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SURVEY OF SELECTED WORLD INDUSTRIES

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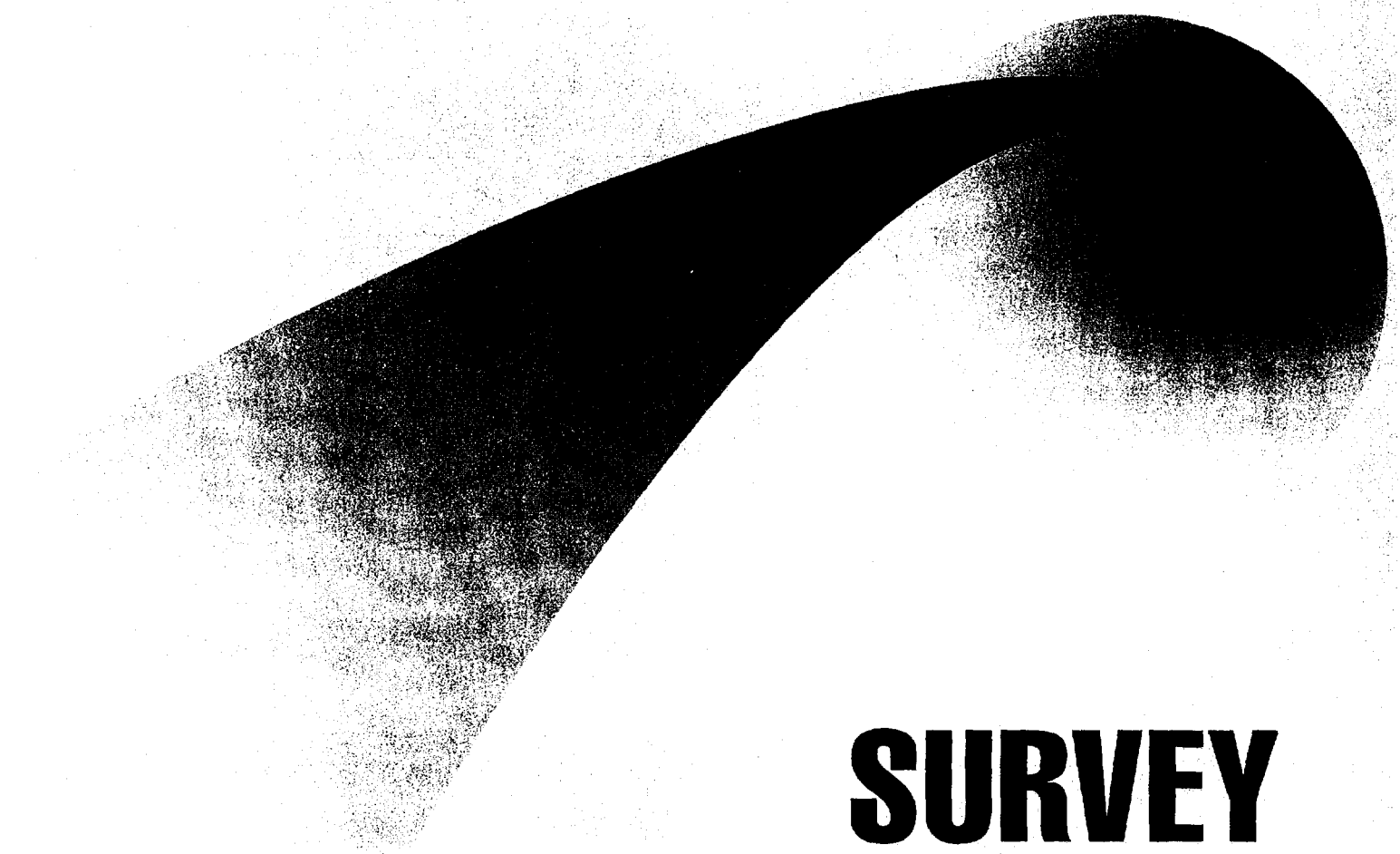

SURVEY OF SELECTED WORLD INDUSTRIES

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna, 1996

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PREFACE

The fast pace of change in the global economic environment, characterized by increasing globalization and liberalization of trade and investment and the rapid diffusion of new technologies, has wrought essential change in the shape of world industry, and given a totally new dimension to the nature and scope of competition. Technological developments have significantly shortened product life cycles, while at the same time reversing the maturation process in some industries and providing a new impetus to growth.

The main aims of this *Survey of Selected World Industries* are to provide a deeper insight into the effects of the rapidly changing economic and industrial environment on the development of industry at the sectoral level, and to provide comprehensive up-to-date information on the developmental trends of industry at the global level in an effort to assist the private sector. To that end, the four industries included in this Survey, namely the automotive, construction equipment, pharmaceutical, and semiconductor industries, have been selected on the basis of their strategic importance, technological intensity and growth potential.

The automotive industry plays a crucial role in the industrial development of a country because of its strong linkages with other sectors in the economy. Increasing demand and rising income levels have contributed enormously to making the automotive industry the largest manufacturing industry in the world. As the industry has matured, new technologies have been developed which are expected to lead to even further expansion, which, in turn, will enhance the development of small- and medium-scale enterprises. Increasing globalization and the current deregulation process, however, will pose tremendous challenges for the industry, particularly in the developing countries.

The construction equipment industry accounts for an insignificant share of total world manufacturing value added. It plays an important role, however, in supporting the construction sector and the development of infrastructure, both of which are essential to successful industrial development. The current globalization process has partially eliminated the need to achieve significant economies of scale to become competitive, hitherto a major constraint to growth. In addition, restructuring efforts undertaken in response to global changes have contributed to reducing constraints to growth.

The pharmaceutical industry has often been looked upon as a source of social benefits, particularly with regard to improving the quality of life and lowering mortality rates, and pharmaceuticals have become indispensable in modern health care. A modern, research-based industry since the 1950s, it is also technology intensive. It has shown above-average long-term growth as well as resilience when downturns in economic and business cycles have occurred. As its performance is dependent on technological innovation, large-scale investment in research and development (R & D) is required, which accounts for its early transformation into a modern, research-based industry.

Technological innovation is also a key determinant of the success of the semiconductor industry. The strong growth registered by the industry over the past few years has been driven largely by the widespread use of electronic equipment in almost all sectors of the economy. More importantly, the industry is rapidly changing the nature of competitive advantage and competitiveness in global industry.

Based on consultant contributions received from the Kia Economic Research Institute (automotive industry), Andrew Baxter (construction equipment industry), Gernot Hutschenreiter (pharmaceutical industry) and Jean-Pierre Dauvin (semiconductor industry), this *Survey* was prepared by staff of the Studies and Research Branch under the direct supervision of Mr. Jang-Won Suh.

Studies and Research Branch
Research and Publications Division

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EXPLANATORY NOTES

The following terms and symbols have been used throughout the present publication:

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

The term "billion" signifies a thousand million.

Countries are referred to by the names that were in official use at the time the relevant data were collected. Where the designation "country or area" appears in the heading of tables or figures, it covers countries, territories, cities or areas.

The term "developed" or "developing" countries is intended for statistical convenience and does not necessarily express a judgement about the stage reached by a particular country or area in the development process.

The following symbols have been used in tables:

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

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

* * *

The following abbreviations and acronyms appear in this publication:

ASEAN	Association of South-East Asian Nations
BiCOMOS	bipolar complementary metal-oxide semiconductors
EFPIA	European Federation of Pharmaceutical Industries Associations
CAD	computer-aided design
CAM	computer-aided manufacturing
CMOS	complementary metal-oxide semiconductors
DRAM	dynamic randon access memory
ECL	emitter-coupled logic
FDI	foreign direct investment
GATT	General Agreement of Tariffs and Trade
GDP	gross domestic product
GNP	gross national product
HHI	Herfindahl-Hirschmann Index
JIT	just in time
Mercosur	Mercade Commun del Sur (Southern Cone Market)
MOS	metal-oxide semiconductors
MPU	microprocessor unit
MVA	manufacturing value added

NCEs	new chemical entities
NMOS	N-channel metal-oxide semiconductors
OECD	Organisation for Economic Co-operation and Development
PMOS	P-channel metal-oxide semiconductors
R & D	research and development
RAM	random access memory
SITC	Standard International Trade Classification
S/LS TTL	speed/large-speed transistor-transistor logic
SRAM	static random access memory
TTL	transistor-transistor logic
TRIPS	trade-related intellectual property rights
ULSI	ultra large-scale integration
VERs	voluntary export restraints
VLSI	very large-scale integration
WTO	World Trade Organization

AUTOMOTIVE INDUSTRY

OVERVIEW

The world automotive industry has grown tremendously over the years, making it the largest manufacturing sector in the world. With rising incomes and growing demand, the production of motor vehicles has increased significantly, reaching an estimated 50 million units per year. Moreover, the very size of the industry has increased its strategic importance in many countries.

In addition, the diversity and number of parts and components used in the manufacture of motor vehicles, estimated to number some 20,000, have created strong linkages with other industries, both in supply and downstream services. Such strong linkages have not only contributed to increasing the strategic importance of the automotive industry in industrial development, but have also helped to spur the growth of supporting industries and broaden the industrial base of countries.

The importance of economies of scale is another distinguishing feature of the industry. The unit cost of a passenger car is highly dependent, in an inverse proportion, on the number of cars produced. Although studies undertaken reveal some discrepancies (see table 1), results show that the minimum production level required to achieve economies of scale is around 200,000 units per year.[1]

The large economies of scale of the automotive industry can in fact lead to oligopolies, allowing a handful of manufacturers to exert dominant control over the market. The oligopolistic structure of the industry, in terms of concentration of major manufacturers, is depicted in figure 1. The figure shows that in 1970, the top three manufacturers in Germany, Japan, the Republic of Korea and the United States of America accounted for shares of 74, 65, 94 and 93 per cent of their respective home market. In 1993, the share was 75 per cent in Germany, 60 per cent in Japan, 91 per cent in the Republic of Korea and 81 per cent in the United States. That the high concentration has remained relatively steady in those countries over the past 20 years underlines the highly oligopolistic structure of the industry.

The persistence of such a structure in the automotive industry is also reflected in the Herfindahl-Hirschman Index (HHI). Figure 1 shows that

HHI for the automotive industry in most countries during the period under review exceeded 0.18. Although reasons for this differ, the large economies of scale required by the industry is the most significant contributing factor.

Table 1. Minimum efficient scale of production in the automotive industry
(Thousands of vehicles per year)

Study	*Mini*	*Compact*	*Intermediate*	*Standard*	*All sizes*
E. J. Toder	400	300	250	200	
Automobile assembly	400	300	250	200	
Body unit	400	400	350	250	
Engine	200	200	200	206	
Frame	317	317	317	317	
Transmission					
C. F. Pratten					500
One model and its variation					1 000
A range of three basic models					
D. P. Quinn					1 000
Engine and transmission					4 000
Body panel pressing					2 000
Foundry work					
Sales network (including					5 000
advertising)					5 000
R & D					
G. Rhys					
Engine casting					1 000
Other casting					100-750
Power-train machining					
and assembly					600
Axle machining and assembly					500
Body panel pressing					1 000-2 000
Painting					250
Final assembly					250

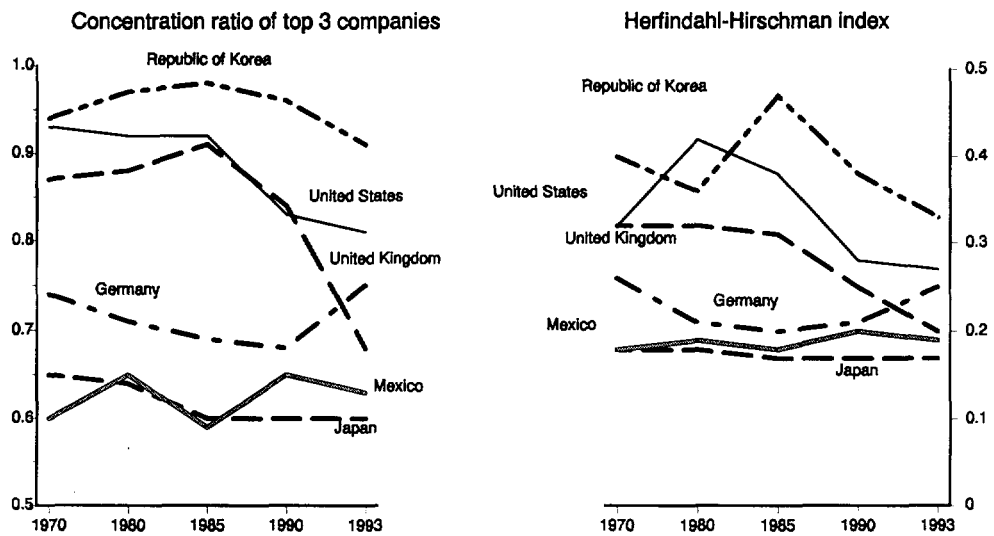
Sources: E. J. Toder, *Trade Policy and the United States Automobile Industry* (New York, Praeger Publishers, 1978); C. F. Pratten, *Economies of Scale in Manufacturing Industry* (Cambride, Cambridge University Press, 1971); D. P. Quinn, *Restructuring the Automobile Industry* (New York, Columbia University Press, 1988); G. Rhys, *The Structure of British Industry* (London, Unwin Hyman, 1988).

In order to derive the maximum benefits from economies of scale and sustain a competitive automotive industry, a large and stable domestic market is essential. The fact that the 11 countries with the largest domestic markets for passenger cars are also the 11 top producers testifies to the key role that a large home market plays in the development of a global automotive industry.

Another characteristic of the industry is that it contributes heavily to the national economy. In Japan, over 11.3 per cent of the total workforce is employed by the automotive and other related industries. The production value of the industry accounted for 12.9 per cent of the total value of

manufacturing production in 1991. Even in the Republic of Korea, where the registration level is still relatively low, the automotive industry alone excluding related industries employs 6.8 per cent of the labour force in the manufacturing sector and accounts for 8.6 per cent of the production value of the sector.[2]

Figure 1. Trends in concentration in the world automotive industry



Source: Daily Automobile News, *Handbook of Automotive Industry* (Japan, 1995).

The importance of the automotive industry is also reflected in the fact that much of the existing trade tensions between countries is centred around that industry. Especially important are the stringent policies adopted by many Governments for its future development.[3] Because of the persistent trade surplus of Japan in the automotive industry with the United States and many European countries, they have reached a compromise on principles of market competition and free trade and are implementing protectionist policies. Such a shift in policy illustrates the significance of the industry.

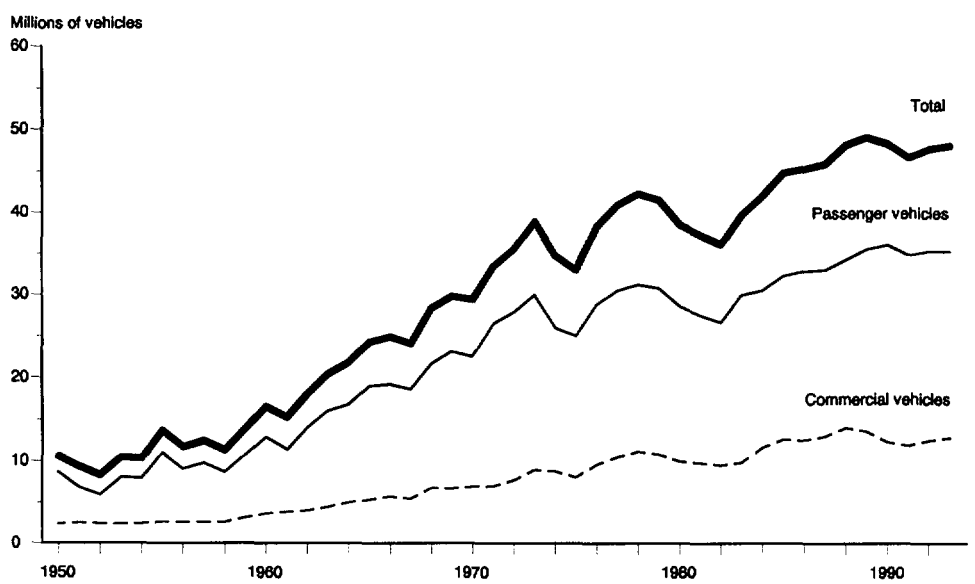
While motor vehicles have facilitated transportation, they have at the same time worsened the problem of air pollution. Furthermore, because of traffic congestion the number of accidents has increased dramatically. Governments are therefore being forced to apply rigorous environmental and safety standards, both of which are supported by consumers. In turn, manufacturers are required to develop technologies to reduce emission and raise fuel efficiency as well as to devise methods to make motor vehicles safer and

recyclable. As a result of intense development of new technologies, the industry, which was until recently a mature industry, has been reinvigorated into a growth industry.

WORLD MARKET STRUCTURE: RECENT TRENDS AND CURRENT CONDITIONS

Production The world automotive industry has suffered a series of recessions over the past decades mainly because of fluctuations in market performance and restructuring efforts within that industry in developed countries. The volume of production in particular dropped rapidly during the world recessions of the mid-1970s, the early 1980s and 1990s. However, despite such fluctuation, world production has increased steadily since 1950 (see figure 2). Between 1950 and 1994, it grew fivefold, reaching a record production level of 50 million vehicles. Passenger cars alone accounted for about 73 per cent, and commercial vehicles accounted for the remaining 27 per cent of the total world automotive production in 1994.

Figure 2. World automotive production, 1950-1993

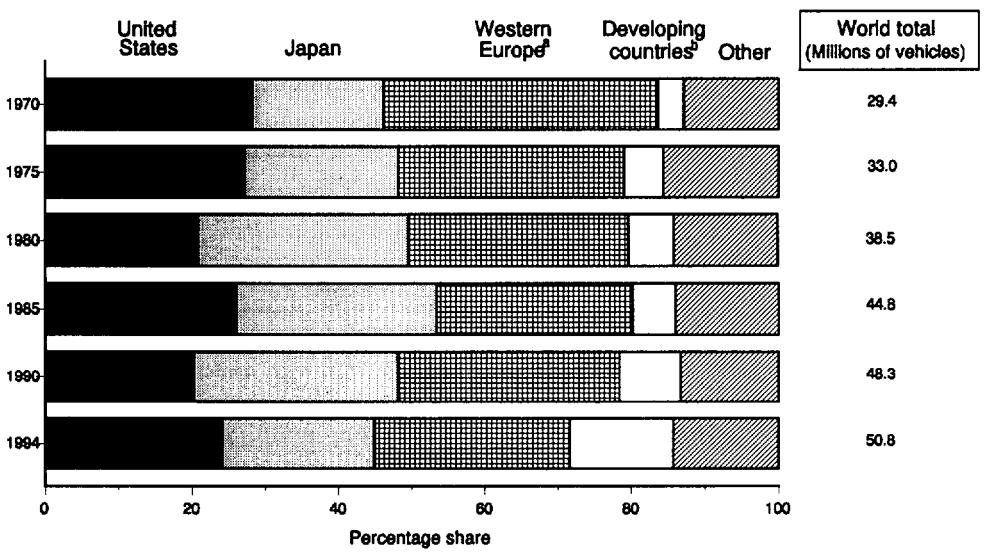


Source: Motor Vehicle Manufacturers Association of the United States, *World Motor Vehicle Data* (Detroit).

A number of striking issues emerged between 1950 and 1994. First, the share of developing countries increased substantially in the 1990s, accounting

for more than 14 per cent of global production by 1994 (see figure 3). Production in those countries increased at an average rate of 8.5 per cent per year during the period 1970-1994, faster than the world's average growth rate of 2.3 per cent. The Republic of Korea has emerged as the forerunner among developing countries, achieving a remarkable annual growth rate of 20 per cent during the same period, and could become the fifth largest producer in 1995. Other major producers among developing countries include Brazil, China and Mexico. As economic growth in these countries continues, a rapid growth in production has been forecast.

Figure 3. Share of world automotive production, 1970-1994



Source: Motor Vehicle Manufacturers Association of the United States, *World Motor Vehicle Data* (Detroit).
a/ Including France, Germany, Italy, Spain and the United Kingdom of Great Britain and Northern Ireland.
b/ Including Argentina, Brazil, China, India, Mexico and the Republic of Korea.

Secondly, the role of Japan as a producer has expanded significantly in comparison with other developed countries. Production expanded at an annual rate of 2.9 per cent between 1970 and 1994, the highest among developed countries, and the Japanese share in total world production rose from 18 per cent in 1970 to 30 per cent in the 1980s.

Japan was also the largest exporting country in 1974, and in 1980, aided by growth in the domestic market, it emerged as the world's largest automobile producer. In 1994, however, due to a recession in the domestic market and the transfer of production lines offshore, the country was nudged out of the

first place by the United States, which regained its position as the world leader.

Thirdly, the transfer of production lines overseas has increased not only in response to rising protectionist barriers and fluctuations in foreign exchange, but also in an attempt to cope better with the changing demand of local markets. Offshore production of United States manufacturers in western Europe reached 6.6 million units by 1992 (see table 2). Recently, France, among other western European countries, has been increasing its offshore production as well.

Table 2. Overseas production by major countries, 1986-1992
(Thousands of vehicles)

Country	*1986*	*1988*	*1990*	*1992*	*Average percentage change 1986-1992*
United States	5 747	6 167	6 319	6 638	2.4
Japan	875	1 542	2 373	2 626	20.1
Germany	1 492	1 714	1 821	1 799	3.2
France	263	244	928	942	23.7

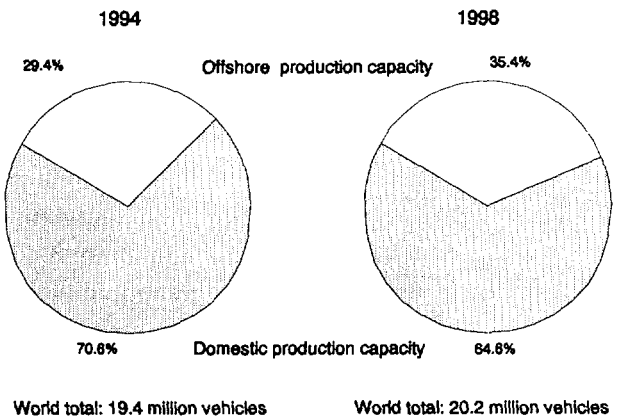
Source: Japan Automotive Manufacturers Association, *The Motor Industry of Japan* (Japan, 1993).

In the case of Japan, offshore production has expanded tremendously since the 1980s. The percentage share of offshore production in total production rose from only 7 per cent in 1986 to 29 per cent in 1994, and is expected to rise further to as much as 35 per cent by 1998 (see figure 4). In 1994, 30 per cent of the total offshore production capacity of Japan was located in Asia. Given the Japanese plan to expand the share of its local production in China, the country with the largest growth potential, and in other South-East Asian countries, offshore production capacity is expected to increase to 39 per cent by 1998.

Finally, the oligopolistic structure of the industry has continued to prevail in the world's largest auto manufacturing countries such as France, Germany, Italy, Japan and the United States. In 1992, the top 20 manufacturers accounted for 70 per cent of world total production, compared with 75 per cent in 1978. In terms of domestic production, Toyota was the world's largest manufacturer, followed by General Motors, Ford, Nissan, and Volkswagen, based on 1992 statistics. In terms of worldwide production,

however, General Motors ranked first, followed by Ford, Toyota, Volkswagen, and Nissan in the same year (see table 3).

Figure 4. Japanese manufacturers' global production capacity plan, 1994 and 1998



Source: FOURIN, *Monthly Report on the Global Automotive Industry* (Japan, 1994).

Table 3. Leading manufacturers worldwide, 1978 and 1992
(Thousands of vehicles)

Rank	*Manufacturers*	*1978*	*Rank*	*Manufacturers*	*1992*
1	General Motors (United States)	8 727	1	General Motors (United States)	6 866
2	Ford (United States)	5 974	2	Ford (United States)	5 744
3	Toyota (Japan)	3 319	3	Toyota (Japan)	4 488
4	Chrysler (United States)	2 769	4	Volkswagen (Germany)	3 286
5	Nissan (Japan)	2 728	5	Nissan (Japan)	2 898
6	Volkswagen (Germany)	2 376	6	PSA (France)	2 438
7	Renault (France)	1 767	7	Renault (France)	2 264
8	PSA (France)	1 692	8	Chrysler (United States)	1 983
9	Fiat (Italy)	1 390	9	Fiat (Italy)	1 800
10	Mitsubishi (Japan)	973	10	Honda (Japan)	1 762

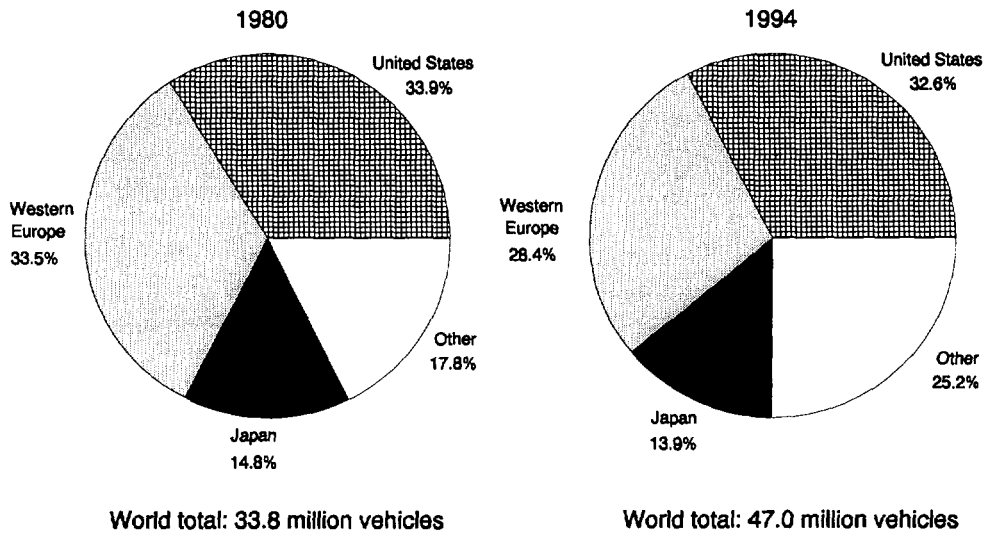
Source: Motor Vehicle Manufacturers Association of the United States, *World Motor Vehicle Data,* (Detroit).

Demand World demand for motor vehicles depends largely on the markets of such developed countries as Japan, the United States and countries of western Europe, which together account for more than 80 per cent of total demand. After a period of steady growth in the 1980s, demand began to decline in the

early 1990s as major developed countries slid into a recession. In early 1994, however, there were signs of recovery as demand increased slightly.

The United States, the world's largest market, accounts alone for more than 30 per cent of world demand, while Japan, the second largest market, accounts for about 15 per cent (see figure 5). In western Europe, 17 countries together account for about 30 per cent of world demand.

Figure 5. World sales of motor vehicles, 1980 and 1994



Source: Motor Vehicle Manufacturers Association of the United States, *Facts and Figures 1992* (Detroit, 1992); Ward's Communications, *Ward's Automotive Report* (Detroit); Japan Automobile Manufacturer Associations, *Monthly Automobile Statistics* (Japan, 1995); Daily Auto Newspaper, Handbook of Automotive Industry (Japan, 1995); DRI-McGraw-Hill, *World Auto Forecast Report* (Lexington, Massachusetts, February 1995).

Trends in percentage shares by region show that demand is increasing in developing countries, particularly in Latin America and South-East Asia. In 1994, the developing countries as a whole increased their share of world demand to 25 per cent, 7 per cent higher than in 1980.[4]

In the United States, cyclical movements in replacement demand resulted in booms in 1973, 1978, and 1986, and depressions in 1970, 1975, 1982 and 1991. Recently, because of trade frictions between Japan and the United States and the high value of the yen, the volume of transplant production by Japanese manufacturers is increasing.[4]

Demand for motor vehicles in Japan increased rapidly during the bubble period in the late 1980s. However, when the bubble burst, demand

suffered, and for the first time since the Second World War, demand decreased for three consecutive years beginning in 1991.

From the late 1980s to the early 1990s, the western European market suffered the worst recession since the Second World War. But in 1994, sales rose by a small margin, showing slight signs of recovery. Moreover, the unification of Germany is seen to have created an extraordinary rise in demand.[4]

Markets in all other regions have been growing steadily. In 1980, sales in these regions accounted for only 17.8 per cent of the world total. But by the mid-1980s, this figure rose to 20 per cent, and by 1994, it surged further to 25.2 per cent. Between 1980 and 1994, the market size of countries in these regions increased by an average annual rate of 5 per cent.

Corresponding with the rise in demand, world motor vehicle registration increased by an average of 4.2 per cent per year during the period 1970-1992 (see table 4). At the regional level, the number of registrations grew by less than 5.0 per cent per year in mature markets such as western Europe and the United States. In Japan, growth was slightly higher than in other mature markets. In developing countries, however, it increased by around 5.8 per cent.

Table 4. World automotive registrations, 1970, 1980 and 1992
(Millions of vehicles)

				Average percentage growth change		
Country	*1970*	*1980*	*1992*	*1970-1980*	*1980-1992*	*1970-1992*
United States	108.4	155.8	189.7	3.7	1.7	2.6
Japan	17.6	37.9	61.7	8.0	4.1	5.9
Western Europe	82.8	144.9	232.1	5.8	4.0	4.8
Developing countries	37.6	72.4	130.1	6.8	5.0	5.8
Total	246.4	411.0	613.6	5.2	3.4	4.2

Source: Motor Vehicle Manufacturers Association of the United States, *Facts and Figures, 1992* (Detroit, 1992); Japan Automotibile Manufacturers Association, *Monthly Automobiles Statistics* (Japan, 1995).

In the United States, the proportion of new demand attributable to women has risen significantly over the past ten years, from around 40 per cent to almost 50 per cent.[5] As this trend suggests, the ratio of women in total registration tends to increase as a country develops economically.

International trade

Current status

Several key factors have affected global automotive trade. First, trade in the industry seems to centre around developed countries. Of the 15 exporting countries that accounted for 95.7 per cent of global motor vehicle exports in 1992, only three are developing countries, namely Brazil, Mexico and the Republic of Korea. Moreover, the share of world automotive trade of the major producers, namely Japan and countries in North America and western Europe, increased from 63.9 per cent in 1980 to 70.5 per cent in 1992.[6]

Secondly, intra-industry trade is very intense in the automotive industry, as witnessed by the fact that six of the 15 major exporting countries recorded intra-industry deficits in 1992. Italy and the United States recorded deficits of $5.7 billion and $39.9 billion, respectively, in the same year.

Thirdly, there are not only horizontal divisions of labour within the industry, but also many vertical divisions, as is evidenced by the fact that in seven countries, including Belgium, Canada, Mexico, the Republic of Korea and Spain, the trade balance differs for the finished and the parts industries.[7]

Trade friction

Most trade frictions in the industry stem from the huge trade surplus of Japan vis-à-vis the rest of the world (see table 5). Japanese car exports totalled $78.3 billion in 1992, while imports totalled $6.4 billion, bringing the Japanese trade surplus to $71.9 billion. The trade imbalance with the United States and the countries of the European Union, particularly acute because Japanese exports far outweigh imports, has triggered constant trade disputes between Japan and those countries.

The disputes, which started in the early 1980s, culminated in the application of voluntary export restraints (VERs) compelling Japan to expand its on-site production in the United States (see table 6). Despite Japanese acceptance of VERs, the trade imbalance persisted (see table 7), triggering a second dispute in the 1990s.

To resolve it, new measures were proposed that included a revision not only of the total number of Japanese cars imported, but also the number of units produced in the United States. In addition, the United States has demanded that Japan opens its market to United States exports of cars and automotive parts.

Table 5. Characteristics of the United States-Japan trade tension in the automotive industry in the 1980s and 1990s

Stage I (early 1980s)	*Stage II (early 1990s)*
Background	
* Japanese car sales within the United States breaks the 20 per cent mark	* Japanese car sales within United States breaks the 30 per cent mark
* Performance of the Big Three deteriorates	* Performance of the Big Three deteriorates
* Unempolyment becomes more pronounced	* United States trade deficit against Japan increases
Initiator	
* UAW International Union	* United States Government
* United States Congress	* United States auto industry (Big Three, UAW)
Major requests	
* Expansion of Japanese transplant production in the United States	* A balanced trade account with Japan
* Request of VER	* Increased purchase of United States made auto parts
	* More cooperation in promoting the sale of United States cars in the Japanese market

Source: Japan Automotive Manufacturers Association, *Monthly Automotive Industry* (Japan, May 1993)

Table 6. VERs on cars exports and real exports of motor vehicles from Japan to the United States, 1984-1993
(Thousands of vehicles)

Year	*Amount of VER (A)*	*Export (B)*	*B/A (percentage)*
1984	1 850	1 850	100.0
1985	2 300	2 300	100.0
1986	2 300	2 300	100.0
1987	2 300	2 210	96.1
1988	2 300	2 180	94.8
1989	2 300	1 950	84.8
1990	2 300	1 850	80.4
1991	2 300	1 730	75.2
1992	1 650	1 570	95.2
1993	1 650	1 390	84.2

Source: Daily Automobile News, *Handbook of Automotive Industry* (Japan, 1995).
Note: Periods are based on Japanese fiscal year which starts on 1 April.

In Europe, restrictions on exports of Japanese cars were first put in place by Italy in 1975, whereby Japan agreed to apply VERs on its exports. In 1983, a similar agreement was reached with other countries in Europe. But in July 1991, the Ministry of Trade and Industry of Japan reached an agreement with countries in Europe to cut back its car exports to 1.23 million vehicles by 1999. Bilateral export restrictions with five countries, including the United Kingdom of Great Britain and Northern Ireland, were simultaneously cleared on the agreement that Japan would monitor its imports against

expected demand. Accordingly, from 1992, both sides began negotiations on the volume of car exports.

Table 7. Trade balances of the United States with Japan, 1988-1993
(Millions of dollars)

Year	*Import from Japan*	*Export to Japan*[a/]	*Trade balance*
1988	28 460	370	- 28 090
1989	28 190	460	- 27 730
1990	28 440	690	- 27 750
1991	28 820	690	- 28 130
1992	28 230	820	- 27 410
1993	29 610	1 130	- 28 480

Source: Ministry of International Trade and Industry, *White Paper 1989-1994*; Daily Automobile News, *Handbook of Automotive Industry* (Japan, 1995).
a/ Excluding exports of automobile parts.

Growing trade protectionism

Since the late 1980s, protectionism has gained momentum in the automotive industry. This trend has been flueled in particular by the United States in an attempt to overcome its trade deficit and by other countries striving to gain economic dominance in the post-cold-war era.

The "economics-first" policies of individual economies have been manifested in the creation of economic blocs. Each economic bloc implemented policies designed to favour regional members. Policies included implementing varying tariff rates for those within and outside the bloc, raising the local content requirement, or adjusting the formula for local content. However, these measures could conflict with article 1 of the General Agreement on Tariffs and Trade (GATT), on the most-favoured-nation status, and with article XXIV, which states that the terms of trade for a third country cannot deteriorate as a result of an agreement reached between two countries.

Liberalization under the WTO framework

The establishment of the World Trade Organization (WTO) in 1995 has given way to a new trade order, which is expected to affect the following areas of the automotive industry significantly. WTO will have a Dispute Settlement Body and a Trade Policy Review Body, which will perform supervisory functions making their decisions legally binding. It is hoped, therefore, that any bilateral measures taken by individual countries will be weakened. With regard to market access, members have agreed to lower their tariffs on industrial products. This will undoubtedly affect developing countries more significantly than developed countries because the

latter already maintain low tariffs. The safeguard category of the regulations sets explicit rules on time limits and procedures for the elimination of such grey areas as VERs. Major exporting countries will therefore be freed from that trade barrier; WTO regulations provide a transparent definition of subsidies, but at the same time strongly restrict their use. Late developers will therefore have less flexibility in operating their subsidy programs. Because of the standardization of the rules of origin, which set a clear and reasonable standard for operation, the trade environment of the industry will improve significantly. Trade-related measures currently include the local content requirement, production mandates, local manufacturing requirements, and foreign exchange restraints, all of which are due to be phased out gradually. Since it will take some time before such measures are abolished, it might be necessary to extend them in exceptional cases.

In sum, for developing countries, the establishment of WTO will mean an improved trade environment through the application of unified rules of origin, a check on bilateral trade pressures and retaliatory measures, and the abolishment of VERs. For developed countries, the lowering of tariff rates, abolishment of subsidies in developing countries and the gradual abolishment of trade-related investment measures will facilitate market access to developing countries.

Current features

Competitiveness

A country comparison of the 1980s shows that Japan was most competitive with regard to product development. To develop a new model in Japan only 46 months were required, whereas in Europe and the United States, manufacturers needed 58-60 months (see table 8).[8] This prompted manufacturers in Europe and the United States to adopt the Japanese product development system in the 1990s in an effort to narrow the gap.[9]

With regard to assembly productivity, Japan was once again at the top. In 1989, it took Japanese manufacturers only 16.8 hours to assemble a car, only 46 per cent and 68 per cent, respectively, of the time spent by manufacturers in Europe and United States.[8] However, because of serious measures taken to reduce assembly time by means of personnel cuts, greater automation, adoption of more efficient parts supply systems and the just-in-time (JIT) system and improvements in work ethics, manufacturers in Europe and the United States were able to reduce the number of assembly hours significantly by 1993; from 36.9 to 25.9 in Europe and from 24.9 to 21.7 hours in the United States.[10]

monitoring of inventory necessary. Lean production, however, involves a team of a multi-skilled workers that operate automated equipment to produce a variety of models and work closely with parts suppliers at each stage of production. Because of close team work and the adoption of JIT it is possible to produce a variety of products and maintain a zero inventory rate.

Table 10. Evolution of automotive production methods

Craft production
* Used in Europe from the 1880s when the first automotive industries were developing.
* A highly skilled craftsman produces many models in small units.
* Produced by receiving specific orders.

Mass production
* Developed in the United States in the 1920s by Ford and Sloan.
* Unskilled and semi-skilled workers use complex equipment and facilities to produce a single model in mass units.

Lean pduction
* Developed and refined in the 1960s by Toyota.
* A multi-skilled work team uses automated equipment to produce a variety of models.

Source: Kia Economic Research Institute database.

Further differences between the two production methods, from initial production to sales include the following:

Table 11. Comparison of mass and lean production methods

Mass Production
* Scope of the labourers' job and function narrowly defined.
* Production process dispersed among many parts suppliers.
* Object is minimum standard of perfection (negative concept).
* Inventory retainment possible.
* Simple products are produced.

Lean Production
* Multi-skilled work team works with parts suppliers at each stage of the production line.
* Object is the greatest possible standard of perfection (positive concept).
* Zero inventory.
* Diverse products are produced.

Source: Kia Economic Research Institute database.

(a) *Product development:* Under the lean production method, a close network is established and maintained between the factory, parts suppliers, dealers and development engineers. Thus, product and production engineering occur simultaneously, saving both time and labour, and the development and production periods can be reduced by one half or one third relative to mass production. It is possible to introduce new models and change models

frequently catering more easily to changing consumer tastes, oil prices, and other external factors.

(b) *Parts supply:* The number of parts suppliers under a given assembler tends to be smaller in lean production than in mass production because suppliers are not selected by competitive bidding, but by past performance and the established relationships between assemblers and parts suppliers. Moreover, the subcontracting structure under lean production is stratified such that the assembler deals directly with the primary subcontractor, the primary subcontractor with the secondary, the secondary with the tertiary, and so on.

(c) *Division of labour:* Production lines used in lean production are less specialized than those used in mass production. While the division of labour is maximized in mass production, in lean production the emphasis is on the flexibility of production lines. Because the lean production system comprises a multi-skilled team, it allows for quick adaptations in the production process so that a given production line can be easily modified to produce different products. Moreover, through *kaisen*, which means improvement, faults are rectified as soon as they are discovered.

(d) *Customer relations:* The lean production system contributes to improving customer relations. A "lean" retail sales system is interlinked with the product development pocess. As a result, dealers can participate in product development and are able to establish and maintain an ongoing relationship between customers and manufacturers.

Strategic alliances

The prolonged recession of the early 1990s has resulted in declining profits and exacerbated the existing oversupply capacity for car manufacturers. Intense competition in technology and the tightening of environmental and safety regulations pose additional challenges.

In response to these trends, many manufacturers are establishing strategic alliances designed to deal with the many problems, especially adverse market situations that are difficult to overcome individually.[13] As can be seen from table 12, the number of horizontal alliances is increasing, as is the proportion of non-joint ventures. Moreover, diverse forms of strategic alliances are developing that include more varied partners than in the past. As part of a larger policy package to strengthen competitiveness, such alliances are strongly supported by Governments. As a result, the world

automotive industry is rapidly entering a period of increased competition as well as cooperation.[14]

Table 12. Major strategic alliances in the world automotive industry

Joint venture	*Non-joint venture*
R & D	
GM-Isuzu, Ford-Mazda	Ford-Nissan[a/], GM-Ford-Chrysler[a/]
GM-Saab[a/]	Mitsubishi-Benz, Peugeot-Renault[a/]
	Mitsubishi-Volve, Toyota-Nissan[a/]
	Nissan-Mazda
Production	
GM-Toyota, GM-Saab[a/]	Toyota-Volkswagen, Ford-Nissan[a/]
GM-Volvo, GM-Suzuki	Chrysler-Mitsubishi, Honda-Isuzu[a/]
GM-Isuzu, Ford-Mazda	Nissan-Mazda[a/], Mazda-Suzuki[a/]
Ford-Iveco, Nissan-Subaru	
Nissan-Nissan Diesel	
Mitsubishi-Volvo[a/]	
Parts sourcing	
GM-Chrysler, GM-Isuzu	Chrysler-Mitsubishi
GM-Suzuki	Volvo-Volkswagen, Mazda-Isuzu[a/]
	Honda-Isuzu[a/]
Sales	
GM-Saab[a/], GM-Isuzu	GM-Toyota[a/], Fiat-Mazda
GM-Suzuki, Ford-Mazda	Volkswagen-Toyota, Peugeot-Mazda
Mitsubishi-Benz	Chrysler-Honda[a/], Chrysler-Mitsubishi

Source: Kia Economic Research Institute database, compiled from newspapers and weekly magazines.
a/ Denotes strategic alliances formed after 1990.

Japan possesses the best record for promoting alliances relating to production, parts sourcing, and parts sharing. Since the latter half of the 1980s, because of domestic and global economic recessions, appreciation of the yen and excessive investment during the economic bubble period, the cost structure of Japanese manufacturers has deteriorated significantly. This has led to a decline in profits and higher production costs.

Accordingly, the focus of many Japanese car manufacturers is on producing a few strategic models in order to take advantage of greater economies of scale. They are also actively forming alliances to reduce product development costs. Furthermore, in order to achieve a more effective system for technology development, even traditional competitors such as Toyota and Nissan are involved in the development of the electronic car. The Ministry of Trade and Industry of Japan played a central role in forming another technology alliance, a consortium that will try to develop a

technology for the electric storage of lithium bulbs used in electronic automobiles.[15]

In the United States, the Big Three (General Motors, Ford and Chrysler) joined forces in 1988 to develop lighter car bodies and new materials. Since then, 15 more consortia have been formed including an alliance established in 1994 for the development of an electric power system. The United States Council for Automotive R & D was established to manage and support strategic alliances which cover a wide range of state-of-the-art technology.[16] In 1984, the United States Government announced the National Cooperative Research Act, enabling competitors to pursue joint research projects without violating antitrust laws. In 1989, the announcement of the Competitive Technology Transfer Act facilitated joint research projects between automobile firms and federal research institutes.

Strategic alliances are also being formed to tackle environmental problems in Europe. Possibilities for alliances are being investigated for the development of mini-vans and diesel-fuelled passenger cars, both viewed as promising niche markets. With the establishment in Europe of a Council for Automotive R & D (EUCAR) in 1994, the number of alliances for the joint development of safety and environment-related technology is expected to increase.

Restructuring

Since the 1980s, increasing global competition and uncertainty in the global economic environment have forced many manufacturers to restructure. By the early 1990s, the restructuring boom had spread throughout the industry, but the degree of restructuring undertaken during those two decades varies. The restructuring efforts of the 1980s consisted primarily of temporary measures, mainly involving downsizing and cost-cutting in response to cyclical economic downturns. But the restructuring of the 1990s has been more fundamental and comprehensive, touching on all areas affecting competitiveness. The adoption of the lean production method, for example, has brought about changes in product strategies that have included a drastic reduction in product development time and costs. Restructuring has also included the revamping of the outsourcing structure, adoption of globalization strategies, including offshore production, and formation of strategic alliances.

Owing to intense restructuring, the competitiveness gap between manufacturers in Japan, the United States and countries in Europe is narrowing and an atmosphere of unlimited and free competition exists among the advanced manufacturers of motor vehicles. In particular, the gains made by United States manufacturers are noteworthy. Restructuring efforts of the Big Three began with a realization of mistakes made in the 1980s, when they decreased their investments in the automotive industry in favour of other, more profitable sectors. They were diligent neither in pursuing cost-cutting measures nor in improving productivity. As a result, their profits declined and market shares fell.

In the early 1990s, the Big Three undertook comprehensive and fundamental restructuring measures such as reducing personnel, shutting down factories and decreasing the number of models produced. They also adopted Japanese-style outsourcing structures and product development systems, engaged new chief executive officers and pursued other measures to motivate the workforce and improve labour relations. In addition, many businesses not directly related to the automotive industry were sold.

The successful introduction of popular new models by the Big Three and the improvement of small-sized cars bear testimony to the success of their restructuring efforts. While developing the Neon, Chrysler reduced development time and costs dramatically, even below that of the Japanese. Moreover, manufacturers in the United States have made significant headway in developing small-sized models and could become serious competitors of manufacturers in Japan and developing countries in this market segment.

Amid prospects for fiercer competition following European integration and increased competition from Japan, European manufacturers are stepping up their efforts to recover their competitive edge against United States and Japanese manufacturers. Faced with worsening profitability structures, however, they are focusing on cost-cutting measures similar to those taken by their counterparts in the United States. Nevertheless, since labour costs are high in Europe, downsizing has been one of the most effective channels for reducing overall costs. In the past two years alone, European motor vehicle manufacturers are estimated to have laid off nearly 100,000 workers.

At a fundamental level, restructuring efforts include strategic alliances for joint research projects, shifts in product strategies, shedding of secondary

businesses and revamping of outsourcing systems. Recently, there has been a trend toward decreasing the number of first-tier suppliers and building multiple tiers instead. Furthermore, increased efforts are being made to involve suppliers in the development processes in an effort to reduce costs and raise the efficiency of the production and parts supply structures.

In Japan, car manufacturers are also trying hard to overcome their high-cost and low-profit structures. Efforts to enhance the profit structure have focused mainly on reducing the product development period, decreasing and simplifying models and standardizing parts. In the 1990s, unlike in the past, Japanese car exports have been sluggish. Given the depressed domestic demand and the strong yen, manufacturers have been forced to find an outlet for growth. Instead of leading to temporary cost-cutting measures, such as reducing manpower and cutting transportation and other miscellaneous expenditures, restructuring has involved shutting down factories that are no longer competitive, shifting production overseas, reducing the number of models and parts, establishing a system for the division of labour between various car types and sizes and forming alliances to expand opportunities for sharing parts.

Japanese manufacturers are also updating their lean production method to keep abreast with the requirements of the changing environment. This has involved reducing the lead time for developing new models, expanding parts standardization, reducing the number of parts and options, and containing "hard automation" at an appropriate level. Such measures are expected to enhance flexibility and profitability, the two main strengths of the lean production process.

MARKET CONDITIONS IN SELECTED COUNTRIES

The world automotive industry is dominated by Japan, United States and western Europe. In the United States and western Europe it has reached a relatively mature stage of development. But the recent rapid growth in developing countries, such as Brazil, China and the Republic of Korea, could reshape the global structure of the industry, significantly.[16]

Developed economies

United States

The automotive industry was first developed in the United States in 1903. By 1965, domestic demand for automobiles had reached over 10 million units, but the industry had started becoming more sensitive to cyclical changes.[17] In 1974-1975, after the first oil shock, it experienced a severe recession along with the rest of the economy. Sales dropped to 8 million units in those years.

During the 1970s, the proportion of small cars in the market grew due to the rapid increase in the number of second-car owners, a trend which became noticeable in the late 1960s (see figure 6). The popularity of small cars gave Japanese manufacturers a firm foothold in the United States. The Big Three responded by introducing subcompact models and by downsizing their medium- and large-sized models. However, as they were unable to maintain their market shares, they faced significant difficulties in their attempts to develop a competitive package of models. Their profitability deteriorated and each underwent a serious management crisis. As a result, the monopoly of the Big Three crumbled, and during the 1980s the United States lost to Japan its place as the primary car-producing country.

Figure 6. Sales structure of passenger cars in the United States, 1983-1994

Source: Kia Economic Research Institute database.

Since then, the Big Three have focused their efforts on raising their competitiveness by intensively restructuring the entire production system. They have also concentrated on establishing sources overseas for small cars, and shifting their production facilities abroad as well as on moving into finance and other high-technology sectors. Because of those efforts, by 1986, when the United States economy had reached the apex of economic recovery, the Big Three recorded unprecedented profits.

In 1991, sales dropped again to 12 million units, but rebounded to 15 million units in 1994 (see table 13). Because of various factors, including the success of some of the competitive new models of the Big Three, the United States industry was able in the period 1991-1994 to reclaim its position as the leading manufacturer after 14 years.

Table 13. Trends of the automotive industry in the United States, 1990-1994
(Thousands of vehicles)

	1990	*1991*	*1992*	*1993*	*1994*	*Percentage change 1990-1994*
Production						
Cars	6 077	5 439	5 663	5 982	6 601	2.1
Commercial vehicles	3 706	3 372	4 038	4 916	5 649	11.1
Total	9 783	8 811	9 702	10 899	12 250	5.8
Sales						
Cars	9 300	8 175	8 214	8 518	8 990	-0.8
Commercial vehicles	4 846	4 365	4 903	5 378	6 071	5.8
Total	14 146	12 539	13 117	13 896	15 062	1.6
Imports						
Cars	2 403	2 038	1 938	1 776	1 735	-7.8
Commercial vehicles	631	551	422	378	409	-10.3
Total	3 034	2 589	2 360	2 153	2 145	-8.3
From Japan	1 719	1 500	1 453	1 328	1 239	-7.9

Source: Ward's Communications, *Ward's Automotive Yearbook* (Detroit, 1994).

A careful study of the sales performance in the United States reveals a few noteworthy trends. The first is the rapid growth in sales of commercial vehicles. In 1994, sales of commercial vehicles jumped by around 40 per cent from its 1980 level[12], reaching an unprecedented level. Growth was not only accounted for by increases in the sales of light trucks, which typically lead growth, but also by single usage vehicles and mini-vans that serve as both commercial and passenger vehicles. This trend signifies the

diversification of consumer tastes. New models are being introduced in the commercial vehicle market, a growing market segment targeted by manufacturers hoping to establish niche markets in the future.

Secondly, the proportion of imported cars is declining. Imports reached 2.4 million units in 1990, constituting 17.3 per cent of the total market. By 1994, that figure had fallen to 1.7 million, or 11.5 per cent of the total market. The driving force behind that decline has been the increase in production by the Japanese manufacturers in the United States. The market share of Japanese manufacturers in the United States, however, remains at 23-24 per cent. In 1994, owing to successful sales strategies, including lease sales, their market share actually increased by 0.3 per cent.

The Big Three were able to regain confidence in the small car sector with the success of Neon, Saturn and other models. This brought about a decline of captive imports in that sector and resulted in a decrease in United States imports. Efforts are being made to increase production capacity by renovating existing facilities instead of building new ones, and it is estimated that sales will be sustained at a relatively high level of 15-16 million units.

Considering the schedule for capacity expansion, it is expected that supply capacity for the domestic market will reach 20 million units by the end of the 1990s, which could result in oversupply. Moreover, taking into account western European manufacturers, such as Volkswagen, who are trying to re-enter the United States market, and the growth in the supply capacities of Canadian and Mexican manufacturers, it is estimated that competition in the United States market will be further intensified.

Japan The Japanese automotive industry grew rapidly during the 1960s, when domestic demand for automobiles sky-rocketed. Growth in the industry was sustained by the increase in exports during the 1970s, and in 1980, Japan became the world's leading producer.

Until the first half of the 1980s, exports provided the main impetus for growth in the industry. In 1981, however, growth was dampened by the implementation of VERs. At the same time as the rapid appreciation of the yen that began in 1985, Japanese manufacturers started realigning their marketing strategies by gradually expanding their on-site production overseas rather than by increasing exports.[18]

Since then, Japanese manufacturers have been very successful in gaining access to markets of the United States and Europe and have been able to increase their overseas production volume significantly. Other factors, such as the introduction of lean production, and the success of their small-sized models and, later, of their luxury models, also contributed to sustaining the growth of sales in the 1980s and early 1990s. In 1994, overseas production reached 5 million units, exceeding the 4.5 million units in exports for the first time.

During the 1990s, however, Japanese car manufacturers have had to deal with a number of important changes in the domestic and international environment that have demanded "structural" transition. Rapid growth in domestic demand in the late 1980s was the result of speculative demand or over-consumption rather substantive growth in the domestic market. Taking on an over-optimistic view of the market, Japanese manufacturers diversified and upgraded their lines to an excessive degree. Investment in facilities and R & D costs soared and production costs per unit increased dramatically. The prevailing production structure, coupled with the rapid appreciation of the yen, caused a deterioration in profitability as the economy plunged into recession. Even major car producers were nearly forced into insolvency.

Moreover, during the same period the Japanese market shifted from a growth phase into a cyclical phase, i.e., it matured into a market that was similar to the North American or western European markets. This implied that Japanese car firms could no longer expect to grow at the high rates achieved in the past amd that they would have to adjust their production schedules according to business cycles.

During 1994, the fourth year of recession for the Japanese automotive industry, domestic sales increased by 0.9 per cent of the 1993 level, rising to 6.5 million units (see table 14) but exports decreased by 11.1 per cent, falling to 4.5 million units. The slight recovery in the domestic market coupled with a significant decrease in exports resulted in a net decline of 6 per cent in total production over 1993 (10.6 million units in 1994). The production of passenger cars fell below 8 million units for the first time since 1987, recording only 7.8 million units. But the production of commercial vehicles rose to 2.75 million, constituting an increase of 0.7 per cent. This was mainly due to the recovery of the economy and a subsequent growth of exports.

Table 14. Trends of the automotive industry in Japan, 1990-1994
(Thousands of vehicles)

	1990	*1991*	*1992*	*1993*	*1994*	*Percentage change 1990-1994*
Production						
Cars	9 948	9 753	9 379	8 497	7 801	-5.9
Commercial vehicles	3 539	3 492	3 121	2 730	2 753	-6.1
Total	13 487	13 245	12 499	11 228	10 554	-5.9
Imports						
Cars	221	197	181	195	276	5.7
Commercial vehicles	3	3	3	6	25	69.9
Total	224	200	185	202	301	7.7
Sales						
Cars	5 103	4 868	4 454	4 199	4 210	-4.7
Commercial vehicles	2 675	2 657	2 505	2 268	2 317	-3.5
Total	7 777	7 525	6 959	6 467	6 527	-4.4
Exports						
Cars	4482	4 452	4 409	3 911	3 361	-6.9
Commercial vehicles	1 349	1 301	1 259	1 107	1 101	-5.0
Total	5 831	5 753	5 668	5 018	4 460	-6.5

Source: Japan Automobile Manufacturer Association, *Monthly Automobiles Statistics* (1995).

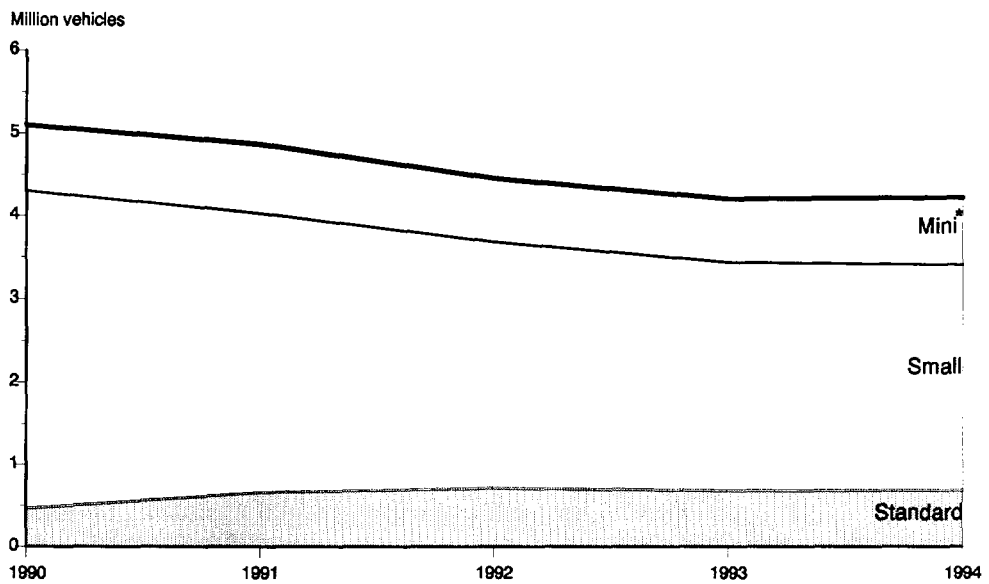
Despite the prolonged recession, domestic sales appear to be recovering for the first time in four years. The recovery could be attributed to a number of factors: the increase in demand for new cars following economic recovery; the upsurge of new cars replacing those purchased during the bubble period; the increase in demand arising from reduced consumption tax and the improvement of the Road and Transportation Act; and the successful sales strategies adopted for recreational vehicles and low-cost models by major manufacturers.

By classification, standard passenger cars (exceeding 2.0 litres) and large trucks grew at a positive rate (see figure 7). Domestic demand for small-sized cars decreased by a large margin. In the case of passenger cars, sales of mini-cars and standard cars are increasing steadily. Since the beginning of the 1990s, however, the proportion of small-sized cars in total sales has been declining steadily. This trend has resulted in the bipolarization of motor vehicle classifications.

Despite the depression in domestic demand, the market for recreational vehicles is expanding rapidly. Higher income levels and increased leisure

time are the two main factors behind this phenomenon. In 1994, more that 1 million recreational vehicles were sold, representing nearly 20 per cent of sales of passenger vehicles. The proportion of imports of passenger car sales also increased dramatically. In 1994, some 301,000 imported vehicles were sold in Japan, establishing a new sales record. That figure represented about 5 per cent of total sales for that year. The proportion of imports in total sales is expected to reach 10 per cent in the near future.

Figure 7. The segmentation of the new passenger cars market in Japan, 1990-1994



Source: Japan Automobile Manufacturer Association, *Monthly Automobile Statistics* (Japan, 1995).
* All cars having engines of up to 600 cc.

The strong value of the yen and continuous trade tensions have gradually eroded Japanese export levels, resulting in a downward trend that has persisted since 1985. In that year, exports made up 54.8 per cent of total production. In 1994, they represented only 42.3 per cent. Despite the decrease in percentage exported, however, the value of export sales reached a new record of $84.1 billion due to increases in unit prices and component volume.

Although domestic production declined in 1994, overseas production continued to increase, reaching 5.2 million units and overtaking exports.[19] Overseas production reached 1 million vehicles per year in the first half of

the 1980s, and exceeded 4 million vehicles in 1992. As a percentage of domestic production, it accounted for only 9.8 per cent in 1985. In the following 10 years, however, it increased threefold to 33 per cent. As trade barriers mount and Japanese manufacturers continue to increase overseas production, this trend is expected to remain unchanged. At the regional level, production in North America commanded the highest portion, 2.77 million units in 1994, followed by Asia, Europe and Latin America.

In 1994, Mitsubishi was able to achieve rapid growth. While the first runner, Toyota, maintained its position, Nissan and Mazda faced collapse. The failure of its restructuring program prevented Nissan from recovering its deficits of the previous few years. Mazda is experiencing serious difficulties because of the over-expansive policies adopted during the bubble economy period. As a result, the gap in market share between the second runner, Nissan, and the third runner, Mitsubishi, has widened and Mazda's ranking in the domestic market has fallen to seventh place, behind Suzuki, Honda, and Daihatsu.

The Japanese automotive industry seems to have recovered in early 1995, and domestic sales are expected to grow by 5 per cent compared with 1994. The market for recreational vehicles, in particular, is estimated to grow by over 10 per cent. Moreover, the effects of the Kobe earthquake in early 1995 on automotive sales have been minimal. The introduction of many new models is expected to increase sales significantly. Despite the recovery of the domestic market, exports are expected to continue to decline, resulting in a net domestic production level of about 11 million units. Overseas production, however, could probably increase to about 5.5 million units.

Western Europe

After the United States, the countries of western Europe form the second largest market in the world. Although there are some barriers hindering western European recovery from the recent recession, given the rapid developments in the European Union, it is expected to become a vast, integrated market. In 1993, sales declined by 17 per cent to 12.6 million units, the highest rate of decline since the Second World War (see table 15). Sales increased by a moderate 5.8 per cent in 1994, aided by the overall recovery of the market, the concomitant gains in purchasing power, the introduction of lower-priced models and the implementation in some countries, of specific policies designed to increase sales.

Table 15. Trends of the automotive industry in western Europe, 1990-1994
(Thousands of vehicles)

Country	*1990*	*1991*	*1992*	*1993*	*1994*	*Percentage change 1990-1994*
Production						
Germany	4 976	5 017	5 193	3 990	4 356	-3.3
France	3 768	3 610	3 763	3 155	3 530	-1.6
United Kingdom	1 565	1 453	1 539	1 568	1 695	2.0
Italy	2 210	1 879	1 686	1 267	1 403	-10.7
Spain	2 053	1 118	2 121	1 767	2 040	-0.2
Western Europe	*15 439*	*14 846*	*15 100*	*12 624*	*13 554*	*-3.2*
Sales						
Germany	3 243	4 490	4 266	3 455	3 468	1.7
France	2 756	2 424	2 466	2 007	2 293	-4.5
United Kingdom	2 291	1 801	1 794	1 975	2 136	-1.7
Italy	2 507	2 494	2 524	1 802	1 735	-8.8
Spain	1 231	1 118	1 222	888	1 085	-3.1
Western Europe	*15 006*	*15 192*	*15 174*	*12 594*	*13 323*	*-2.9*

Source: Automotive Industry Data Ltd., *AID Data Yearbook* (1995).

Production, which fell by 16.4 per cent in 1993, showed a partial recovery in 1994, increasing by 7.4 per cent. That recovery could be attributed to rebounding demand, expanded production of new models and the growth in exports to Asia, Latin America and other regions.

A review of the sales performance, by type, shows that passenger cars accounted for over 85 per cent of total sales, primarily because of the rapid increase in the sale of small-sized cars. This is due in part to the fact that such cars have traditionally been popular in western Europe, unlike in the United States. Perhaps a more important reason, however, is that manufacturers are competing with each other to introduce new models into that market segment, for example, the Twingo of Renault, Corsa and Tigra of Opel, Ibiza of Seat, Punto of Fiat, and Polo of Volkswagen.

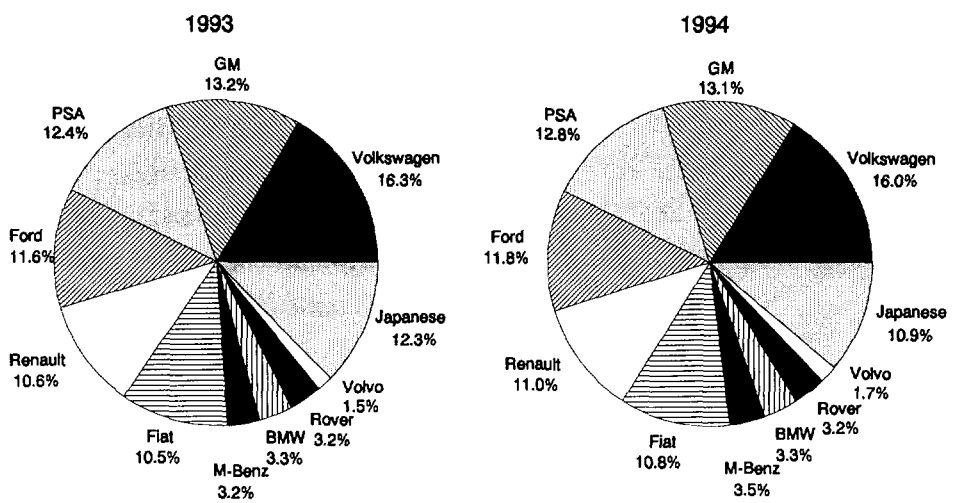
Manufacturers of luxury cars, such as Mercedes Benz and BMW, are also expected to introduce new, small-sized cars. The shift towards the production of small-sized cars is advantageous because they are relatively less vulnerable to recessions, and because manufacturers are better able to respond to any future enforcement of regulations on fuel efficiency and emission.

Sales of commercial vehicles, however, which are more sensitive to cyclical changes, reached 1.8 million units in 1989, but declined steadily subsequently. In 1994, sales rose by a mere 4 per cent. As was the case

in the United States market, however, the market for multi-purpose vehicles, including mini-vans, and single usage vehicles has grown dramatically, despite the general economic recession. In western Europe, the market for multi-purpose vehicles, which had a capacity for only 80,000 units in 1990, grew by an average of nearly 20 per cent annually; by 1994, it had grown twofold. Given that trend, a steady introduction of new models is expected in that market segment. By around 2000, market capacity is estimated to reach around 400,000 vehicles.

An overview of the performance of manufacturers in 1994 shows that Volkswagen, the biggest manufacturer in western Europe, experienced a slight decline, with its market share falling to 16 per cent (see figure 8). This drop is mainly attributed to the slow recovery of the German economy. Market shares of most other manufacturers increased by a small margin because of their relatively good performance resulting from their restructuring efforts of the past few years.

Figure 8. Market shares of major automotive manufacturers in western Europe, 1993-1994



Source: Automotive Industry Data Ltd., *Auto Industry Data Newsletter.*

In contrast, the market share of Japanese manufacturers decreased by about 1.4 per cent owing primarily to the decline in competitiveness associated with the appreciation of the yen. That trend, however, contrasts sharply with the situation in the United States market, where the Japanese market share of cars rose despite the appreciation of the yen. The relatively weak presence of Japanese automotive parts suppliers in Europe has caused

bottlenecks, especially with regard to the timely supply of key parts and effective quality control. As a result, their overseas production capabilities have suffered. Another factor has been the delayed recovery of the German market, where exports are not restricted.

The active institution of strategic alliances designed to gain competitiveness over United States and Japanese manufacturers has been a conspicuous trend among western European manufacturers. The merger of BMW and Rover, the alliance of Saab and General Motors and the formation of a joint mini-van production line by Volkswagen and Ford are better understood in the context of this larger trend.

The emergence of strategic alliances could be seen as a natural phenomenon, given the prospects for fiercer competition among European manufacturers following the integration of the European market. But such alliances represent the desire of European manufacturers to establish new production lines and acquire new environment-related technology.[10]

Developing economies

A distinguishing characteristic of the world's automotive industry since the beginning of the 1980s has been decentralization, a major manifestation of which has been the increasing involvement of developing countries in the industry. While markets of developed countries have reached a certain level of maturity, accompanied by declines in growth rates, markets of developing countries are still at an early stage of motorization and are experiencing high growth rates. There are, however, large disparities among developing countries, depending on the stage of economic development, the degree of political and economic stability and the industrial policies adopted by individual Governments.

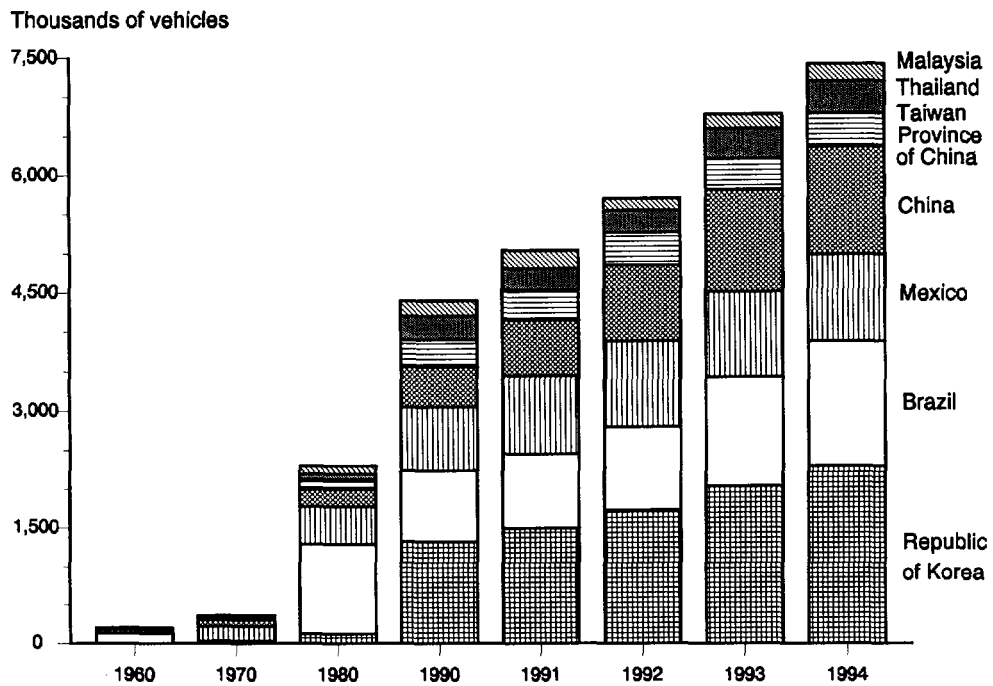
Republic of Korea

Among the developing countries, the automotive industry in the Republic of Korea has exhibited the most significant growth (see figure 9). Since 1985, production has grown at the high rate of about 20.3 per cent per year, reaching 2.3 million vehicles in 1994, ranking it the sixth biggest manufacturer in the world. In addition, exports grew dramatically, reaching over 740,000 units in 1994.

The growth in production and exports, experienced amid stable and rapid economic growth, was largely due to the success of the country's policy developing the domestic automotive industry. Rapid motorization has led to

a rise in the proportion of medium-sized cars, and growth in domestic demand has already started to decline. It will not be long, however, before the market structure is able to match that of the more advanced markets in developed countries.

Figure 9. Automotive production in developing countries, 1960-1994



Source: Motor Vehicle Manufacturer Associations, *World Motor Vehicle Data* (Detroit).

Brazil The economic development and growth in the domestic market of the Brazilian automotive industry attracted the attention of advanced manufacturers to Brazil as a possible production site as early as the 1960s. As a result of the oil shocks, however, the country experienced problems stemming from foreign debt and inflation. Because of such economic difficulties, the Brazilian automotive industry witnessed many years of recession. But the success of the economic reforms of the late 1980s led to unprecedented growth in the 1990s. Moreover, a domestic model introduced in 1993, which has an engine displacement of under 1.0 litre, has gained great popularity and has been leading the market since.

With the launching of the Common Market of the Southern Cone (MERCOSUR) in 1995, Brazilian exports to other countries in Latin America are expected to increase. Moreover, investments by Fiat,

Volkswagen, General Motors, Ford and other on-site producers are also expected to increase. Thus, the present growth trend will probably be sustained.

Mexico The automotive industry in Mexico has grown relatively steadily over the years, with production reaching 1 million vehicles in 1992. Subsequent to the signing of the North American Free Trade Agreement (NAFTA) in December 1992, the proportion of exports in total production increased to over 40 per cent, establishing Mexico as a major production site for small-sized cars in North America. However, following the foreign exchange liberalization measures adopted in 1994, interest rates and unemployment have risen rapidly, draining investment funds. In addition, economic hardship has forced many foreign companies on-site in Mexico to resort to a temporary freeze in production and to suspend existing investment plans. In sum, the Mexican industry cannot be expected to recover before the end of the 1990s.

China Fuelled by rapid economic growth, automobile production in China increased greatly, by around 30 per cent per year. By 1993, production had reached 1.3 million vehicles per year. In contrast, demand did not grow as fast because of contractionary monetary policies adopted by the Government, including policies to curb domestic demand. Based on these trends, however, it is estimated that yearly production and sales could reach 2- 2.5 million vehicles by the year 2000. China is receiving the keen attention of many western manufacturers because of its vast potential. The Government of China, well aware of the importance of the automotive industry, has been making every effort to encourage its development.

In 1989, the Government announced an Automobile Industry Promotion Policy, and in 1994 the New Automobile Industry Promotion Policy was effected in an effort to promote the industry. In addition, the Government has announced plans to apply more rigorous standards to foreign manufacturers wishing to enter the Chinese market and has taken steps accordingly to increase domestic production of automotive parts. It is also pursuing the development of a mini-car, in order to make the use of cars more popular.

Association of South-East Asian Among the countries of the Association of South-East Asian Nations (ASEAN), the performance of the automotive industry in Malaysia and

Nations Thailand is noteworthy. Sales of passenger cars alone make up 30 per cent of total motor vehicle sales in Thailand, which has the biggest market in the region. This suggests that commercial vehicles could lead the future growth of Thailand's market. Targeting the whole South-East Asian market, companies such as Mazda, Nissan and Toyota are penetrating the market of Thailand in particular.

In Malaysia, car sales have not yet exceeded 200,000 vehicles per year. The economy is growing rapidly, however, and its per capita GNP is one of the highest in the region. Malaysia is also acquiring a substantial amount of technology and know-how from the domestic manufacturer, Proton. Considering these facts, the potential of the industry and the market seems very bright.

TECHNOLOGICAL TRENDS

Progress of technology development

Automotive technology has developed rapidly since the mid-1970s, fuelled by the two oil shocks, increased motorization and the resulting need for safer and more environment-friendly technology. Rising oil prices have increased consumer demand for energy-saving, small-sized models. A growing awareness of the need for alternative energy sources and greater fuel economy has forced Governments to adopt stringent environmental regulations. An example is the establishment of the Corporate Average Fuel Economy standard by the United States.

During the 1980s, automotive technology development focused heavily on electronic devices, with remarkable results. The need for an engine control system with low-emission devices and improved fuel efficiency led to the development of the electronic injection system that is now widely applied to shock absorbers, anti-lock brake systems (ABS), air-bags, and electronic automatic transmissions.

Since the beginning of the 1990s, Governments have tightened environmental regulations further in an effort to protect the global environment. The United States introduced the Clean Air Act in November 1990. The state of California has proposed new regulations whereby a certain minimum number of new cars produced would have to be non-polluting. Since the regulations

are expected to take effect in 1998, R & D activities in the industry are focusing on the development of non-polluting cars and alternative fuels.

Vehicle weight reduction

The growing number of electronic parts and safety devices being installed in vehicles has led to a steady increase in their weight. Research is under way not only to reduce weight, but also to ensure that stricter standards for emission and fuel consumption are observed. Furthermore, since current technologies devised to improve engine performance with lower fuel consumption and to reduce air resistance have their limits, attempts are being made to develop technologies to produce lighter cars.

Accordingly, the use of steel is diminishing and research on developing parts made of aluminium and plastics is under way. The high price of aluminium restricts its use to luxury cars. New alloys are being developed for cheaper cars, however, specifically for the lower and upper arms of shock absorbers and compressors for air-conditioning units. Plastics are also being more widely used for bodies, drive shafts, double plate springs and bumpers. The use of plastics is increasing because their use makes it easier to adapt to changes in design.

Since cylinder blocks made from aluminium will reduce the weight substantially, research is under way in Japan and the United States and several countries in Europe to that end and it is expected that by the year 2000 such blocks will be installed in more than 30 per cent of all motor vehicles worldwide.[20] Metals and materials used for other parts include titanium for engine valve systems and metal matrix composites for engines and parts for supporting loads. In the near future, magnesium will be used for the oil pan and cylinder head covers, and plastics, which are currently used only for the interior and exterior, will be used for the air-intake manifold as well.

Safety technology

Two types of safety technology have been developed: active, to prevent accidents; and passive, to minimize damage in case of accidents. Active safety technology includes ABS, traction control system, and four-wheel drive. Passive safety technology includes air bags, door impact bars and seat belts. A rapid increase in demand for vehicles with such safety devices is expected and Governments are currently reviewing regulations with a view to tightening them further (see table 16).

Table 16. Prospects for passenger car safety technology in North America
(Percentage of vehicles)

	1992	*1998*	*2003*
Anti-lock brake system	19.0	60.0	90.0
Traction control system	0.2	5.0	20.0
Active suspension	n.a	1.0	3.0
Air bag			
Driver side	51.0	90.0	100.0
Passenger side	4.0	50.0	90.0
Side	0.0	1.0	5.0

Source: Delphi VII Forecast and Analysis (University of Michigan, 1994).

Anti-lock brake system

ABS was devised to improve safety, provide greater control and prevent the wheel from locking while steering. In the past, ABS was installed only in luxury cars, but as increasing demand will lead to mass production, such costs will be reduced significantly, which will allow ABS to be included in cheaper cars as well.

Traction control system

There is growing concern regarding the use of spiked tyres, which cause a road deterioration. It was therefore necessary to devise a system that would assure traction while accelerating on icy roads. It is expected that the traction control system, together with the anti-lock brake system, will be installed in more vehicles, including those with four-wheel drive, soon.

With prices of parts declining, it is anticipated that future R & D activities will focus on features common to the anti-lock brake and traction-control systems and on the optimization of size and weight of vehicles.

Air bag system

Research on air bags started towards the end of the 1960s in an effort to offer better safety. The air bag has been devised in such a manner that, upon impact, air is pumped into it within 0.05 seconds. Mercedes-Benz was the first to install the air bag in the late 1970s. Since then, technology development has accelerated especially since major countries are expected to make the installation of air bags mandatory. In the United States, this is due to take effect in 1997. In Europe and Japan, Governments are considering taking similar measures.

Environmental considerations

In order to minimize environmental pollution caused by vehicles, the United States Government has regulated the volume of motor vehicle emission by law since 1968. The California Air Resources Board, introduced regulations requiring that a certain percentage of total vehicle production had to be transitional, low-emission vehicles by 1994, low-emission vehicles and ultra-low-emission vehicles by 1997, and zero-emission vehicles by 1998.

The Big Three in the United States together with other major manufacturers and research centres around the world are therefore striving to develop new engine systems and alternative fuels to comply with the ever-increasing emission standards. The automotive industry is also focusing its attention on recycling wastes generated during production.

Alternative energy sources for motor vehicles

Studies on alternative fuels for motor vehicles have been ongoing for some time. The use of electricity, methanol, natural gas and hydrogen gas are considered to be important alternative fuels for the future (see table 17).

Table 17. Prospects for alternative energy sources in North America
(Percentage of vehicles)

	Passenger car		*Light truck*	
	1998	*2003*	*1998*	*2003*
Alcohol or alcohol/gasoline	1.0	5.0	1.0	2.0
Electricity	0.2	1.0	0.0	0.3
Electricity/gasoline hybrid	0.0	1.0	0.0	0.5
Natural gas	0.5	2.0	1.0	2.0
Propane	1.0	0.5	0.1	1.0

Source: Delphi VII Forecast and Analysis (University of Michigan, 1994).

Methanol

Methanol, when used as a fuel, emits less nitrogen than petroleum, combusts at lower temperatures and incomplete combustion occurs less frequently because it contains high octane. Vehicles that run on methanol are considered low-polluting vehicles and are currently in use in California and other parts of the United States on a trial basis. Research is also under way to develop flexible-fuel vehicles that will be powered by a mixture of methanol and gasoline. Such vehicles are expected to be in the market before vehicles that use methanol alone.

Natural gas A fair amount of research has been undertaken on the use of natural gas, which can be used without reconfiguring existing engines. It is found to emit less gaseous pollutants compared with fossil fuels and leaves no residue during combustion, thus increasing the life span of the engine. Natural gas is also advantageous because it is not only available in abundance, but is also cheaper.

Hydrogen gas Hydrogen gas has advantages in that it is easily available, possesses high thermal efficiency and does not pollute. A number of problems regarding its use as fuel for automobiles are yet to be resolved, such as safe storage and high costs of production.

Electricity Since electricity is a clean form of energy and possesses high energy efficiency, extensive research is being carried out to develop electric vehicles. The State of California has already introduced regulations requiring the inclusion of a certain percentage of electric vehicles in total vehicle production. As the production of electric vehicles involves large amounts of investment and sophisticated technologies, Government-led consortia are being formed in many countries for their development. The electric vehicles developed so far are not viable replacements for petroleum-powered cars because of their low battery capacity. At present, the maximum mileage possible is only 200 kilometers, despite the lengthy duration required for charging such batteries. Accordingly, technology development is being focused on developing high-capacity batteries and faster charging systems.

New coolant In accordance with the Vienna Convention for the Protection of the Ozone Layer adopted in March 1985, and the Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in September 1987, tighter restrictions have been placed on the use of chlorofluorocarbons in air-conditioners for motor vehicles. The Vienna Convention was adopted to protect the ozone layer, while the Montreal Protocol stipulates detailed provisions on the production and consumption of specific pollutants, such as chlorofluorcarbons and halon. Reflecting global concern about the destruction of the ozone layer, regulations on such pollutants were further tightened at the fourth meeting of Parties to the Montreal Protocol in November 1992.

In response, a number of firms in various countries, such as ELF Atochem of France, Hoechst of Germany, Daikin, Showa, Denco, and Ashai Glass of Japan, ICI of the United Kingdom, and Dupont and Allied Signal of the

United States have stepped up their efforts to develop alternative substances to be used as coolants for motor vehicles. HFC-134 which seems to be the most promising alternative for chlorofluorcarbons, is already in use.

Recycling Around 95 per cent of the steel used in motor vehicles is recycled. Increasing demand for lighter cars and devices to satisfy changing consumer needs, however, has resulted in increased use of other materials, such as plastics, glass, fabrics, leather, and paints In one vehicle, 100 kilograms of plastics are used, accounting for 8 per cent of its total weight.[21] Of a used car, 75 per cent is currently recycled and the remaining is treated as waste.

The automotive industry is now focusing on the development of a design for easier disassembly in an attempt to enhance recycling. This will, of course, involve the restricted use of screws, adhesives and paints. Efforts are also being made to develop methods to provide for clearer labelling on materials used for parts and new technologies to produce easily recyclable plastic.

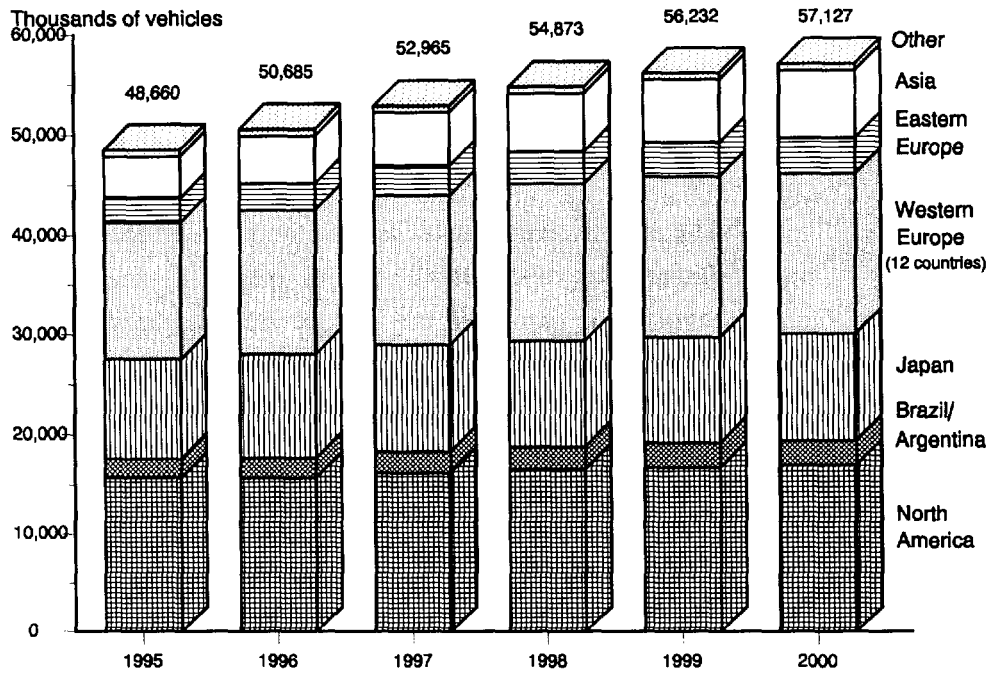
FUTURE PERSPECTIVES

Production outlook Worldwide production is expected to increase gradually at an annual average of 3.3 per cent until the year 2000 (see figure 10). A decrease has been forecast in the relative production shares of Japan, the United States and countries of western Europe. Because of intensive development policies being implemented by Governments in regions such as East and South-East Asia, Latin America and eastern Europe, however, the relative production shares of those regions will increase. Morever, markets will expand and advanced manufacturers in those markets are expected to increase their volume of on-site production.

In Asia, excluding Japan, production is estimated to increase by an annual average of about 10 per cent between 1995 and 2000. Rapid motorization and the expansion of on-site production by advanced manufacturers are the two main reasons for that increase. The Chinese market, in particular, is expected to grow rapidly. That country's positive policy stance on the development of the automotive industry and its vast market potential will continue to draw the attention of the world manufacturers. This will enhance

Chinese growth in the industry by around 20 per cent, a figure which exceeds that of other developing countries.

Figure 10. Forecasts of automotive production, by region, 1995-2000



Source: World Auto Forecast Report (Lexington, Massachusetts, DRI-McGraw Hill, February 1995).

Automotive production in eastern Europe is also expected to grow rapidly, by about 7.4 per cent, which could increase that region's share of the total world production to about 6 per cent by the year 2000. Demand is also expected to rise significantly owing to increased economic development. Moreover, many western European manufacturers will probably move on-site production to eastern Europe because of lower labour costs. As a result of such changes, Eastern Europe and other developing regions will account for nearly 22 per cent of the total world production as against the present 17 per cent.

In contrast, growth in the production levels of Japan, United States and countries in western Europe will slow down due to the market maturity, cyclical economic downturns and increased overseas production. Japanese manufacturers, in particular, are expected to continue moving their production sites to Europe, North America and South-East Asia in order to

minimize exchange rate risk and overcome various trade barriers. As a result, production in Japan will decline steadily. Overall, the combined production share of Japan, North America, and countries in western Europe is expected to decline from the current 81 per cent to 71 per cent by the year 2000.

Because of the expansion of overseas production facilities in the wake of growing economic regionalism and the rise in productivity due to production rationalization, overall supply capacity is expected to exceed demand. This disequilibrium could worsen in the near future, especially since demand in developing countries is declining. More specifically, in North America, despite the fact that the Big Three are closing down outdated factories and shifting their production activities to Mexico, upper-line manufacturers from Japan and western Europe are expanding their production in the United States. Thus, production capacity in North America is expected to remain relatively unchanged in the long term.

Steady dissemination of the lean production process

When Japan became the world's leading producer and exporter of cars in the 1980s, other manufacturers started actively adopting the lean production process in an overall effort to enhance their competitiveness. The first Japanese-style production system in the United States was set up by Honda, which began on-site production to overcome VERs. Later, Nissan, Toyota, and other Japanese manufacturers followed, establishing both wholly owned subsidiaries or joint ventures with the Big Three in the United States. In particular, General Motors, together with Toyota, established NUMMI, and adopted the Japanese-style system. With Toyota taking charge of management-related affairs, General Motors made great efforts to learn Japanese production methods, which were directly applied to the Saturn project. Later, Chrysler also applied those methods when the Neon was developed. In both instances, product development time was reduced significantly.

The United Kingdom was the first country in Europe to adopt the lean production method. After Nissan's establishment of a production line in 1986, Honda and Toyota followed in 1992. Business relations established with those firms led to the dissemination of lean production among parts suppliers in the United Kingdom. Nissan's local content in the United Kingdom had already reached 80 per cent. Moreover, a joint venture between Honda and Rover, established in 1989, became another channel for transferring Japanese-style production and management techniques. By means

of that joint venture, Rover was the first large company in the United Kingdom to adopt a single labour union and institute a lifetime employment system.

Recently, the lean production system has also spread to Germany. Opel established its Eisenach factory in 1992 and adopted many aspects of the lean production method that General Motors had acquired in North America through NUMMI. After scouting General Motors in May 1993, Volkswagen actively adopted the team system and rapidly increased the number of teams within the group. The reform efforts, however, were not confined to the production process. They were soon adopted by parts manufacturers and dealers. Attempts were also made to standardize parts and promote the integration of parts manufacturers which triggered restructuring and resulted in the stratification of the parts industry.

Although the lean production system has enabled many car manufacturers to gain competitiveness, it is not void of problems. The biggest pitfall in the dissemination process lies in the fact that labour and management relations in most countries differ from those in Japan. In some cases, non-Japanese firms rejected the labour processes prescribed by lean production. For example, the *kaisen* process, a characteristic of lean production, actually intensifies the labour process. Thus, in countries like the United States, lean production has had difficulties taking root. Labour unions in the United States, unlike those in Japan, prohibit the adoption of an ability-based incentive system in the pay schedule. In the absence of such incentives, the performance of small-group activities has been very poor.

The lean production system has been modified when adopted in various countries. Even in Japan it is constantly undergoing changes, undoubtedly in keeping with those in the econmic environment. Japan is not only beginning to experience a shortage of labour, but also a higher turnover rate because of the changing tastes and values of its younger group of workers. Moreover, other factors, such as rising death rates caused by onerous working hours, frequent changes in models, the appreciation of the yen and the consequent deterioration in the profit structure, demand an urgent revision of the lean production system as a whole.

In addition, environmental problems caused by worsening traffic congestion have prompted a large number of Japanese manufacturers to opt for retaining an appropriate level of inventory unlike that in the JIT system. This trend

is expected to increase in the future, especially since recent earthquakes have made it very difficult for assemblers to acquire parts and components. As public criticism against deaths associated with overwork and other inhumane working conditions increases, shorter working hours and an improved working environment are becoming issues of high-priority in Japan. The system of lifetime employment is being phased out gradually and more companies are beginning to work closely with parts suppliers.

Amid the worldwide recession of the early 1990s and the persistently strong yen, many Japanese manufacturers are opposed to frequent model changes. They are also modifying the lean production model, which specializes in producing many different products in small units. It is difficult to predict exactly how lean production will evolve in the future. It is certain, however, that production activities will have to become more adaptable to cyclical changes and changes in consumer tastes.

Demand outlook

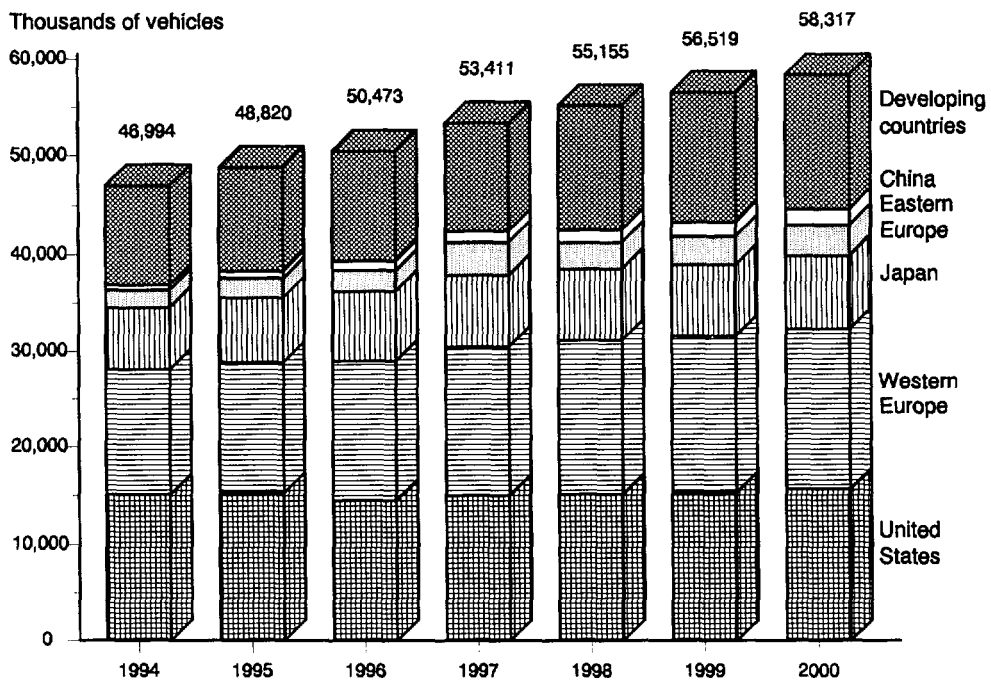
World demand for cars is expected to increase by an average of 3.7 per cent per year by the year 2000 (see figure 11 and table 18). With growth rates of 4.1 per cent, 2.8 per cent, and 0.6 per cent forecast for Europe, Japan, and the United States, respectively, demand in most developed countries, however, is not expected to grow too rapidly.[4] Demand in the other regions is expected to increase at around 6.8 per cent per year owing to the fact that markets in most developed countries have already reached a mature stage, whereas those of the developing countries still possess a potential for growth. Moreover, rising income levels and economic development could result in a corresponding increase in demand in these economies.

The consumption cycle in the United States is around nine years. The lowest point of the cycle was experienced in 1991. Therefore, consumption is expected to peak in 1995 before starting to decline again in 1996. Although the increase in the demand for cars slowed down in the latter half of 1994, indices for economic growth, employment and consumer confidence continue to be quite strong. Thus, it is estimated that recovery will continue, albeit sluggishly, until 1995. The market will fluctuate in 1996 and 1997, but will recover again by the year 2000.

Demand in western Europe began recovering in 1994, especially in France, Spain, the United Kingdom and the countries of northern Europe, and this recovery could be sustained. By 1997, a new sales record, exceeding the

15.5 million vehicles per year produced in the early 1990s, is expected. As of the latter half of the 1990s, however, demand is expected to decline again. Because of the significant reduction in sales experienced in the early 1990s, a relatively high growth rate of 4.1 per cent per year has been forecast until the year 2000, a rate significantly higher than that of Japan or the United States.

Figure 11. Forecasts of world automotive sales, by region, 1995-2000



Source: World Auto Forecast Report (Lexington, Massachusetts, DRI-McGraw-Hill, February 1995).

In Japan, the recent recession caused a delay in the replacement of cars. Nevertheless, because of the recovery in replacement demand and overall high demand induced by the success of sales expansion strategies of most manufacturers, total demand is expected by 1996-1997 to reach a level comparable with that of 1989-1990, a period of strong growth for the Japanese economy. Although a slight decrease in demand has been forecast for 1998, it will grow towards the end of the decade.

It can be concluded that markets of developed countries are rather sensitive to business cycles because of market saturation. Rapid growth and the supportive policy stance adopted by developing countries in favour of the automotive industry will contribute to increasing demand in the next few

years. Since the 1980s, demand for cars in developing countries increased dramatically; their share of total world demand (25.1 per cent in 1994) is expected to rise to 30 per cent by 1998 and to 31.7 per cent by the year 2000.[22] In particular, demand in China will increase by an average of 20.2 per cent annually, bringing its share in global demand from 1.2 per cent in 1994 to 2.8 per cent in 2000. Moreover, if advanced manufacturers continue to invest large amounts of capital in developing countries, it is possible that they will develop into large markets in the future.

Table 18. Forecasts of world automotive sales up to 2000
(Thousands of vehicles)

	1994	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*Percentage change 1994-2000*
United States								
Cars	9 039	8 997	8 625	8 950	8 946	8 978	9 270	0.4
Commercial vehicles	6 015	6 195	5 853	6 015	6 116	6 247	6 320	0.8
Total	15 054	15 192	14 477	14 966	15 062	15 225	15 590	0.6
Western Europe								
Cars	11 914	12 399	13 166	14 081	14 593	14 846	15 141	4.1
Commercial vehicles	1 154	1 254	1 360	1 439	1 485	1 506	1 531	4.8
Total	13 068	13 653	14 527	15 520	16 078	16 352	16 673	4.1
Japan								
Cars	4 210	4 424	4 810	4 884	4 796	4 794	4 984	2.9
Commercial vehicles	2 182	2 285	2 410	2 495	2 535	2 545	2 560	2.7
Total	6 392	6 709	7 220	7 379	7 331	7 339	7 544	2.8
Other countries								
Cars	9 398	9 959	10 708	11 764	12 676	13 428	14 180	7.1
Commercial vehicles	3 083	3 307	3 541	3 784	4 008	4 175	4 330	5.8
Total	12 480	13 266	14 249	15 547	16 684	17 603	18 511	6.8
China								
Cars	384	528	753	911	1 035	1 155	1 300	22.5
Commercial vehicles	159	185	215	256	289	312	335	13.2
Total	543	713	968	1 167	1 323	1 468	1 635	20.2
Eastern Europe								
Cars	1 567	1 732	1 871	2 086	2 389	2 557	2 779	10.0
Commercial vehicles	284	286	302	323	348	364	378	4.9
Total	1 851	2 018	2 173	2 409	2 737	2 921	3 158	9.3
World total								
Cars	34 561	35 779	37 309	39 679	41 011	42 046	43 575	3.9
Commercial vehicles	12 433	13 041	13 164	13 733	14 143	14 473	14 742	2.9
Total	46 994	48 820	50 473	53 411	55 155	56 519	58 317	3.7

Source: *World Car Industry Forecast Report* (Lexington, Massachusetts, DRI-McGraw-Hill, February 1995)

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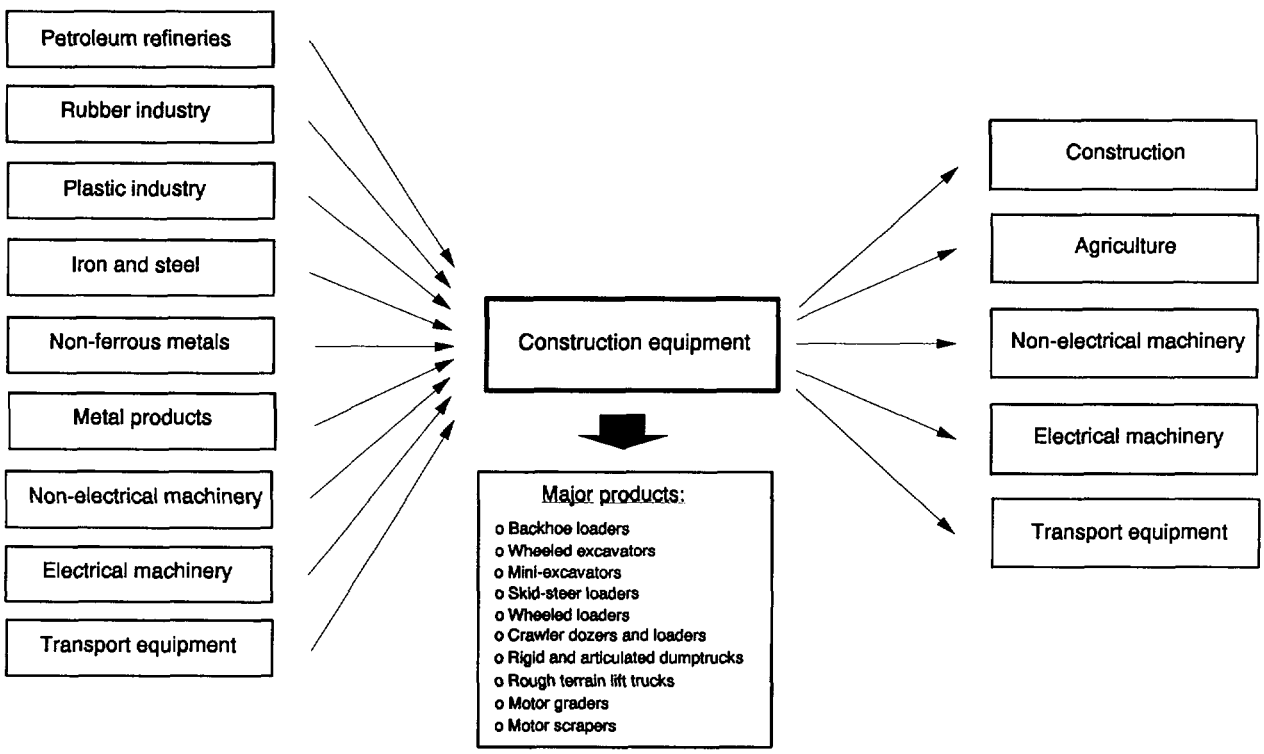
CONSTRUCTION EQUIPMENT INDUSTRY

OVERVIEW

The construction equipment industry plays an important role in almost every sector of an economy as well as in every phase of business cycles. Although the construction equipment industry represents only a minor share - less than 1 per cent - of a country's total manufacturing value added (MVA) it contributes nevertheless to overall economic growth through its role in infrastructure building, housing and industrial development (see figure 12). Furthermore, it plays a key role in the construction sector, which accounts for approximately 5 per cent of gross domestic product (GDP) in most countries.

Figure 12. Usage of construction equipment by other industries and economic sectors



Advances in technology have introduced various forms of automation into the production processes of every industrial sector. In the construction sector, the use of construction equipment has enhanced labour productivity enormously. Preference for employing construction equipment as opposed to manual labour is increasing even where wage rates are low and labour supply is plentiful. The use of construction equipment, particularly off-road

transport equipment such as loaders, excavators, crawler dozers, rigid and articulated dump trucks and lift trucks, has proved to be economical, efficient and effective.

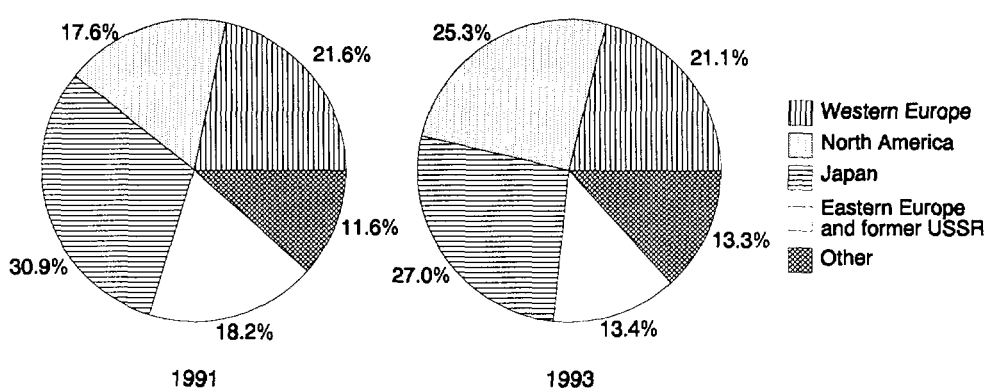
In general, the construction equipment industry has viable prospects in any country that has a large, growing population and sound economic fundamentals. Several obstacles have hindered the development of the industry in developing countries, however, including the lack of a large domestic market, overcapacity in developed countries, the strong technology positions of current global competitors that make them hard to dislodge and the lack of key components and industrial infrastructure locally.

WORLD MARKET STRUCTURE: RECENT TRENDS AND CURRENT CONDITIONS

Regional overview

The world market for construction equipment, valued at $45 billion, can be broken down as follows: Europe (including eastern Europe and the former Union of Soviet Socialist Republics (USSR)), 30 per cent; Japan, 30 per cent; North America, 25 per cent; and 15 per cent for the rest of the world (see figure 13). Apart from Europe, Japan and North America, the main markets for construction equipment are Western Asia (including Turkey), East and South-East Asia, and the Indian Subcontinent.

Figure 13. World sales of construction equipment, by region, 1991 and 1993



Source: J. I. Case, *Market Planning and Research Europe, 1994.*

Between 1991 and 1993, a decline in sales in Africa, Europe, Japan, and the Republic of Korea was partly offset by positive growth in East and South-East Asia, Latin America and North America (see table 19). Worldwide

sales dropped from 420,300 units of equipment in 1991 to 365,460 units in 1993.[1] In terms of regional shares between 1991 and 1993, that of North America which was just emerging from a recession, rose from 17.6 to 25.3 per cent. The share of eastern Europe and the former USSR, however, dropped from 18.2 to 13.4 per cent as did that of western Europe, from 21.6 to 21.1 per cent. In Japan, domestic market sales dropped from 129,895 units of equipment in 1991 to 98,715 in 1993. This was due to the bursting of the economic "bubble", signalling the end of the construction boom. As for the market in the United States, total unit sales were estimated as follows: 63,511 in 1990; 46,920 in 1991; 43,017 in 1992; and 54,710 in 1993.[2] The recovery in 1993 was due to improved macroeconomic conditions and an increase in housing construction.

Table 19. World sales of construction equipment, 1991 and 1993
(Units of equipment)

	Sales		*Percentage change*	*Percentage share*	
Region, country	*1991*	*1993*	*1991-1993*	*1991*	*1993*
Western Europe	90 660	77 010	-15.1	21.6	21.1
North America	73 970	92 390	24.9	17.6	25.3
Japan	129 895	98 715	-24.0	30.9	27 .0
Eastern Europe and former USSR	76 630	48 865	-36.2	18.2	13.4
Latin America	8 190	9 490	15.9	1.9	2.6
Africa/Western Asia	11 110	8 770	-21.1	2.6	2.4
Republic of Korea	13 155	12 060	-8.3	3.1	3.3
East and South-East Asia and other	16 690	18 160	8.8	4.0	5.0
World total[a/]	420 300	365 460	-13.0	100.0	100.0

Source: J. I. Case, *Market Planning and Research Europe, 1994.*
a/ Including the following products: backhoe loaders, wheeled excavators, mini-excavators, skid-steer loaders, wheeled loaders, crawler dozers and loaders, rigid and articulated dump trucks, rough terrain lift trucks, motor graders and motor scrapers.

After 1990, when the German Democratic Republic and the Federal Republic of Germany united to form a single sovereign state, the significance of Germany as a market for construction equipment increased, and accounted for a large proportion of the European market for construction equipment. In 1993, Germany accounted for 35-40 per cent of the western European market share, compared with some 18 per cent in 1989. Demand for construction equipment in Germany, which started declining from its peak in 1992, rose two to three times higher than the normal level, because of the

increase in construction activities caused by the unification of the two German States.

The markets of Latin America and East and South-East Asia, including in particular, ASEAN countries have shown the best overall growth among developing countries. In Latin America, that growth could be attributed to the signing of the North American Free Trade Agreement (NAFTA), and to the fact that the region has gradually overcome its debt crisis. Markets in ASEAN countries are gaining momentum mainly because of the high level of both foreign and domestic investment to support their rapidly developing economies.

In eastern Europe, interest in new construction equipment has increased, but countries in that region unfortunately do not possess the hard currency needed to purchase such equipment. Structural reforms introduced to transform eastern European countries into open, market economies have not yet been fully realized.

In African countries, demand for construction equipment has decreased and their share of the world market dropped slightly during 1991-1993. It is hoped, however, that the political reforms introduced in South Africa will stimulate economies in the region and increase the demand for construction equipment.

World prices for construction equipment have been forced downward over the past three years owing to declining demand, a result of the recessionary environment in developed countries in particular. Manufacturers have been forced to cut prices in order to dispose of old inventory and reduce the prices of used-machinery in order to stimulate sales and improve liquidity in the market. The fall in prices seems to have been checked, however, because of economic recovery in North America and a halt to the market decline in Europe. Prices have also stopped falling in Japan. In selected markets there have even been price increases. Overall, prices are expected to begin a slow recovery, assuming that demand continues to increase in developed countries. Nevertheless, price competition will continue to prevail, especially in Europe, given the large number of competitors.

As discussed above, major shocks to the world economy and recent political changes have had an impact on the construction equipment industry. The unification of Germany has generally been positive in terms of its effects on

the industry, since the dramatic increase in German sales compensated for the decrease in sales in other European countries. The collapse of the former USSR and the regimes in neighbouring countries in eastern Europe has had negative effects, especially for eastern European producers that formerly had a ready market for their products in the former USSR. The creation of the European Union after the ratification of the Maastricht Treat in 1993, has so far had little impact on the industry, in so far as it has not led to the development of a single market for construction equipment and existing local safety requirements still prevent that identical products from being sold in all markets within the European Union. Producers expect this to change as noise and safety standards become harmonized, but progress is likely to be slow.

The global recession has had a negative effect on employment in the construction equipment industry in developed countries, where manufacturers were forced to cut thousands of jobs between 1990 and 1992. That trend has now ceased and may be reversed, at least in the short term, since companies will employ more workers to cope with the recent increase in orders. In response to the effects of the business cycle, long-term structural adjustments have been made to downsize companies and reduce the industry's manufacturing overcapacity.

Share of production capacity

Table 20 provides regional shares of production by major products in 1991, the latest year for which data are available. Japan, the largest producer of, construction equipment, accounted for 42.0 per cent of world production, followed by western Europe (20.3 per cent), and North America (15.7 per cent). Of the major products, mini-excavators and backhoe loaders account for more than 50 per cent of world production.

The large share of Japan in world production bears testimony to the achievements of Japanese producers in building their position in the industry over the past 30 years. The total Japanese share of world production would be even higher if Japanese plants in Europe and the United States were taken into account. Since 1991, production levels in the United States and Europe have increased, probably because of recent improvements in market conditions and an increase in Japanese overseas production in response to an appreciating yen. Consequently, domestic production in Japan has fallen, and has remained low because of the severity of the recession.

The construction equipment industry suffers generally from overcapacity in manufacturing production, especially in developed countries. Estimates of the manufacturing overcapacity vary, but according to Joseph Cyril Bamford (JCB), there is approximately 20 per cent overcapacity worldwide, all of it in the developed countries. In contrast, undercapacity in developing countries is estimated at approximately 50 per cent.

Table 20. World production of construction equipment, 1991
(Units of equipment)

Product	*Western Europe*	*North America*	*Japan*	*Eastern Europe & former USSR*	*Republic of Korea*	*Other*	*World total*
Backhoe loaders	23 800	14 000	..	21 500	..	900	60 200
Large wheeled excavators	10 750	350	800	300	2 700	200	15 100
Large crawler excavators	9 000	3 300	57 500	20 500	5 200	2 000	97 500
Mini-excavators	7 600	..	63 500	..	3 800	500	75 400
Skid steer loaders	3 500	31 100	5 200	5 000	1 100	200	46 100
Large wheeled loaders	12 500	7 000	17 500	6 100	1 400	200	44 700
Mini-wheeled loaders	8 000	..	7 500	..	..	..	15 500
Crawler dozers	3 300	5 300	13 500	14 500	400	300	37 300
Crawler loaders	1 500	1 000	400	..	..	..	2 900
Total	79 950	62 050	165 900	67 900	14 600	4 300	394 700
Percentage share of world production	20.3	15.7	42.0	17.2	3.7	1.1	100.0

Source: J. I. Case, *Market Planning and Research Europe, 1994.*

Major players in the industry

Despite the strong position held by Japanese producers, Caterpillar of the United States is the largest company worldwide in the construction equipment industry, followed by Komatsu of Japan. In spite of a damaging strike at the North American plants of Caterpillar, that company achieved record sales and profits in the second quarter of 1994, continuing a strong trend of quarterly profit improvements. A comparison between the second quarter of 1994 and the same period a year earlier shows sales rising by 24 per cent (from $2.9 billion to $3.6 billion), which greatly contributed to the increase in profits of 258 per cent (from $67 million to $240 million). In terms of turnover, Caterpillar and Komatsu are far ahead of the following ten companies worldwide: John Deere (United States), Hitachi (Japan), J.

I. Case (United States), VME (United States/Sweden), Liebherr (Germany), Orenstein and Koppel (Germany), JCB (United Kingdom), Fiat (Italy), Kobelco (Japan) and Sumitomo (Japan).

The performance of certain companies has been far from satisfactory. J.I. Case saw its worldwide net sales plummet from $5.4 billion in 1990 to $3.7 billion in 1993 because of the global recession. In 1993, its profits stood at only $82 million. Strong recovery in the first half of 1994, however, resulted in an operating profit of $192 million on sales of $2.12 billion.

A similar trend was also observed by VME. In 1992, it incurred a loss of $94 million, including $19 million on costs involved in restructuring plants in North America. This performance was worse than the loss of $45 million in 1991. The effect of price competition on margins is illustrated by the fact that despite a sharp increase in overall losses, total sales slipped only slightly to $1.36 billion in 1992. Currency factors and the collapse of the Scandinavian market, strongly affected by the recession, also took their toll. In 1994, however, the company showed positive signs of recovery, reporting a net income of $30 million in the first six months, and net profits in 1994 of $58.6 million compared with just $6 million in 1993.

Precise rankings of companies by performance are virtually impossible as many companies are a part of larger groups, whose interests extend beyond construction equipment. The production strategies of the largest companies correspond to their sales strategies, namely to be global producers with significant positions in the three main regions of the world. Those strategies have formed the basis for many joint ventures, manufacturing agreements and takeovers within the industry.

Restructuring and corporate strategies

Given the overcapacity prevalent in the industry, virtually no expansion activities have occurred in the last few years. However, internal reorganization within companies has taken place to increase efficiency and rationalization measures involving factory closures and job cuts have been implemented, particularly during the recent recession. Many companies have concluded agreements on manufacturing and distribution, allowing them to build up a sales image in various markets without having to undergo takeover exercises or invest in new sites. Companies have begun outsourcing components in easter Europe rather than producing them in the main production areas of Japan, North America and western Europe.

Recent developments at J. I. Case provide an excellent example of internal restructuring measures taken by construction equipment companies. In 1993, the parent company, Tenneco, announced a three-year restructuring program for Case involving $920 million. The program included shifting the focus of the company to core product lines where it would have a potential to become a market leader, that is, from medium to large agricultural equipment and from light to medium construction equipment. The program involved $441 million for rationalizing the production of selected components, $161 million for consolidating and resizing production capacity, $126 million for discontinuing or replacing unprofitable products, $91 million for privatizing retail stores owned by Case and restructuring its parts distribution network and $101 million for associated costs of restructuring. In 1994, the latest developments in the program were announced. These included, in the United States, the closure of a plant at Wausau, Wisconsin, and the transfer of production of wheeled loaders to the plant at Fargo, North Dakota. In France, plans for 1995 included the closure of the outdated Vierzon plant, transfer of Case's backhoe loader production to Crepy and concentration at Crepy of all functions ranging from product design to after-sales support for European construction equipment. Integral to the strategy of the program was the goal of profit-taking rather than simply seeking to maintain a market share irrespective of the losses incurred. Restructuring was triggered by overcapacity and pressure on prices arising from marked competition from companies in Japan and the Republic of Korea. Over a four-year period, Case closed down three of its construction equipment plants in Europe, and reduced employment at its plants worldwide by 43 per cent. One important element of the restructuring program was a reduction in the company's vertical integration activities in favour of outsourcing. An arrangement for procuring weldments in Hungary, for example, has proved satisfactory in terms of quality, price and reliability, and similar results were achieved in the case of backhoe buckets procured from Mexico. Case will continue to explore the possibility of outsourcing component manufacturing to low-wage countries in eastern Europe as well as India and the Republic of Korea.

While problems faced by Case have been particularly acute, extensive restructuring has also been undertaken elsewhere in the industry, especially in Europe, where manufacturing overcapacity and duplication of production efforts are evident. In 1990, the Brussels-based producer VME cut its workforce from 10,400 to the current level of 6,400 in response to the worldwide recession and in order to enhance its long-term profitability by

reducing break-even levels. Major plant closures occurred at Landskrona, Sweden and Saint Thomas, Canada, and the plant at Asheville, North Carolina, was made the focus of the North American production and marketing activities of VME. New Holland has retrenched heavily since its establishment, reducing its workforce from over 30,000 in 1991 to 18,200 in 1994.

O&K of Germany also undertook a number of reforms to increase its competitiveness and profitability following the failure of talks with a large German engineering company, Mannesmann, on a possible merger with its Demag construction machinery subsidiary. The number of employees in O&K construction equipment, mining equipment and excavators divisions has fallen from 6,429 in 1991 to 5,294 in 1993. In its construction equipment division, which employs less than 3,500 people, a wheeled loader plant in the United States was closed in 1992 and production was rationalized and modernized at two plants in Germany. Such measures were necessary to offset the effects of high labour costs. Rationalization was also undertaken at the Komatsu Dresser construction equipment joint venture in the United States.

However, internal change in the industry has not focused entirely on retrenchment. Modernization programs have been widely introduced to maintain competitiveness. At Caterpillar, for example, a program called Plant With A Future was introduced in 1987. The main objective of the program was to equip production facilities to enable the company to compete globally. Initial efforts were directed towards building up core items identified by Caterpillar to make them competitive; non-core items were outsourced to low-cost, high-quality producers. In addition the company continued to automate its manufacturing processes and rearrange manufacturing into cells for greater efficiency. The program, which was completed in 1993 at a total cost of $1.8 billion, suffered initial problems but is now functioning smoothly. On a smaller scale, the German-owned company, Atlas Hydraulic Loaders, has reorganized and expanded two of its plants in the United Kingdom of Great Britain and Northern Ireland and turned them into modern centres for manufacturing truck-mounted cranes with product quality on a par with German standards. Mini-excavators were also added to the production line in 1990, and the parent company, Atlas Weyhausen, chose the United Kingdom rather than Germany as the production centre. Elsewhere, company structures were changed to improve efficiency and cater to customer demands. A notable example of this

occurred in 1993 at JCB where the main production lines were reorganized into clear product-based divisions, largely replacing the function-based structure.

Some companies have been re-examining sourcing arrangements within the corporate group in addition to outsourcing. In the case of Japanese producers, a clear stimulus has been the strength of the yen, which made exports from Japan more expensive but imports of components cheaper. In June 1995, in response to the currency situation, Sumitomo shifted production of one of its hydraulic excavators to its wholly owned United States subsidiary, which was already manufacturing a slightly larger model. The company announced that it would widen its overseas parts procurement beyond South-East Asia to include Europe and the United States and would also increase the level of overseas procurement from the present 2-3 per cent to 5 per cent by the end of 1995. The dilemma posed by the appreciation of the yen is whether Japanese producers should continue manufacturing parts and components in their factories at home, as does Komatsu at Osaka, for example, which has one of the most modern factories in the world, or continue exporting more of their capacity to their overseas plants. Komatsu announced a series of measures in 1993 aimed at addressing that dilemma. The measures included transferring production of small crawler dozers from Japan to its plant in Sao Paulo, Brazil, increasing its participation in its United States joint venture, Indresco (better known as Komatsu Dresser), to 81 per cent and transferring additional wheeled loader production from Japan to Hanomag, an affiliate based in Germany. Komatsu is also trying to purchase, for use in its Japanese factories, more components in Europe from the suppliers that are working with its European plants.

In addition to changing component sourcing strategies, equipment producers have been entering into more collaborative relationships with key suppliers to reduce product development time and to use the expertise of suppliers effectively so as to avoid duplication of effort and unnecessary expense. This trend is illustrated by supplier development programs introduced recently by European producers such as JCB and VME, which are currently transferring more responsibility to strategic suppliers than was done in the past. Cooperation between engine suppliers and customers is increasing, as evidenced by the business relationship announced in early 1994 between Komatsu and Cummins Engine, the first significant cooperative arrangement between a western diesel engine producer and an integrated Japanese user and producer of engines. Sharing technological development spending,

eliminating areas of redundant investment, combining production and unifying certain engine models were the main features of the arrangement.

Corporate action within the industry

Joint ventures

Many recent manufacturing and distribution agreements and joint ventures concerning more than one company or the transfer of production from one plant to another, involve Japanese companies. The most significant such agreement is one in which two companies in different regions announce a joint venture, sometimes involving one or two specific products, with each having something to offer. Three notable joint ventures initiated since the start of the 1990s are the following:

(a) *VME and Hitachi Construction Machinery* announced in 1993 an agreement to establish a joint venture company in the rigid dumptruck business. Under the terms of the joint venture, VME transferred its rigid dumptruck business and operations to the new company, in which Hitachi acquired a substantial majority stake. Hitachi was to handle the distribution of rigid haulers in Japan and in select markets in Asia and Oceania. The joint venture would also cover the distribution in Japan of VME's Volvo BM branded and articulated dumptrucks and large wheeled loaders;

(b) *JCB and Sumitomo Construction Machinery* entered into a joint venture in 1991 under which JCB was to produce Sumitomo-designed crawler excavators in the United Kingdom for the European market. With JCB holding a 51 per cent stake in the joint venture, it was of mutual benefit to both parties. Although JCB's own crawler excavator line went out of production by 1991 and its other products never gained popularity, Sumitomo saved the expense of developing its own product, because of the link with an acknowledged leader in the product technology. Furthermore, Sumitomo, virtually an unknown name in the European market, gained access to the distribution channels of JCB.

(c) *Komatsu and FAI* announced in 1993 an agreement that deepened their long-standing marketing and manufacturing capabilities. Management, production facilities, distribution networks and corporate strategies were to be further consolidated, with Japanese and European manufacturers pooling resources to ensure success in an increasingly competitive market.

Some inter-company transactions are designed with a specific geographic market in mind. The industry's players are linked by a dense distribution

network. A classic example is the 1994 agreement between Fermec of the United Kingdom, which owns the MF Industrial brand, and Japanese-owned Kobelco in the United States. Kobelco was to sell MF Industrial's new backhoe loader series through its 100 dealers in Canada and the United States. A more complex arrangement was announced in 1992 by Caterpillar, which formed a Munich-based joint venture company, namely European Excavator Design Centre, with three German concerns to design and market small- to medium-sized wheeled excavators. Sennebogen, one of the three German concerns was to produce such excavators with the specific aim of combining German design and manufacturing expertise with Caterpillar's pan-European distribution network. Caterpillar benefited from the arrangement by gaining knowledge from the other German partners in the German market.

Other joint ventures illustrate benefits derived by equipment manufacturers by seeking new sources of supply. In 1991, O&K closed down its German dump truck factory, and transferred production to its Dortmund excavator plant. However, since production of the two types of machines differs widely, when the volume of sales fell, it became beneficial for O&K to source dump trucks from a factory manufacturing them. Consequently, a competitor in the United Kingdom, Terex Equipment, signed a long-term agreement in 1992 to manufacture and supply O&K with a range of rigid and articulated dump trucks.

Takeovers

The competitive nature and overcapacity of the industry has led manufacturers to resort to takeovers in order to expand their geographic presence or product range rather than to establish new sites. Purchasing companies is at times less costly and is likely to have a faster pay-back period than starting afresh. There has always been a moderate amount of takeover activity in the industry, usually among smaller companies. Large mergers have been seldom in the past three years, because of recessions that have forced companies to curtail capital spending and focus on trying to reduce their losses. The last large-scale merger in 1990, was that between the agricultural and earthmoving equipment divisions of Fiat of Italy and Ford of the United States to form a new company called New Holland, which is now fully owned by Fiat. The rationale for the merger was to create a financially stronger and geographically broader company by rationalizing and simplifying global production while at the same time retaining the identities of the product lines.

More recent takeovers display some of the characteristics of the merger between Ford and Fiat. Geographical presence is a powerful motive behind takeover bids. The resurgence of the German market following unification and the strong preference of German customers for locally built construction equipment, motivated the 1990 takeover by VME of Zettelmeyer, a German producer of small wheeled loaders. VME itself was the result of a very important 1985 merger between Volvo of Sweden and Clark Equipment of the United States. Another takeover occurred in Germany in 1990, when Ingersoll-Rand of the United States purchased ABG Verwaltung, a manufacturer of paving equipment and other road construction machinery. Other recent transactions include the purchase by Japanese companies, such as Hitachi Construction Machinery and Marubeni, of a majority stake in the Australian subsidiary of the BM Group of United Kingdom and, in the components sector, the acquisition by Titan Wheel International, the world's largest manufacturer of off-highway and agricultural rims and wheels, of the United Kingdom-based New Warrington Wheel to establish a major presence in Europe.

There have also been a number of takeovers aimed at expanding the product range of companies. These include the acquisition of Akerman, a Swedish producer of hydraulic excavators, by VME, which previously did not possess an excavator line; the purchase by Ingersoll-Rand of Montabert, a French manufacturer of hydraulic rock-breaking and drilling equipment; the purchase in 1990 by Clark Components of United States of Hurth Axle, the family-owned Italian manufacturer of axles and gearboxes, enabling the new company to offer itself as a single source for drive-train components; and the acquisition by Caterpillar of a telescopic material handler range previously produced by DJ Industries of the United Kingdom.

Other deals have had both a geographic and product-related motive. The most recent transaction occurred in 1994, when Manitou BF, the French company that is the world's largest producer of rough-terrain lift trucks, bought the wheeled loader division of Ahlmann Maschinenbau of Germany. The new product line for Manitou is featured as the biggest-selling product in the sector in Germany. Other takeovers have occurred as a result of merger activity among companies whose main business excludes construction equipment. The most significant example is the merging of O&K, whose previous majority shareholder was the steel company Hoesch, with Krupp. The 1990s also witnessed two significant examples of takeovers to protect the survival of important suppliers: in 1991 Komatsu of Japan and a

Norwegian State enterprise bought Moxy of Norway, which supplies articulated dump trucks to Komatsu. Moxy suffered from a year of uncertainty following the collapse of its former owner, the Brown Group of the United Kingdom. In 1990, Ford, Tenneco and Kubuto agreed to buy a combined 27 per cent shareholding in Cummins Engine for $250 million. The recapitalization allowed Cummins to maintain its R & D spending during the recession.

Disposals

The industry also witnessed some cases of partial or full disposal by companies that no longer wished to participate in the industry because they sought better profit margins elsewhere or because they decided to sell their non-core businesses. In 1995, the diversified United States industrial group, Tenneco, disposed of 25 per cent of Case's farm and construction equipment company in an initial public offer on the New York Stock Exchange. The corporate and operational restructuring described in the previous section along with improved conditions in the equipment market in the United States, clearly gave Tenneco the opportunity to carry out the sale. Also in 1994, Electrolux of Sweden sold Blaw-Knox (B-K), a producer of asphalt finishers, to Clark Equipment for $144 million. Electrolux, known primarily as a manufacturer of domestic appliances, bought B-K as part of a major white goods acquisition in the 1980s. In another disposal Varity of the United States sold its United Kingdom-based MF Industrial business in a management buy-out in 1992 as part of a strategy to concentrate on diesel engines and automotive components. A loss-making engineering company, BM Group of the United Kingdom, has undertaken a series of disposals of its Blackwood Hodge construction equipment company to reduce its debt.

Construction equipment companies have also been disposing of unnecessary parts of their business and placing greater emphasis on the production of core products. In February 1995, Caterpillar sold the Vernon Foundry in France to Bailey Corporation in the United States, which specializes in foundry work. The foundry will continue to supply Caterpillar with castings, but has more potential under its new owners. At Eskilstuna in Sweden, VME has negotiated a similar deal to sell its plate shop to an external company, Ahan AB.

International trade issues

Trade in construction equipment has recently been dominated by the increase in Japanese exports to Europe and North America, a consequence of the shifting of Japanese plants to both regions, where local production would

otherwise replace imports from Japan. The aims were to serve markets better and to avoid the high costs of shipping equipment.

The plants that have been established in Europe by 10 Japanese producers manufacture all main product types and have proved to be wise investments in the light of the strong appreciation of the yen. The scale of many such plants is smaller than that of their Japanese counterparts, meaning that component supplies are less in volume. In many cases, Japanese companies have agreed to a relatively high level of local content for the machines produced, thus forcing them to develop relationships with parts suppliers, a practice previously unknown to them. Costs arising from the local purchase of parts are, however, compensated for by currency factors that make local purchasing more desirable.[3] The introduction in Europe, in 1985, of anti-dumping duties for Japanese hydraulic excavators exceeding six tonnes in weight came as a shock to Japanese producers and encouraged them to set up their own plants in Europe. They had already been concerned in the mid-1980s about the forthcoming Single European Market reforms in the European Union and realized that it was better to manufacture in the European Union rather than sell into it from the outside.

The net result of the heavy investments by Japanese producers in European manufacturing was that the anti-dumping duties had lapsed by the time they were up for renewal in 1990. There seems to be a repetition of the Japanese experience currently, however, as European producers are becoming increasingly concerned over the pricing of imports of machines from the Republic of Korea and, to a lesser extent, from China. There has been mounting speculation in the industry about an anti-dumping case against the Republic of Korea, that has made producers in that country cautious about expanding in Europe. In the next few years it will be interesting to see whether history will repeat itself and whether producers in the Republic of Korea take the Japanese route.

Market access to Japan and the negative impact of import tariffs there and elsewhere have been constant problems for equipment importers. Those problems have been addressed by the successful conclusion of the Uruguay Round of GATT world trade negotiations, and Caterpillar of the United States has responded positively. The immediate impact of the agreements reached by the Uruguay round, once put into effect by Caterpillar, would be that its customers in Australia, Japan and Europe and many developing countries would no longer be forced to pay a high premium for United States

products. It is estimated that tariffs cost Caterpillar's customers worldwide $100 million per year, and the elimination of tariffs are expected to stimulate an additional $125 million in annual sales for the company. The essence of the Uruguay Round negotiations was that the United States would eliminate all import tariffs if other countries did the same. Some countries, however, are not members of GATT, including Taiwan Province of China, which came under pressure in 1994 from the United States to introduce a zero tariff rate on construction equipment and other products.

Another major development in trade, NAFTA, is also likely to bring about short- and long-term benefits for the construction equipment industry in the United States. The most significant provision is the phasing out by Mexico of all import duties for goods sourced from Canada or the United States by the year 2003. Many such duties have already been phased out. In return, the 2.5 per cent tariff levied by the United States on construction equipment imports will be phased out over a 10-year period. It is unlikely, however, that NAFTA will encourage manufacturers of construction equipment to move more production to Mexico than they already have, especially since the elimination of tariffs under NAFTA make the Mexican plants uneconomic. It is likely that the machinery sold in Mexico during the next 10 years will be sourced primarily from United States plants.[4]

MARKET CONDITIONS IN SELECTED COUNTRIES

China The marked changes in the economic profile of China since the beginning of the 1990s, has been accompanied by real advances in technology and industrialization. The decision of the Chinese Government to adopt a more open market economy has led to the successful development of special economic zones, greater acceptance of western technology and the realization that its neighbours are pricing themselves out of some industrial markets.

Since 1988, demand for construction equipment and its local production increased threefold in unit terms.[7] The basic infrastructure of the country, including its communications network, is still rudimentary, thus necessitating unquantifiable levels of construction in the next decade if the country is to feature prominently among developed countries. The Government has total

control over the production and importation of construction equipment, and there is a very substantial domestic construction equipment industry. Technologically, China is probably 20 years behind its western counterparts and local production accounts for close to 95 per cent of all domestic requirements. The industry is developing rapidly, however, through a number of joint ventures and licensing agreements.[7]

There are close to 45 construction equipment groups in China. The largest is the Xuzhou Construction Machinery Group based in Jiangsu Province, which controls more than 150 enterprises. It employs 20,000 persons at 43 factories and has operations in eight construction equipment subsectors. The biggest in terms of production is the compaction equipment subsector, which in 1992 accounted for 3,000 units or three fifths of total production. The Group also produces a wide range of components. It has a number of important technical agreements with leading western manufacturers, namely Dynapac in compaction equipment, Vogele in asphalt finishers, Kawasaki and Caterpillar in wheeled loaders, Liebherr in mobile cranes and Hiab in truck-mounted cranes. Its most recent deal, signed with Caterpillar in May 1994, could prove to be the most significant. Valued at $70 million the joint venture is based at Xuzhou, and will adopt Caterpillar's designs and introduce quality standards, special technology and management methods to manufacture four types of Caterpillar-brand hydraulic excavators. As the largest Chinese-foreign joint venture in China, it will not only help Caterpillar expand its business in China but will also fill an important gap for Xuzhou, which does not manufacture hydraulic excavators. The excavators made by the joint venture will be well poised to compete against imported equipment owing to their high quality and favourable prices resulting from lower domestic labour costs. At present, excavators represent about 43 per cent of construction machinery sales worldwide, but only about 9.5 per cent of the Chinese market.

Sales of hydraulic excavators in China rose from 2,000 units in 1992 to 2,750 in 1993, most of which were produced domestically.[7] Leading manufacturers are currently Fushun in Lioning Province and the Hefei Mining Machinery Plant in Anhui Province. Competitors of Xuzhou in other product sectors include Puyuan of Hunan Province and Chang Jiang of Sichuan Province and Beijing in mobile crane production. The second largest supplier of compaction equipment is Luo Yang, but there are 23 other domestic manufacturers as well. In asphalt finisher production, still in its infancy in China, the main competitors of Xuzhou are Xian Construction

Machinery Factory, which has an agreement with Ingersoll-Rand of the United States (the owner of the German ABG road-making machinery producer) and the Zhengliang Construction Machinery Factory, which uses technology from Sakai. There are 12 other manufacturers in addition to Xuzhan engaged in wheeled loaders production, the biggest of which are Xiamen of Fujian Province, Liuzhou of Guangxi Province and Chengdu of Sichuan Province.

Exports of Chinese machinery were not very high - Xuzhou sold some 100 mobile cranes annually in 1991 and 1992 to the Democratic People's Republic of Korea, Pakistan, the Philippines and Viet Nam. Only a few machines were exported in 1993, however, because of insufficient capacity to cope with domestic demand. Growth in domestic demand for construction equipment in recent years has been very strong, and this trend is likely to continue. For example, demand for mobile cranes rose from 3,000 units in 1991 to an estimated 6,500 units in 1994. In the medium to long term, however, it is clear that Xuzhou, in particular, will use its technical agreements and joint ventures to develop full product lines with the aim of becoming a major supplier to the domestic market and to other developing countries. It is also clear that with so much domestic capacity, China will want to keep imports of machinery at a minimum.

Apart from Caterpillar's Xuzhou deal, there have been several other recent joint ventures, either finalized or under consideration, between western and Chinese companies. In 1995, Caterpillar signed a joint venture agreement with Shanghai Diesel Engine to build a range of diesel engines in China for domestic consumption. An extension of a technology transfer agreement made in 1986, the agreement allows Caterpillar to manufacture diesel engines in China and market them under the Caterpillar trademark. The United States-owned Perkins engines announced a 10-year agreement with Tianjin Engine Works to produce diesel engines in China for industrial, agricultural and construction applications. Terex, another United States-owned producer, formed a joint venture in 1993 with Linyi Construction Machinery in Shandong Province, taking a minority stake in a joint venture company that will build wheeled loaders and articulated dumptrucks. Terex already has a joint venture with the Second Inner Mongolian Machinery Company, which builds rigid dumptrucks. Such deals are clearly important to bolster attempts to import machine parts and reinforce western producers' positions. As mentioned above, ABG has

clearly taken this route to capitalize on the huge opportunities arising from the road-building program of China.

Another joint venture was unveiled in 1994, when Kobe Steel, a Japanese steel and construction equipment maker, agreed with the Chengdu Engineering Machinery Group of China to set up a joint venture company to manufacture and market construction machinery in China. The joint venture, Kobelco Chengdu Machinery, will initially be capitalized at $1 million, with Kobe Steel and Chengdu Engineering Machinery each taking an equity stake of 45 per cent. Shinso Corporation, a trading company affiliated with Kobe Steel, and Itochu, a Japanese trading company, will own the remainder, at 5 per cent each. Kobelco Chengdu Machinery will initially manufacture, market and service hydraulic excavators and other types of Kobe Steels construction machinery. Full-scale production is expected to begin after June 1996, at which time each of the partners will consider expanding manufacturing facilities and equipment to achieve 1,000 units of production with annual sales projected at $100 million.

India In India, the mining industry has traditionally accounted for about 80 per cent in value of the construction equipment market.[8] This is likely to change, however, within the next three to five years because in the eighth national industrial plan great emphasis has been placed on the establishment of an upgraded road network and on the proper type of equipment to be used for each project. This could have major implications for suppliers of compaction and asphalt equipment.

The leading manufacturers of construction equipment in India are listed in table 21. Until recently, India, as a closed market, did not permit the import of machines, thereby requiring local manufacturers to meet the demand for construction machinery. In 1990, around 2,500 units were produced by its construction equipment industry.[8]

The largest manufacturer, Bharat Earthmovers (Beml), produces 1,200 units a year, consisting mainly of dumptrucks and crawler dozers, at its three plants at Kolar Goldfields, Bangalore and Mysore. Originally Komatsu technology was employed, but now Bharat Earthmovers has developed its own, and is currently one of the few producers that have developed an impressive export business. Hindustan Motors (HML), the second largest producer, manufactures a range of equipment under licence from Caterpillar. In 1990, 420 units were produced. Escorts, the third largest producer, has

been manufacturing JCB backhoe loaders in a joint venture agreement with that company for the past 14 years. It also manufactures cranes, wheeled loaders and compaction equipment. The growing popularity of the backhoe loader resulted in a record year for Escorts JCB in 1991, with sales exceeding 400 machines.

Table 21. Leading manufacturing companies in India, 1990

Company	*Product type*
Ashok Leyland	Dump trucks
Bharat Earthmovers	Crawler dozers, dump trucks, wheeled loaders, graders (Komatsu), excavators (Komatsu and Liebherr), draglines (Marion)
Escort	Backhoe loaders, wheeled loaders (JCB), compaction equipment (Dynapac), cranes (Faun)
Hindustan Motors	Crawler dozers, dump trucks, wheeled loaders (Caterpillar), excavators (Caterpillar and Demag), cranes and shovels (Marion)
Larsen & Toubro	Backhoe loaders, wheeled loaders, excavators, compaction (Case)
Marshall	Wheeled loaders (Atlas Weyhausen)
Stanford Engineering	Excavators (Eder)
Tata Engineering	Excavators, cranes (Hitachi)
Voltas	Cranes (Century II)

Source: The Corporate Intelligence Group, *Market Report*, No. 106 (London, August 1990).
Note: Includes foreign companies with licence agreement or other links.

In general, there is growing optimism among Indian manufacturers regarding prospects for the industry. Domestic demand, which has been increasing, is likely to continue growing by at least 8 to 10 per cent per year for the next five years. Demand for larger equipment used mainly in opencast coal mining, major irrigation projects and iron mines is likely to remain constant. Strongest growth has been registered for small machines such as backhoe loaders, mobile cranes, pavers and compactors. While exports increased, sales were restricted to Indian contractors working overseas. This was partly due to licensed contractual arrangements, but more because of the lack of overseas distribution channels. Iraq, Jordan and the Syrian Arab Republic offer the most potential in the medium-term as export markets.

The quality of most construction equipment manufactured in India is very good. Large benefits have been derived from foreign involvement in the industry. For example, in 1992, the Escorts JCB factory introduced major

changes in its production methods, including a new assembly system based on pre-painted components, using the experience from JCB's plant at Rochester in the United Kingdom as a guide. This change resulted in major improvements in quality and productivity. The productivity benefits realized by using machines rather than relying on manual labour are increasingly being recognized. With the Indian economy developing rapidly, JCB feels assured of a bright future.

Mexico Table 22 outlines the state of the Mexican market for road construction equipment and parts and reveals its heavy reliance on imports from the United States. Local Mexican manufacturers produce only light machinery and equipment such as small concrete mixers, petrolizers, asphalt and concrete plants, energy generators and spare parts. The Government of Mexico opened highway construction to private investment and the companies involved have acquired new machinery, thus creating an increase of 122 per cent in imports between 1990 and 1992.[4] During the same period, sales of new equipment were between 1,200 and 1,500 units per year and sales of used and almost new equipment were three to four times higher. Imports of equipment will depend on the volume of infrastructure construction that will be opened for bidding. Several equipment manufacturers have had plants in Mexico for many years. Caterpillar has been building components, engines and sub-assemblies in its Mexican plant at Monterrey since the early 1970s. Komatsu has a 20-year-old joint venture agreement with Dino Komatsu National, in which Komatsu has a stake of 68.4 per cent. The joint venture was expanded to include the production of the first Mexican bulldozer in 1975. Its 200 employees also make sheet metal parts for construction equipment.

Poland Poland possesses the most developed construction equipment industry in eastern Europe, although the industry is currently suffering from a number of problems.[10] The domestic market remains depressed and sales in many sectors stand at only 25-30 per cent of the levels enjoyed in the late 1980s. The Government has extended little support to the construction equipment industry in terms of long-term strategies, construction programs and incentives. Local manufacturing companies are overstaffed, export markets (especially the former USSR) are very weak and many Polish-made products do not meet western standards. Supplying parts and components is also a problem. Polish companies cannot afford to buy the necessary components, such as engines, axles and transmissions from western Europe because they are subject to an import levy of 21 per cent. This narrows the price

differential between Polish-made and imported machines at a time when local customers are starting to opt for western technology.

Table 22. Market structure of road construction equipment and parts in Mexico, 1990-1992
(Millions of dollars)

Item	*1990*	*1991*	*1992*
Total machinery market	***327***	***588***	***727***
Local production	70	82	102
Exports from Mexico	41	28	37
Total imports to Mexico	297	534	662
Imports from United States	236	437	504
United States share of imports (percentage)	79.5	81.8	76.1
Total parts market	***68***	***86***	***117***
Local production	43	76	89
Exports from Mexico	27	56	63
Total imports to Mexico	52	66	90
Imports from United States	40	54	69
United States share of imports (percentage)	76.9	81.8	76.7
Total machinery and parts	**395**	**674**	**844**

Source: United States Secretariat of Commerce and Industrial Promotion, cited in Manfred and Associates, *Machinery Outlook*, vol. 93, No. 8 (Buffalo Grove, Illinois, August 1993).

Huta Stalowa Wola, the largest equipment manufacturer in Poland, is relatively well placed, largely because of an agreement under which it manufactures a range of machines for Komatsu Dresser. Exports to North America are growing at a very strong pace. The firm could be attractive to other western producers because of the relatively low labour costs in Poland. Other Polish equipment suppliers, including Warynski, Fadroma, Proma and Ursus, have been manufacturing mainly agricultural tractors but have recently launched a backhoe loader range.

There is some scope for Polish companies to supply component parts to western producers. Under an agreement signed in 1992, Burnar-Labedy will produce structural steel elements, such as bodywork, for Swedish-built articulated dump trucks manufactured at the VME plant. The agreement was envisaged as a long-term cooperation program between the two companies aimed at developing Polish-made rigid dump trucks for VME.

Republic of Korea

The Republic of Korea has the potential to become a major competitor of western construction equipment suppliers. Technology in the Republic of Korea is well advanced, and despite the fact that the country imports key components such as engines and hydraulics, it is almost at par with western suppliers for earthmoving equipment.

Investments made in the Republic of Korea in the late 1980s and early 1990s resulted in a flourishing construction market. Until 1987, local producers, apart from Samsung, were restricted from producing machines for the domestic market. There were limits on the number of domestic manufacturers that could produce any particular product. Since then, manufacturers have been expanding their production capacity in all products, hydraulic excavators in particular. In 1991, the country's demand for excavators exceeded 9,100 and was ranked the third largest in the world after Japan and the United States. Domestic sales and local production have since slipped because of cutbacks in domestic expenditure and difficulties in selling in more competitive markets overseas. The market held steady in 1993 amid intense price competition, however, and the construction equipment industry is expected to grow at an average annual rate of 10 per cent or more in the next 10 years as the Republic of Korea develops further.[5]

The leading companies in the Republic of Korea are Daewoo, Hyundai and Samsung, followed by Halla and Lucky Goldstar. As table 23 shows, Daewoo and Hyundai have the fullest range of construction equipment and, like Samsung, possess a strong, internationally diverse list of technical partners.

Daewoo also produces about 80,000 diesel engines per year. While some of those engines were originally designed by MANN of Germany, and are produced by Daewoo under licensing agreements, increasing number of them are storm engines developed by Daewoo itself. Daewoo has benefited from having had a domestic market share of 90 per cent in crawler excavators in 1986, but that share decreased to about 45 per cent in 1992, when Samsung and Hyundai entered the market.

Hyundai Construction Equipment Industries was incorporated in 1989, though it had been in operation previously, and its sales increased sharply from $180 million in 1990 to $280 million in 1992. A new factory has been added to the original plant at Ulsan, thus increasing the manufacturing area

to some 70,000 square metres. The new facility is modern, fully automated, and has an automatic conveyer system based on methods used at Komatsu's excavator factory at Osaka. Samsung's product lines focused on hydraulic excavators, mini-excavators, wheeled loaders and mobile cranes.

Table 23. Operations, production, technical partnerships and overseas manufacturing of leading companies in the Republic of Korea, 1992

Operations	*Daewoo*	*Halla*	*Hyundai*	*Samsung*
Sales (millions of dollars)	400	80	280	620
Employees	500	1 200	1 100	3 000
Head Office	Inchon	Seoul	Seoul	Seoul
Factory	Inchon	Soi	Ulsan	Changwon
Production (units)				
Crawler excavators	1 500	200	1 300	1 500
Wheeled excavators	1 500	a/	400	800
Mini-excavators	1 500	a/	300	1 700
Wheeled loaders	250	300	300	650
Skid-steer loaders	400	..	500	..
Crawler dozers	50	70	40	150
Technical partnerships	Hitachi	Hitachi	Nissan	Tadano
	Kubota	Fiat	Komatsu	Komatsu
	Hanomag	-	Dresser	Poclain
	Deere	-	Trak	Case
	Furukawa	-	-	Yanmar
Overseas manufacturing	Belgium	-	-	-
	China	-	-	-

Source: The Corporate Intelligence Group, *Market Report*, No. 145 (London, November 1993).
a/ Production initiated in 1993.

Halla, which has focused on crawler excavators, has now begun manufacturing Fiat construction equipment for domestic consumption. In 1991, it began producing a range of Hitachi excavators and is currently developing its own machines intended for export.

Lucky Goldstar is the most recent manufacturer in the Republic of Korea to produce wheeled loaders under licence from the Japanese firm Kawasaki. It also manufactures mini-excavators and crawler excavators under licence from IHI of Japan.

Among domestic component suppliers, the most important is probably the 10-year-old Soosan Heavy Industries, which commands a market share of 60 per cent of the hydraulic breakers used on excavators and truck cranes. The company has four factories and has recently set up a joint venture with a Japanese partner to strengthen specialized manufacturing.

Daewoo is the country's best known firm worldwide in terms of exports and was the first of the three big domestic manufacturers to export actively during the mid-to-late 1980s. Presently, around 20 per cent of its crawler excavators are exported. Recently, Daewoo launched an eight-tonne crawler-dozer model aimed at the United States market, where sales of hydraulic excavators first began in 1988. Hyundai's exports currently generate around $100 million per year. Almost all the construction equipment sold in North America, which is sold by around 30 of its dealers, is powered by the Cummins engine. By the end of 1992 Samsung was selling excavators and wheeled loaders in the United States and Europe. Halla is exploring markets in Asia, Europe and North America for its range of products. It is unable to sell the majority of its products overseas because of joint venture agreements. Soosan has already broken into neighbouring Asian markets, and is keen on expanding.

Overall, manufacturers in the Republic of Korea aim at offering value for money, if not total state-of-the-art technology. Their main advantage over Japanese exporters is that the strength of the yen has made their products more price competitive. It is not surprising, therefore, that China and South-East Asia, especially Singapore and Thailand, are rapidly emerging as major buyers for construction equipment manufactured in the Republic of Korea. During the first quarter of 1994, total overseas sales of excavators, bulldozers, loaders and other equipment amounted to $74.6 million, up 81.6 per cent over the same period in 1993.[6] While exports to the United States and countries of the European Union increased by 22.7 and 11.8 per cent to $15 million and $18 million, respectively, sales to China increased by 694 per cent to $5.19 million, sales to Thailand by 516 per cent to $4.14 million and sales to Singapore by 328 per cent to $3.28 million.

So far, only Daewoo is involved in overseas manufacturing. In the early 1990s, just as the European market began to decline sharply, Daewoo opened a plant in Belgium to produce hydraulic excavators. Output rose to a modest 150 units in 1992 from 60 in 1991. Daewoo's latest overseas venture is with the Chinese manufacturer Hubei. Under the terms of

agreement of the venture, Daewoo's DH280 crawler excavator is being manufactured by Hubei, which is assembling knock-down kits; it is planned that a higher percentage of Chinese components will be used later. It is well known that other manufacturers in the Republic of Korea are looking closely at possible manufacturing sites in Europe, partly because they fear further restrictions on trade. But their approach has been cautious so far. It is clear that they have certainly missed out on the market boom that followed German unification. Hyundai, meanwhile, plans to help organize the production of earth-moving equipment at the Donetsk excavator plant in the Russian Federation.

Turkey Turkey has been a producer of construction equipment for some time. Import duties have deterred many established foreign suppliers from entering the local market. Those duties were introduced mainly to protect many local companies that function as mere back-street workshops, producing one or two customized copies of used machines. In the 1980s, these machines were favoured by government agencies and municipalities because they were cheap and locally manufactured.[9] But the situation has changed since, with the public sector cutting back on the purchase of equipment. The private sector, for its part, prefers purchasing high-quality products regardless of their origin. The liberalization schemes implemented by the Government in the 1980s included a gradual decrease of the tax levied on imported machines. Even though the current rate is still very high, prices of imported machinery can compare with those produced locally mainly because of the difference in economic scales of production.

At least seven companies manufacture one or more of the main types of construction equipment. The largest is Cucurova, which has been Caterpillar's representative for almost 50 years. It has two factories, one that produces a range of Caterpillar products under licence, and another that manufactures its own brand of machines. The Caterpillar crawler loader uses components imported directly from Caterpillar. Products with lower technical requirements are sourced locally. Products designed and built by Cucurova traditionally incorporate low-cost and low-technology components. However, the importation of highly specific and competitively priced products from Japan has forced Cucurova to upgrade the specification of its machines. This prompted other suppliers to use a much higher proportion of imported European components in their products. The second largest producer, the Temsa group, became the dealer for Komatsu equipment in 1983 and began producing Komatsu lift-trucks in 1986. Since then, it has

added wheeled loaders and crawler excavators to its manufacturing range at Adana.

Dampened local business conditions and the economic problems of the country have posed difficulties to suppliers of construction equipment. Moreover, public sector spending has been severely constrained. An optimistic forecast would be that the industry will experience slow growth in the next few years.

Former USSR Most of the construction equipment in the Russian Federation is imported from eastern Europe, notably from the Czech Republic, Poland and Slovakia. According to the Russian Federation Committee for Mechanical Engineering, the industrial production growth rate in 1994 was expected to remain relatively stable, but could show slight signs of improvement.[11] Heavy excavators are among the various types of equipment where a slump in production can be expected mainly because of a drastic fall in demand. Caterpillar sales of close to $200 million worth of construction and mining equipment to countries of the former USSR in 1994 reveal that the market has not declined completely.

The most important instance of cooperation with western companies was the agreement, announced in February 1994, on a joint venture between Caterpillar and Kirovsky Zavod (KZ), an integrated manufacturing company based at St. Petersburg. Under the agreement, base frames and other components would be manufactured for use in Caterpillar's manufacturing facilities. KZ already supplies forging to Caterpillar in Belgium.

In Ukraine, ATEK, a Kiev-based company, recently unveiled a 70-horsepower backhoe loader using mainly western components. The lack of hard currency to purchase expensive imported components along with economic difficulties faced by countries of the former USSR make sales of construction equipment to those countries almost impossible. The company is trying hard to promote the machine in western markets, but lacks a reliable distribution network. It may be able, however, to export to some developing countries where trading companies of the former USSR are still influential.

In Belarus, the first excavators manufactured in the country were produced by the Beleks works at Minsk. One hundred ground-levelling machines with a telescopic jib were manufactured and sold to enterprises in Belorussia and

Russian Federation.[11] The Belorussian machine apparently undercuts Czech imports with respect to price.

Other countries

In Malaysia, large infrastructural development plans are creating a buoyant market for importers of construction equipment. One of the most important importers is Tractors Malaysia Holdings, which distributes Caterpillar equipment. Its plans are to broaden the range of products it imports in order to increase turnover. Another Malaysian company, UMW Holdings, makes bulldozer assemblies, that are attached to Komatsu bulldozers and sold locally.

In Viet Nam, a construction boom began in 1990 that was confined mainly to the building of houses and private facilities. With the recent resumption of credit relations with international monetary and financial bodies, more large-scale infrastructure projects and public works are likely to be commissioned. Modern construction equipment will be needed by State-owned firms involved in such construction projects. Furthermore, demand for foreign-produced equipment is likely to increase as there is no local industry.

In Brazil, the construction and industrial equipment markets recovered sharply in 1993. As can be seen from table 24, total consumption for the year, an estimated 5,743 units is still far below the levels that prevailed during the period 1986-1990.[13] Brazil produces about 6,000 unit of small- and medium-sized construction equipment annually.

Among the United States-owned producers making equipment in Brazil, Case has a wholly-owned manufacturing facility for backhoe loaders, excavators and wheeled loaders and Caterpillar has a manufacturing plant at Piracicaba. Komatsu, a Japanese plant, employs some 1,000 workers at Sao Paulo in the manufacture of excavators, motor graders and bulldozers.

TECHNOLOGICAL TRENDS

As with most branches of the mechanical engineering industry, construction equipment has already reached a high level of technological maturity and new technological developments have been made with regard to the

manufacturing process and product specifications. No major advances in product development are expected in the future. Generally, companies in the construction equipment sector spend 2 to 3 per cent of their revenues on R & D, which is representative of the industrial sector as a whole.

Table 24. Sales of construction equipment in Brazil by selected types of machinery, 1990-1993
(Units of equipment)

Product	*1990*	*1991*	*1992*	*1993*
Crawler tractors	1 139	589	529	919
Wheeled loaders	2 045	1 186	931	1 489
Motor graders	773	315	174	323
Hydraulic excavators	239	196	197	223
Tractors	1 559	1 140	1 015	1 305
Lift trucks	1 500	1 014	799	1 236
Compactors	713	352	252	248
Total	7 968	4 792	3 897	5 743

Source: Manfred and Associates. *Machinery Outlook*, vol. 94, No. 3 (Buffalo Grove, Illinois, August 1994).

New technology development in manufacturing

CAD/CAM software in simultaneous engineering

Along with the consolidation and internal reorganization of manufacturing processes used in the construction equipment industry, major changes have been introduced in the type of technology used to produce construction equipment. Heavy investments have been made in computer-aided design and manufacturing (CAD/CAM) software in order to achieve concurrent or simultaneous engineering, a cross-functional approach to product development in which tasks are done contemporaneously rather than in sequence, as was practiced in the past. Increasing competition in a maturing industry and the necessity of ensuring that new product designs have a market potential have prompted western suppliers to adopt this approach. Sales and marketing executives are involved in the product planning process at an early stage, an interdisciplinary approach that is maintained throughout the product development cycle. Japan can be considered the first country to have realized the importance of reducing the duration of product development, which not only reduces costs but also enables manufacturers to increase the frequency of model changes and thus maintain more up-to-date product ranges.

An early example of simultaneous engineering in Europe occurred between 1989 and 1991 at VME. The first in a new generation of wheeled loaders was produced within a period of three years from the time the product was conceived, a time considerably shorter than previous product development intervals. The company aims at shortening the development program even further for subsequent models. Modern three-dimensional CAD/CAM software is a vital part of this whole development process, as evidenced by recent orders for software from leading suppliers such as Parametric Technology.

Cellular manufacturing

On the factory floor, production routes have been reorganized to optimize the path taken around the factory by various components. Cellular manufacturing, involving a set of certain machine tools together to perform specific tasks, has been widely introduced. Heavy investments have been made to automate welding and painting operations. Along with the use of advanced computer systems these new machining centres not only improve production efficiency, but also enhance flexibility and materials control. Nevertheless, the industry is less automated than the automotive sector, a more specialized market for robotics suppliers. The introduction of more advanced automated systems is possible as robotics suppliers such as IGM Robotersysteme of Austria become increasingly aware of the demand for greater consistency and quality in continuous welding, which has become standard in the construction equipment industry. It is worth noting that some companies, such as Case, do not believe there is much potential for further automation, but foresee rather a trend towards greater simplification of the manufacturing processes following a period of investment in highly sophisticated technology.

New product development

In the last 30 years, the industry has witnessed the development of a full range of construction equipment products. The mini-excavator developed by Kubota of Japan and the articulated dump truck by Volvo of Sweden, for example, have experienced unparalleled acceptance by the market. The articulated dump truck is recognized as the best solution for short-haul muck-shifting, in combination with a hydraulic excavator.

It is hard to visualize the construction equipment industry introducing more innovative products, in its mature state. Recently, however, JCB introduced the Fastrac, a high-mobility tractor, for the agricultural market.

Electronic monitoring system

In the absence of totally new concepts in machine design, the industry is committed to a process of perpetual improvement or upgrading of its current products, replacing the current series of loaders, excavators or other product lines with another. The objective is to modernize and improve the design or the break-out force, enhance comfort and visibility in the cab, and also update the electronics available to the driver. Because of the trend to offer a better product than their competitors for the same price, product life cycles are now as short as six years in comparison with a decade or so in the past. Consequently, efforts to shorten product development times are becoming increasingly important. At present, standard features of quality construction equipment are electronic diagnostics to monitor all main machine functions in the cab, and touch controls which are computerized and economically designed.

New innovative products

Given the maturity of the market and the wide choice of suppliers, there appears to be little incentive for manufacturers to introduce new product lines unless there is some real innovation in the product offered. Recent innovations in construction equipment have included changes made by VME to the linkage with the lift-arm system of wheeled loaders. JCB and Fermec produce the MF Industrial range of backhoe loaders and have recently introduced backhoe loaders with four-wheel drive.

In 1993, JCB entered the skid-steer loader market with its robot range. Unlike other skid-steers, which are compact, multi-purpose machines, the robot has a single arm that allows the operator access through a side door, thereby minimizing the risk of injury when the operator climbs over or under the bucket to reach the cab. Another innovation by JCB was the 1CX, the world's smallest backhoe loader, introduced in 1994, which combines the digging ability of a two-tonne mini-excavator with the loader performance of a 600-kilogram skid-steer loader.

Peripheral equipment development

The most significant peripheral equipment related to construction machinery is the puncture-free wheel and tyre system by Airboss Ground Engagement of the United Kingdom. The tyre comprises a number of hollow-moulded rubber segments bolted onto a special wheel rim. Airboss began by offering such tyres for smaller equipment, notably for skid-steer loaders, but has since expanded its product range to include larger equipment types. Other innovations include the following: a time-saving automatic coupling system for backhoe loaders and excavators from Soneruds Maskin of Sweden; an

anti-theft device for construction equipment produced by Houston-based Malvy Technology; a satellite-based system for the precise measurement of construction equipment on building sites by Topcon of Japan; and a new system to monitor contamination in hydraulic oil offered by UCC International of the United Kingdom. It should be noted that more than 50 per cent of the breakdowns in construction equipment are caused by dirt in the fluid power system.

In general, technological developments are making it harder, but not impossible, for developing countries to enter the market, as exemplified by the Republic of Korea.[1] Financial resources and management skills remain problems in eastern Europe and the former USSR though their technology and manufacturing competence meet the required levels. In general, suppliers do not envisage any technological threats in the industry that might endanger any of the traditional markets for construction equipment.

Environmental considerations

The construction equipment industry on the whole does not produce significant levels of pollutants in the manufacturing process. The main environmental concerns of the industry are associated with the products themselves, for example engine emissions and noise, not only from the engine but also from attachments such as hydraulic hammers.

Emissions legislation for off-highway equipment has lagged behind that for the automotive industry. Countries of the European Union and the United States, however, are expected to agree on emissions legislation by 1997.

There is a tendency for off-road emissions legislation to follow that for on-road vehicles, which could mean that the Environmental Protection Agency of the United States would make the use of low-sulphur diesel fuel mandatory so as to help reduce the incidence of acid rain. Some construction equipment producers concerned with environmental protection are offering engines that meet the on-road criteria and are using the expertise that diesel engine producers have built up over the past decade. Komatsu announced plans to equip, by the end of 1994, its entire line of construction equipment with low-emission diesel engines featuring 10 to 20 per cent lower nitrogen oxides and black lead emissions compared with engines manufactured in 1991. Given that neither Japan nor Europe had emission control requirements for construction equipment when that announcement was made,

it is clear that Komatsu is already responding to mounting global pressure for environmental protection.

With respect to noise pollution, European manufacturers, in the United Kingdom in particular, fear that the estimated cost of $200 million for meeting the new European noise emission regulations will result in a price increase of 5 per cent for an average machine that costs $75,000. In March 1994, the European Union agreed on new rules to reduce noise levels by 3 - 4 decibels (dB) for all main types of large equipment, apart from dump trucks and pile drivers. The maximum permitted sound output for such machines will range from 83 - 87 dB, but because noise reductions are worked out on a logarithmic scale, a drop of 3 dB is equal to a decrease of approximately 50 per cent decrease in noise levels. A further reduction of 3 dB is expected to be made obligatory by the year 2001.

Producers of hydraulic hammers or breakers, which are attached to construction machinery for rock-breaking work, have also had to respond to pressures to produce quieter hammers in order to meet noise regulations in city areas. One of the pioneers of quiet hammers, Rammer of Finland, recently introduced its city line of hammers that operate at a local noise level of 85 dB, the level above which it is generally recommended that workers wear ear protectors.

There has been a considerable increase in customer expectations for environmentally-friendly fluids to be used in machines, hydraulic oil in particular. The development of a biodegradable fluid that is interchangeable with conventional hydraulic oil has been problematic and the fluids developed to date are very expensive.[1] Another area where equipment suppliers must be aware of stricter rules concerns electromagnetic waves. JAB machines are tested to ensure they do not emit excessive electromagnetic waves that could have an effect on other machinery. Legislation to enforce the European Directive on Electromagnetic Compatibility will be finalized in 1995. Such legislation is important, given the much higher use of electronics in modern construction machinery.

FUTURE PERSPECTIVES

In the short term, moderate growth for the industry is expected.[14] Significant increases are forecast in Canada and the United States, a moderate increase in Australia, and only a slight increase in Europe. Recent increases in interest rates in Europe are expected to have little impact on demand. Low industry growth is forecast for Japan, but the moderately higher demand in Asia and Latin America will more than offset the decline in Africa and Western Asia.

According to JAB, the continued growth of markets in North America and the United Kingdom along with an expected recovery in markets of Europe (excluding Germany), would result in significant growth for that company starting in 1994. Its investment plans have been brought forward by the expected recovery, after two to three years of poor market performance in developed countries.

Forecasts for the Japanese and North American construction equipment markets until 1998 are given in tables 25 and 26. It should be noted that the accuracy of the forecasts is highly dependent on world macroeconomic conditions, which directly affect the industry.

At the time of writing, it was expected that sales of construction equipment in Europe would rise by 2 per cent in 1994 to more than 90,000 units, and climb a further 6 per cent in 1995 (see table 27). That improved outlook was partly due to a slower-than-expected decline in the biggest market, Germany. Meanwhile, the United Kingdom continued to enjoy very strong growth, while Spain and France were recovering well, and Scandinavia showed interest in returning to that market. The overall sales forecast for 1994 was 90,051 units, 10 per cent below the 1991 level and 16 per cent lower than the peak demand in 1989-1990.

VME has indicated that two distinct markets will dominate the construction equipment industry over the next few years. The first is formed by countries of the Organisation for Economic Cooperation and Development (OECD) in Europe, North America and Japan. That will be cyclical, as has been the case over the past 20 years, and fluctuations can be expected as economic, and hence construction, activity surges and declines.

Table 25. Forecasts of sales of construction equipment in Japan, 1994-1998
(Units of equipment)

Product	*1994*	*1995*	*1996*	*1997*	*1998*
Articulated dump trucks	50	50	60	70	80
Asphalt finishers	600	620	650	670	700
Backhoe loaders	15	15	15	15	15
Crawler dozers	5 000	5 300	5 500	5 700	6 000
Crawler excavators	34 000	35 500	38 500	40 000	42 000
Crawler loaders	200	250	250	250	250
Mini-excavators	39 000	41 000	46 000	51 000	53 000
Motor graders	500	550	600	650	700
Motor scrapers	50	50	60	60	60
Rigid dump trucks	250	220	300	300	300
Rough terrain lift trucks	10	10	10	10	10
Skid-steer loaders	1 400	1 500	1 700	2 000	2 200
Wheeled excavators	300	400	500	500	500
Wheeled loaders	7 800	9 000	9 700	10 500	11 500
Total	89 175	94 465	103 845	111 725	117 315

Source: The Corporate Intelligence Group, *The International Database Service Management Review* (London, 1994).

Table 26. Forecasts of sales of construction equipment in North America, 1994-1998
(Units of equipment)

Product	*1994*	*1995*	*1996*	*1997*	*1998*
Articulated dump trucks	925	1 025	1 050	950	850
Asphalt finishers	1 770	1 910	1 855	1 760	1 650
Backhoe loaders	24 500	26 500	27 000	24 000	21 000
Crawler dozers	10 150	10 850	11 600	11 100	9 900
Crawler excavators	10 600	11 200	11 150	10 600	9 900
Crawler loaders	2 075	2 200	2 200	2 000	1 800
Mini-excavators	1 100	1 225	1 325	1 200	1 125
Motor graders	5 750	6 000	6 300	6 000	5 300
Motor scrapers	1 075	1 200	1 325	1 200	1 100
Rigid dump trucks	850	925	925	825	750
Rough terrain lift trucks	5 400	6 150	6 600	6 200	5 550
Skid-steer loaders	36 800	38 700	36 000	32 000	30 000
Wheeled excavators	675	725	725	675	625
Wheeled loaders	12 800	13 500	13 200	12 300	11 400
Total	114 470	122 110	121 255	110 810	100 950

Source: The Corporate Intelligence Group, *The International Database Service Management Review* (London, 1994).

Table 27. Estimated sales of construction equipment in Europe, 1993-1995
(Units of equipment)

				Percentage change		*Percentage share*		
Product	***1993***	***1994***	***1995***	***1993-1994***	***1994-1995***	***1993***	***1994***	***1995***
Austria	2 380	2 315	2 395	-2.7	3.5	2.7	2.6	2.5
Belgium	1 982	2 247	2 450	13.4	9.0	2.2	2.5	2.6
Denmark	1 010	1 521	1 647	50.6	8.3	1.1	1.7	1.7
Finland	328	339	400	3.4	18.0	0.4	0.4	0.4
France	8 957	10 405	11 840	16.2	13.8	10.1	11.6	12.4
Germany	40 550	36 920	36 960	-9.0	0.1	45.9	41.0	38.7
Ireland	369	505	594	36.9	17.6	0.4	0.6	0.6
Italy	11 093	9 861	10 472	-11.1	6.2	12.6	11.0	11.0
Netherlands	2 334	2 642	2 721	13.2	3.0	2.6	2.9	2.8
Norway	829	937	1 061	13.0	13.2	0.9	1.0	1.1
Portugal	1 501	1 105	1 525	-26.4	38.0	1.7	1.2	1.6
Spain	1 974	2 435	3 380	23.4	38.8	2.2	2.7	3.5
Sweden	702	738	865	5.1	17.2	0.8	0.8	0.9
Switzerland	1 259	1 115	2 080	-11.4	86.5	1.4	1.2	2.2
United Kingdom	13 017	16 966	17 148	30.3	1.1	14.7	18.8	17.9
Total	88 285	90 051	95 538	2.0	6.1	100.0	100.0	100.0

Source: The Corporate Intelligence Group, *Market Report*, No. 153 (London, July 1994).

The market can be characterized as a replacement market for construction equipment, owing to two factors. First, changing construction methods have resulted in more emphasis being put on one type of product at the expense of another; for example, increasing use of articulated dump trucks and excavators in combination has eroded the market for scrapers and bulldozers. Secondly, growth of demand for light construction, repair and maintenance, will cause mechanization to replace manual methods.

The second market is the rest of the world, where real demand for construction equipment is growing and will continue to do so as long as political stability in developing countries persists. There is a strong demand for medium and heavy construction equipment in developing countries for building up infrastructure. Accordingly, industry leaders have targeted the East and South-East Asian and Latin American countries as major markets in the future.

Caterpillar's sales to East and South-East Asian countries in 1993 rose by 23 per cent to $1.6 billion, and sales of machinery, particularly to China, rose considerably. Caterpillar's long-term goal is to be the primary supplier to China of not only earthmoving and mining equipment but also diesel and natural gas engines and electric power generator sets. Hence, Caterpillar is moving beyond the technology transfer arrangements of the 1980s to establish manufacturing facilities in China and to expand its operations in order to provide independent dealer distribution and support services.

China, a population of more than 1.2 billion and GDP growing at an annual rate of 13 per cent compared with 2.5 per cent in developed countries, is expected to become one of the world's largest economies within the next 15 years and hopes to finance much of its own growth. The massive infrastructure development required to meet Chinese economic goals, is clearly a major opportunity for construction equipment producers in the next few years. There exists already a well-established construction equipment industry in China, and Chinese-based manufacturing joint ventures could be far ahead of their established western counterparts.

Latin America has been identified by Caterpillar as another important market, since it has a population of 450 million and a growing economy buoyed by increasing liberalization of trade barriers, pluralistic Governments and openness to privatization and foreign investments. In the next 10 years, Latin American countries are expected to spend $50 billion to improve their infrastructure, and Mexico alone is expected to spend $35-50 billion on infrastructure development by the year 2010.

The emergence of two very different markets for construction equipment, along with factors such as trade liberalization and currency movements, has implications on the shape of the industry and its manufacturing base worldwide. As discussed above, major producing regions will correspond to the major markets of Europe, North America and Japan. Most producers believe the process of consolidation in Europe and North America will continue, with winners getting stronger and the gap between winners and losers becoming wider. Among Japanese producers, the shift towards overseas production seems likely to continue. More mergers or collaboration among medium-sized players in various regions might lead to a global presence, although the process may not be as fast as is predicted by some in the industry. Improvement of business conditions will reduce pressure for further consolidation. Another factor in the consolidation process is related

to the various stages in the life cycle of a product. According to VME, the industry is highly fragmented, especially in younger products such as mini-excavators, which could in the next few years be expected to undergo the same thinning-out process as was the case with more mature products.

The position of Japan and Europe as producing regions is likely to weaken. It is important to note, however, that the position of Japanese producers as a whole does not necessarily need to decline because of their strong manufacturing presence overseas. The industry in the Republic of Korea seems likely to grow stronger, particularly if, like the Japanese, it is able to build on its initial success in overseas markets. Because of strong demand in domestic markets in addition to their long-standing technology links with western producers, the industry in China and India could emerge as big exporters of construction equipment among developing countries. However, in the near future, those two countries are likely to be preoccupied with domestic demand for equipment.

Overall, no major shift in production is envisaged for several reasons. First, enormous capital investments have been made in the three main producing areas over the past decade to increase productivity from which companies need to derive returns. There is a general perception of overcapacity in some parts of the world and growing demand elsewhere because future developments in the industry are likely to involve joint manufacturing agreements in developing countries between domestic and foreign producers. However, if new factories are going to be built, they will be located in developing countries. While the conclusion of the Uruguay round of GATT negotiations is a step in the right direction for exporters, the progress of trade liberalization can be slow. Hence manufacturing facilities will continue to be made available within the market concerned so as to avoid high shipping costs and import tariffs. Finally, trend towards sourcing certain basic components from countries where production costs are cheaper will continue, a practice that will put greater pressure on the financial viability of manufacturing plants in Europe, Japan and North America. Purchases of parts by western European companies from eastern Europe, by Japanese companies from Asia and Europe, and by North American companies from Mexico and Latin America will undoubtedly increase.

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PHARMACEUTICAL INDUSTRY

OVERVIEW

The world pharmaceutical industry has been a source of enormous social benefits since its establishment as a modern, research-based industry in the 1940s. The success achieved in combating and eradicating many forms of disease has improved the quality of life and changed global mortality patterns. Pharmaceuticals have become a vital aspect of modern health care.

The pharmaceutical industry is a technology-intensive industry the long-run performance of which has been above-average, both in terms of growth and profitability. The growth of the industry has demonstrated its resistance to downturns of economic activity caused by business cycles. Long-term growth has been driven by innovation based on large-scale investment in research and development (R & D). Consequently, R & D expenditure has become a major component in the cost structure of leading companies in the pharmaceutical industry. In addition to R & D expenditure, marketing costs account for an extraordinarily high share of total costs because of the nature of competition in specific market segments. Moreover, intellectual property rights and related policies play a more distinct role for pharmaceuticals than for most other industries.

Technological advancement has revealed weaknesses in the traditional methods applied in drug development. The opening-up of new technological opportunities is thus perceived as being of key importance to the long-term development of the industry. Advances in modern biotechnology have aroused expectations of a new innovative potential for the industry. Such advances are bound to have a positive impact on the development of conventional chemical drugs. However, interaction between industry and academic research in biotechnology needs to be more focused.

The industry as a whole has long been subjected to government regulation. Although primarily motivated by considerations of safety and efficacy, Governments, given the structure of the market, often exert control on the admission of new drugs into the market, the prices at which they are sold and, accordingly, their profitability. In addition, they control or supervise a variety of other aspects of manufacturing, including the delivery of drugs to the market. Government regulations are thus an integral part of the political economy of the pharmaceutical industry.[1] Attitudes towards

government regulations, however, have changed dramatically over the past two decades. The focus of economic research and public debate in the United States and other countries has clearly shifted to regulation rather than monopoly.[1]

With regard to demand, the market for pharmaceutical products possesses distinct features. Unlike most product markets, the demand for drugs does not depend exclusively on consumer tastes. In many instances, pharmaceuticals are chosen by doctors or pharmacists and are paid for subsequent to their purchase by health insurance schemes, that is, by actors other than the final consumers. Those particular market features have contributed to rendering the demand for drugs price-inelastic. A number of measures included in recent reform plans for financing health care tend in fact to increase the price-elasticity of demand.

Pharmaceutical production has been fairly international for several decades. Transnational corporations, which handle overseas marketing and distribution and operate manufacturing subsidiaries in a number of countries, dominate the global pharmaceutical industry. Despite the dominance of the industry by such corporations, a comparatively small fraction of world pharmaceutical production is traded internationally, in comparison with the volume of local production by subsidiaries of transnational corporations. Those two characteristics of the industry - high stocks or flows of foreign direct investment (FDI) and relatively low international trade - are interrelated. International competition between firms, varying national regulations and the consequent segmentation of markets (often encouraged deliberately for industrial policy purposes) have promoted the emergence of transnational corporations. Such corporations are viable in the pharmaceutical industry because of the technical characteristics involved in the manufacturing and delivery of drugs. Key functions of pharmaceutical companies include R & D, the production of active ingredients and dosage forms, marketing and sales. Each function requires different resources. Since the volumes involved are small and transportation costs are low, local separation of production is technically and economically feasible. Active material can be made at one site and converted to a bulk mixture at a second; that mixture can be divided into dosage units and packed at a third site.[2]

Market segments

A closer look at the industry reveals that it is far from homogeneous. Rather, it comprises several segments with distinctly different features.

Whether or not pharmaceuticals are therapeutic is one example of a method used regularly in research to break them down horizontally. Alternatively, taking the technological content of products and the nature of competition in corresponding markets as a criterion, the pharmaceutical industry can be divided into the following three broad segments.[2]

The first segment, in-patent drugs sold by prescriptions, can be considered the heart of the industry. The rapid expansion of the pharmaceutical industry after the Second World War was largely due to the development of innovative drugs in this segment. In-patent drugs account for approximately 70 per cent of the world market in pharmaceuticals. Innovation is the major means of competition between major research-based drug companies, and bold innovation promises high returns. According to empirical evidence, quality, in terms of the therapeutic improvement brought about by a drug, is definitely correlated with the price of a new product. However, the investment in R & D necessary for developing a new drug requires large funds making such investments risky. Only a limited number of firms have the resources and capabilities for developing patents of this kind. After a certain time lag, determined by the duration of intellectual property rights protection, such products could provide a basis for the generic drugs segments of the pharmaceutical industry.

Generic or multi-source drugs, out-of-patent drugs usually manufactured by more than one company, are also available on prescription. Generic drugs are sold under either specific brand names or generic names. There is evidence that brand loyalty fostered by advertising may allow original patent holders to keep prices above the level charged by new generic competitors.[3] This segment of the industry includes many small and non-innovative local firms that tend to be exposed to fierce price competition and to have low profit margins. There are considerable differences among various countries in the share of generic drugs in the total prescription drug market.

The third segment comprises over-the-counter (OTC) drugs, which are usually sold directly to consumers. While no prescription is required, marketing OTC drugs involves different sales techniques. Competition in the segment is based heavily on marketing established brands and using strategies that aim at fostering brand loyalty among consumers. Consequently, advertising plays a major role in the competitive strategies of business firms, causing marketing costs to escalate while R & D costs remain low.

The first and second segments are often jointly referred to as ethical drugs. Recently there has been a significant shift in the relative dynamics of the three market segments accompanied by a change in business strategies. The generic and OTC markets have grown significantly and further rapid growth is expected. Large research-based companies are therefore strengthening their access to generic and OTC markets by diversifying their operations and extending their product lines or by acquiring and forming alliances with companies established in those markets.

Although analysts of the pharmaceutical industry identify a two-tier structure in which the largest 20 firms account for almost half the sales in ethical and OTC markets and for about 85 per cent of R & D expenditure, the world market share of any single company is well below 5 per cent.[4] Concentration ratios may be misleading, however, since drugs serve different purposes, and therapeutic markets are segmented. Moreover, companies tend to focus their operations on a limited number of therapeutic categories. Between 1963 and 1989, three therapeutic categories accounted for 58 per cent of the 2,153 new chemical entities tested in the United States: the cardiovascular and central nervous system categories accounted for 21 per cent, and the anti-infective category for 16 per cent.[5] Of the top 10 pharmaceutical products manufactured in 1992, eight belonged to the cardiovascular, gastro-intestinal or anti-infective categories.[6] In summary, the structure of the industry can be described as being highly oligopolistic. Whatever the precise assessment of the prevailing degree of monopoly power may be, there seems to be widespread agreement that product competition in the industry is intense.[1]

Taking a more disaggregated view of pharmaceutical manufacturers, three types of companies can be distinguished. First, there are large, integrated companies operating on a multinational basis that to a great extent influence the popular image of the industry. Such companies are able to fund and implement large-scale R & D programs required for developing new substances for which international patent protection is necessary. Firms belonging to the second group are typically much smaller, integrated firms, but they possess technical competence and innovative capabilities in certain fields. The third group is made up of small companies with little or no innovative capability, typically operating in national or regional markets. Dedicated biotechnology firms (DBFs), a relatively young group of players in the pharmaceutical innovation system, are set aside as a particular phenomenon with a set of distinguished features.

The share of each of the three types of company in the composition of the drug industry varies widely among regions and countries. For western Europe it was estimated that 60 - 65 per cent of the market or employment in the industry can be attributed to the first group of firms, between 30 to 35 per cent to the second, and approximately 5 per cent to the third group.[7] That structural composition reflects regional or national technological capabilities. An attempt to develop a typology of national pharmaceutical industries worldwide revealed that only a few countries possessed a sophisticated pharmaceutical industry and a significant research base: Belgium, France, Germany, Italy, Japan, Netherlands, Sweden, Switzerland, United Kingdom and United States. A second group, comprising 17 countries, was categorized as having innovative capabilities. The vast majority of countries, however, possessed either reproductive capabilities only or no pharmaceutical industry at all.[8]

Overall, the industry plays a significant role in manufacturing and provides a significant number of industrial jobs. As a high-growth industry, pharmaceuticals have been strengthening their position in relation with other branches of manufacturing. Moreover, the industry does not stand isolated, but features backward linkages to industries such as chemicals, starch and sugar, medicinal plants, scientific instruments and packaging as well as forward linkages to wholesalers, pharmacies and hospital care. More importantly, however, is the role of the industry as a source of technological innovation, which, in turn, has provided large social benefits spilling over to the final consumer, namely the patient.

Major developments

The world pharmaceutical industry is undergoing far-reaching changes in its institutional framework and technological basis. Among the most important long-term trends underlying recent and future developments in the industry, are the following: the conclusion of Uruguay Round negotiations; developments regarding the funding of health care; the innovative performance and rising costs of pharmaceutical R & D; and the impact of new biotechnology.[9]

Pharmaceutical companies have made strategic responses to those trends. Continuously rising R & D costs have necessitated restructuring within the industry. Sharply rising development costs together with shorter and more effective patent protection periods have prompted the rapid introduction of new drugs in a multitude of markets thereby strengthening the global

orientation of companies. On the technological side, advances in biotechnology have provided new technological opportunities for drug development that have had a profound impact on the organizational structure and research strategies of the pharmaceutical innovation system on a global scale.

The conclusion of the Uruguay Round, particularly the agreement on trade-related intellectual property rights (TRIPS), will have far-reaching implications for the future development of the pharmaceutical industry. Transnational enterprises from developed countries can be expected to gain most from the agreement, while developing countries will be net losers. This is mainly because the industry is dominated by developed countries, which account for more than 80 per cent of world production. The TRIPS agreement will strengthen the market power of transnational enterprises and price increases will pressure developing countries even more. This is particularly true for developing countries that are in the early stages of industrialization and depend heavily on imports of intermediate and finished pharmaceutical products. Given the rising costs of R & D and the increasing difficulty in accessing new technologies, the agreement is likely to retard the development of the industry in those countries. The international community and Governments could play a constructive role in assisting developing countries in upgrading quality control standards, to promote R & D in cooperation with international consortia and to help in formulating effective responses to changes in the world pharmaceutical market.

Reforms of health care funding are a driving force behind much of the present reorientation. Owing to rapidly rising costs, the funding of health care systems has become a major policy issue in many countries. Reasons for increasing health care costs include the following: demographic developments, such as the increasing number and longevity of the elderly who are dependent on the provision of health care services; the use of expensive medical services that are often based on newly developed, sophisticated medical technologies; and deep-rooted inefficiencies in the organization of health care systems.[8]

In OECD countries an average of 7.9 per cent of GDP was allocated to health care in 1991. In the United States 13.4 per cent of GDP was spent on health care whereas in the United Kingdom and Japan the figure was 6.6 per cent. In China, in comparison, 3.6 per cent of GDP was spent on health care in 1990. The share of expenditure on pharmaceuticals in total health

care spending varies considerably between countries, but is in the range of 10-20 per cent in developed countries. In developing countries, that share tends to be significantly higher, accounting for as much as two thirds of total health care spending, in China, for example. This may suggest, at least in the case of developed countries, that the potential contribution of pharmaceuticals for stabilizing health care budgets is limited. Furthermore, expenditure on drugs has come under intense scrutiny. This can be attributed to the image of the industry as a highly-profitable industry that performs well and to the above-inflation price increases that have occurred in both Europe and the United States.[6] Given the tight budget constraints introduced by health-care reform programs, pressures on the industry with regard to legitimation are likely to continue or even increase. This concerns, for example, drug price levels and the role of "me-too" drugs such as drugs of low therapeutic value and innovative content involving slight modifications to existing drugs. Discussions do not focus exclusively on drug prices, but cover a broader perspective that includes the evaluation of economic costs and benefits on the use of pharmaceuticals *vis-á-vis* alternative therapeutic options. In that sense, drugs may be a more important tool for measuring cost containment than their share in total health care spending suggests. Pharma-economic considerations are likely to play a more important role in the future and there are signs that it will become standard procedure to conduct pharma-economic trials alongside clinical trials.[6]

Increased pressure on prices lends renewed prominence to a trade-off between competitive prices and quantities of existing drugs and extensive innovation.[1] Undoubtedly consumers benefit from competitive prices of drugs already in use. In a dynamic perspective, however, the introduction of innovative products sustains large welfare gains accruing to consumers over time. In practice, this leads to the issue of "appropriate" returns on innovation in the pharmaceutical industry. Such returns are affected by controls of profitability and drug prices, competition policy and protection of intellectual property rights. Governments and health care organizations are therefore faced with the challenge of devising health care reform programs that enhance instantaneous efficiency without undermining dynamic efficiency by reducing the incentives to innovate. Independent of other goals pursued by policy makers towards pharmaceuticals, it must be borne in mind that research in this field has revealed that dynamic product competition generally brings about higher increases in consumer welfare than price competition.

The above-mentioned trends have resulted in a number of strategic reactions by pharmaceutical companies that are changing the face of the industry. In particular, rising R & D costs combined with a tightening of prices call for a response. Industry responses include: mergers and acquisitions; moves into generics and OTC markets as well as into emerging markets; the restructuring and globalization of R & D activities; and the formation of technology-oriented cooperation agreements.

Mergers and acquisitions

There is currently a wave of consolidation in the global pharmaceutical industry involving mainly United States and western European companies. The industry currently appears to have adopted a trend that was observed earlier in other industries. In 1994, an unprecedented wave of mergers and acquisitions activities resulted in vertical and horizontal integration that changed the landscape of the industry as a whole, in the United States in particular. Large-scale mergers and acquisition operations continue to occur in 1995.

Moves into generics and OTC markets

Some of the mergers and acquisition activities observed have been motivated by attempts towards the diversification of R & D-based companies into the generics and OTC markets. Such activities have become more significant in the recent past and are expected to continue to do so in the near future. Reasons for those activities in the generics market could be attributed to the expiration of patent protection for high-selling drugs. Between 1994 and 2001, drugs valued at $12 billion sold by United States pharmacies and hospitals are expected to be from off-patent drugs.[5] The generics market is expanding owing to institutional reforms in the health care system such as the introduction of generic substitution. OTC markets have been boosted by profound changes in the attitudes of both patients and health care authorities who view self-medication as a way of containing public health care expenditure. There are indications that generics markets will open up in a number of countries.

The extension of product lines, acquisitions and joint marketing arrangements have allowed companies to enter the OTC market by switching from prescription to OTC drugs. For drugs for which the patent is about to expire, switching to OTC production has the advantage of prolonging the life of the brand, thus creating a competitive advantage over potential generics competitors. The increasing presence of brand-name firms, however, could change the nature of competition in the OTC market. According to recent

observations, decreases in the market share of United States brand-name companies within the first year of patent expiry is increasing.[5]

Established producers of pharmaceuticals differ widely with respect to the role of the drugs contained in their product portfolio. These differences influence the strategic options available in corporate restructuring.[6] Research-based ethical drug companies, such as Glaxo, tend to shed non-pharmaceutical operations and concentrate on core activities. Of the large chemical companies involved in the production of pharmaceuticals, many might follow the example of ICI, which restructured its bioscience division in 1992 and created the Zeneca company. Companies heavily involved in consumer goods, in contrast, seem to rely on the production of such goods for switching to OTC.

Moves into emerging markets

The presence of large, integrated pharmaceutical companies in global markets has strengthened mainly because of the high and continually rising costs of developing new drugs and ensuring their fast introduction in a large number of markets. The basic trend towards globalization has forced pharmaceutical companies to consider extending their activities to newly emerging markets as a potential way out of the difficulties faced by the more mature markets in developed countries. This constellation may in turn offer additional opportunities for developing the pharmaceutical industry in dynamically evolving countries.

Reorganization and globalization of R & D

As a consequence of the pronounced long-term increase in R & D costs, the management of R & D itself has come under intense scrutiny. This has led to streamlining and cost cutting through the reorganization of R & D departments, often in the wake of mergers, which has gained momentum in the past two or three years. The pooling of R & D resources was one of the motives leading to revised merger and acquisition decisions. Companies have shown a renewed tendency to concentrate their R & D resources in areas where they have established advantages. Rationalization pressures encourage the outsourcing of clinical tests and R & D cooperations. International procedures for registration are also expected to contribute to reducing development time. Globalization of R & D could also be considered part of a broader process requiring pharmaceutical companies to reshape their key functions on a global scale.[10] Large research-based companies tend to establish research establishments in each of the major technological centres of the world.[11] The establishment of "listening posts" in high-technology districts is strikingly different from some of the traditional motivations for

performing R & D abroad. Their establishment has been in many instances virtually unrelated to R & D considerations, but they can lead to enhanced market approval, thus operating as a means to overcome non-tariff trade barriers.[12]

Technology-oriented cooperation agreements

While the extension of cooperative relations between enterprises is part of industrial restructuring, in particular in connection with streamlining in-house R & D, international technology-oriented cooperation agreement are a key element of globalization of the pharmaceutical industry. Such agreements may be used to create a common product portfolio drawing on the respective strengths of the collaborators. Moreover, a number of limited alliances involving specific products and research tasks have evolved. Alliances between established pharmaceutical companies and biotechnology companies are particularly important for the emerging innovation system.

WORLD MARKET STRUCTURE: RECENT TRENDS AND CURRENT CONDITIONS

Production

Production is highly concentrated in Japan, United States and western Europe. Excluding centrally planned economies, approximately 90 per cent of world production originates in these three regions. In 1992, world production of pharmaceuticals was estimated at $234 billion.[13] Western Europe, defined as the group of countries represented in the European Federation of Pharmaceutical Industries Associations (EFPIA) as listed in table 28, is the main producing region, accounting for a share of more than 40 per cent of world output in 1992. The United States held a share of 31 per cent, while Japan accounted for 19 per cent. Output in western Europe has been growing faster than that in Japan and United States. Between 1987 and 1992 members of the European Community (EC) increased production by 44 per cent (at constant prices), while in Japan and United States production increased by 17 per cent and 8 per cent, respectively.[14] In the European Community, pharmaceuticals were one of the fastest-growing industries, with an average real growth rate of 7.4 per cent per annum between 1986 and 1993.[7] That growth rate was significantly above both the growth rate of total manufacturing and the real growth rate of GDP, 2.1 per cent.

Because of changes in demand, however, production started to slow down in western Europe, plunging from a level close to 12 per cent in 1991 to approximately 7 per cent in 1992. This deceleration in output growth continued in 1993, when the growth rate dropped once more to a low of approximately 3 per cent (see figure 14). Thus, a rather pronounced downward trend was observed, both from the high growth rates of the late 1980s and the long-term trend growth rate. In 1993, production in western Europe was estimated at $91.5 billion (ex-factory prices).

Table 28. Pharmaceutical production and R & D expenditure in western Europe (EFPIA countries), 1993

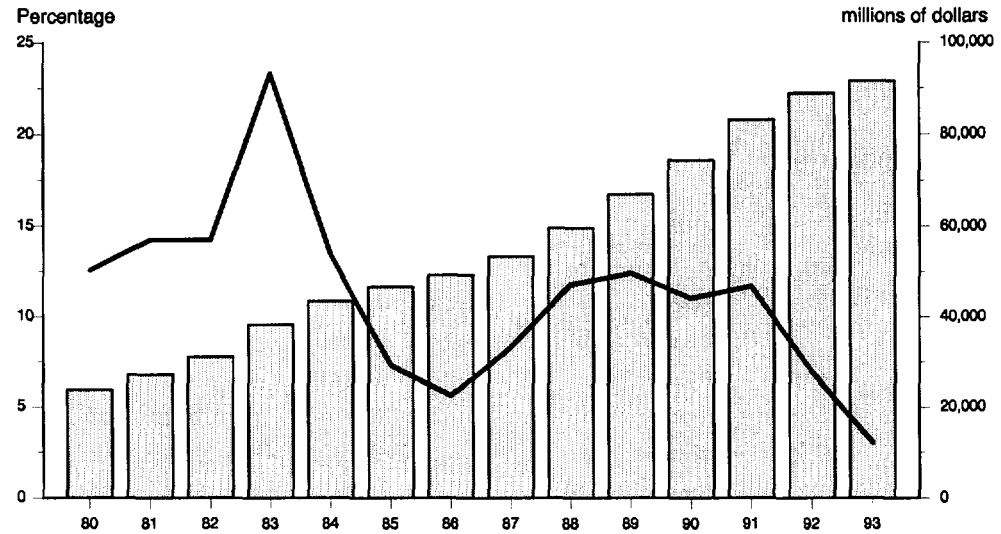
Country	*Production (Millions of dollars)*	*Percentage share*	*R & D expenditure (Millions of dollars)*	*Percentage share*
Austria	1094	1.2	42[a/]	0.4
Belgium	2 469[a/,b/]	2.7	278[b/]	2.4
Denmark	1 773[a/]	1.9	300	2.6
Finland	518	0.6	61[b/]	0.5
France	19 059[a/b/]	20.8	1 879[b/]	16.5
Germany	18 651	20.4	2 654[b/]	23.4
Greece	475	0.5	..	..
Ireland	1 453[b/]	1.6	..	..
Italy	11 867	13.0	1 040	9.2
Netherlands	2 038[b/]	2.2	239[b/]	2.1
Norway	431	0.5	69[b/]	0.6
Portugal	935[a/,b/,c/]	1.0	..	..
Spain	5 706[c/]	6.2	300[a/]	2.6
Sweden	2 112[a/,d/]	2.3	593	5.2
Switzerland	8 657	9.5	1 420	12.5
United Kingdom	14 258[a/]	15.6	2 489[a/]	21.9
Total	91 496	100.0	11 364	100.0

Source: European Federation of Pharmaceutical Industries Associations, *L'EFPIA en Chiffres* (Bruxelles, 1994).
a/ Estimate.
b/ Data for 1992.
c/ Excluding veterinary products.
d/ Data for 1991.

As can be seen from figure 15, the largest producer of pharmaceuticals in western Europe is France, followed by Germany, United Kingdom, Italy and Switzerland. The total number of people employed by the pharmaceutical industry in the region was 535,000 in 1993, of which 81,000 employees were involved in R & D. In 1993, however, employment in the industry in

western Europe stagnated for the first time in 15 years. Prior to 1992, an average of 10,000 additional jobs were created by the industry each year. The percentage of jobs in the pharmaceutical industry relative to the total number of jobs in the economy was expected to decrease by 2.3 per cent in 1994 and 1.9 per cent in 1995.[13]

Figure 14. Pharmaceutical production in western Europe (EFPIA countries), 1980-1993



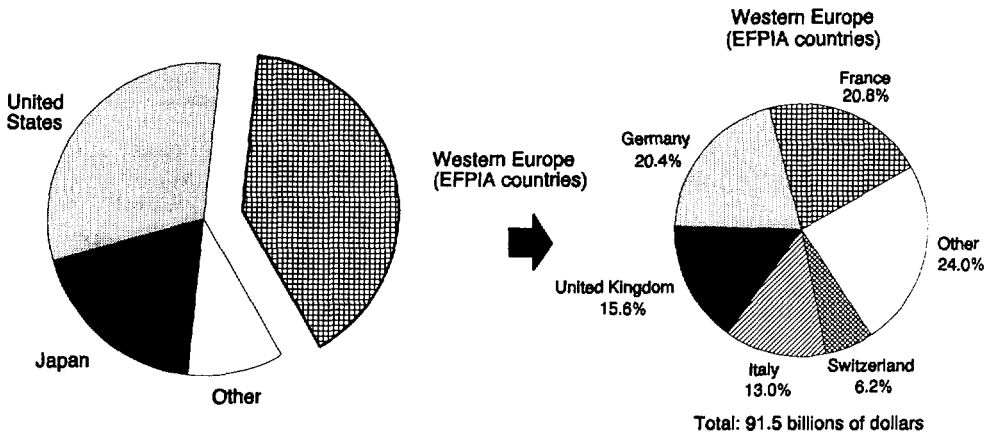
Source: European Federation of Pharmaceutical Industries Associations, *L'EFPIA en Chiffres* (Bruxelles, 1994).

The United States witnessed a similar deceleration in the growth rate of the value of pharmaceutical industry shipments.[15] Referring to product rather that industry data, the growth rate has continuously declined, in nominal terms, from 10.8 per cent in 1989 to 5.1 per cent in 1993. Reasons for that decline included price discounting, health care reforms and the weak economic performance of trading partners.

For 1994, the value of shipments based on industry data was forecast to grow by 2.1 per cent. Certain smaller segments of the industry were among the 15 fastest growing industrial segments during the period from 1987 to 1994. The compound annual percentage change, based on 1987 dollar shipments, in those industry segments were as follows: in diagnostic substances, 10.9 per cent; in medicinals and botanicals, 7.1 per cent; and in biological products (except diagnostics), 5.9 per cent. Pharmaceutical preparations, however, which accounted for 78.4 per cent of the shipments

of the industry in 1993, expanded at an annual growth rate of only 1.5 per cent in real terms.

Figure 15. Pharmaceutical production in western Europe, by country, 1993



Source: SCRIP, *SCRIP's 1995 Yearbook,* vol. 1 (Richmond, PJB Publications, 1995); European Federation of Pharmaceutical Industries Associations, *L'EFPIA en Chiffres* (Bruxelles, 1994).

In 1992, production in Japan fell for the first time in seven years. That decline was attributed to revisions in the level of reimbursements, reforms on distribution practices, and the introduction of the invoice price system.[5]

Table 29 lists the top 15 pharmaceutical companies in the world in terms of their 1993 sales. Merck and Glaxo with sales of $8.8 and $8.5 billion, respectively, were by far the largest pharmaceutical companies, approximately $2 billion ahead of the third-ranking firm, Bristol-Myers Squibb. Pfizer and Roche made the biggest jumps in that year moving from eleventh to seventh place and from seventh to fifth place, respectively, while Ciba fell back from fifth to eighth place.

The leading 15 pharmaceutical firms included 7 firms from the United States and western Europe each (with all 7 European companies among the leading 10). Takeda, which showed the highest growth in sales, re-entered the leading 15 after a lapse of several years. Recent merger and acquisition activities are bound to change the picture even among the leading group of companies. The relative position of Roche and American Home Products, for example, will be boosted by the Roche/Syntex and AHP/American Cyanamid operations, two of the largest pharmaceutical companies involved

in spectacular operations in 1995. The European leader, Glaxo, took over Wellcome in the United Kingdom and Hoechst made a take-over bid for Marion Merell Dow involving more than $7 billion. That transaction was recently cleared by the antitrust authorities in Europe and the United States.

Table 29. Leading pharmaceutical companies worldwide, 1992-1993

Rank in 1993	*Rank in 1992*	*Company*	*Sales (Millions of dollars) 1992*	*1993*	*Percentage change 1992-1993*	*Pharmaceutical sales in percentage of total sales 1993*
1	1	Merck & Co (United States)	8 216	8 775	6.8	83.6
2	2	Glaxo (United Kingdom)	8 004	8 484	6.0	100.0
3	3	BMS (United States)	6 316	6 524	3.3	57.2
4	4	Hoechst (Germany)	6 041	6 010	-0.5	21.6
5	7	Roche (Switzerland)	4 899	5 286	7.9	54.6
6	6	SmithKline Beecham (United Kingdom)	5 099	5 231	2.6	57.7
7	11	Pfizer (United States)	4 559	5 129	12.5	68.6
8	5	Ciba (Switzerland)	5 192	5 104	-1.7	33.3
9	8	Sandoz (Switzerland)	4 885	4 973	1.8	48.7
10	9	Bayer (Germany)	4 671	4 792	2.6	19.3
11	10	AHP (United States)	4 591	4 775	4.0	57.5
12	12	Lilly (United States)	4 537	4 759	4.9	73.3
13	13	J&J (United States)	4 338	4 490	3.5	31.8
14	15	Abbott (United States)	4 027	4 389	9.0	52.2
15	16	Takeda (Japan)	3 641	4 205	15.5	64.2

Source: SCRIP, *SCRIP's 1995 Yearbook*, vol. 1 (Richmond, PJB Publications, 1995).
Note: Figures are for 1993 except for Glaxo and Takeda, whose figures are for the year ended June 1994 and March 1994, respectively. Pharmaceutical sector sales are as defined by the companies.

Demand Estimates of the size of the world market differ depending on the source of information. According to estimates made by Glaxo, the world pharmaceutical market was worth $204 billion in the year ending 31 March 1994, while estimates made by IMS are higher, namely $233 billion at manufacturer's prices in 1993.[16] According to estimates made by Glaxo, the United States is by far the largest single market, accounting for almost one third of the world pharmaceutical market (see table 30). The second-largest single market is Japan, with a market share of 21 per cent. Western Europe, taken as an entity, has a slightly larger market than the United States. However, markets in Europe remain fragmented despite moves to overcome market segmentation. The most important markets in western Europe are

France (7 per cent), Germany (6 per cent), and Italy and the United Kingdom (5 per cent each).

Table 30. Estimated growth rates of pharmaceutical markets, fiscal year 1994

	Market value (Millions of dollars)		*Percentage share*		*Percentage change*
Country or area	*1993*	*1994*	*1993*	*1994*	*1993-1994*
Western Europe	62.1	64.0	32.3	31.4	3.0
France	13.5	14.0	7.0	6.9	4.0
Germany	13.8	13.0	7.2	6.4	-6.0
Italy	9.4	9.0	4.9	4.4	-4.0
United Kingdom	5.5	6.0	2.9	2.9	9.0
United States	60.0	63.0	31.2	30.9	5.0
Japan	42.3	44.0	22.0	21.6	4.0
Latin America	10.4	13.0	5.4	6.4	25.0
Asia Pacific	8.0	9.0	4.1	4.4	13.0
Africa and Middle East	2.8	3.0	1.4	1.5	8.0
Australasia	1.8	2.0	0.9	1.0	14.0
Other	5.2	6.0	2.7	2.9	15.0
World	192.5	204.0	100.0	100.0	6.0

Source: SCRIP, *SCRIP's 1995 Yearbook*, vol.1 (Richmond, PJB Publications, 1995).
Note: Fiscal year ending 31 March 1994.

Recently, world market growth has slowed down markedly, to an annual rate of 6 per cent in the year ending 31 March 1994 compared with a growth rate of 10 per cent in 1993. That slow-down, which was most pronounced in major developed countries, can be attributed to increased competition in the United States, price cuts in Japan and various cost containment measures adopted in western Europe. Latin America, with a growth rate of 25 per cent, and to a lesser extent, Australasia and Asia, with growth rates of 14 and 13 per cent, respectively, are expected to grow significantly faster than markets in major developed countries.

According to IMS data, Italy was the only major European country where pharmacy sales declined (by 6 per cent) in the first eight months of 1994 as compared with the corresponding period in 1993. Seven major European markets expanded at a rate of 2-3 per cent. Pharmacy sales in the United States increased by 8 per cent in the first eight months of 1994. In Japan, corresponding sales increased by just 1 per cent and were thus weaker than in the United States and western Europe.

It is estimated that the world OTC market was worth $30.4 billion in 1992 and is forecast to reach $43.4 billion (in constant dollars) in 2002.[16] Rapid growth is expected in Europe (58 per cent), followed by Japan (34 per cent) and the United States (22 per cent). In a number of countries, switching to OTC has picked up momentum, with the United Kingdom leading the process. In 1995, for example, a version of Glaxo's anti-ulcer drug, Zantac (rantitidine), which had a sales volume of over $3.5 billion in 1993, was sold as an OTC drug in the United Kingdom. The patent on form 1 rantitidine hydrochloride, patented in the United States, expires at end of 1995, while that on form 2 rantitidine hydrochloride, related to Zantac, and patented in the United States expires in 2002.[17] Management of the switching process requires specific skills as well as substantial resources. Glaxo, in preparing for its future activities in OTC markets, formed an alliance with Warner-Lambert. In 1994, Tagamet, a SmithKline-Beecham product, entered the market as an off-patent drug in the United States and in 1995, Capoten is expected to follow in the United States and Germany, thus exposing sales of products valued at $680 million to generic competition. According to survey results reported by SCRIP, 60 per cent of the pharmaceutical firms in Europe were looking for ways to exploit OTC opportunities.[16] Ciba-Geigy intends doubling its share of OTC sales to 20 per cent. Companies that recently moved to generics include, BASF, Bayer, BMS, Pfizer and Boots. The number of joint marketing arrangements which may be seen as an alternative to costly acquisitions is on the rise.

International trade

International trade in pharmaceuticals has been growing dynamically in the recent past. Most international trade in medicinal and pharmaceutical products takes place between developed countries, where the world's largest production capacities and markets are located. In 1993, OECD countries reported exports of medicinal and pharmaceutical products (Standard International Trade Classification (SITC) 541) worth $46.6 billion, most of which originated in western Europe (see table 31). Member countries of the European Economic Community accounted for exports of $29.8 billion and countries of the European Free Trade Association (EFTA) for $9.1 billion (including intra-Community and intra-EFTA trade, respectively). The United States exported pharmaceuticals worth $5.7 billion, while corresponding exports from Japan amounted to only $1.5 billion in 1993. Unlike the United States and western Europe, Japan is a net importer of pharmaceuticals. Developing countries reported exports of $3.1 and imports of $7.2 billion. Developing countries, however, are generally net importers of medicinal

and pharmaceutical products, with two exceptions, namely China and India

.

Table 31. Exports and imports of medicinal and pharmaceutical products, 1990 and 1993
(Millions of dollars)

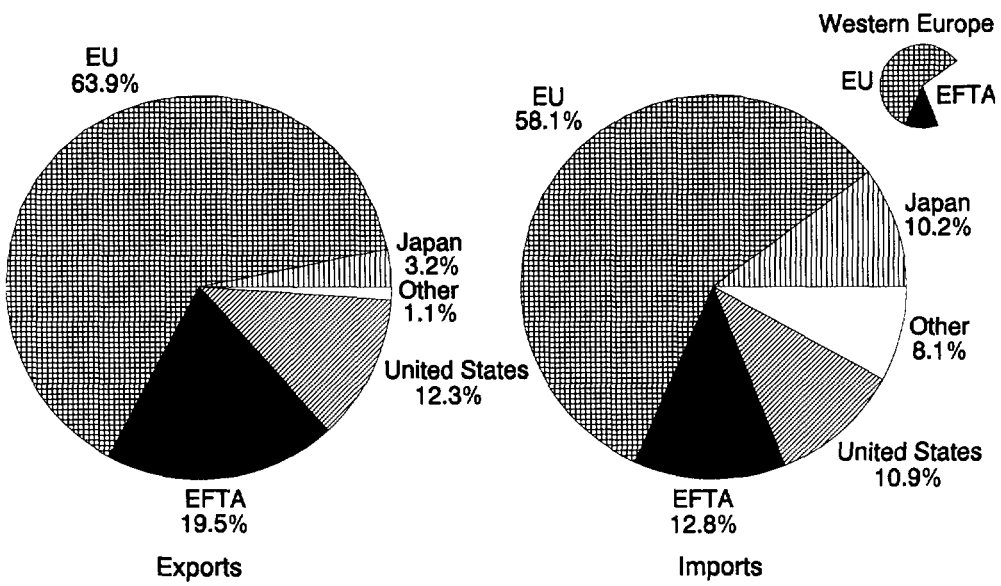
Country or economic grouping	*Exports*		*Imports*		*Trade balance*	*Percentage change 1990-1993*	
	1990	*1993*	*1990*	*1993*	*1993*	*Exports*	*Imports*
Austria	695.7	890.3	940.3	1 228.8	-338.4	8.6	9.3
Belgium	1 632.9	2 716.4	1 509.9	2 147.0	569.4	18.5	12.5
Brazil	78.0	110.8	367.0	491.3	-380.5	12.4	10.2
China	..	905.1	..	416.1	488.9	..	..
Denmark	1 160.0	1 729.0	493.4	688.0	1 041.0	14.2	11.7
France	3 665.2	5 204.8	2 646.2	3 753.7	1 451.1	12.4	12.4
Germany	5 860.4	7 599.9	3 396.4	4 221.7	3 378.1	9.1	7.5
Hungary	..	249.8	..	326.0	-76.2	..	..
India	452.8	482.9	260.2	257.8	225.0	2.2	-0.3
Ireland	960.2	1 392.4	425.2	442.1	950.3	13.2	1.3
Israel	76.2	187.9	179.1	315.7	-127.8	35.1	20.8
Italy	1 517.0	2 640.4	2 817.7	3 424.7	-784.4	20.3	6.7
Japan	878.5	1 472.6	2 836.2	3 930.4	-2 457.9	18.8	11.5
Jordan	60.7	102.4	58.1	100.2	2.1	19.0	20.0
Mexico	89.0	235.7	270.4	533.9	-298.2	38.3	25.5
Netherlands	1 377.2	2 102.8	1 447.3	2 398.0	-295.2	15.2	18.3
Republic of Korea	115.4	181.2	280.5	470.1	-288.9	16.3	18.8
Singapore	209.4	371.1	199.8	434.6	-63.4	21.0	29.6
Slovenia	..	234.7	..	114.1	120.6	..	..
Spain	632.6	833.9	975.7	1 558.7	-724.8	9.7	16.9
Sweden	1 311.7	2 177.8	747.7	879.2	1 298.6	18.4	5.6
Thailand	26.6	126.5	210.3	326.9	-200.3	68.1	15.8
United Kingdom	4 040.6	5 476.9	2 064.0	3 200.1	2 276.8	10.7	15.7
United States	4 103.6	5 746.7	2 539.7	4 198.3	1 548.4	11.9	18.2
European Community	21 004.7	29 811.5	16 420.5	22 439.0	7 372.5	12.4	11.0
EFTA	6 658.8	9 079.8	3 567.9	4 945.8	4 134.0	10.9	11.5
OECD	33 184.0	46 621.2	27 421.0	38 638.2	7 983.0	12.0	12.1
Total	34 292.2	49 809.2	29 246.3	42 424.8	7 384.4	13.3	13.2

Source: Austrian Institute of Economic Research database; L. Jörg, K. Bayer and G. Hutschenreiter, *Specialization and Diversity: The Economic and Technological Competitiveness of the Austrian Pharmaceutical Industry in an International Context* (Vienna, tip Program, 1995).

Imports of medicinal and pharmaceutical products by OECD countries were worth $38.6 billion in 1993. The structure of OECD imports at the country level tends to be slightly less concentrated than the exports. Exports of OECD countries of pharmaceutical products were expanding more rapidly in the early 1990s than total manufacturing exports. The average annual export growth rate between 1990 and 1993 for the OECD countries reached 12 per cent, which can be compared with the annual 12.1 per cent for imports. Among the OECD countries, Italy had the highest annual export growth rate of 20.3 per cent, followed by Japan with an average annual increase of 18.8 per cent.

Figure 16 and table 32 show the structure of OECD exports by country of origin, the structure of OECD imports by country of destination and the evolution of export and import market shares during the period from 1990 to 1993. While the export structure by country of origin reflects the relative competitive position of a country *vis-à-vis* other developed countries in the world market, the export structure by country of destination reflects the ranking of each country in terms of demand of internationally traded pharmaceuticals, irrespective of their origin.

Figure 16. Structure of OECD exports and imports, by region, 1993



Source: Austrian Institute of Economic Research database; L. Jörg, K. Bayer and G. Hutschenreiter, *Specialization and Diversity: The Economic and Technological Competitiveness of the Austrian Pharmaceutical Industry in an International Context* (Vienna, tip Program, 1995).

Table 32. Structure of OECD exports and imports, by country, 1993

Country or economic grouping	*1993 (Millions of dollars)*		*Percentage change 1990-1993*	
	Exports	*Imports*	*Exports*	*Imports*
Austria	1.9	3.2	-3.1	-2.5
Belgium	5.8	5.6	5.8	0.3
Canada	0.9	3.8	3.4	6.8
Denmark	3.7	1.8	2.0	-0.4
Finland	0.3	1.1	-11.1	-11.3
France	11.2	9.7	0.3	0.2
Germany	16.3	10.9	-2.6	-4.1
Greece	0.5	1.4	23.6	11.7
Ireland	3.0	1.1	1.1	-9.7
Italy	5.7	8.9	7.4	-4.8
Japan	3.2	10.2	6.0	-0.6
Netherlands	4.5	6.2	2.8	5.6
Norway	0.4	1.2	-	-4.5
Portugal	0.2	1.1	-14.7	-0.6
Spain	1.8	4.0	-2.1	4.2
Sweden	4.7	2.3	5.7	-5.8
Switzerland	12.1	5.0	-2.6	8.9
United Kingdom	11.8	8.3	-1.2	3.3
United States	12.3	10.9	-0.1	5.5
European Community	63.9	58.1	0.3	-1.0
EFTA	19.5	12.8	-1.0	-0.5
OECD Non-European Community	16.4	28.1	-	2.4
OECD Europe	83.6	71.9	-	-0.9
Total OECD	100.0	100.0	100.0	100.0

Source: Austrian Institute of Economic Research database; L. Jörg, K. Bayer and G. Hutschenreiter, *Specialization and Diversity: The Economic and Technological Competitiveness of the Austrian Pharmaceutical Industry in an International Context* (Vienna, tip Program, 1995).

Belgium, Greece, Italy, Japan and Sweden increased their export market shares significantly. On the other hand, major producers and exporters of pharmaceuticals, namely Germany, Switzerland and the United Kingdom, started losing their export market shares to other OECD countries. On the import side, the share of Canada and the United States in OECD imports increased remarkably due to above-average import growth rates. In Europe, the import shares of Switzerland and, to a lesser extent, the Netherlands increased noticeably.

While some of the major exporters among developing countries experienced a rapid expansion of their exports, it was often accompanied by a sharp rise in imports.

The share of exports of medicinal and pharmaceutical products in total exports of manufactures in 1990 was 1.45 per cent in the United States, 1.91 per cent in the European Community, and 3.60 per cent in EFTA countries. As before, European Community and EFTA figures include intra-regional trade. The share of pharmaceuticals in total exports of manufactures had risen considerably by 1993, when pharmaceuticals accounted for 1.68 per cent of United States, 2.61 per cent of European Community and 5.27 per cent of EFTA exports of manufactured goods (see table 33).

In Japan, exports of pharmaceuticals play only a minor role in the share of total manufacturing exports, which stood at 0.32 per cent in 1990 and had risen to only 0.42 per cent by 1993. Among the major exporters of pharmaceuticals in developing world, India stands out with a high share of pharmaceuticals in total exports of manufactures. However, that share declined substantially, from 3.59 per cent in 1990 to 2.94 per cent in 1993. In China, the share of pharmaceuticals in total exports was comparatively high (1.21 per cent in 1993).

Unit values (United States dollars per kilogram) of exports and imports could be regarded as an indicator of the quality of traded products. Unit values of exports of the majority of important exporters of pharmaceuticals, such as Germany, the United Kingdom and the United States, exceed those of imports (see table 34). The unit value of imports of Japan is extraordinarily high ($129.09 per kilogram) whereas its export unit value is at a level typical for developed countries. Another extreme is Sweden, where the export unit value is $110.38 per kilogram, and imports are valued at $27.38 per kilogram. Developing countries usually have lower export unit values than developed countries, indicating a gap in product quality. In addition, their export unit values are, in most cases, significantly lower than their import unit values.

There are also striking differences among countries regarding the specialization in exports of medicaments (SITC 542) and of medicinal and pharmaceutical products other than medicaments, referred to as intermediates (SITC 541). The share of OECD countries in Europe in total OECD exports of medicaments exceeds 90 per cent while that of non-European OECD

countries, including Japan and the United States, together command a market share of below 10 per cent.

Table 33. Share of medicinal and pharmaceutical products in total exports and imports of manufactures, 1993

Country or economic grouping	*1993 (Millions of dollars)*		*Percentage change 1990-1993*	
	Exports	*Imports*	*Exports*	*Imports*
Austria	2.4	3.0	9.7	9.6
Belgium	2.8	2.7	18.3	14.9
Brazil	0.5	2.8	1.3	-0.4
China	1.2	0.5	..	..
France	3.1	2.3	11.2	16.3
Germany	2.3	1.7	12.0	8.0
Hungary	4.0	3.3	..	..
India	2.9	2.0	-6.5	-0.1
Ireland	7.1	2.8	6.9	1.2
Israel	1.4	1.9	24.4	7.9
Italy	1.7	3.4	18.0	12.0
Japan	0.4	3.3	10.1	8.5
Jordan	20.0	4.4	15.7	1.3
Mexico	0.6	1.0	-6.4	-7.5
Netherlands	2.4	2.6	11.3	17.6
Republic of Korea	0.2	0.9	7.7	12.2
Singapore	0.6	0.6	4.8	12.9
Slovenia	4.4	2.5	..	..
Spain	1.7	2.6	4.3	19.5
Sweden	5.1	2.6	23.5	15.3
Switzerland	9.4	3.7	9.6	27.6
Thailand	0.5	0.9	38.1	2.8
United Kingdom	3.9	1.9	13.3	17.3
United States	1.7	0.9	5.1	10.4
European Community	2.6	2.3	11.1	13.0
EFTA	5.3	3.1	13.6	17.6

Source: Austrian Institute of Economic Research database; L. Jörg, K. Bayer and G. Hutschenreiter, *Specialization and Diversity: The Economic and Technological Competitiveness of the Austrian Pharmaceutical Industry in an International Context* (Vienna, tip Program, 1995).

Table 34. Unit values in exports and imports of medicinal and pharmaceutical products, 1990 and 1993
(Dollars per kilogram)

	Exports		*Imports*		*Percentage growth 1990-1993*	
Country	*1990*	*1993*	*1990*	*1993*	*Exports*	*Imports*
Austria	42.0	40.6	50.5	52.2	-1.1	1.1
Belgium	56.6	57.9	46.7	48.3	0.7	1.2
Brazil	19.6	20.1	84.7	52.6	0.8	-14.7
China	..	16.2	..	60.0	..	..
France	31.0	33.5	45.3	49.6	2.6	3.1
Germany	40.4	47.5	43.6	41.1	5.5	-2.0
India	16.1	24.3	48.4	50.7	14.8	1.5
Ireland	19.2	23.7	24.2	24.4	7.3	0.2
Italy	26.3	49.1	50.4	60.9	23.1	6.5
Japan	39.0	50.4	118.0	129.1	8.9	3.0
Jordan	7.6	18.9	20.8	18.9	35.4	-3.1
Mexico	23.9	16.2	13.7	33.6	-12.2	34.7
Netherlands	53.5	62.8	57.4	26.9	5.5	-22.3
Republic of Korea	25.5	25.7	27.3	29.5	0.2	2.7
Singapore	84.3	33.6	18.7	22.1	-26.4	5.7
Slovenia	..	28.5	..	37.2	..	..
Spain	45.1	25.3	57.7	50.1	-17.5	-4.6
Sweden	72.7	110.4	30.8	27.4	14.9	-3.8
Switzerland	..	..	64.7	85.7	..	9.9
Thailand	3.7	12.3	21.8	25.7	50.0	5.6
United Kingdom	40.5	47.1	32.4	39.4	5.1	6.8
United States	13.9	49.6	31.6	40.3	52.8	8.4

Source: Austrian Institute of Economic Research database; L. Jörg, K. Bayer and G. Hutschenreiter, *Specialization and Diversity: The Economic and Technological Competitiveness of the Austrian Pharmaceutical Industry in an International Context* (Vienna, tip Program, 1995).

The market share of Japan has been growing considerably since the early 1990s and exports of finished preparations have more than doubled, from $208 million in 1990 to $420 million in 1993. The United States has also increased its exports of medicaments significantly faster than western Europe (from $1,244 million in 1990 to $2,002 million in 1993). Among developing countries, India is the largest exporter of medicaments. In 1993, its exports of medicaments amounted to $410 million compared with exports of intermediates of only $73 million. While exports from India remained stagnant in the early 1990s, however, countries such as Israel, Jordan, Mexico, the Republic of Korea and Singapore experienced high export growth rates. The share of non-European OECD countries in OECD exports of intermediates is considerably higher than that of medicaments, close to 30

per cent. The United States, in particular, is traditionally an important supplier of intermediates (partly destined for overseas subsidiaries), primarily to western Europe. Chinese exports of pharmaceutical products are concentrated in intermediates, which accounted for $671 million, whereas exports of medicaments amounted to only $234 million in 1993.

With the conclusion of the Uruguay Round of GATT negotiations, particularly the TRIPs agreement, the pharmaceutical industry will benefit from tariff abolitions in Canada, Japan, the United States and Europe. Moreover, the formation of NAFTA is expected to have a positive impact on the exports of the United States.

MARKET CONDITIONS IN SELECTED COUNTRIES

A comprehensive analysis of market conditions in various countries is beyond the scope of the present study. However, demand patterns, therapeutic categories, regulatory environments, and organization of health care and distribution systems vary considerably across countries. Certain recent developments could exert a profound impact on the market conditions in selected countries or regions.

United States

Historically, the pharmaceutical industry in the United States has been the most successful and innovative industry in the world. Of all the major pharmaceutical markets where price levels are comparatively high, however, the United States experienced the highest increase in drug prices in the 1980s because of free pricing.[6] Pressure on prices led to a voluntary price restraint agreement in 1992 in which 10 major companies agreed to contain their average prices in keeping with the rate of inflation. The subsequent formation of large buying groups had further dampening effects on prices.

Three major developments have recently had implications for markets in the pharmaceutical industry. The first such development was the intense debate and ultimate political failure of the health care reform plan presented by the current United States administration, the realization of which would have had strong repercussions on United States pharmaceutical markets. Some industry

analysts have interpreted that debate as a catalyst for the restructuring of the United States pharmaceutical industry that reached a climax in 1994. Secondly, unprecedented merger and acquisition activities have changed the structure of the United States pharmaceutical industry dramatically. Thirdly the recent turbulence has been caused by the biotechnology sector, which in the United States is the most advanced in the world, and by the worldwide research strategies of the pharmaceutical industry.

The most important long-run effects on the pharmaceutical market structure in the United States might be attributed to the large-scale merger and acquisition activities that have been increasing in importance since 1994, several of which have involved vertical integration (see table 35). After the previous takeover by Merck of the distribution group Medco in July 1993, several United States companies bought or formed alliances with companies possessing pharmacy benefits. Pharmacy benefit management has become increasingly important as an intermediary between drug manufacturers and end-use decision makers, and may be on the way to replacing traditional wholesalers and distributors and controlling drug spending by negotiating discounts and other means. SmithKline Beecham offered $2.3 billion for Diversified Pharmaceutical Services and Lilly offered $4 billion for PCS. Vertical integration along the lines of the Merck-Medco transaction has provoked objections by the Federal Trade Commission on antitrust grounds. Apart from vertical integration, classical horizontal acquisitions continue. An example is Roche's bid of $5.3 billion made by Roche for Syntex. After Kodak moved out of pharmaceuticals, Sanofi acquired the prescription drug division of Sterling for $1.7 billion. SmithKline Beecham offered $2.9 billion for Sterling OTC medicines, but then resold the North American part for $1 billion to Bayer, thereby enabling Bayer to regain the right to its name and trademark in the United States. American Home Products made a bid of $8.5 billion for American Cyanamid. In early 1995, the German company Hoechst launched a takeover bid for Marion Merell Dow involving more than $7 billion.

Another important recent development concerns the biotechnology sector in the United States. It has been observed that small new biotechnology firms, United States institutions *par excellence* are the joint outcome of a number of factors.[4] Among the factors conducive to the emergence of biotechnology firms in the United States were the following: large-scale investment in life sciences, the science base of new biotechnology; an entrepreneurial culture among academics; and developed venture capital markets that are able to

explore promising areas of investment or other high-technology areas of high commercial potential. Those factors were to the mutual advantage of pharmaceutical companies, venture capitalists and scientists. Thus, in two decades the United States biotechnology industry grew until it comprised over 1,300 private and public companies that have succeeded in raising about $20 billion.[17] New biotechnology firms were booming in the mid-1980s. Expectations on Wall Street were particularly high when the approval of the Amgen product Neupogen in February 1991 followed the approval of its enormously successful predecessor, Epogen.

Table 35. Major acquisitions in pharmaceutical industry, 1994

Acquiror	*Acquiree*	*Purchase value (Millions of dollars)*	*Vendor/Notes*
AHP	Cyanamid	9 700	Takeover bid
Roche	Syntex	5 300	Agreed offer
Lilly	PCS	4 000	McKesson
SB	DPS	2 300	United Health Care
Sanofi	Sterling Rx pharma operations	1 000	Kodak
SmithKline Beecham	Sterling OTC	2 925	Kodak
Ciba	Chiron (49%)	2 100[a/]	Strategic alliance incl. asset transfer
Bayer	Sterling North American OTC	1 000	SB (incl. rights to Bayer name in the United States
BASF	Boots Pharma	1 320[b/]	Boots
Astra	Astra Merck	820	50% of JV

Source: SCRIP, *SCRIP's 1995 Yearbook*, vol.1 (Richmond, PJB Publications, 1995).
a/ Subject to completion.
b/ Subject to negotiation.

Recently, however, biopharmaceutical products in the United States have performed poorly and in 1993, biopharmaceutical companies faced serious financial problems. Although revenue increased, 106 out of 120 biopharmaceutical firms surveyed lost money in 1993, with the exception of the branch leader, Amgen.[18] The situation continued to be difficult in 1994 due to uncertainties stemming from health care reforms and severe product failures. Synergen, for example, suffered a serious setback with an antisepsis drug, the interleukin-1 antagonist Antril. This resulted in a staff reduction of 60 per cent, and a takeover offer being made by Amgen. From mid-1993 to mid-1994 biopharmaceutical companies in the United States suffered a net loss of $4.1 billion on product sales of $7.7 billion, while total revenue went

up by 12 per cent to $11.2 billion.[5] Recent events have also led to a slump in biotechnology stock prices and the collapse of the capital market for biotechnology companies, with the exception of that for companies with proven products.[17] Financial difficulties compelled companies to sell stocks and to incur debts at heavy discounts. In view of the diminishing flow of public equity, research alliances gained importance in company management as an alternative to discounted private investment and mergers. Under the prevailing conditions, biotechnology companies are using strategic alliances with pharmaceutical companies and others to raise capital. A number of biotechnology firms with related and complementary technologies have merged.[16] R & D expenditure of the United States in the biopharmaceutical industry was still growing at a rate of 23 per cent and reached $7 billion between mid-1993 and mid-1994, with Biogen investing over $79 million (an additional 31 per cent).[5] As a consequence of recent developments, however, some industry analysts expect that only the top quarter of the firms will remain independent, others will merge and the numerous one-product companies that do not possess the resources to undertake the research required to develop additional products will be affected.[17] Developments in the near future will be influenced by product approval of the Food and Drug Administration and by results of clinical tests currently being conducted.

Western Europe

In western Europe, the 1990s were marked by efforts made to reduce pharmaceutical prices and to contain health care expenditure. As a result, several major European markets for pharmaceuticals declined in 1993, Germany and Italy in particular. Compared with 1992 and considering events taking place concurrently in the United States, 1994 was a relatively calm year for the industry in Europe and topics high on the agenda included pricing, the rationalization of prescribing practices and increased interest in generics. As western European markets are still fragmented, the industry continues to be confronted by different sets of rules in each national market. International harmonization progressed in recent years, albeit at a slow pace.

Significant changes taking place in the European Union include the establishment of the new drug admission system in 1995, and the associated establishment of the European Medicines Evaluation Agency located in London. In anticipation of such changes, national regulatory agencies of European Union member States have taken measures to prepare themselves for the new institutional arrangements. The new registration system includes the following three conditions for the admission of drugs in the European

Union: (a) a decentralized procedure based on the principle of mutual recognition that is applicable for the majority of drugs; (b) a centralized procedure that is optional for certain new drugs but mandatory for biotechnology drugs in which applications are directly forwarded to the European Medicines Evaluation Agency; and (c) a national procedure limited to applications of local relevance in the relevant member State. The new registration system is intended to improve access to the single market in order to facilitate the rapid redemption of R & D investment by pharmaceutical companies. Furthermore, it is expected that it will shorten the duration of the procedure considerably (to approximately 300 days), and increase its transparency.[19]

Industrial policy guidelines for the pharmaceutical industry were issued recently by the European Union.[20] While a considerable number of European pharmaceutical companies are among the leading firms worldwide and the industry generates a substantial trade surplus, the European Commission has identified a number of structural weaknesses in the pharmaceutical industry in the European Union relative to its major rivals. One such weakness is the limited capacity of the industry to fund R & D aimed at the development of new drugs. Considering that 90 per cent of R & D expenditure is internal, that weakness is attributed to the low profitability of pharmaceutical companies in the European Union in comparison with those in the United States. Secondly, serious concerns have been raised with respect to biotechnology in Europe. The United States holds a share of around 65 per cent of biotechnology patents, while the shares of the European Union and Japan are only 15 and 13 per cent, respectively. Any lag in biotechnology could pose problems in the future in view of the rising importance of biopharmaceuticals in the drug market. In the Fourth Framework Program of the European Union for research and technological development, of a total of $403 million allocated for biomedicine and health, 11 per cent is devoted to pharmaceuticals. An additional amount of $662 million is allotted to biotechnology. A third weakness, which is related to the second, concerns the lack of innovative, science-based, small- and medium-sized firms in the European Union, as illustrated by the exceedingly small number of dedicated biotechnology firms, considering the United States as a benchmark. Although a number of measures have been taken to harmonize and improve the environment for business activities, such as introducing regulatory reforms, extending effective property rights protection for pharmaceuticals and reserving research funds, a number of problems still remain unsolved. In particular, pronounced differences in the national systems regarding price

control and reimbursement practices are reasons for the fragmentation of European markets.

One of the reasons why Europe lags behind the United States in investment in biotechnology is that the venture capital market in Europe is less developed than that of the United States. Venture capital investment in the European biotechnology industry actually declined by more than half between 1989 and 1992. Moreover, universities, which are a key element in biotechnology innovation, are considerably less motivated to engage in entrepreneurial ventures than their United States counterparts. As a consequence of such deficiencies, European companies tend to invest more heavily in the United States than in Europe itself. According to survey results, major criteria for such investment location decisions include the availability of skilled staff, regulatory constraints and product approval delays in the European Union, adequate patent protection, profitability considerations and an adverse view of biotechnology in Europe.[16]

Japan Pharmaceutical companies in Japan differ from their competitors in western Europe and the United States in a number of ways. The largest Japanese pharmaceutical companies are, on an average, smaller than those in the United States and Europe and are more inward oriented. They rely more heavily on licensing-in as a source of new products, and tend to have lower R & D intensities. Their research strategy is focused more on product modification than on radical innovations in new therapeutic areas.[5] Government influence on pricing has kept drug prices low in the past, contributing to a comparatively low share of health-care expenditure in GDP. The resulting squeeze on profits, has made it difficult for Japanese companies to compete internationally.[6]

Recently, corporate restructuring has featured prominently on the agenda of pharmaceutical companies in Japan, both in Japanese-owned firms and subsidiaries of transnational companies operating in Japan. The urgency of restructuring has been reinforced by the harsher environment arising from regular price cuts and additional reimbursement reductions for certain products, such as interferon and hypolipaemic products. As in other countries, attempts to contain health care expenditure have raised concern over the cost-effectiveness of the use of pharmaceuticals. Those changes have given rise to the expectation of low growth, both in volume and value terms, in the industry in the near future. A number of foreign subsidiaries

have streamlined their Japanese operations, even though Japan remains the primary area of many transnational companies for overseas activities. Unlike the United States and western Europe, merger and acquisition activities in Japan have been insignificant. There have been a number of agreements, generally concerning specific products, between Japanese companies and small biotechnology companies located mainly in the United States.[16] In general, the industry must become more competitive in the light of the new conditions under which it operates and render their R & D activities in a more focused and efficient manner.

The Japanese pharmaceutical industry was heavily oriented towards the domestic market in the past. Breaks in domestic demand have contributed to forcing the Japanese pharmaceutical industry to pursue new opportunities abroad. Since 1989, Japanese outward FDI has grown by 10 per cent annually, increasing significantly in western Europe. However, from FDI stocks of $3.2 billion in 1992, 62.5 per cent was allocated to North America, 28.4 per cent to western Europe, and 8.5 per cent to Asia and Oceania. Overseas production of Japanese companies increased by more than 80 per cent between 1989 and 1992.[5] Japanese companies already operating in Europe and the United States have continued to strengthen their operations. In addition, they have become increasingly involved in joint ventures and collaboration with China, which appears to be evolving as the preferred destination for Japanese pharmaceutical operations in Asia.

Japanese producers of pharmaceuticals have historically lagged behind their rivals in the United States and western Europe with respect to R & D, an issue that is currently being taken up in Japan. Recently, the Ministry of Health and Welfare initiated a public debate aimed at developing policies to stimulate domestic R & D activities. One outcome of the increasing interest in pharmaceutical-related research is the establishment of the joint Agene Research Institute set up to explore the genetic mechanisms of ageing.[16] Another interesting attempt to promote R & D and innovate the pharmaceutical industry is an orphan drug scheme initiated in 1993. In that scheme, 29 products were granted official orphan status in 1994 based on the criteria that the total patient population to be treated should be less than 50,000 and that the drugs involved would be restricted to the treatment of intractable and serious diseases and disorders lacking effective therapies. Incentives granted under the orphan scheme include R & D subsidies, a reduction in the corporate tax rate and an extended period for marketing.[5] A similar orphan drug scheme is also in operation in the United States.

Selected emerging markets

The selected emerging pharmaceutical markets that reveal a high-growth potential include the large economies of China and India and, in the light of the current economic reform taking place there, central and eastern Europe, with the Russian Federation as a special case.

China

The pharmaceutical industry in China has witnessed a high level of operational activities recently. From 1980 to 1992, pharmaceutical production in China increased eightfold, creating around 850,000 jobs, and the industry is expected to sustain a rapid growth up to the end of the decade. China is the second-largest producer of pharmaceutical raw materials in the world. It is a major exporter of intermediates (SITC 541). After Japan, China has the largest pharmaceutical market in Asia worth $6 billion.[5] According to some estimates, it will reach $11 billion by the year 2000.[16] Per capita consumption of pharmaceuticals ($5 per year) amounts to just one fifth of the average consumption in developed countries but has been increasing rapidly over the 1980s. China is planning a massive increase in health care spending that will undoubtedly be accompanied by a reduction in the amount spent on medicines.

The vastness and dynamic economic performance of China render it a promising location for foreign companies. A large number of major pharmaceutical companies from Japan, United States and western Europe are entering the Chinese market. Since 1978, China has been encouraging multinational pharmaceutical operations in the form of independent foreign companies and Chinese foreign joint ventures and collaboration. By the end of 1993, foreign investment amounting $600 million had been allocated to joint ventures and collaboration. The number of joint ventures has been growing rapidly over the past decade, reaching 623 by August 1993.[5] The sales of some pharmaceuticals launched by multinationals operating in China have increased significantly. In 1992, products originating from joint ventures were estimated to be worth $400-480 million.[5] Problems still exist, however, regarding the repatriation of profits and protection of intellectual property rights. In early 1993, China introduced patent protection for pharmaceuticals.

India

The total sales of the Indian pharmaceutical industry reached $2 billion in the financial year 1992/93, an increase of 16 per cent over 1991/92. In the wake of economic reforms and increased effective demand, the market has been expanding continuously and is forecast to rank among the top 10

pharmaceutical markets by the end of the decade.[5] Problems are perceived regarding drug pricing and the protection of intellectual property rights. Pharmaceutical R & D expenditure is still low in India, with a ratio of R & D expenditure to pharmaceutical industry sales of 1.5 per cent in 1993/94 (as compared with about 1 per cent for the total industry). The new drug policy comprises a number of incentives for R & D, including price freedom for pharmaceuticals discovered and developed in India, the possibility of tax deductions of as much as 125 per cent of R & D expenditure and import concessions regarding goods required for R & D.[5] More importantly, the policy will liberalize industrial licensing, reduce Government control on drug prices and simplify the pricing system. Further changes in policies regarding FDI can be expected. In new joint ventures, foreign equity of up to 51 per cent is allowed and foreign equity in existing joint ventures can be raised to that level.

Central and eastern Europe

Countries of central and eastern Europe are by no means homogeneous with respect to certain market conditions such as their endowment of human capital, their innovative capabilities and their prospects of economic reform, that provide the general background for the evolution of effective demand and industrial activity.[21] Some countries, in particular those bordering the European Union, can be expected to embark on a catch-up process even though the process of convergence to European Union levels may be protracted. All central and eastern Europe countries, excluding those of the former USSR, once again achieved positive real rates of change in GDP in 1994.[22] The largest single pharmaceutical market in central and eastern Europe, apart from the Russian Federation, is Poland, which according to IMS is estimated to be approximately $1 billion. The second largest market, Hungary, is estimated to be $623 million. It has a comparatively strong pharmaceutical industry of its own and its output is expected to grow by around 10 per cent in the future. Hungary started specializing strongly in pharmaceuticals while it was still a member of the former Council for Mutual Economic Assistance (CMEA) and continues to attract a number of foreign investors. While the Russian Federation may be best described as having the greatest potential of all eastern European countries, it runs considerable risks of seriously falling short of that potential, especially since declining domestic productio has affected supplies of medicines. There is an urgent need for restructuring and reform of health care funding and regulations. Estimates of the pharmaceutical market of the Russian Federation are particularly unreliable. It is currently estimated at $1.5 billion

and forecasts for the year 2000 range between $2 and $8 billion, reflecting the high degree of uncertainty involved.[16]

TECHNOLOGICAL TRENDS

Innovative performance

As the pharmaceutical industry is particularly technology intensive, it is vital for large research-based pharmaceutical companies to maintain an innovative product pipeline as a prerequisite for future competitiveness. The innovative performance of pharmaceutical companies is commonly considered a key to commercial success. Consequently, current R & D efforts under way are perceived as options for future earnings that are reflected in the valuation by capital markets. The drug industry contains various segments that differ sharply in the innovative activity they require. In comparison with developed countries, the R & D activities of the pharmaceutical industry in developing countries are not so intense and the cost structure in such countries indicates a very low share of R & D in total operating revenues.[8]

The industry is confronted with sharply rising costs of R & D that have already reached very high levels. Drawing on data obtained from 12 United-States companies, and based on a sample of 93 new chemical entities (NCEs) developed by the companies themselves that were first tested on human beings between 1970 and 1982, the average cost for developing an NCE was estimated at $114 million (1987 dollars). However, capitalizing the out-of-pocket cost at a discount rate of 9 per cent over a period of nearly 12 years (from synthesis to marketing approval) would raise the figure to $231 million.[23] Those figures may be interpreted as belonging to the premier league of new NCEs. Bearing in mind that the NCEs under examination were entirely self-originated, the R & D expenditure required for developing a "second league" new substance could be considerably lower. The size of funds required for developing a single NCE could induce the concentration of innovative activities and lead to greater polarization within the industry.

The time factor involved in developing and introducing a new drug plays a major role in costs. Requirements by regulatory authorities regarding clinical testing have increased substantially. The clinical test phase now takes about seven years on an average, a much longer time than it did in the

1960s. This has led to a reduction of effective patent protection to which legislators of various countries have recently responded by taking suitable countermeasures. There is currently a trend towards outsourcing clinical tests in order to reduce development times. In the United States, under the Prescription Drug User Fee Act of 1992, drug companies will contribute to covering the expenses of the reviewing process by making payments to the Food and Drug Administration. This is seen as an attempt to hasten the introductory pace of pharmaceuticals to the market.

In the United States, where the pharmaceutical industry is the most successful and innovative, R & D investment has doubled every five years over the past 25 years. In 1993, the industry invested more than $12.6 billion in R & D. Current investment amounts to 16.7 per cent of total industry sales, more than twice as much as R & D investment in any other high-technology industry.[15] Biotechnology companies in the United States spend as much as 91 per cent of their revenue on R & D. In western Europe (EFPIA countries) the pharmaceutical industry is estimated to have spent $11.4 billion on R & D in Europe in 1993 (see table 28). R & D expenditure in pharmaceutical in Japan amounts to less than one half that of western European or the United States. Expenditure on R & D in western Europe expanded at an annual rate of over 10 per cent in the 1980s. Together with the slowdown in the growth of pharmaceutical markets and corporate restructuring, R & D expenditure has come under more intense scrutiny. Recently, growth in R & D expenditure has in fact decelerated. The streamlining of R & D activities initiated in 1993 and 1994, partly in connection with mergers such as that between Roche and Syntex, and recent announcements by leading companies in Europe and the United States suggest that further attempts at trimming R & D budgets are imminent. This does not mean, however, that R & D is assigned lower priority, but reflects rather an attempt to increase R & D activity under changed circumstances. In the business sector, in-house R & D streamlining is complemented by external R & D collaborations. Moreover, efforts are being made in many countries to strengthen their pharmaceutical research base.

As can be seen from table 36 the top 10 pharmaceutical companies in the world with respect to R & D spending include three companies each from Switzerland and the United States and two each from Germany and the United Kingdom. Glaxo, Roche and Merck are the top three with Roche investing close to one quarter of its sales (23.2 per cent) on R & D. In terms of the number of products being developed, Roche, which now includes

Syntex, leads with 115 drugs at the end of 1994, followed closely by Merck. Based on the number of products being developed the top 10 companies would include five from the United States, two from Switzerland and one each from France, Sweden and the United Kingdom.[16]

Table 36. Leading pharmaceutical companies worldwide, by R & D spending, 1993-1994

Company	*R & D spending (Millions of dollars)*	*Sales (Millions of dollars)*	*R & D as percentage of sales*
Glaxo (United Kingdom)	1 287.0	8 484.0	15.2
Roche (Switzerland)	1 226.3	5 285.6	23.2
Merck & Co (United States)	1 120.0[a/]	8 774.6	12.8
BMS (United States)	972.1	6 524.0	14.9
Hoechst (Germany)	955.8[b/]	6 811.8	14.0
Sandoz (Switzerland)	900.8	4 972.9	18.1
Pfizer (United States)	888.1[c/]	6 210.3	14.3
Bayer (Germany)	840.1[d/]	5 788.4	14.5
SmithKline Beecham (United Kingdom)	743.5	5 231.3	14.2
Ciba (Switzerland)	714.7[e/]	4 466.0	16.0

Source: SCRIP, *SCRIP's 1995 Yearbook*, vol. 1 (Richmond, PJB Publications, 1995).
a/ Relates to human and animal health products.
b/ Includes cosmetics.
c/ Relates to the health care division, including hospital products.
d/ Relates to the health care division, including diagnostics.
e/ Relates to prescription pharmaceuticals.

The number of newly introduced NCEs is commonly used as an indicator of innovative performance. Of the 256 NCEs introduced worldwide between 1988 and 1993, 113 (44.1 per cent) were of European origin, 29.3 per cent from Japan and 24.6 per cent from the United States.[7] The European share, though remaining high, has gradually eroded over the past decades. In the first half of the 1960s, Europe held a share of more than 60 per cent of newly introduced NCEs, while Japan accounted for only 10 per cent. Out of the 39 NCEs introduced in 1993, 16 were of western European origin. In 1994, 47 NCEs were introduced. Of those, about half were introduced by Japanese firms. One was introduced by a Japanese and United States company, namely Toyama and Pfizer. Companies in Western Europe introduced 12 NCEs and United States firms introduced 8. One each was introduced by a Canadian and a Chinese company.[16]

The use of regional shares of NCEs as an indicator of innovative performance should be handled with caution since differences exist in the quality of the NCE in question. It must be noted, for example, that by 1993, only 6 per cent of the NCEs of Japanese origin launched over the previous 20 years had achieved international status (meaning that they were sold in Japan, the United States and in at least three countries in Europe) compared with 27 per cent of NCEs of United States companies and 14 per cent of NCEs of European companies. Moreover, a large share of NCEs recently launched by Japanese firms were licensed-in, although those presently under development tend to be originated by the firms themselves.[5] Similarly, in an earlier study Grabowski found that despite the high share of Japanese companies introducing new drugs they had a share of only 4.1 per cent in "consensus NCEs", defined as NCEs approved for marketing in at least 6 of the 11 major national markets between 1970 and 1985.[24] Japanese share continued to increase in the 1980s, however, reflecting the fact that the Japanese pharmaceutical industry has been evolving from a generic-oriented and imitative industry in the 1960s and 1970s to a more innovative one.[24] Building on their strength, companies have begun to focus their R & D efforts more effectively than in the past. In Japan, in particular, R & D was less concentrated, owing in part to the policy to reward premium prices to any new drug, regardless of its therapeutic value. Currently, Japanese authorities grant premium prices only to drugs possessing a significant therapeutic advantage.[6]

The progress made with some products contrasts with the low performance and setbacks of others in 1993 and 1994.[16] Areas where positive developments were made in 1994 include products used for lowering cholesterol levels, peptic ulcer disease, multiple sclerosis and gene therapy. Disappointments were recorded in cardiology, sepsis and epilepsy. The 20 top therapeutic categories, by the number of compounds in development, are shown in table 37. As can be seen, the anti-cancer and anti-inflammatory categories continue to lead in number. Upward movements in ranking can be observed with respect to pharmaceuticals designed to combat intractable diseases (e.g. anti-HIV agents), diseases that are the main cause of mortality in the developed world (e.g. cardiovascular drugs) and diseases afflicting the elderly (e.g. neuroprotectives, memory enhancers).

Table 37. Leading therapeutic categories of development worldwide, 1994

Ranking in 1994	*Ranking in 1993*	*Therapeutic category*	*Number of compounds*
1	1	Anticancer, other	374
2	2	Anti-inflammatory	282
3	5	Antiviral, anti-HIV	255
4	8	Cardiovascular	254
5	4	Anticancer, immunological	251
5	3	Anti-asthma	251
7	12	Neuroprotective	211
8	6	Recombinanta	208
9	11	Memory enhancer	193
10	9	Antiviral, other	184
11	7	Vaccine	182
12	10	Non-recombinants, antibodies	179
13	14	Immunosuppressants	178
14	13	Antithrombotic	171
15	15	Antihypertensitive, other	154
16	17	Hypolipaemic/anti-atherosclerotic	154
17	19	Alimentary/metabolic	146
18	18	Anti-arthritic, other	142
19	16	Monoclonal antibody	135
20	--	Analgesic, other	131

Source: SCRIP, *SCRIP's 1995 Yearbook*, vol. 1 (Richmond, PJB Publications, 1995).

Efforts to harmonize rules regarding pharmaceuticals in the European Union, Japan and the United States are reflected in the framework of the International Conference on Harmonization. In 1991, at the first session of the Conference, a five-year trilateral harmonization program was agreed upon. In 1994, at the second session of the Conference, further progress was made towards harmonizing formats for clinical testing. The harmonization process will continue in Japan in 1995 at the third session of the Conference, where intensive efforts will be made to reduce worldwide R & D costs significantly.

Research strategies

The traditional research strategy in the pharmaceutical industry was strongly based on trial-and-error processes involving the screening of large numbers of chemical entities, often closely-related known derivatives, in search of desired therapeutic properties.[25] In such processes, thousands of substances were screened for their potential efficacy for treating specific medical disorders. Of a total of 10,000 substances tested, only a few were introduced to the market. After the Second World War, molecule manipulation proved to be a viable and efficient way for deriving new drugs and has led to a

large number of innovations. However, innovative output based on that method slowed down in the 1960s as shown by a significant decrease in the number of NCEs introduced annually to the pharmaceutical market. While there is agreement about that fact, there is still some dispute about its causes. Some economists view the increased stringency of government regulations as the prime reason. Although tighter regulatory procedures have slowed the pace of innovation to some extent, a more fundamental problem is involved, namely the exhaustion of technological opportunities. Research strategies have changed significantly, becoming more sophisticated since the 1960s and relying less heavily on trial and error. The most important development affecting research on industry is the advent of modern biotechnology which has made significant inroads into the traditional technology applied in drug development, organic chemical synthesis. This has had a deep impact that could bring about reversal in the decline in innovative performance of traditional technologies in drug development.

Biotechnology has been described as a "broad generic technology" with major applications in pharmaceuticals as well as other industries such as chemicals, agriculture, food, environment, mining.[26] By an expanded definition, drawing on definitions attempted by a number of specialists, biotechnology is not a single technology, but rather a general term encompassing the novel techniques of genetic engineering and monoclonal antibody technology as well as an array of new technologies derived from the biosciences. This new approach which uses scientists' understanding of the disease process at the molecular level is aimed at designing therapies that will block the disease process with high specificity.[27] It has been envisaged that more effective drugs could be developed by rational design drawing on substances occurring naturally in the human body.

The advent of modern biotechnology is associated with two major achievements in molecular biology in the early 1970s that led to the emergence of genetic engineering: (a) the discovery that restriction enzymes could be used to cut and splice genes (recombinant DNA); and (b) the use of cell fusion to develop hybrid cells of desired characteristics that would multiply themselves rapidly (hybridomas). Using the methods of recombinant DNA, the genes of micro-organisms, such as yeast, could be "reprogrammed" to produce useful proteins. As a micro-organism multiplied would become, in effect, a mini-factory for producing (cloning) the protein.[4] Applying those techniques, genes were cloned to produce proteins such as insulin, human growth hormone and Factor VIII (for treatment of

hemophilia). Those developments opened the way for a whole new range of protein drugs based on naturally occurring proteins in the body's immune system, such as interferons, interleukins with potential for cancer treatment, tissue plasminogen activator (TPA) used to dissolve blood clots in arteries and erythropoietin (EPO) used to treat kidney failure. Hybridomas led to the development of monoclonal antibodies, which, possessing having the antibody characteristics specific to a particular antigen, have a wide application in separation processes, diagnostics and therapeutics.[4]

Biotechnology firms are usually comparatively small and in their infancy. The development phase for biopharmaceuticals lasts 12 years on an average.[28] Start-up firms require access to venture capital. Expectations of private investors may require such enterprises to generate adequate flow of revenue at the outset. In order to realize that goal while simultaneously preserving their research agenda, biotechnology companies enter into co-operative agreements with firms that infringe on their independence. Instruments used by start-up companies include product swaps, licensing-in of a more developed product and acquisitions.[6] Strategic alliances between large, established pharmaceutical and biopharmaceutical firms are of crucial importance from the former's perspective as well. Large pharmaceutical companies interested in biotechnology tend to establish a whole spectrun of alliances with small, specialized firms. Such alliances sometimes lead to joint ventures or at least partial acquisitions. Finally, there is the option of forming alliances with other biotechnology firms. According to an Ernst & Young survey, United States biotechnology companies concluded 152 strategic alliances, 130 marketing, licensing, supply and distribution agreements, 27 acquisitions and 6 joint ventures within a year. The majority of the partners are from North America, while 24 per cent are from Europe and 8 per cent from Japan.[5] Between 1988 and 1992, 760 alliances were formed between pharmaceutical and biotechnology companies, including universities and research institutes, representing a total of $48 billion.[16]

The impact thus created by modern biotechnology has forced established pharmaceutical companies to depart from traditional vertical integration for developing new technologies and products, even though an increase in horizontal strategic alliances between competing pharmaceutical companies has been observed. The traditional mode of procuring technology in-house was eroded by a shift towards external sources. Following an industry-wide trend towards functional specialization, biotechnology companies have been increasingly taking on the role of suppliers of innovation thereby changing

significantly the functional characteristics of the pharmaceutical system of innovation.[27] Despite recent difficulties in the biopharmaceutical sector of the United States, large pharmaceutical companies have been showing intense interest in biotechnology companies. Ciba invested $2 billion to gain access to the research pipeline of Chiron, and currently holds a stake of 49 per cent in the company.

Test filing of biotechnology-derived drugs first took place in 1980 in the United States and had increased nearly tenfold by 1988.[5] Since 1987, 32 biotechnology-derived drugs have been registered in the European Union. In the meantime, new drugs involving biotechnology have been launched very successfully. A number of biotechnology products have achieved substantial sales volumes (see table 38). According to a pharmaceutical sales forecast to the year 2000, two out of the four drugs for which sales are expected to exceed $2 billion are biotechnology products. Epogen/Procrit is forecast to be the only drug with sales exceeding $3 billion. Moreover, 5 of 17 pharmaceuticals with sales of more than $1 billion are expected to include biotechnology products.[16]

Table 38. Leading biotechnology drugs on the market worldwide, 1994

Product	*Developer*	*Marketer*	*Net sales (Millions of dollars)*
Neupogen	Amgen	Amgen	719
Epogen	Amgen	Amgen	587
Intron A	Biogen	Schering-Plouch	572
Humulin	Genentech	Eli Lilly	560
Procrit	Amgen	Ortho Biotech	500
Engerix-B	Genentech	SmithKline Beecham	480
Recombivax HB	Chiron	Merck & Co	245
Activase	Genentech	Genentech	236
Protropin	Genentech	Genentech	217
Roferon-A	Genentech	Roche	172

Source: Ernst & Young "Biotech 95: Reform, Restructure, Renewal", survey of the United States biotechnology industry, quoted in SCRIP, *SCRIP's 1995 Yearbook*, vol. II (Richmond, PJB Publications, 1995).

Gene therapy is attracting intense interest. Rhone-Poulenc Rorer announced an allocation of $100 million annually for cell and gene therapy research. Gene therapy was an important element of other biotechnology operations in 1994. It is forecast to generate worldwide revenues of $2.6 billion, with

treatments for genetic diseases accounting for 30 per cent, viral diseases 11 per cent, anaemia 7 per cent, and other treatments 4 per cent of the market.[16] Over a dozen clinical tests are presently under way, but a wide gap still exists between the promises of recent technological breakthroughs and viable treatment itself.

The global pattern of allocation of research establishments seems to reinforce a clustering of R & D activities reminiscent of Alfred Marshall's analysis of industrial "localization", which has recently been taken up by a number of eminent economists. While traditional investment incentives and low costs are generally important in decision-making for the establishment or extension of manufacturing sites, different criteria seem to apply to biotechnology R & D facilities, to start-up operations in particular.[30] One criterion is the availability of qualified personnel. While top scientists are recruited globally, there remains a need for qualified local staff. Moreover, the proximity of a leading university-cum-medical centre is perceived as being of great advantage, especially to start-up companies. Pharmaceutical research identifies itself closely with the realm of what was recently termed transfer sciences, in which the borderlines between academic and firm-based research have become fuzzy and new modes of cooperation have evolved.[31] Of course, extra-scientific factors, such as the regulatory environment, accessibility, business culture and living conditions are also taken into account. The external effects of a sophisticated educational and science base, research infrastructure, availability of highly-qualified academics and dense information exchange networks may create positive feedbacks or virtuous cycles. The nurturing of such nuclei or clusters are a major challenge for policy makers for science and technology that is on the way to becoming - at least in developed countries - the core of industrial policy. Local networks are less footloose and therefore less vulnerable to spatial reallocations than activities relying heavily on highly mobile factors of production such as capital.

Environment concerns

In western Europe, efforts to control pollution are directed towards water, air and noise pollution, which account for three quarters of related expenditure.[7] In the pharmaceutical industry, one quarter of solid waste contains active ingredients and therefore requires special treatment. It is mostly incinerated in off-site installations. The share of environment-related investment in total investment is about 4 per cent, which is above the total industry average, and is expected to rise further. Efforts being made

upstream in the production process to find substitutes for polluting products include replacing chlorine-based solvents or PVCs used for blister packs by suitable alternatives and reducing packaging sizes and materials, including information as long as it does not infringe on the information needs of patients. Downstream efforts include establishing systems for recovering pharmaceutical waste.

In the United States, four areas of environmental policy having an impact on the pharmaceutical industry include the following: Clean Air Act regulations; pollution prevention; guidelines and limitations for wastewater discharges, and environmental assessment.[15] Regarding the Clean Air Act, the pharmaceutical industry is cooperating with the Environmental Protection Agency (EPA) to develop standards relating specifically to the manufacturing of pharmaceuticals. With respect to pollution prevention, the pharmaceutical industry is involved in the EPA voluntary program to reduce toxic waste. EPA is scheduled to introduce new requirements for the pharmaceutical industry against toxic pollution in the future. A wastewater survey conducted by EPA will assist in developing new guidelines for the pharmaceutical industry. Finally, according to the National Environmental Policy Act of 1969, pharmaceutical companies submitting applications for approval are required to state the effects that production of the drugs will have on the environment.

FUTURE PERSPECTIVES

Reliable assessments for the future of the global pharmaceutical industry are not easily available even for the near future owing to structural discontinuities presently afflicting the industry that emanate from developments affecting both supply and demand. There is considerable evidence that the global pharmaceutical industry, in some respects, has reached a crossroad. It is likely that overall demand conditions will continue to be affected by efforts to curb the rising costs of health care. The industry will be exposed to cost- and innovation-related pressures for longer periods than previously anticipated. There is evidence, however, that Governments are responding positively to the requirements of the pharmaceutical industry in many countries.

Recent forecasts of production and market volumes published by a variety of authoritative sources indicate that the decrease in growth is not simply a short-term, transitory phenomenon. In the European Union, the production volume of pharmaceuticals is forecast to grow by 3 per cent annually between 1993 and 2000.[7] The growth rate of the domestic market within the European Union is estimated at 3.5 per cent annually, less than half that experienced in the second half of the 1980s and the early 1990s. Thus, the decrease in the rate of pharmaceutical output growth experienced in recent years cannot be attributed to a short-term fluctuation of activity, but is expected to persist. In the United States, the expansion of the drug market expected over the next five years will be accompanied by pressures on prices. In the near future, low volume and value growth rates are also expected in Japan. It is estimated that the world pharmaceutical market will grow from its value of $192 million in 1992 to $257 million (in actual prices) in 1997.[16] This implies an annual average growth rate of 6 per cent, which corresponds with the current rate of expansion.

However, despite the recent decline in its growth rate relative to the previous phase of rapid growth, the pharmaceutical industry will continue to grow. Current industrial restructuring efforts, some of which have been documented above indicate that the pharmaceutical industry is making vigorous attempts to adapt to changes in its environment and match the impact of tendencies towards depressed prices. Some industry experts believe that the industry has the ability to fully compensate average prescription-drug price cuts of 20 per cent by implementing cost-cutting measures, the major targets of rationalization being R & D and administration.[16] Capacity utilization in pharmaceutical manufacturing is estimated to be low, between 40 and 50 per cent. Accordingly, restructuring within the industry is likely to involve plant closures and consolidation accompanied by job losses. Since the entry of major manufacturers is unlikely under these conditions, further merger and acquisition and other restructuring operations appear imminent. It therefore remains to be seen how restructuring will affect the long-term innovative performance of the industry. By the end of the 1990s, however, after the necessary streamlining has been undertaken, it is hoped that the industry will have adapted to its profoundly changed environment and will have prepared the ground for its long-term development.

Moreover, it must be noted that the pharmaceutical industry cannot be seen as a mature industry operating in generally saturated markets. Demographic trends will continue to stimulate demand for qualitatively adequate, low-cost

pharmaceuticals and health care services. Challenges remain for medical research and product development, and the emergence of new, dynamic markets for pharmaceuticals will offer plenty of opportunities that will provide a new impetus to the global industry. In some dynamic economies, a continuous expansion of the pharmaceutical markets can be expected. In other economies, those in transition in particular, the growth of the market for pharmaceuticals depends crucially on the prospects of economic reform.

The most important factor affecting the long-run prospects of the industry, however, is its ability to develop new drugs that offer major therapeutical advantages. Modern biotechnology remains the primary hope for improving substantially the performance of companies in drug development. Significant scientific breakthroughs are being made in the wake of molecular and genetic revolutions. Since biotechnology is still young, the development phases are long. Although the process of deriving marketable biotechnology products is slow, there have been major successes. Studies in the history of major technologies have shown that the full realization of the potential embodied in a new technological paradigm is a protracted process that often requires substantial institutional change. Relationships between established pharmaceutical firms and small biotechnology companies are intricate, and the rapidly evolving biopharmaceutical sector will experience turbulent phases. However, pursuing new opportunities for breakthroughs, research-based pharmaceutical companies have given the use of new collaborative research strategies features a prominent place on their agendas.

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SEMICONDUCTOR INDUSTRY

OVERVIEW

The semiconductor industry has grown rapidly for the past three years in succession, and continues to do so for the fourth consecutive year. Never before has any other industry experienced success of this duration or magnitude. Since the inception of the industry in 1960, the semiconductor market has developed tremendously achieving an average annual growth rate of 16 per cent and generating $102 billion in revenues in 1994.[1] The high growth rate can be attributed to the continuous decline in the price of eletronic equipment and elementary micro-electronics components, namely memory chips and gates for logic integrated circuits, as well as the increasing number of semiconductors used in electronic equipment. Stated as a percentage of equipment costs, the portion attributable to semiconductors grew from around 3 to 4 per cent in the 1960s to 15 per cent in 1995 and is expected to reach 30 per cent in 2000, thus doubling within a span of five years.

Product categories

Major categories of products in the semiconductor industry are memory devices, microcomponents, analog and logic integrated circuits and discrete semiconductors.

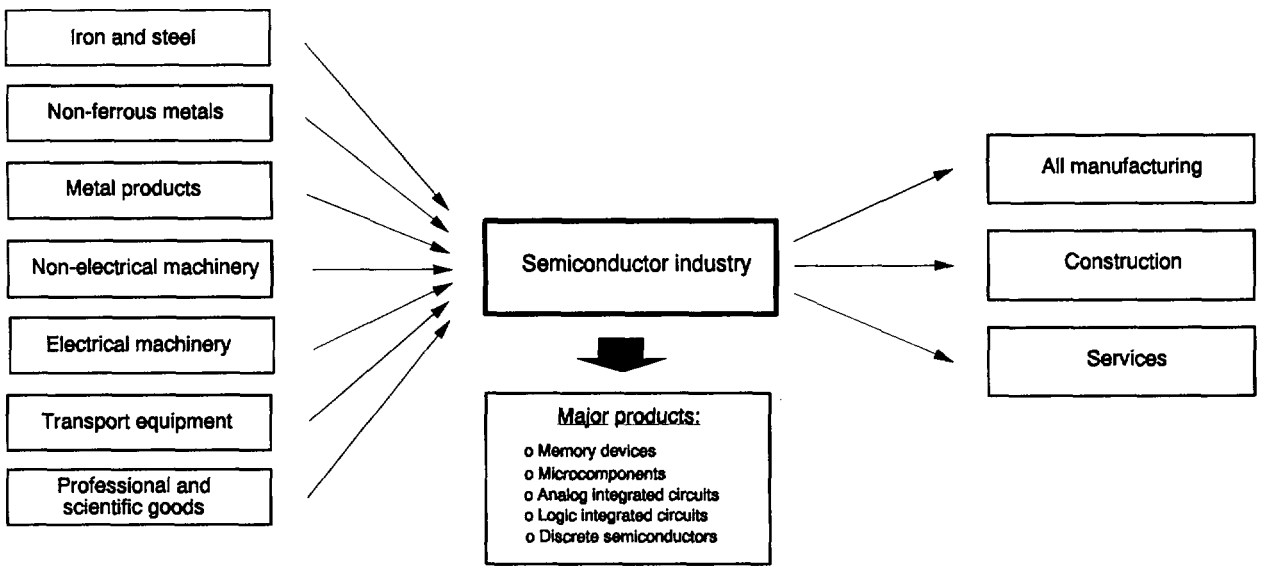
Characteristics

The significance of the semiconductor industry lies not only in its size, but also in the substantial role it plays in industrialization. The introduction of recently developed semiconductor technologies has become the driving force behind the electronics industry as a whole, in which sales are expected to reach $700 billion in 1995. Besides the rapid growth of semiconductor use in electronics equipment (consumer goods, data-processing, military and space, industrial telecommunications and applications) recent technologies have led to new applications such as automotive electronics. Practically unknown in the 1970s, the contribution of semiconductors to automotive electronics could have amounted to as much as $8 billion in 1995.[1]

Owing to its stable growth and profitability, the industry has become one of the highest value-added industries. Because of its relatively short development period, however, the industrial structure has yet to be consolidated, and the concentration movement of the industry has not really

started. Overall, the success of the industry is determined mainly by technological developments and by its ability to maintain close links with other end-user industries (see figure 17).

Figure 17. Linkages of the semiconductor industry with other industries and economic sectors



Success factors Five key factors determining the success of the industry are described below:

Ability to sustain rapid sales growth If the industry is to develop at a rate of at least 15 per cent per year up to the year 2000, companies need to establish appropriate sales targets to expand their production capacities accordingly and to develop appropriate marketing strategies. During the past seven years, however, only five companies, namely Intel, Samsung, Goldstar, Siemens, SGS-Thomson Microelectronics and Motorola, have enjoyed such a growth rate.

Broad range of product portfolios In order to ensure that supply meets demand, producers need to concentrate on the development of the following three product categories: (a) memory devices; (b) market-oriented integrated circuits; and (c) discrete devices.

Memory devices Memory devices, which include volatile or non-volatile memories, guarantee a world market with high profits and stable growth in the long-term, since they are most advanced technologically for mastering small lithography features (below 0.35 micron). The development of memory

devices could contribute to further improvements in testing methods that could, in turn, help to master the production of high-quality products. Moreover, it would offer the opportunity to amortize the fixed costs of manufacturing plants.

Integrated circuits

Integrated circuits assure long-term growth because of the constantly increasing content of semiconductors in electronic equipment needed for mobile phones, integrated circuits for telecommunication line cards, automotive and disk-drive, as well as MPEG devices for multi-media applications. They are also profitable, since the prices of such devices are high.

Discrete devices

Discrete devices, especially power semiconductors such as power transistors, thyristors, traces and rectifiers, show signs of profitability and stable growth, and there is a possibility of new market development as automotive applications (integrated power or smart power) increase.

Globalization

Conditions in the world market are favourable for the integration of semiconductor companies. While Japan and the United States continue to possess the largest markets, the fastest-growing market is that of Asia and the Pacific. Europe offers a large potential for newly emerging applications such as mobile telecommunication. The semiconductor industry in each region specializes in specific markets, for example, the computer market in the United States and Asia and the Pacific, and the telecommunications and automotive markets in Europe.

Because of the cost advantages in production, 40 per cent of the back-end operations (i.e. assembly lines) worldwide are located in Asia and the Pacific. Recent technological developments have also increased the number of front-end operations (i.e. diffusion processes) in that region.

Investment capability

Since the industry is estimated to grow at more than 15 per cent per year, investments in manufacturing plants could become a critical issue over the next few years. Assuming this average growth rate for the industry, it is estimated that a company would have to set up at least one new manufacturing plant every 15 months. This would involve an investment of

$700 to $800 million per year in capital spending.[2] Costs for setting up a front-end plant increased at an annual average rate of 14 per cent between 1970 and 1994, from $30 to $800 million, and it is estimated that it will increase further to $2.5 billion by the year 2000.[2]

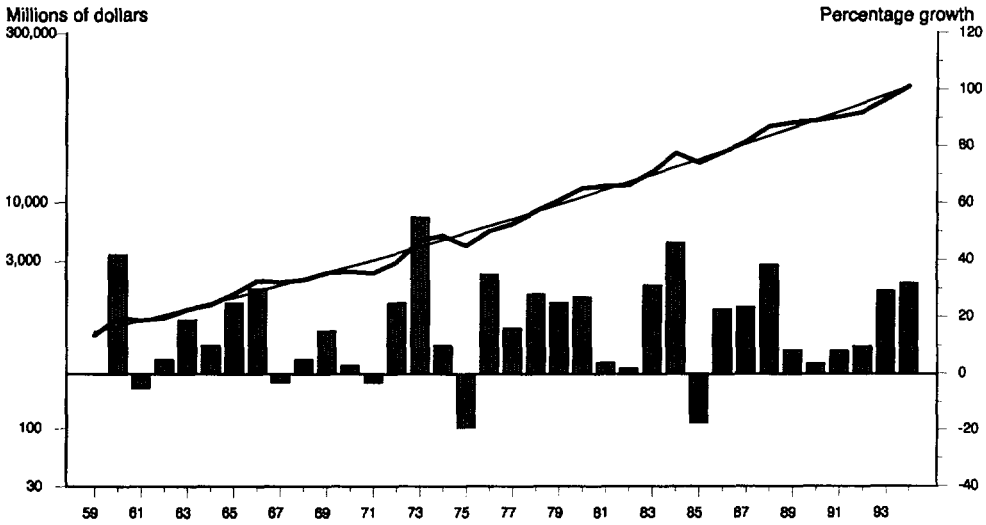
Alliances Of considerable importance are alliances between partners, including large customers and international R & D cooperation organizations, such as JESSI in Europe and Sematech in the United States. Such alliances promote easy access to system architecture and long-term programs and ensure stable long-term growth and the probability that costs can be shared for setting up plants and for R & D.

WORLD MARKET STRUCTURE: RECENT TRENDS AND CURRENT CONDITIONS

Market trends The growth of semiconductors has been cyclical during the past 35 years of its history (see figure 18). In any five-year period, the market has generally experienced strong growth for around three years, followed by a strong decrease or negative growth for one or two years. Looking at the history of the industry, the five years of negative growth were 1961, 1967, 1971, 1975 and 1985 and the five years of very slow growth were 1962, 1968, 1970, 1982 and 1990. The most recent period of growth began in 1993, when the industry grew by 29 per cent of its 1992 level. In 1994, the growth rate increased to 32 per cent and was expected to be 30 per cent in 1995.[3]

Reasons for the cyclical behaviour have always been the same. The emergence of new integrated-circuit technology generates strong demand. An adjustment phase follows while sufficient production capacity is built up to meet new demand. During the adjustment phase, the price of semiconductors either soars (the under-capacity phase) or collapses (the over-capacity phase). The magnitude of a cycle depends on the type of semiconductors being developed. The cycle could be less severe for dedicated integrated circuits and discrete semiconductors than it is for memories, especially for dynamic random access memory (DRAM).

Figure 18. Trends in the world semiconductor market, 1960-1994



Source: World Semiconductor Trade Statistics, *Blue Book* (San Jose, California, March 1995) and Dataquest, *Market Share Report* (San Jose, California, April 1995).

World semiconductor market

As mentioned above, worldwide sales of semiconductors in 1994 stood at $102 billion and sales are forecast to reach $300 billion by the year 2000. The largest regional share of sales for 1994 was achieved by North America (33 per cent), followed by Japan (29 per cent), and Europe and Asia and the Pacific (19 per cent each) (see table 39).

Table 39. World semiconductor sales, 1994 and 1998[a/]

	Sales (Billions of dollars)		*Annual average growth rate (percentage)*	*Percentage share*	
Region	*1994*	*1998*	*1994-1998*	*1994*	*1998*
North America	33.5	74.9	22.3	32.9	32.1
Europe	19.7	44.1	22.3	19.4	18.9
Japan	29.4	63.6	21.3	28.9	27.3
Asia and the Pacific	19.2	50.5	27.3	18.9	21.7
World	101.8	233.1	23.0	100.0	100.0

Source: World semiconductor trade statistics, presented at Kyoto forecast meeting, April 1995.
a/ Forecast.

Between 1985 and 1994, the regional distribution of semiconductors changed dramatically reflecting the various production growth rates of the electronic

industry. The share of Asia and the Pacific in the world market increased considerably, from less than 10 per cent in 1985 to 19 per cent in 1994. The Japanese market share, however, decreased from 39 per cent in 1989 to 29 per cent in 1994, while Europe maintained its share, which decreased by only 1 per cent between 1985 and 1994.[1]

A similar growth pattern has been forecast for the period from 1995 to 1998. Asia and the Pacific will benefit enormously from the increasing relocation of plants, especially from Japan, and strong domestic demand. Moreover, China is expected to fuel growth in Asia and the Pacific. In 1995, the semiconductor market in China was estimated to grow to $1.8 billion, about 1 per cent of the world market share. It is expected to increase rapidly at an annual growth rate of 25 per cent to reach $5.4 billion by the year 2000. Europe will continue to maintain a stable market share, owing to the revitalization of its electronic production

Product segments

Strong growth in semiconductors has led to dramatic changes in the structure of the market. While the world market expanded fourfold between 1984 and 1994, the microcomponents market increased eightfold, the memory chip market fivefold, the analog integrated circuit market nearly fourfold, and the discrete semiconductor market twofold.

The market share of individual market segments also changed significantly, (see table 40). In 1994, as a result of strong growth in demand for semiconductors for personal computers and for automotive applications, the biggest market segment was that of memory devices, followed by microcomponents (30.3 and 23.3 per cent, respectively). In contrast, the share of the segment of logic integrated circuits decreased from 26 per cent in 1984 to 17.4 per cent in 1994.

In terms of production, the United States clearly dominated the world share for microcomponents in 1994: its production share exceeded 70 per cent. Japan continues to dominate world production of memory chips with a share of close to 50 per cent of the world market. However, that dominance is currently being challenged by countries in Asia and the Pacific, especially by the Republic of Korea, which succeeded in capturing 23 per cent of world memory chip production in less than 10 years. The increasing market share of countries in that region has been stimulated by DRAM production.[1]

Table 40. World semiconductor market growth, 1984 and 1994

Type of device	Sales (Millions of dollars) 1984	Sales (Millions of dollars) 1994	Percentage change 1984 - 1994	Percentage share 1984	Percentage share 1994
Memory devices	6.1	30.8	17.6	24.3	30.3
Microcomponents	2.8	23.7	23.8	11.2	23.3
Logi/asic	6.5	17.7	10.5	26.0	17.4
Analog/mixed	4.3	16.2	14.3	17.0	15.9
Discrete semiconductors	4.3	9.9	8.6	17.3	9.7
Optical semis	1.1	3.5	12.7	4.2	3.4
Total	25.0	101.8	15.1	100.0	100.0

Source: World Semiconductor Trade Statistics, *Blue Book* (San Jose, California, March 1995); SGS-Thomson Microelectronics.

Memory devices

In 1994, the fastest-growing market segment in the semiconductor industry was that of memory devices, which also represented the biggest market share. In the same year the market share of metal-oxide semiconductors (MOS) grew by 53 per cent worldwide, after an increase of 43 per cent in 1993 over its 1992 level. At the time of writing, it was expected that the market share would reach 57 per cent in 1995. The growth of the market for memory chips has been fuelled by the increasing demand for personal computers, which represent 60 per cent of total demand in that market segment.

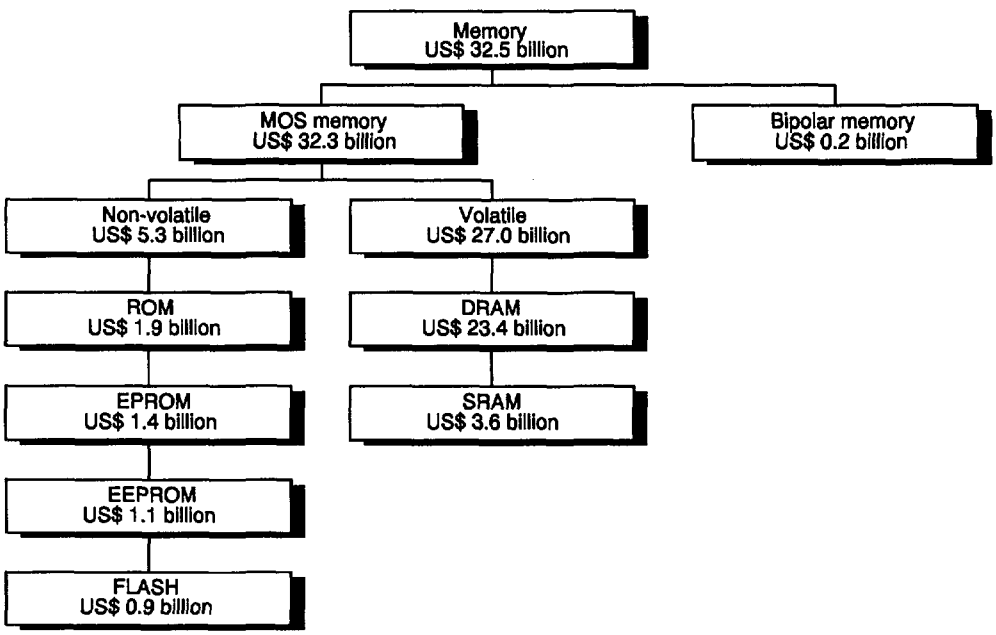
From 1994 to 1998, the memory chips segment is forecast to increase at an annual average growth rate of 29 per cent because of continuing strong demand for personal computers and newly emerging applications for cellular phones which require mainly non-volatile memories and static random access memory (SRAM). Figure 19 shows the market share of the memory segment by type.

Forecasts for 1998 show that the world market for memories could represent close to 40 per cent of the total semiconductor market. By the year 2000 the market for volatile memories in particular will enjoy new demand that will be stimulated by the consumer goods category, for example for digital television applications.

Micro-components

Microcomponents are a type of digital integrated circuits developed from the original 4-bit microprocessor component originally used in calculators. From those humble beginnings in 1971, microcomponents have become the dominant driver of electronics, resulting in the establishment of the entire personal computer industry and the dominant semiconductor supplier, Intel.

Figure 19. World market share of memory chips, by type, 1994



Source: Database of J. P. Dauvin, SGS-Thomson Microelectronics, Paris.

In general, microcomponents can be divided into two groups, namely microprocessors and microcontrollers (see figure 20). Microprocessors are used mainly in personal computers, which account for 80 per cent of their total usage. Microcontrollers have broader applications, ranging from consumer goods to automotive parts, to nearly all industrial applications. The technology used in microcontrollers is about two generations ahead of microprocessors. In 1995 the biggest market was for 8-bit microcontrollers and for 32-bit microprocessors, such as the Pentium of Intel.

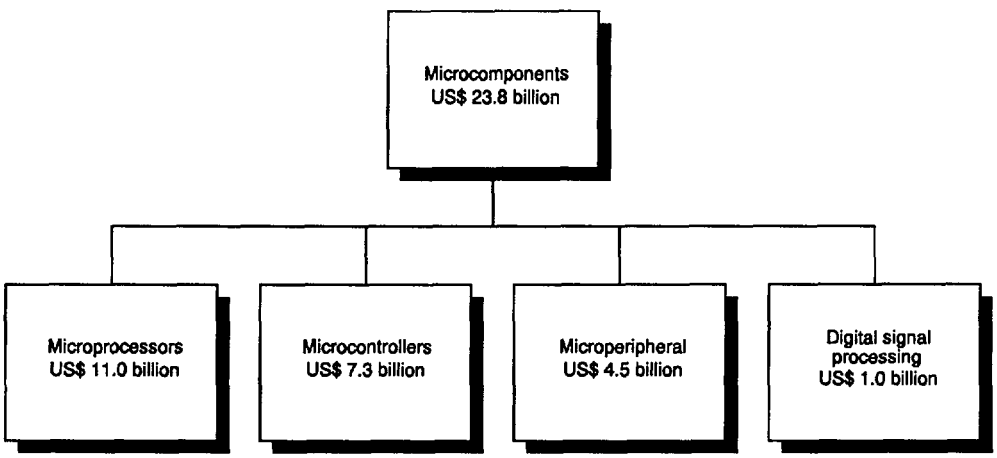
The future of the microcomponent market seems bright. Microprocessors will continue to be used in personal computers, and microcontrollers will pervade even more applications.

Analog integrated

Analog products are semiconductors that deal with electrical signals and power (see figure 21). Analog components carry information

circuits through voltage, current, frequency, phase, duty cycle or other electronic parameters. Since they are not based on number values, analog information is not limited to a finite range of values and therefore has no inherent quantification of noise or error. On the negative side, analog signal information can be garbled because the information-carrying electronic parameters vary due to noise, drifts and component instability.

Figure 20. World market share of microcomponents, by type, 1994

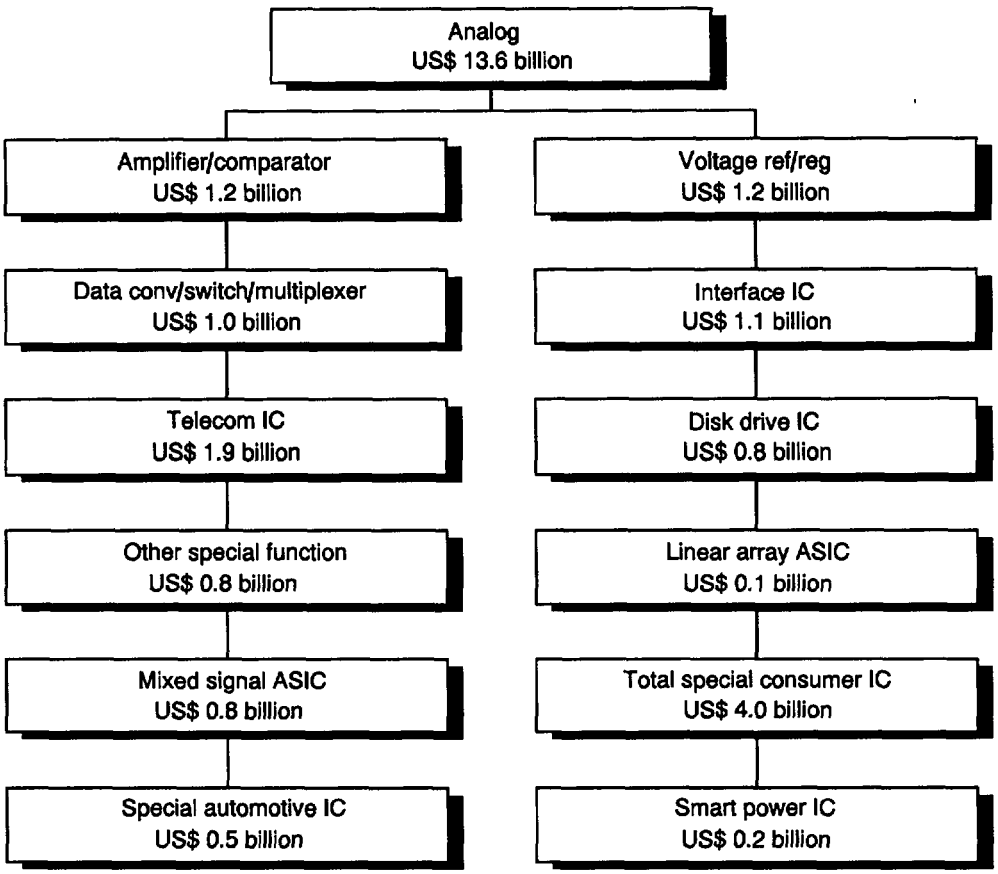


Source: Database of J. P. Dauvin, SGS-Thomson Microelectronics, Paris.

The consumer market for analog integrated circuits continues to grow even though its importance is declining. Data-processing applications such as disk drives and integrated circuits, which together accounted for 38 per cent of the semiconductor market share contributed to an increase in the use of analog integrated circuits. In 1994, the market for analog integrated circuits grew by 27 per cent over 1993, and was expected to grow by 29 per cent in 1995. It is estimated that sales of analog integrated circuits could reach $27 billion by 1998, that is, 12 per cent of the total semiconductor market share with an average annual growth rate of 18.4 per cent.

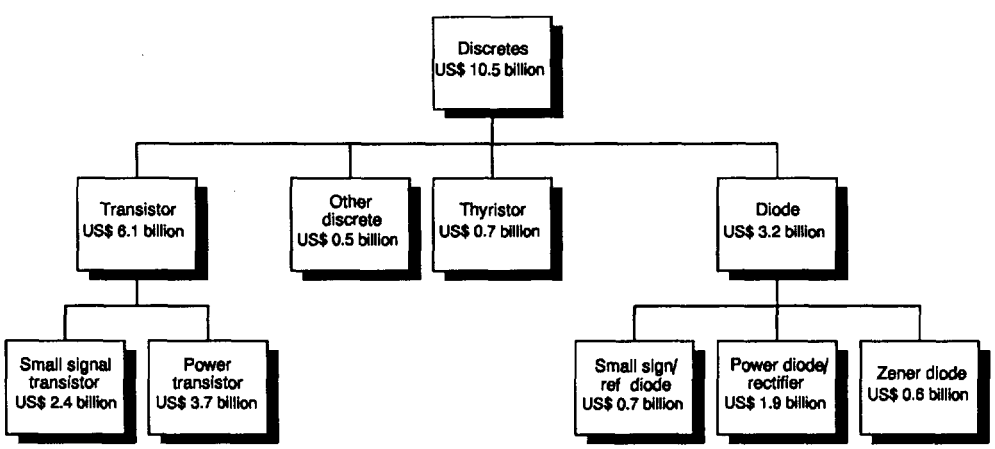
Discrete semiconductors Discrete semiconductors were the first devices manufactured by the industry as a whole. Despite its peripheral role, the market for discrete semiconductors continues to grow steadily and that growth could accelerate in the future. Discrete semiconductors are often referred to as the "cash cow" in the portfolio of a company. The future growth rate is expected to be 10-12 per cent per year, and in 1998, sales are expected to reach $19 billion, or 8 per cent of the total semiconductor market share. Figure 22 presents the market share of discrete semiconductors by type.

Figure 21. World market share of analog integrated circuits, by type, 1994



Source: Database of J. P. Dauvin, SGS-Thomson Microelectronics, Paris.

Figure 22. World market share of discrete semiconductors, by type, 1994

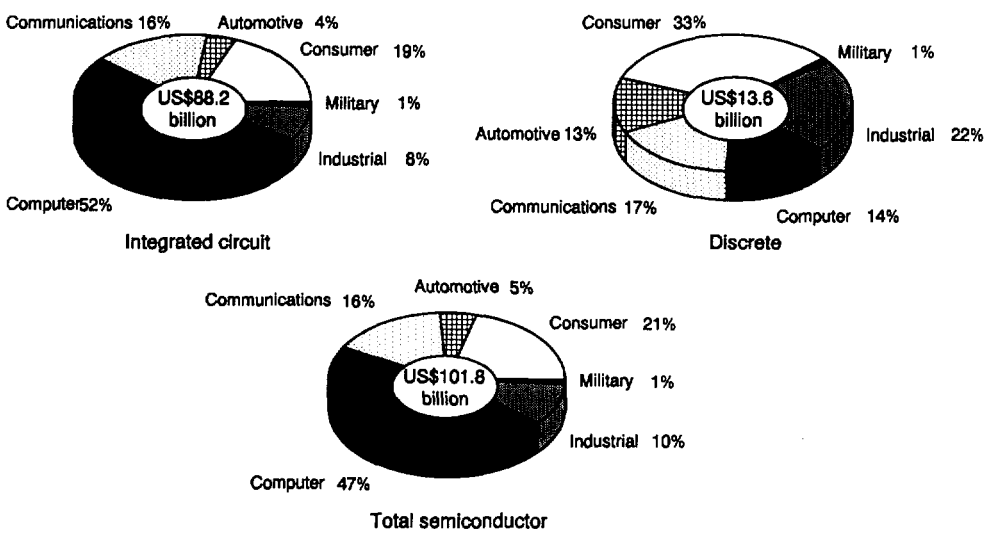


Source: Database of J. P. Dauvin, SGS-Thomson Microelectronics, Paris.

Market by end use

In terms of end use, the market for semiconductors can be divided into two specific markets, integrated circuits and discrete semiconductors. In 1994, the market for integrated circuits was driven primarily by their use in the computer industry, while the greatest demand for discrete semiconductors stemmed from their applications in the consumer segment (see figure 23). 1993 was the first year when the computer segment represented more than half of the integrated circuits market (an increase of 2 per cent over 1992). In 1994 the computer segment gained an additional point because of the increased demand for personal computers. Military applications, which represented around one per cent of the total semiconductor sales (down from two per cent in 1993), are likely to decrease even further throughout the second half of the 1990s, especially as budgets, including that for military spending in the United States, are slashed.

Figure 23. World semiconductor market, by end use, 1994

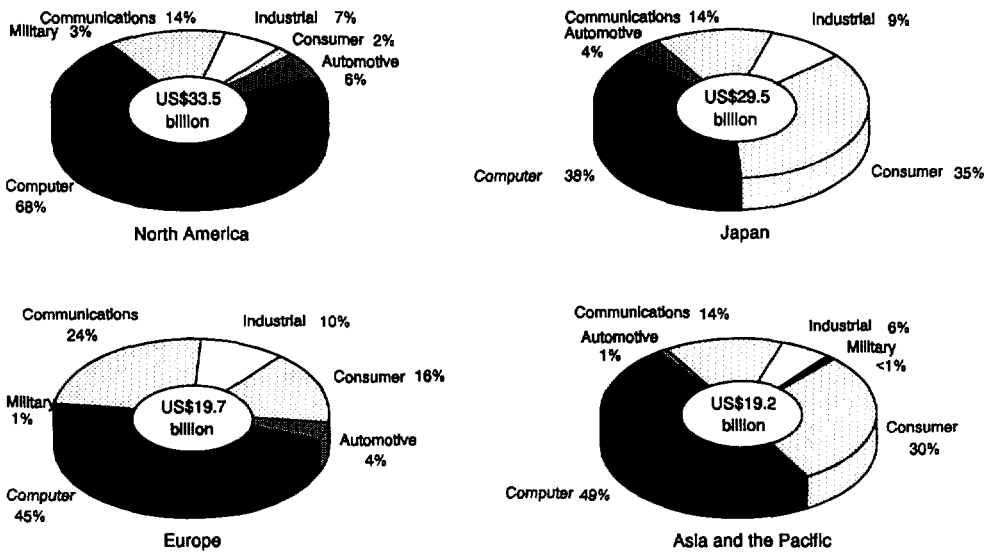


Source: World Semiconductor Trade Statistics, January 1995, ICE status (San Jose, California, April 1995) and database of J. P. Dauvin, SGS-Thomson Microelectronics, Paris.

One of the major segments of the semiconductor market in 1994 was the communications segment, which accounted for 16 per cent of total world semiconductor demand, or 2 per cent above the 1993 level. In many countries, the telecommunication industry is growing even more rapidly than the personal computer industry. Total production of cellular phone handsets, which require both analog and digital technologies, reached $12 million in 1994, twice the level of 1993.

The markets for integrated circuits in the major regions, namely Japan, North America, Europe and Asia and the Pacific, vary with respect to end use, as can be seen in figure 24. The market in North America was highly dependent on the computer industry, which accounted for 68 per cent of the market share in 1994. The computer and telecommunications industries together represented 82 per cent of total use of semiconductors in the region.

Figure 24. Regional breakdown of the world semiconductor market, by end use, 1994



Source: World Semiconductor Trade Statistics, January 1995, ICE status (San Jose, California, April 1995) and database of J. P. Dauvin, SGS-Thomson Microelectronics, Paris.

The Japanese market was very reliant on the consumer segment in 1994. Given mounting economic uncertainty, and the lack of new consumer products, Japanese sales of consumer systems decreased by three per cent in 1994. Furthermore, being shut out of several high-volume personal computer markets, many Japanese companies have focused on the sales of telecommunications systems.

In the communications segment faired well in Europe in 1994. With the opening-up of eastern Europe, a tremendous pent-up demand for structural change and telecommunications systems arose that required a great deal of integrated-circuit-based telecommunications equipment. As mentioned above,

the communications segment represents almost one fourth of Europe's total semiconductor market.

The Asia and Pacific region benefited from its participation in the fast-growing personal computer industry, unlike Japan where much of the computer sales are in large mainframe systems. Although 30 per cent of consumption was claimed by the consumer segment in 1994, Asia and the Pacific has taken over the Japanese market share in that segment because production costs are much lower. As a result, the semiconductor market segment in Asia is forecast to surpass that of Europe, thus becoming the third largest consuming region in 1995.

By the year 2000, as shown in table 41, it is envisaged that the following changes in the structure of the various segments of the semiconductor market will occur.

Table 41. World market growth, by segment, 1994 and 2000[a/]

	Sales (Billions of dollars)		*Percentage change*	*Percentage share*	
Segment	*1994*	*2000*	*1994-2000*	*1994*	*2000*
Computer	47.8	144.0	20.2	47.0	48.0
Communications	16.3	54.0	22.1	16.0	18.0
Automotive	5.1	18.0	23.4	5.0	6.0
Consumer	21.4	54.0	16.7	21.0	18.0
Military	1.0	3.0	19.7	1.0	1.0
Industrial	10.2	27.0	17.7	10.0	9.0
Total	101.8	300.0	19.7	100.0	100.0

Source: World Semiconductor Trade Statistics, *Blue Book* (San Jose, California, March 1995); SGS-Thomson Microelectronics and Dataquest, *Market Share Report* (San Jose, California, April 1995).
a/ Forecast.

The computer segment, or data processing, will maintain its leading position owing to the growing demand for personal computers. The existing installed base will be replaced by a new market segment, namely home applications. With the emergence of new products such as the personal digital assistant and linkage with the communication devices such as cellular phone handsets the home applications segment could represent as much as 48 per cent of the total market share by the year 2000.

The communications segment, fuelled by the rapid growth of portable and wireless communication, more than 150 million sets will be produced by the

year 2000. This segment is forecast to command at least 18 per cent of the market share.

The automotive segment is also likely to register high growth. With an annual growth rate of 23.4 per cent, its share could reach 6 per cent by the year 2000.

The consumer segment is a very slow-moving market and its revitalization through digital technologies is not expected until after 2000. Its share could decrease to 18 per cent of the total market. Similarly, the shares of the industrial and military segments are expected to decrease to 10 per cent.

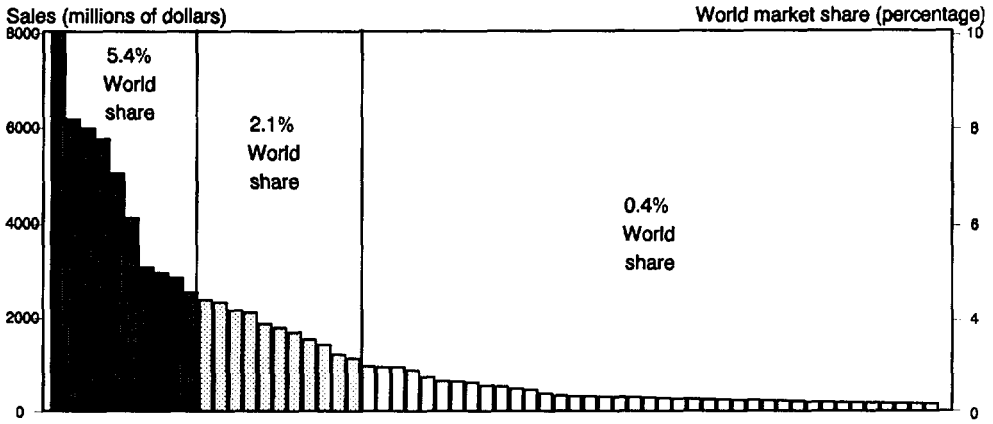
Performance of major companies

In 1994, approximately 120 companies were producing semiconductors for the world market. In addition to the companies producing for the merchant market, however, there are several captive manufacturers that produce exclusively for their own use. This stable portion of total production is estimated to be around $3 billion in value. IBM, the largest captive manufacturer, is currently selling certain products, mainly DRAM memories, on the merchant market.

Among the 120 companies producing semiconductors, the leading 60 companies produce more than 90 per cent of the world market share. As figure 25 shows, they can be divided into three groups. The first group of 10 companies comprises a broad range of suppliers, covering almost all the different types of products. The second group of 11 companies includes a broad range of suppliers and specialists. The third group, niche suppliers, are highly specialized in a specific market segment or subsegment. The industry structure has remained practically unchanged for the past 10 to 15 years and has a very stable concentration ratio, suggesting that the industry is still in its early developmental phase.

Over the past few years, some companies have either dissolved or merged. The most important mergers have been between National Semiconductor and Harris and between SGS and Thomson Semiconductors in 1987. General Electric merged with RCA and Harris Semiconductors in 1989. The latest merger of groups of companies occurred in 1992 between Matra Harris Semiconductor (France), Telefunken (Germany) and Siliconix (United States) to form TEMIC Semiconductor.

Figure 25. Structure and market share of the leading 60 semiconductor-producing companies worldwide



Source: Dataquest, Market Share Report (San Jose, California, April 1995).

Major semiconductor companies

In 1994, the top 20 companies claimed more thean 75 per cent of the world market share (see table 42). Intel (United States) continued to be far ahead of its competitors, achieving a world market share of more than 9 per cent generated by microprocessors. Japanese companies, such as NEC and Toshiba, with a world market share of 7.2 per cent and 6.8 per cent, ranked second and third, respectively. The ranking of other Japanese companies remained almost the same, reflecting their relatively poor performance during the past three years in comparison with their strong performance in 1980s.

The strongest growth was registered by companies in the Republic of Korea, namely Samsung and Lucky Goldstar, and was brought about by the extensive production of DRAMs. Samsung remained at seventh place in 1994, with an annual growth rate of 59 per cent, and Lucky Goldstar ranked twentieth for the first time, with an annual growth rate of 79 per cent in 1994. That IBM remained in tenth position reflects its strategy of increasing merchant sales, especially in the DRAM segment.

Among the three major European companies, SGS-Thomson of France and Siemens of Germany performed well in 1994, although they did not address the DRAM market. They ranked at thirteenth and seventeenth, with annual growth rates of 30 and 38 per cent, respectively.

Table 42. Leading semiconductor-producing companies worldwide, 1993-1994

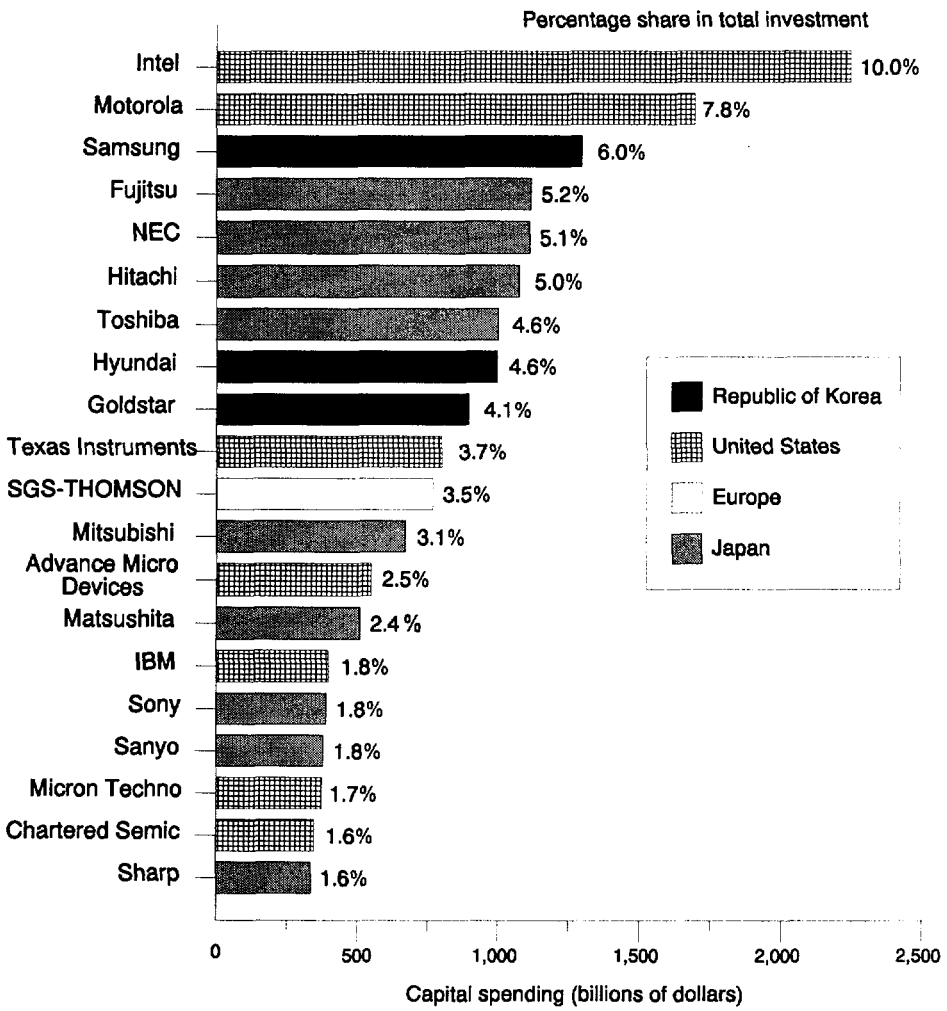
Rank	Company and country	Sales (Millions of dollars) 1993	Sales (Millions of dollars) 1994	Percentage change 1993-1994	Market share (percentage) 1993	Market share (percentage) 1994
1	Intel (United States)	7 970	10 099	26.7	9.3	9.2
2	NEC (Japan)	6 141	7 961	29.6	7.2	7.2
3	Toshiba (Japan)	5 727	7 556	31.9	6.7	6.9
4	Motorola (United States)	5 957	7 238	21.5	7.0	6.6
5	Hitachi (Japan)	5 015	6 644	32.5	5.9	6.0
6	Texas Instruments (United States)	4 083	5 224	27.9	4.8	4.7
7	Samsung (Republic of Korea)	3 044	4 832	58.7	3.6	4.4
8	Fujitsu (Japan)	2 928	3 869	32.1	3.4	3.5
9	Mitsubishi (Japan)	2 823	3 772	33.6	3.3	3.4
10	IBM (United States)	2 510	3 035	20.9	2.9	2.8
11	Philips (Netherlands)	2 300	2 920	27.0	2.7	2.6
12	Matsushita (Japan)	2 344	2 896	23.5	2.7	2.6
13	SGS-Thomson Micro- electronics (France, Italy)	2 038	2 640	29.5	2.4	2.4
14	Sanyo (Japan)	1 843	2 321	25.9	2.2	2.1
15	Sharp (Japan)	1 760	2 188	24.3	2.1	2.0
16	Advanced Micro Devices (United States)	1 660	2 134	28.6	1.9	1.9
17	Siemens (Germany)	1 510	2 090	38.4	1.8	1.9
18	National Semiconductor (United States)	2 060	2 023	-1.8	2.4	1.8
19	Sony (Japan)	1 398	1 876	34.2	1.6	1.7
20	Goldstar (Republic of Korea)	946	1 697	79.4	1.1	1.5
	TOTAL	64 057	83 015	29.6	74.9	75.3
	All others	21 411	27 237	27.2	25.1	24.7
	World	85 468	110 252	29.0	100.0	100.0

Source: Dataquest, *Market Share Report* (San Jose, California, March 1995).

Capital spending of major companies

At the time of writing, it was expected that a slight change in the ranking would occur in 1995, since all major companies would enjoy excellent market conditions. Their continuing performance will depend on the extent to which they invest in expanding production capacity. Figure 26 shows the capital spending of the top 20 semiconductor companies in 1994. Companies in the United States and the Republic of Korea increased investment, stepped up, unlike companies in Japan. It was estimated that in 1995 the world market share of Japanese and United States companies would be the same, even though Japanese companies performed better than their United States competitors, especially in the market for DRAM, during the second half of the 1980s.

Figure 26. Capital spending of major companies, 1994

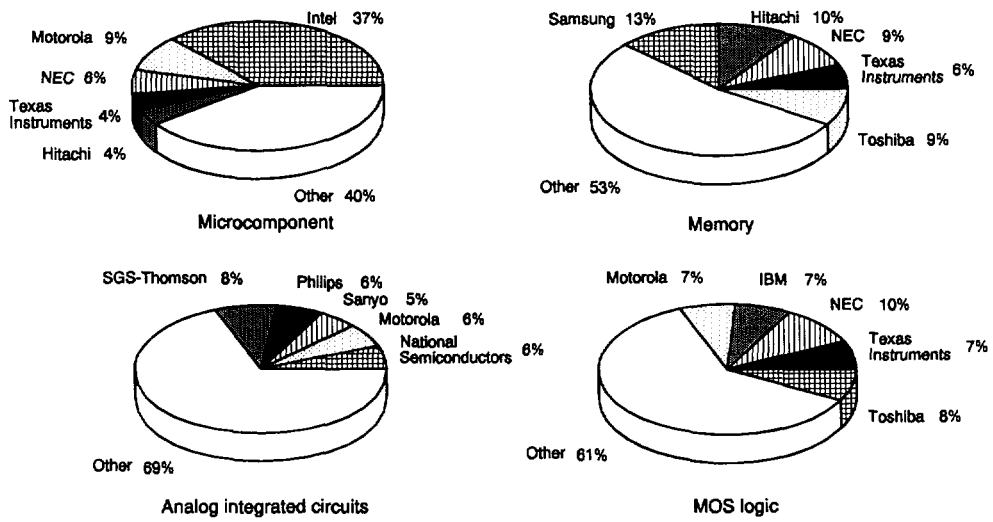


Source: Dataquest, *Market Share Report* (San Jose, California, April 1995).

Leading five companies by segment

Figure 27 provides the market share of the five leading companies in each of the major segments in 1994, and as can be seen, no significant change in any of the major segments has occurred over the past few years, with the exception of the microcomponent segment. Intel continues to dominate that segment, registering 37 per cent of the market share. In the memory segment, Samsung, with a world market share of 13 per cent, has established itself as the dominant supplier. In the DRAM segment, again Samsung occupied 25 per cent of the world market share in 1994. In the analog integrated circuits segment, the top five companies continue to compete with each other, occupying between 5 and 8 per cent of the market share.

Figure 27. Performance of the leading five companies, by major market segment, 1994



Source: Dataquest, *Market Share Report* (San Jose, California, April 1995).

International trade

Global trade in semiconductors has increased significantly. Specifications for each product category have been established worldwide, and trade barriers do not seem to pose serious problems for exporters. As can be seen from table 43, all regions, excluding Japan, tend to import more than they export, thus creating a trade deficit. Until recently, Japan was a net exporter in the industry, with a positive balance of $18 billion.

The negative trade balance of the United States is difficult to explain if the strong competitiveness of its semiconductor industry alone is considered. In 1994, its sales of semiconductors amounted to $46.1 billion, around 42 per cent of the total world market, but sales in the domestic market stood at only $35.9 billion.[4] This could be attributed to the following: (a) the growing demand for DRAMs which are only marginally produced by United States manufacturers; (b) imports of large amounts of Japanese electronic equipment; and (c) while the trade balance reflects regional exchanges, sales of companies take into account the national origin of the corporation. This has led to a strong relocation of many United States plants, compelling manufacturers not only to buy and operate back-end plants in countries such as Singapore and Malaysia, but also to re-import components to the United States both for internal use and for export to Europe.

Table 43. World semiconductor trade, by region, 1994
(Billions of dollars)

Country or region	*Exports to:*					*Imports from:*					
	United States	*Japan*	*European Union*	*Asia and the Pacific*	*Exports total*	*United States*	*Japan*	*European Union*	*Asia and the Pacific*	*Imports total*	*Trade balance*
United States	-	3.4	3.8	10.7	17.8	-	7.7	1.8	14.4	23.8	-6.0
Japan	7.7	-	2.7	14.4	24.8	3.4	-	0.2	3.1	6.8	18.0
European Union	1.8	0.2	-	3.6	5.6	3.8	2.7	-	4.8	11.2	-5.6
Asia and the Pacific	14.4	3.1	4.8	-	22.3	10.7	14.4	3.6	-	28.7	-6.4

Source: World Semiconductor Trade Statistics, *Blue Book* (San Jose, California, March 1995).

Owing to the increasing competitiveness of the Asia and Pacific region in terms of production capacity and increased demand in internal markets, the European Union has suffered a negative balance of more than $5 billion.

A similar trade deficit has been registered by the Asia and Pacific region due mainly to the imports of DRAM memories and microprocessors from Japan and the United States. However, recent heavy investments by Asian companies in the emerging economies of Asia, particularly the Republic of Korea and Taiwan Province of China, could contribute towards reducing the current trade deficit of the region (see table 44).

TECHNOLOGICAL TRENDS

Technology is clearly the root of the success of the semiconductor industry. Even if its relative importance is currently lower than it was during the early stages of the industry, technology continues and will continue to promote the industry as a whole. Overall, technological evolution in the next few years will concentrate on following: miniaturization of the multifunction from the present 0.8-micron to 0.1-micron technology; low-voltage devices in portable systems and "green" PCs from 5 volts to less than 1 volt; integration from 1 million transistors to 100 million transistors on a 1- to 4-square centimetre chip; and packages from 1,000 pins up to several thousand pins.

Table 44. Trade balance of countries and territories in the Asia and Pacific region, 1994
(Millions of dollars)

Country or area	*Exports*	*Imports*	*Trade balance*
China	121	281	-160
Democratic People's Republic of Korea	3	1	2
Hong Kong	921	3 862	-2 941
India	12	95	-83
Indonesia	73	159	-86
Malaysia	5 774	6 047	-273
Philippines	1 849	2 382	-533
Republic of Korea	6 290	3 487	2 803
Singapore	3 298	6 513	-3 215
Taiwan Province of China	3 015	4 223	-1 208
Thailand	919	1 634	-715
Viet Nam	1	1	-
Total	22 276	28 685	-6 409

Source: Japan Annual Trade Statistics Report (1994); United States Annual Trade Report (1994); Eurostat: Echanges commerciaux intérieurs et extérieurs de l'UE (1994).

Process technology

The nature of technologies involved in semiconductor processing has changed considerably since the 1970s. Table 45 presents the product life cycle of each of the major technologies. In the 1970s, the main technologies developed included P-channel metal-oxide semiconductors (PMOS); N-channel metal-oxide semiconductors (NMOS); and bipolar technology, such as emitter-coupled logic (ECL), transistor-transistor logic (TTL), speed/large-speed TTL (S/LS TTL) and linear technology, all of which are being phased out in the 1990s. For instance, in the 1970s, almost two thirds of the total integrated circuits market used bipolar technology. In 1994, that market share stood at 17 per cent. ECL-based integrated circuits are the fastest silicon-based devices available and have been in use for the past 24 years, but because of the dissipation of high power and steep costs, they have been relegated to a niche process technology. The market share for ECL-integrated circuits has been diminishing steadily, and is currently at 3 per cent. It has been forecast that such circuits will have a market share of less than 0.5 per cent by 1999.

No other technology has dominated the market for integrated circuits as much as that of complementary metal-oxide semiconductors (CMOS). Integrated circuits using CMOS represented 75 per cent of the total merchant

market in 1994, and are likely to rise to 86 per cent by 2000. Integrated circuits using bipolar complementary metal-oxide semiconductors (BiCMOS) are likely to register an average annual growth rate of 29 per cent between 1994 and 2000 (increasing from $0.4 billion to $8.5 billion).[3,4] Despite such a high growth rate, BiCMOS integrated circuits will represent only 5 per cent of the total integrated circuits market, and will continue to be considered a high-performance niche technology.

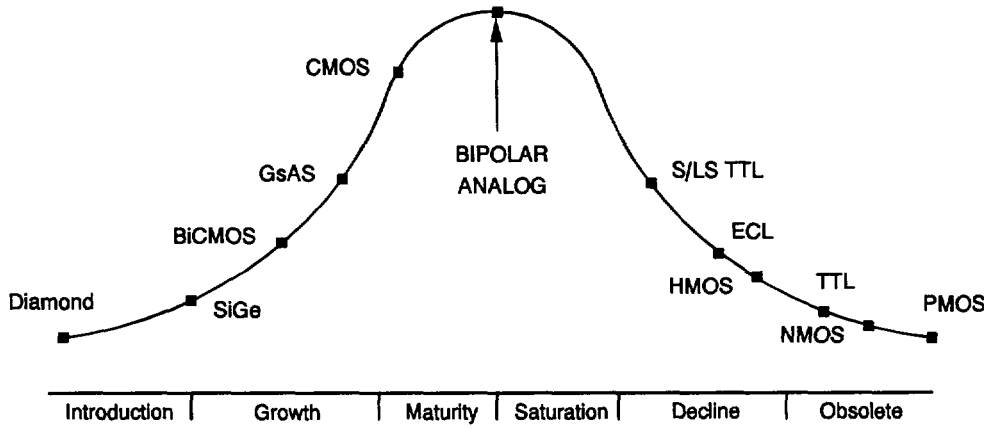
Table 45. Changes in market share of semiconductor process technologies, 1970-1999

		Market share (percentage)				
Process technology	*Characteristics*	*1970*	*1980*	*1993*	*1994[a]*	*1999[b]*
MOS						
PMOS	Slow, obsolete	31	5	-	-	-
NMOS/higher- frequency MOS	Obsolete	2	37	2	1	1 [c]
CMOS	Mainstream technology, (latch-up, slow operation)	2	10	77	78	85
BiCMOS	Early in its life cycle, offers both MOS and bipolar advantages, high cost/complexity limits application	-	-	3	5	5
Emitter-coupled logic	Fastest silicon-based process, receiving increased attention while competing with gallium arsenide, becoming obsolete	3	3	2	1	1 [c]
Transistor-transistor logic	Slow, obsolete	29	8	1	1 [c]	-
Speed/large-speed TTL	Mainstream bipolar logic, under pressure from MOS application-specific integrated-circuits	7	13	2	2	1 [c]
Linear	Mainstream analog technology, some competition from CMOS, especially in analog/digital converters and amplifiers, and gallium arsenide	26	24	13	12	8
Gallium arsenide	Cost competitive with emitter-coupled logic. To be used especially for analog application in the future	-	-	1 [c]	1 [c]	1 [c]

Source: World Semiconductor Trade Statistics, *Blue Book* (San Jose, California, March 1995).
a/ Estimated.
b/ Forecast.
c/ Less than one per cent.

CMOS technology reached maturity in the mid-1980s and no change is foreseen well into the twenty-first century (see figure 28). As of late 1994, no new technology had evolved, that could threaten CMOS as the main process for processing integrated circuits in the foreseeable future. CMOS circuits are likely to tay ashead if their manufacturers maintain cost effectiveness, improve their performance gradually and invest consistently high levels of profits in R & D.

Figure 28. Process technology life cycle, 1995



Source: World Semiconductor Trade statistics, January 1995 - ICE status (San Jose, California, April 1995) and database of J. P. Dauvin, SGS-Thomson Microelectronics, Paris.

It should be noted that integrated circuits using CMOS applications will continue to replace NMOS DRAMs and microprocessor units (MPU). The switch from one technology to another in the memory market for metal-oxide semiconductors (MOS) (for example, 256-kilobyte DRAMs are primarily NMOS, whereas 1-megabyte DRAMs are all CMOS) occurs very quickly when moving from one generation of products to the next. The popularity of CMOS as compared with NMOS, PMOS, and BiCMOS is very evident. In fact, CMOS and BiCMOS are likely to represent 100 per cent of the MOS market in 2000. As mentioned earlier, the recent dramatic shift from NMOS to CMOS is primarily due to memory devices. CMOS became the technology of choice as MOS memory density reached and surpassed 1 megabyte. All 1-megabyte DRAMs that are produced use CMOS technology, and nearly all the very large-scale integration (VLSI) and ultra large-scale integration (ULSI) technology of memory devices in the future will use CMOS or BiCMOS technology.

Japanese companies currently dominate the market for MOS integrated circuits, and their market share has risen to 50 per cent. United States companies occupy the largest percentage of the bipolar market, 43 per cent. Some of the large companies in the United States are still heavily involved in bipolar digital technology, which may eventually prove to be advantageous for manufacturing BiCMOS devices. Companies having

expertise in ECL, such as Motorola and National Semiconductor, could benefit the most initially.

On the basis of the announcement made by NEC of Japan of its 64-megabyte DRAM devices in March 1993 and by Samsung of the Republic of Korea about its production of a fully functional 256-megabyte DRAM in 1994, it appears that the density trend line of DRAM integrated circuits will stay intact through the late-1990s. Despite the fact that the Intel Pentium MPU (3.1 million transistors) fell slightly short of MPU/logic trend line in 1993, it is expected that the introduction in 1995 of the P6 and PowerPC 620 MPUs, each having more than 7 million transistors, maintain the density trend line of MPU/logic as well.

CMOS CMOS technology continues to be more popular than other technologies because of several important advantages: low-powered density; relatively good noise immunity and soft error protection; low-threshold bias sensitivity; design simplicity and relatively easy layout, especially for application-specific integrated circuits, and capability for low-powered analog and digital circuitry on the same chip. Because of those advantages, CMOS is expected to be used for VLSI and ULSI products in the future. Just as NMOS replaced PMOS technology, CMOS has replaced NMOS. The speed and power features of CMOS are major reasons for an increase in the market share. In fact, CMOS is expected to acquire bipolar speeds as lithography techniques improve and smaller feature sizes are manufactured.

BiCMOS Because of the greater advantages offered by BiCMOS over both bipolar digital and CMOS integrated circuits, they will eventually replace many s uch circuits. These include microprocessor units, bus drivers, analog-to-digital converters, track/hold amplifiers, disk-drive controllers, memory controllers, SRAMs, DRAMs, video RAMs, programmable logic devices, gate arrays and standard cells. The move to incorporate megacell functions on to a chip is also enhancing the acceptance of BiCMOS technology for gate array devices. Because of the high degree of flexibility of the circuit characteristics in BiCMOS technology, which makes it possible to use high-drive and high-performance bipolar and low-power-consumption CMOS, and because of its overall performance edge over pure CMOS, BiCMOS is one segment of the market for integrated circuits that continues to gain popularity.

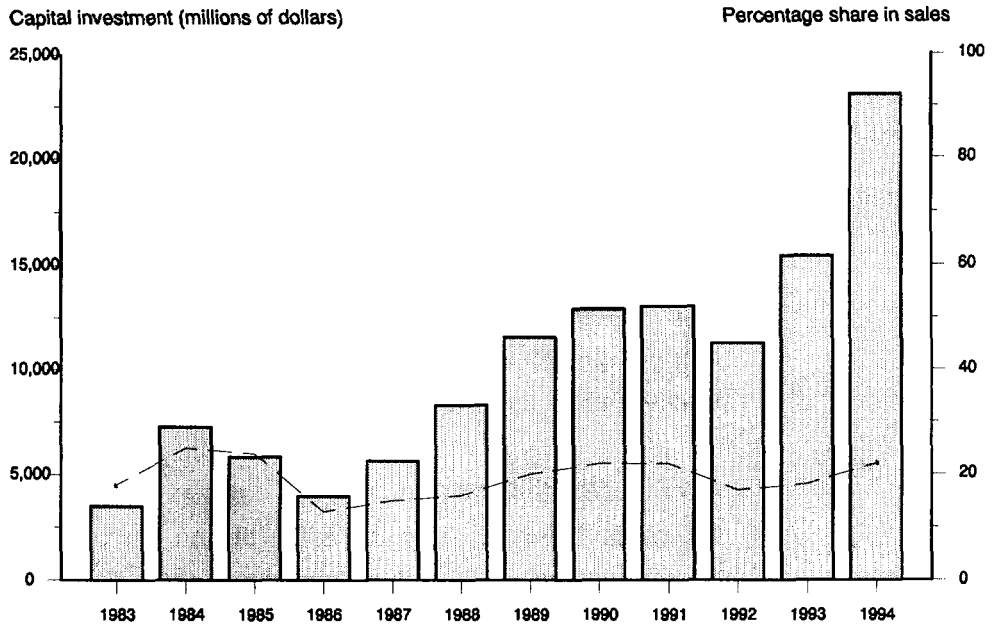
Integrated circuits

Integration levels have grown steadily since the invention of the integrated circuit. The integration levels of MOS have increased by an average of 35-50 per cent per year over the past 24 years. MOS memory devices using VLSI integrated circuits are expected to contain over 256 million transistors per chip by 1998, and over 1 billion transistors per chip are forecast for the year 2000.[5] As the number of transistors per die escalated, the die area of new integrated circuits increased by about 13 per cent annually between 1970 and 1994. The trend towards larger die sizes is expected to continue until the late 1990s. In 1994, 256-megabyte DRAM die sizes ranging from 472 to 638 kilobytes per square millimetre were produced, and the measurement of the longest side of the largest DRAM chip was 1.1 inches. The size of a "tight production resolution" device decreased from about 3 microns in 1980 to around 0.35 microns in 1994, representing an annual decrease of around 15 per cent. This trend is expected to continue, and its sizes is forecast to reduce further to about 0.15 micron by 2000. It is interesting to note that by 2000, 0.7-micron feature sizes will be considered obsolete. Because of its relatively low cost and owing to technical advances, optical lithography is now expected to remain viable much longer than originally expected. Optical techniques will therefore be the mainstream of integrated circuit lithography by 2000.

Investment requirements

The semiconductor industry has always been capital intensive and will continue to be so. On an average, the industry has invested 20 per cent of its total value of sales on an annual basis (see figure 29). A major part of those expenses have been devoted to new facilities (90 to 95 per cent of the total amount spent each year), with a minor part allocated to maintenance of equipment. The recent dramatic increase in the cost of technology, largely because of increases in the level of chip integration, has raised manufacturing costs considerably. During the past 30 years, the cost of a manufacturing plant or a typical diffusion facility such as wafer manufacturing plant soared from $30 million in the mid-1970s to $1 billion in 1995, with 80 per cent of the costs used for equipment in 1995, as compared with 40 per cent in the mid-1970s. The costs of setting up such a plant could reach $2-$2.5 billion in 2000. The rise in costs is due to the smaller critical dimensions, the merging of various technologies involving the same die (logic, memories, power), and the increasing quality requirements and wafer output.

Figure 29. Capital investment flow of the semiconductor industry, 1983-1994



Source: J. P. Dauvin, *Semiconductor Market Forecast* (Paris, SGS-Thomson Microelectronics, 1995).

Table 46 summarizes the latest cost estimates of a manufacturing plant. The total cost of establishing a front-end production facility amounted to $1 billion in 1995. The weekly production of 8-inch wafers was $4,000, and such a facility could generate $1.2-1.3 billion in revenues each year for at least five to six years before becoming obsolete. Currently, the proportion of a manufacturing plant installed for manufacturing 8-inch wafers is less than 15 per cent. It is estimated, however, that that proportion could increase to as much as 70 per cent by the year 2000.

Table 46. Estimated costs and capacity of wafer-manufacturing plant

	Wafer fabrication cost	*Technology*	*Wafer size (inches)*	*Annual wafer output*	*Output (sq. in./yr.)*[a/]	*Annual revenue*
Early 1990s	300[b/] - 1[c/]	1.0 - 0.6μm	6 - 8	250 - 300K	10[a/]	500[a/] - 2.5[b/]
Late 1990s	1.0 - 1.3[b/]	0.5 - 0.25μm	8	250 - 300K	15[a/]	1 - 4[b/]
Early 2000s	1.5 - 5.0[b/]	< 0.2μm	12	250 - 300K	35[a/]	2 - 10[b/]

Source: Robertson and Stephens, "Semiconductor capacity", Institutional Research (San Francisco, 27 July 1995).
a/ Millions of dollars.
b/ Billions of dollars.

Manufacturers of semiconductors are focusing not only on process capability, but also on the costs involved for achieving that capability. The cost of purchasing, operating and maintaining a unit of capital equipment is generally quantified in terms of cost of ownership. Since such costs are linked to specific equipment, an indication of the operating efficiency of a plant can be gained from its return on net assets. Another measure of the effectiveness of capital spending is given by the capital spending efficiency ratio, which is defined using four consecutive years' incremental revenues divided by four consecutive years' capital expenditures displaced by one year. Chip companies have tightened their manufacturing operations and composite average selling prices have increased over time, with the result that the ratio has increased from the historical 1:1 to the current 1.4:1.

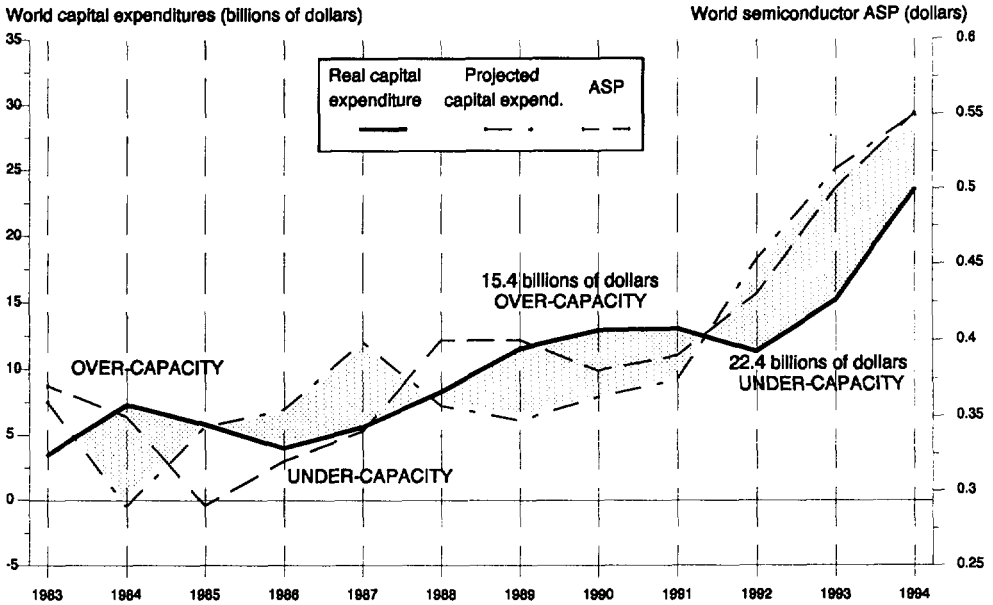
Considering the above mentioned costs as well as the sales market volume, which is forecast to reach $300 billion by the year 2000, an expected investment of $170 billion will be made for setting up 110-115 new production facilities globally. Clearly, such a large investment matches closely investments made in the automotive industry.

The growth pattern of investment has not been linear in the past. In 1993 there was an increase of 35 per cent in investment over the 1992 level. Despite intensive spending in 1994, investment increased by 55 per cent over that in 1993. In 1995, total investment was expected to reach $31 billion, an increase of 30 per cent over 1994. This is bound to influence the price of semiconductors, and could give rise to under- or over-capacity periods in the future. In 1992, the semiconductor market entered an under-capacity period following a period of over-capacity.

Figure 30 illustrates the successive under- and over-capacity periods, based on a model of projected capital spending in the industry worldwide. The figure also plots the average selling price of semiconductors, which shows the correlation between over- and under-capacity as well as the market price of semiconductors.

Looking at the level of investment generated by the industry, especially in DRAM memories, it is estimated that in 1997 and 1998, the semiconductor industry as a whole will enter a period of over-capacity, but without a drastic decrease in sales, as was the case in 1985 and 1990 (-17 and 4 per cent, respectively). Sales will slow down in 1995 and 1996, but will recover in 1997 and 1998 to 16 and 19 per cent, respectively.

Figure 30. Trend in world semiconductor capacity, 1983-1994



Source: World Semiconductor Trade statistics, *Blue Book* (San Jose, California, March 1995); database of SGS-Thomson Microelectronics and Dataquest, *Market Share Report* (San Jose, California, April 1995).

Technology requirements

The semiconductor industry is also heavily dependent on R & D spending. That dependence is increasing because the rapid pace of technological change requires constant advancement in process technology and in device capabilities, which also helps to maintain competitiveness between companies in the industry. Over time and several product generations, the costs of R & D have also increased rapidly. For example, the cost of R & D for prototyping of the 256-kilobyte DRAM which was introduced in the market in 1983 and shipped in bulk in 1985, amounted to $110 million. The current generation of the 16-megabyte DRAM, introduced in 1992 and delivered in volume in 1994, cost $850 million; it is estimated that R & D costs for developing the 64-megabyte DRAM expected to be shipped in volume in 1997-1998 will amount to more than $1 billion.

In general, R & D expenditure represents 15 per cent of the total value of annual sales. In 1994, companies in the United States spent 16 per cent of their sales volume in R & D. Japanese companies lagged behind, spending less than 13 per cent of their sales.

Human resource requirements

In 1994, workers employed by the semiconductor industry numbered 850,000, a slight increase of 2 per cent over 1993. Owing to its remarkable success, especially in the chip industry. Labour expenses in 1994 equaled approximately 30 per cent of total sales revenues, but there are currently signs of a steady downward trend as production facilities become more automated. Another key factor has been the relocation of manufacturing operations, especially assembly operations, to developing regions where cheap, semi-skilled labour is available in abundance, Asia, for example.

Labour productivity, measured as a proportion of sales revenue per employee, increased as of 1978. The long-term annual growth rate of 15 per cent corresponds closely to market growth.

Government contributions

Because of the importance of the semiconductor industry as a key high -technology industry, Governments have been supporting its development by economic and technology policy measures. The bulk of such support is directed towards R & D, the intensity and form of which vary between countries. Governments encourage R & D by investing in production sites, providing tax incentives and constructing and financing research organizations that play an important role in the success of R & D efforts. Such measures are supplemented by competition policy and aid for education and training. Table 47 illustrates the assistance afforded to the industry by Governments of selected countries.

In the United States, an economic policy offensive was initiated in the 1980s, when the semiconductor industry began to lose its international competitiveness. The basis for assistance was provided by the National Cooperation Research Act (84), which foresaw the formation of research consortia, such as Sematech, a consortium for semiconductor machinery and technology established in 1987. The R & D strategy of Sematech is to develop the software technologies, such as modelling, simulation and computer-integrated manufacturing, that are available for chip production. One goal is to reduce the length of the technology development cycle by 25 per cent. Its efforts also focus on the needs of high-volume, integrated circuit manufacturing with broad product portfolios.

Table 47. Internal comparison of State assistance for the semiconductor industry in selected countries

	Japan	*Republic of Korea*	*Taiwan Province of China*	*United States*	*Germany*	*United Kingdom*	*Ireland*	*France*
General								
Economic and technology policy[a/]	Y	Y	Y	Y	Y	Y	Y	Y
Sectoral industrial policy[b/]	Y	Y	Y	P	N	N	N	Y
State planning	Y	Y	Y	N	N	N	N	Y
Government-industry cooperation	Y	P	Y	P	N	N	N	Y
Rule-oriented assistance[c/]	N	N	Y	Y	N	Y	Y	Y
R & D policy[d/]								
Tax incentives	Y	Y	Y	P	N	N	N	N
Financial aid	Y	Y	Y	Y	Y	Y	Y	Y
Research infrastructure	Y	Y	Y	Y	Y	Y	P	Y
Investment assistance								
Tax incentives	Y	Y	Y	Y	Y[e/]	P	Y	N
Financial aid	N	Y	Y	P	Y	Y	Y	Y
Infrastructure policies[f/]	N	N	Y	Y	Y	Y	N	P
Market access								
Customs protection	N	Y	N	N	Y[g/]	Y[g/]	Y[g/]	Y[g/]
Anti-dumping measures	N	N	N	Y	Y[g/]	Y[g/]	Y[g/]	Y[g/]
Structural market barriers	Y	Y	N	N	N	N	N	N
Offensive trade policy	N	N	N	Y	N	N	N	N
Competition policy								
General	N	N	N	Y	Y	Y	Y	P
Allowance of R & D cooperation	Y	Y	Y	Y	Y	Y[h/]	Y[h/]	Y

Source: Institute for Economic Research (Ifo), Munich 1994.
Note: Y: Yes; N: No; P: Partial.
a/ Employment of subsidies and regulatory instruments beyond general measures to make locations more attractive.
b/ In terms of the semiconductor industry.
c/ Does not imply result-oriented assistance.
d/ Of less importance in the United Kingdom and Ireland.
e/ Only in the new Länder.
f/ Particularly directed at semiconductors.
g/ From the European Union.
h/ Of little relevance in the United Kingdom and Ireland.

In the past ten years, but especially under the present United States administration, a new policy has been established to provide State assistance to industrial R & D by means of various programs that promote high-technology R & D and by redeployment of the military budget towards civilian applications. The programs include: a technology reinvestment program to help in the conversion of the defence industry and to share technology with the private sector; an advanced technology program to

promote high-technology projects of the private industry; small business innovative research to guide the diffusion of new technology among small businesses; and cooperative research development to support the collaboration between the 726 federal laboratories and private industry. The main source of funding for the programs is the Department of Defense of the United States, and some 20 per cent is financed by public authorities.

In the European Union, R & D in semiconductors is assisted by national and Europe-wide programs. ESPRIT I (1984-1988) focused on research at the pre-competitive stages. ESPRIT II (1988-1992) aimed at advancing ASIC development and ensuring commercial uses of ESPRIT I results. The original strategy of the Joint European Submicronic Silicon Initiative project was to further the development of memory chip technology. In 1990-1991 a reorientation of the program focused its research efforts towards application-oriented chips.

The efficiency of the European Union measures existing side by side is, however, questionable. Between 1987 and 1994 sales of key European companies doubled from $4.2 billion to $9.8 billion, while the R & D funding in Europe remained constant at $60 million, representing only 0.6 per cent of the sales in 1994.

In Asia, the structure and organization of national assistance systems are more important for R & D than the actual amount of subsidies received. In Japan, for instance, MITI played an important role on the development of the semiconductor industry in the 1980s. In the Republic of Korea, the Electronics and Telecommunications Research Institute extended assistance until prototypes became marketable export products. In Taiwan Province of China, the State-owned Electronics Research and Service Organization made its laboratories and scientists available either at no charge or for nominal licence fees until national research projects were completed. Overall, maximum assistance is being extended in the newly industrializing countries of Asia.

In terms of investment aid, the methods of investment assistance differ among individual countries. In the United States, since the Federal Government does not provide any investment aid, states and local communities offer sales and property tax exemptions to attract companies. They also provide special training and recruitment assistance. State taxes, which represent 44 per cent of the total United States taxes, are fully

negotiable. In Europe, unlike in the United States, sectoral investment aid does not exist. Regional policy assistance can be claimed directly by all industrial companies. Priority is given to some selected regions and countries (the new *Länder* in Germany, the whole of Ireland, the southern part of Italy and Scotland). In Ireland, in addition to European regional assistance, benefits can be derived from a corporation tax rate of 10 per cent until the year 2010. Primary aid in Japan includes the granting of a special depreciation allowance of up to 80 per cent for equipment. In the Republic of Korea, investment assistance is marked by low-interest loans and corporation taxes at rates of between 10 and 20 per cent. Taiwan Province of China offers favourable conditions in the Hsinchu Scientific Park, where companies are exempt from paying corporation taxes for four to five years.

In addition to financial grants, other influencing factors provided by Governments are low-cost sites and buildings, infrastructure facilities, cheap rates for energy and water and financial assistance for pollution control equipment. Apart from assistance in R & D and investment, other factors that impede fair international competition include import duties, anti-dumping measures, public procurement regulations, vertical integration of firms and labour and production costs.

Environmental considerations

The semiconductor industry has traditionally been considered one of the cleanest industries. Nevertheless, like most other industries, it has some common problems, namely the use and emission of harzadous substances in the manufacturing process, disposal of waste residuals and difficulty in establishing and maintaining an ecological balance.

In general, the air emissions of the industry involve acids, solvents and hazardous gases generated by plasma etching, ion implementation, epitaxial growth, CVD processes and back-end processes. The total acidity of a typical wafer manufacturing plant in 1994 was 0.10 milligrams per cubic metre and the total alkalinity was 1.33 milligrams per cubic metre.[6]

New methods have been developed for the treatment of emissions, namely abatement of acids by wet scrubbers, dry absorption, dry thermal treatment, dry plasma treatment and wet scrubbers for toxic gases. The industry has pursued several programs in recent years with success, including practically eliminating ozone-depleting substances from manufacturing processes, reducing the use of potentially hazardous materials and reprocessing and

recycling acids. Efforts have also been made to design facilities with decreased energy consumption, chemicals and wastes segregation and minimal effluents and emission. With the gradual increase of environmental regulations, however, particularly with regard to disposal options, an efficient design for the environment becomes more essential than ever. In order to conserve resources, prevent pollution, minimize wastes, save costs, decrease toxicity and improve the control of hazardous substances.

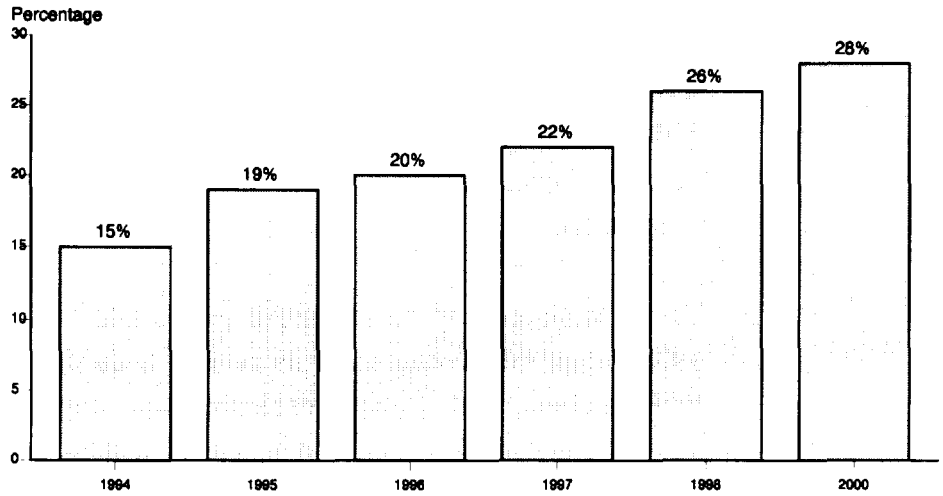
FUTURE PERSPECTIVES

As the industry is still in its early phase of development, the world semiconductor market is expected to grow at more than the estimated rate of 16 per cent per year. From 1994 to 1998, it is expected to grow at an annual rate of 23 per cent to reach $233 billion, and by 2000, it is forecast to reach $300 billion.[7] The dramatic increase in growth is mainly due to the continuous increase of the semiconductor content in electronic equipment, from 15 per cent in 1994 to 26 per cent in 1998, and possibly to 28 per cent by the year 2000 (see figure 31). This evolution will affect all categories of semiconductors, including discrete devices.

Table 48 provides the estimated market structure of major product categories of semiconductors in the year 2000.

A strong evolution has taken place in semiconductors, especially in memories and microprocessors, because of the rapid increase in the demand for personal computers, multimedia applications, portable communication and the digitalization of consumer goods. The evolution of discrete devices will depend on the continuous penetration of the semiconductor technology in applications such as industrial control and the automotives. The market share of each of the segments in 2000 is estimated as follows: 57 per cent for the computer segment, 17 per cent for telecommunications, 15 per cent for the consumer segment, 4 per cent for the automotive segment, and 7 per cent for industrial, military and space segment.

Figure 31. Trends in the semiconductor content in electronic equipment, 1994-2000



Source: J. P. Dauvin, *Semiconductor Market Forecast* (Paris, SGS-Thomson Microelectronics, 1995).

Table 48. World semiconductor market structure, by major product category, 2000

	Percentage
Discrete semiconductors	**11**
Microprocessors	13
Microcontrollers	10
Microperipherals	4
Memories	
DRAM	**26**
SRAM	3
Non-volatile	4
Semi-custom	**8**
Dedicated integrated circuits	**16**
Standards and commodities	**5**
Total	**100**

Source: J. P. Dauvin, *Semiconductor Market Forecast* (Paris, SGS-Thomson Microelectronics, 1995).

The semiconductor industry is forecast to have a less cyclical pattern because of the increasing use of semiconductors in the personal computer industry, the continuous proliferation of microelectronics technology guaranteeing

more stable growth, improved methods for forecasting additional production capacities and a continuous increase in the average price of semiconductors. During the past 15 years, the average price of semiconductors has oscillated, depending on the over- or undercapacity of the industry. On an average, from 1985 to 1990, the price grew by a modest 3 per cent per year. From 1991, the average price increased by 10 per cent per year. That trend should continue because of the steady increase in the electronic level of chip integration.

The consolidation of the semiconductor industry will accelerate in 1997 and 1998, when the market recovers rapidly from the stagnation of the second half of 1995 and 1996. Successful and unsuccessful companies will subsequently be identified and survivors will be ready to capitalize on the next semiconductor market boom. It is forecast that by 2000, only 10 to 12 companies (3 companies from United States, 4 from Japan, 3 from Asia and 2 from Europe) will be able to guarantee individual shareholders and customers both viability and profitability of 4-9 per cent of world market share in the long term. The future of these companies will continue to be bright, since the industry will become more profitable with average net returns estimated to be between 10 and 12 per cent.

As a result of increasing complexity and interdependence of technologies, there is a need for standardization and an increase in the investment scale. Uncertainties caused by the heavy competition among markets will force companies to enter into alliances in order to increase their flexibility to keep abreast of the rapid changes in the industry. Accordingly, medium-sized companies will either merge with others or disappear. Manufacturing plants will have to strive hard to achieve more than 2 per cent of total market share, while niche suppliers and specialists will continue to survive and develop, catering to specific markets with shares below 15 per cent of the total market share. The shrinking trend will continue in the long term.

In the medium term, in response to high rates of investment in the industry spurred by increasing market opportunities, dramatic innovation in the semiconductor industry can be expected to be to the advantage of major semiconductor companies. Rapid improvements are being made with regard to density, process development, product evolution and product life. As far as hardware, software, standards, and communications (personal computers, set-top boxes, multimedia, high-density television, internet, satellite etc.) are

concerned, extensive interaction is taking place. Companies will accordingly be forced to react or invest on faith.

With regard to the world production structure based on capacity expansion and the portfolio of regional manufacturers, there will be a progressive dislocation of the Japanese industry in Asia and the Pacific. Japanese industry will be in a position to capitalize on the rapid growth of the region and escape from continuous rising costs, especially those related to equipment for wafer manufacturing plants. The United States will continue to be the leading producing country, maintaining a stable production share of 39 per cent in 2000, while Europe will once again face a relative decline (see table 49).

Table 49. World semiconductor production development, by region, 1980-2000
(Percentage)

	1980	*1990*	*1995*	*2000*
United States	57	49	40	39
Japan	27	45	40	38
Europe	15	11	9	7
Asia and the Pacific	1	5	11	16
World	100	100	100	100

Source: J. P. Dauvin, *Semiconductor Market Forecast* (Paris, SGS-Thomson Microelectronics, 1995).

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