a new small-scale industry with a high level of technological advancement and innovative capacity and a labour force consisting primarily of graduates and technical specialists.

The required industrial policy should be focused on establishing an attractive investment climate and on strengthening human resources (also in existing small- and medium-scale industry) by means of training programmes, channelling them into business activities in specific fields of technology. It would also be necessary to set up specific and possibly centralized data banks, providing access to the new type of small-scale enterprise. This strategy thus requires the following policy package:

- A macro-economic policy including the development of human resources, expansion of the industrial base and creation of a favourable environment for small-scale investors and risk-taking as regards investment and foreign trade;
- Clear and continuous government priorities directed towards the private sector;
- An industrial policy favouring the expansion of inter-industrial linkages (co-operation, sub-contracting and complementation);

14/ UNIDO, "Small-scale electronics industry as subcontractor in Asia and the Pacific region", Vienna, August 1985.

- Support programmes involving scientific, technical and financial institutions.

The industrialized countries and, as we have seen by way of example, the Republic of Korea are succeeding with strategies of this kind.

4.3 Policy and promotion measures

4.3.1 Expansion of inter-industrial linkages

It is evident that the technological specialization of small- and medium-scale industry and the interchange of products between enterprises are typical of the capital goods sector. The most common forms of co-operation are:

- Sub-contracting: an enterprise (generally a large-scale enterprise) purchases from another enterprise (generally a small- or medium-scale enterprise) parts, pieces or components which it then incorporates in a more complex product;

- Complementation: complementary products (e.g. electric motors or computer peripheral equipment) are purchased by enterprises offering capital goods systems (e.g. computer systems, processing plants in the chemical industry or others);

- Contracting of services: e.g. engineering maintenance or software development services;

- Co-operation between enterprises with complementary end products.

Whereas these forms of co-operation play a large part in industrialized countries, they are normally hard to find in developing countries. The reasons for this are generally numerous and may be summarized as infrastructure inadequacies, legal and political inadequacies, promotion and incentive inadequacies and inadequacies at enterprise level.

The legal and political context is dominated by the fiscal and regulatory aspects of co-operation. In Europe, sub-contracting and complementation advanced with the elimination of the double taxation of production by the sales tax, i.e. with the introduction of value added tax. In the Republic of Korea this greatly contributed to inter-industrial co-operation with legal regulations governing payment of small-scale suppliers and the reservation (subject to continuous monitoring) of products for manufacture by small-scale enterprises.

The promotion of co-operation incentives, leading to production and service specialization, plays a decisive role in expanding the industrial base. It is the authorities' task to determine which promotion and incentive system to adopt. This may involve, for example, tax incentives for the purchasing enterprise, contributions to self-help structures in the private sector for this purpose, granting of production licences or credits subject to inter-industrial co-operation, etc.

At enterprise level there are external and internal inadequacies. Externally, mention should be made of the very frequent absence of self-help organizations to defend common interests and to promote the small- and medium-scale industry sector, because the production range is relatively narrow and there is sharp competition between small-scale enterprises. Internally, there are deficiencies in human resources development aimed at achieving progress in technologically more complex production areas and in awareness among entrepreneurs of new technologies, or information on the potential for business growth connected with technological advance and the supply of entrepreneurial training.

4.3.2 Orientation of promotion policies

As a general rule, industrial promotion policies concern both large-scale enterprises and small- and medium-scale enterprises. Experience shows that large-scale enterprises derive far more benefit than small-scale enterprises from support programmes because their ability to fulfil the requirements (applications, loan guarantees, export licences and exemptions) is greater than that of a small-scale enterprise and better tailored to the agencies involved in the execution of such programmes. Consequently, promotion programmes are in many cases disadvantageous to small-scale enterprises.

The case of the Republic of Korea, generally based on the model of Japan, indicates that a range of specific measures to promote technological advance in small- and medium-scale industry may profoundly improve its position in the industrial context and help to expand industrial value added with an ensuing increase in employment.

The following are the central features of promotion measures:

- Improvement of access to credit for small- and medium-scale industry;
- Improvement of access to technological information and support in technical areas, particularly with regard to new products;
- Financial programmes for technological innovation and for enterprises establishing themselves in advanced-technology areas;
- Promotion of sub-contracting and establishment of "rules of the game" to protect sub-contracting enterprises (e.g. guarantees for payment for sub-contracted products);
- Sub-contracting incentives for large-scale enterprises;
- Financial support for self-help organizations in small- and medium-scale industry;
- Training programmes.

One area which can make a large contribution to small- and medium-scale enterprise development is that of government purchasing. Various countries (e.g. the United States, Japan and the Republic of Korea) give preference to supplies which include small-scale enterprise contracting.

Another factor that is closely connected with the promotion of small- and medium-scale enterprises is the expansion of the country's scientific and technological base. This capacity represents, firstly, a basic requirement to permit penetration of new-technology areas and, secondly, the formation of a base for the "spin-off" of new small-scale enterprises (e.g. in the area of software development).

4.3.3 Support requirements of new enterprises

The principal objective of the promotion of new enterprises in advanced-technology areas should be to strengthen these enterprises' internal resources, rather than to establish protection systems which may be out of proportion. This type of new enterprise requires different support measures from the traditional small-scale enterprise. Whereas the latter essentially needs technical assistance to improve its economic and technical position, the former requires, above all, pre-investment guidance, support in human resources development, logistic support in the development of new technology and risk capital to begin business operations. It may be assumed that the new small-scale enterprise is capable of solving its management problems by itself or by bringing in experts from outside (specializing, for example, in accounting, market surveys, technology access or training). Such enterprises' basic requirements are thus:

- Human resources development;
- Favourable climate for the establishment of the enterprise;
- Logistic support and access to information on technological progress in its area;
- Access to up-to-date data banks;
- Sources of risk capital;
- The political and legal climate mentioned earlier;
- Access to the industrial infrastructure.

4.4 Institutional aspects

Most advanced developing countries possess the necessary support and promotion institutions. Nevertheless, in many instances one wonders whether their structures, modes of operation and programmes correspond to the current needs of small- and medium-scale industry, particularly in the capital goods sector. In each case, it is necessary to make an analysis, together with an examination of the political measures described above, of the institution's reorientation needs. In addition to the reformulation of the content, the services offered by each institution must introduce new forms of contact with enterprises which, in many instances, should be closer and more direct than those currently in existence.

5. CONCLUSIONS AND RECOMMENDATIONS

The aim of the previous chapters was to demonstrate the importance of small- and medium-scale industry in the capital goods sector. In the industrialized countries, it makes a substantial contribution to the value added in that sector. This is due to the high level of technological specialization of the enterprises and the trading systems based on various forms of inter-industrial co-operation, particularly sub-contracting. Small-scale industry is generally independent because, in most cases, it has a number of customers for its products. Specialization of small-scale enterprises has frequently reduced competition between enterprises.

The situation is generally different in the developing countries. In those countries, small- and medium-scale enterprises manufacture a relatively narrow range of products, leading to severe competition between enterprises. The products are characterized by relatively low technological complexity. The small-scale enterprises lack qualified personnel (engineers and technicians) and access to technological information for the manufacture of more complex products.

Since the beginning of the current decade, the engineering (design and construction) system and production of the capital goods industry in the industrialized countries have undergone rapid innovation. This technological innovation is the result of advances in new working instruments, i.e. computer systems and the corresponding software. The CAD and CAM systems, with production planning automation, bring about greater production flexibility, an appreciable reduction in new product design and, in addition, a considerable reduction in production costs. The influence of this technology on small- and medium-scale industries is great since microcomputers offer the same working capacity as before, but at a relatively low price.

This technological development will have wide-reaching effects on international trade as a result of lower product prices in future. It may be expected that this development will have greater impact on the more advanced developing countries than on the less developed ones. How are those countries to react to this development? An exaggerated protectionist policy can be ruled out straight away because capital goods prices have an impact on production costs throughout the economy. There will clearly have to be policies for the rapid introduction of these advanced technologies. Together with CNC machine tools, whose prices will also benefit from the new technological development, fresh production areas will be opened up for developing countries which have a policy to introduce new technologies. The new product design instruments permit the construction of technologically advanced products and the new machine centre flexibility permits the production of high-quality products in small batches at relatively low prices (future production will be less affected by the human skill factor and its influence on product quality). This development will have profound effects on employment.

In the industrialized countries there is a considerable reduction in operating personnel and construction plants and an increase in highly qualified staff. Analysis at enterprise level indicates a net deficit of between 1 and 3 per cent. In the medium term, the impact on employment in developing countries may be quite positive: firstly, new jobs will be provided for graduates in engineering and data processing and, secondly, with the expansion of the industrial base to cover products that were previously imported, employment in general will benefit.

New areas of activity will open up for small- and medium-scale industry. There will also be increased potential for new small-scale enterprises in software development, which is still highly intensive in skilled manpower. However, in order to achieve small- and medium-scale industry expansion it will be necessary to analyse the industrial policy framework and the integration of small- and medium-scale industry in the production system. One example is an industrial policy specifically aimed at developing this branch of industry, which is still lagging behind large-scale industry. On the basis of the specific conditions in each country, it is recommended that an analysis be made under the heading of "technological progress" of the different areas of industrial policy, particularly policy relating to small- and medium-scale industry, promotion and support programmes and institutions. These areas have been examined in depth in the preceding chapter. The following areas stand out: creation of a favourable business climate; promotion of inter-industrial linkages, particularly sub-contracting; support for young scientists and engineers working in areas of technology with a view to the creation of new enterprises. There should be broad access to technological information, both with regard to software and with regard to engineering, i.e. data banks on construction specifications and standards.

BIBLIOGRAPHY

Economist Intelligence Unit	Chips in Industry, London, 1986
Grabowski, H.	Die automatisierte Fabrik, Karlsruhe, 1985
Katz, Jorge M. and collaborators	Desarrollo y crisis de la capacidad tecnológica latinoamericana, el caso de la industria metalmecánica, Buenos Aires, 1986
Klos, Walter F.	Datenbanken for Technische Anwendungen, ihre Bedeutung für CAD/CAM, Stuttgart, 1984
Martin, W.	MAP in Rahmen CAD/CAM-CIM, Rüsselsheim, 1984
Nissing, Th.	Die Fertigung hat ihr eigenes System - Dezentrale Betriebsdatenerfassung und Werkstattsteuerung mit Observer, Aachen, 1984
Poths, W., and Löw, R.	CAD/CAM: Entscheidungshilfen für das Management, Frankfurt, 1985
Schiele, O.H.	CAD/CAM/CIM - 2D/3D, Was braucht der Maschinenbau, Frankfurt, 1984
Sokolowski, P.	CAD mit Personal-Computern, Frankfurt, October 1985
UNCTAD	The capital goods sector in developing countries: technology issues and policy options, New York, 1985 (United Nations publication, Sales No. E.85.II.D.4)
UNIDO	Capital goods industry in developing countries: a second world-wide study, UNIDO/IS.530, Vienna, 9 May 1985
UNIDO	Prospects for industrial development and for a capital goods industry in Indonesia, UNIDO/IS.479 and Add.1 and 2, Vienna, 20 July 1984
UNIDO	The engineering industry in the Republic of Korea, UNIDO/IS/R.43, Vienna, 8 May 1986
UNIDO	The impact of electronics on the international economic setting - the case of computer-aided-design, UNIDO/IS.297, Vienna, March 1982
UNIDO	Mechanisms for small-scale industry development: ancillarization - development of feeder industries, UNIDO/IS.551, Vienna, August 1986
UNIDO	Policies and strategies for small-scale industry in Asia and the Pacific region, UNIDO/IS.617, Vienna, March 1986
Verband Deutscher Maschinen- und Anlagenbau e.V. (VDMA)	Maschinen- und Anlagenbau in Zentrum des Investierens, Frankfurt, 1986

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QUESTIONNAIRE

Scope for the use of new information technologies by small- and medium-scale metalworking and engineering industry

	(please check appropriate box) yes	no
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