

# **The Rise of the New Data Industries**

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Information technology is to modern industrial societies what steel was to the industrial societies of the late nineteenth century or automobiles and consumer durables to those of the early twentieth century. Microelectronics, computers, telecommunications, consumer electronics, and other dynamic industries are products of technological developments of the last three decades. They are dynamic because the rapid technological changes that occurred in those decades coincided with a strong demand for information products and services. The ability of humans to store, process, and transmit great volumes of information at rapidly decreasing cost is the key to understanding this cluster of industries.

The main manufacturing industries connected with information technology are semiconductors, computing equipment, and telecommunications equipment. As in other industrial clusters, the information technology group of industries contains a set of service industries that will be considered along with the manufacturing industries: data processing, information services, software, and telecommunications services. The term "information technology services" will be used to stand for this subgroup within the larger group of information technology industries.

## **The Semiconductor Industry**

The semiconductor industry is a relatively new industry, beginning with the invention of the transistor by a group of researchers at Bell Laboratories in 1947/48. The production of semiconductors for commercial markets did not begin until the mid-1950s (Braun & MacDonald 1982; Tilton 1971). The industry has been characterized since that date by very rapid changes in technology. The rapid pace of change has produced two major effects: (a) intense competition among firms for the new markets opened up by technological innovations, and (b) a proliferation of submarkets within the overall semiconductor market as the circuitry on each "chip" grew more complex.

The most complex semiconductors are called integrated circuits, because they contain more than one "discrete" device along with lines connecting them on a single chip of silicon. The most important types of integrated circuits are: (a) logic circuits; (b) microprocessors; (c) random access memories (RAMs); (d) read only memories (ROMs); and (e) custom circuits. RAMs have grown in density from 1K (1,000) bytes of storage in 1970 to 256K in 1984 by a steady doubling of capacity. In the same time period, microprocessors have evolved from calculators to 32-bit circuits with an ability to process larger and larger bytes (a byte is a collection of

bits where a bit is a basic unit of information), and thus capable of making numerical calculations of greater accuracy and performing more and more complex tasks.

The combination of increased memory capacity and size of bytes, together with a steady reduction in the price per bit of memory and per instruction performed by a microprocessor, has reduced the difference between what a small computer can do and what a huge mainframe computer used to do. In addition, the amount of raw computing power per dollar has decreased most rapidly for the smallest computers. Only in very large organizations with thousands of users are the per user costs lower for large mainframe computers than they are for mini or microcomputers. This technological evolution has very interesting implications, perhaps the most important of which is the increased potential for decentralizing information processing, allowing any small firm or even an individual with an average income to purchase almost as much computing power as is available to very large corporations.

### The Structure of World Production

In 1984 world production of semiconductors was estimated to be around US\$26 billion (see Exhibit 1) and that of integrated circuits US\$19 billion (see Exhibit 2). Between 1978 and 1983, world production of integrated circuits grew annually at an average rate of 19 percent. The United States accounted for over two thirds of world production of integrated circuits between 1978 and 1985, while Japan increased its share of world production of integrated circuits from 18% in 1978 to 27% in 1985. According to the Dataquest estimates, the United States, Europe, and Japan produced more than 93% of all semiconductors in the world market for the entire period and more than 98% since 1980.

#### Exhibit 1

World Semiconductor Production by Region: 1983-86  
(billions of US dollars)

Year	U.S.A.	Europe	Japan	Rest of World	World Total
1983	\$7.8	\$3.0	\$5.5	\$1.0	\$17.3
1984	11.9	4.7	8.1	1.7	26.3
1985	8.3	4.5	7.6	1.2	21.6
1986p	10.6	8.7	4.8	1.4	25.5

SOURCE: World Semiconductor Trade Statistics (WSTS) data of the Semiconductor Industry Association (SIA) of the United States as cited in *Electronic News* (30 September 1985, 6; 1 October 1984, 40).

## Exhibit 2

World Production of Integrated Circuits: 1978-83 .  
(millions of US dollars)

Year	U.S.A.	Europe	Japan	Rest of World	World Total
As estimated by Dataquest*					
1978	\$4,582	\$453	\$1,195	\$382	\$ 6,712
1979	6,681	600	1,750	675	9,706
1980	9,055	710	2,450	130	12,345
1981	8,950	790	2,590	160	12,490
1982	9,300	790	3,130	160	13,380
1983est	10,450	855	3,910	190	15,405
As estimated by Benn Publications					
1983	\$6,137	\$2,275	\$3,265	\$ 842	\$12,519
1984	9,390	3,322	5,126	1,289	19,129
1985est	10,329	3,521	5,536	1,397	20,782
1986p	11,981	3,978	6,533	1,619	24,111

\* These statistics include captive production of integrated circuits by large computer firms like IBM.

SOURCES: Dataquest data as cited in *Trade in HighTechnology Products: Industrial Structure and Government Policies* (Paris: OECD, 1984), p. 110; Benn data as published in *Profile of the Worldwide Semiconductor Industry* (UK: Benn Publications, 1985), p. 12.

A fairly large proportion of semiconductor production in the United States is sold on the open market by merchant firms. Generally speaking a lower proportion of semiconductors is sold on open markets in Japan and Europe because the firms in those two regions tend to be larger and more vertically integrated than many of the US semiconductor firms. In addition the end-use of semiconductors differs considerably among the regions. In the United States the largest market for semiconductors is the one created by computer manufacturing. In Japan the largest market for semiconductors, at least until quite recently, was created by consumer electronics. In Europe consumer electronics and telecommunications equipment are the most important customers of the European semiconductor industry.

The structure of demand for semiconductors was a factor of considerable importance in the initial development of the industry in the three regions. In the early days of the U.S. industry, production was geared to military and space applications. It changed quite drastically when the computer industry displaced government purchasers as the largest source of demand. Computer applications of

semiconductors generally required devices that were relatively complex, fast, and ran at cool temperatures. Industrial applications, which figured larger in the early development of the European semiconductor industry, required devices that could handle large amounts of power and be reliable at high temperatures. Consumer electronics, which were the most important customers for the first Japanese semiconductor producers, generally required devices that used less power than either computer or industrial devices and which had the capacity to handle analog as well as digital signals (i.e., in radios or TVs). As a consequence of the different demand structures, the Europeans did well in power devices, the U.S. did well in developing microprocessors and computer memories with MOS circuitry, and the Japanese did well in CMOS circuits for watches, calculators, and consumer electronics items (Borras 1982; Dosi 1984; Malerba 1985).

In the mid-1970s, the Japanese perceived that the market was pushing them in the direction of specialization in devices for consumer electronics. Worried that production of consumer electronics would shift to the Third World while the U.S. would continue to dominate the world computer industry, a major effort was undertaken by the Ministry of International Trade and Industry (MITI) and the

**Exhibit 3**  
**Largest Semiconductor Producers: 1982-84**  
 (rank ordered by 1984 Revenues in millions of US dollars)

Name of Firm	Country	1982	1983	1984
Texas Instruments	USA	1,422	1,768	2,390
NEC	Japan	1,100	-	2,350
Hitachi	Japan	800	-	2,140
IBM (estimate)	USA	-	-	2,000
Toshiba	Japan	680	-	1,750
Motorola	USA	1,235	1,412	1,729
Intel	USA	900	1,122	1,629
Philips/Signetics	Netherlands	500	-	1,150
Fujitsu	Japan	440	-	1,070
National Semiconductors	USA	746	785	1,030
Matsushita	Japan	-	-	920
Siemens	Germany	-	-	700
Gould	USA	318	368	435
Harris Corporation	USA	147	151	234

NOTE: Data are for fiscal years ending on the column year; variation in the fiscal reporting systems used by firms is substantial.

SOURCE: Berkeley Roundtable on the International Economy, various publications; annual and quarterly reports.

Ministry of Posts and Telecommunications to promote the development of new devices more suitable for advanced information technology. The Very Large Scale Integrated (VLSI) Program of 1976/79 was the result, one of the most successful examples of government promotion of technological development after World War II. A major shift has occurred as a consequence of this intervention: the Japanese semiconductor firms were in a much stronger position vis-à-vis their US competitors by the late 1970s.

While the United States dominated the overall market for semiconductors, Japan led increasingly in certain key segments. For example, by the end of 1979 the Japanese firms controlled 43% of the US market for 16K RAM devices (Borras, Millstein & Zysman 1982, 106). By the end of 1981 they supplied almost 70% of 64K RAM devices in the open part of the US market (Bylinsky 1982). In 1984 the Japanese firms introduced 256K RAM chips before a number of major US firms. U.S. firms like Intel, Motorola, HewlettPackard, and AT&T (Western Electric) still dominated the markets for microprocessors, however, Japanese firms began to eat into this market as well in the 1984/85 period as they introduced their own "state-of-the-art" microprocessors. NEC and Hitachi have been particularly strong in this regard; NEC displaced Texas Instruments in 1985 as the number one seller of semiconductor devices in the world ("NEC Tops List" 1986, D4).

### **Semiconductor Production by Specific Firms**

Japanese and U.S. firms dominated the markets for semiconductors and integrated circuits in 1984 (see Exhibit 3). Only two European firms ranked among the top ten firms, Philips and Siemens. While this ranking excludes consideration of captive production of semiconductors (which if included would bring IBM and Western Electric into the list), it nevertheless gives a good indication of market shares in the open market for semiconductors and the ranking of merchant firms.

### **The Computer Equipment Industry**

The information technology industries have been strongly affected by the declining costs of computing hardware and of transmitting information over telecommunications infrastructures. The following estimated average percentage changes in unit cost per year for 1985 to 1990 illustrate the fact that while hardware and data transmission costs are likely to continue their rapid decline, software and data processing services costs are likely to increase in cost:

Main computer storage	-35%
Bulk storage	-30
Instruction executions	-25
Conventional data transmission	- 8
MIS and DC technical specialist	7
Application software products	8
System software products	16

Microcomputers are much cheaper to operate (based on cost per million instructions per second) than minicomputers, and minicomputers are much cheaper than mainframes. However, because minicomputers and mainframes are typically used by a large number of individuals in a given organizations, and because they are more likely to be used on a 24 hour basis rather than just during working hours, they may still be more cost-effective for large organizations. The competition from the smaller computers is most intense for those functions that do not require access to a common data base or that do not require massive memory capacity.

The rapidly declining cost of computing and communicating has made it necessary for data processing service firms to make sure that they have access to the most up-to-date hardware to remain competitive. Declining computing/communication costs plus wider availability of packaged software has made it easier and much less expensive for users of these services to do some processing on their own. So the data processing industry has suffered from high capital equipment costs and a stagnant or even declining demand for their services. The result of these pressures has been to reduce the number of firms in the industry and to increase the average size of firms.

Information technology services depend on raw computing and telecommunicating power. To compete for data processing jobs involving the manipulation of millions of items, which is typical for large industrial data processing jobs, one must have access to clusters of large mainframe computers. The costs of computing depend on the ability to keep machines working and operating as close to a 24 hour schedule as possible. The costs of communicating depend on the type of technology, but one rule of thumb is that unit costs (per bit) are inversely and linearly proportional to the volume of data transmitted. If transmitting over a leased line, the cost of transmission is the cost of the line. Thus, the key to low per unit communications costs is to compress the data as much as possible and to use the highest-speed data transmission systems that are compatible with the form of the data.

The consequences of these cost factors, together with the shifts in technology, have been to produce fewer firms operating from a selected number of locations with large concentrations of networked computer systems. Because 24 hour use of machines is desirable, firms have adopted a variety of strategies to keep machines working outside of normal business hours:

- Reducing prices for after-peak-hour business usage
- Offering services for home computer users at lower prices
- Selling or leasing after-hours computer time to others
- Diversifying their business geographically

In addition to a reduction in the number of firms, there has been a tendency for smaller firms or new entrants to try to build strengths in particular market niches so as to insulate themselves from the competitive strengths of the larger service

providers. For example, in the area of data processing services for hospitals, Shared Medical Systems and McDonnell Douglas dominate the market. Amherst Associates, a new entrant, located a niche within this market, however, by combining standard services with financial planning and modelling services (US Department of Commerce 1984, 5).

## **The Telecommunications Equipment Industry**

The telecommunications equipment industry is shared by major firms in the U.S., Western Europe, and Japan. While major U.S. firms like AT&T, ITT, GTE, Hughes, and Ford Aerospace all provide both services and products, the largest foreign firms are divided into firms that produce equipment and those that provide services. Of the service providers, most are either regulated private firms or agencies of the government.

The most important change in the market for telecommunications equipment is the rapidly growing costs for the development of new central office (CO) switches, the equipment mainstay for large Value-Added Networks (VANs) and public switched networks. One could compare the CO switch situation with that in the production of large airframes for commercial aircraft. The costs of developing wide-bodied aircraft like the Boeing 747 and the Airbus 310 were so high that only a small number of firms could afford them. Unless the smaller firms were able to cooperate to pool development costs, as in the case of Airbus, they were excluded from the competition. The same thing seems to be happening in CO switches.

Much of the political pressure for maintaining public monopolies or private regulated monopolies in telecommunications services stems from the desire of national governments to preserve the market power of "national champions" in telecommunications equipment and computer manufacturing. Federal Republic of Germany has a stake in buttressing Siemens, France in Alcatel Thomson and Bull, Britain in British Telecom and ICL, Japan in NTT, NEC, Hitachi, and Fujitsu. The Europeans appear to be somewhat weaker in this round of competition in switches than either the U.S. or Japanese firms. Many major European firms have made alliances either with U.S. or Japanese firms. The European Community has promoted joint research among European firms in ESPRIT and RACE so that in the next round of competition, Europeans may be able to maintain a market presence without U.S. or Japanese partners. Finally, a consortium of European telecommunications equipment-makers under the leadership of Italtel has been formed for the same purpose.

## **Data Processing Services**

Data processing services include the selling of batch and remote computing services, facilities management, and systems implementation products. Batch processing involves the physical transfer of data to a facility owned by the

processor, usually in non-machine-readable form, where the data is then converted into some machine-readable form (typically punch cards or files on magnetic media) and then analysed. Remote data processing involves the transfer of data from the client to a remote site via some form of telecommunications terminal, the analysis of the data, and the transfer of the results of analysis back to the client. Facilities management is the management of all or part of a user's data processing functions under a longterm contract (not less than one year). The global market for data processing services exceeded US\$21 billion in 1985, with the U.S. accounting for over 70%.

## Information Services

Information services are also of two main types: the provision of information through access to electronic data bases and information made available through network services. Data bases are computerized banks of data collected and maintained by the service provider and made available to clients in a variety of forms: in print, on various types of machine-readable media, and via telecommunications networks. The last form of providing data is the characteristic feature of "online" data base services. Online data bases can be passive (user consultations do not alter the contents of the data base) or interactive (the opposite). Network services differ from those provided by the conventional public telecommunications network by allowing additional services such as file storage, message switching, protocol conversion, error detection, and interfaces for different types of terminals.

**Exhibit 4**  
Number of On-Line Data Bases by Region: 1983

Region of Origin	Number of Data Bases	Number of Hosts
United States	1,140	190
European Community	528	55
Rest of World	352	25
<b>Total</b>	<b>2,020</b>	<b>270</b>

SOURCE: Cuadra Associates, *Directory of On-Line Databases*, as analyzed in J. Decker, "Electronic Information Impact of the Database", *Futures* (April 1985), p. 165.

The United States has been the leader in the supply of data base services (see Exhibit 4). Around two-thirds of all publicly available data bases are located in the United States (Williams 1985), and the industry was estimated to have earned approximately US\$1.9 billion in revenues in the United States in 1985, an increase over 1984 of 36%. The market is expected to grow to around US\$3.6 billion in



1989, at an annual growth rate of 18%. Over 2,600 data bases were offered in 1985, up from 362 in 1977 and 1,800 in 1984. The number of customers served by these data bases is estimated to have been 784,900 in 1984, up 400,000 from the year before. Nineteen percent of the total revenues of U.S. firms was derived from foreign sources in 1982, with European revenues comprising about 76% of that amount. It is estimated by the U.S. Department of Commerce that at least 50% of data base services purchased in Europe are supplied by U.S. vendors.

In Japan 62 data bases were offered as of the end of 1976 by government agencies and 20 online service companies (Welke 1982, 86). Many of the early entrants to the market were joint ventures with U.S. firms (e.g., Information Services International/Dentsu was a joint venture of Dentsu with General Electric Information Services). The number of distributors increased to 30 by 1982, but none of these was profitable. The annual revenues of the 30 data base firms was 12 billion yen (about US\$49 million) in 1982 (Komahashi 1982, 8-12).

In Europe 800 data bases were offered in 1985, 600 of which are available via the Euronet Diane, a public data network run in cooperation with the national PTTs as a Europe-wide public service by the Commission of the European Communities. Most of the data bases available via Euronet were subsidized by the European Communities and/or by member governments. These publicly available data bases dealt primarily with bibliographic citations, technical data, and training or instruction (Euronet 1985).

Besides online data bases, an increasingly important type of information service is being provided through local-area networks (LANs) and value-added networks (VANs). It is already possible to access a wide variety of data bases through VANs such as Tymshare's Tymnet and GTE's Telenet. These VAN services make it possible for individuals to dial a local number in order to connect up with a data base anywhere in the United States. Network data services will be offered both by public telecommunications systems and by private vendors.

## **Computer Software Services**

Software services involve the writing of software for clients either by providing personnel to write customized software for the client's hardware (called "professional services" in the INPUT/ADAPSO surveys) or by selling/leasing the software itself on some form of computer medium (called "packaged" software or "software products" in INPUT/ADAPSO surveys). In addition to writing the software, software services may also involve fixing errors or updating software.

In 1984, U.S. firms sold US\$10.4 billion worth of software products. The largest portion of these revenues came from the sale of operating systems and applications software for large mainframe computers, but the share of small computer software in the total has been growing rapidly and comprised 20% by 1985.

The overseas sales of U.S. firms were estimated to account for more than 50% of total revenues in 1982. Firms based in the United States have been market leaders for a long time and probably will continue to be market leaders. But foreign markets are beginning to grow more rapidly than they did in the past, and both U.S. and local producers are beginning to take advantage of larger markets and increased demand for packaged, as opposed to customized, software. According to International Data Corporation, the total world market for software and data processing services (reflected in sales of U.S. suppliers) was US\$30 billion in 1984. Of that total, 41% was software products, 40% professional services, and 19% data processing services.

## **Telecommunications Services**

Telecommunications services involve the provision of access to telecommunications infrastructure to clients - e.g., to public switched telecommunications networks (PSTNs), public data networks (PDNs), or to private dedicated and leased lines. Changes in technology have made it possible to offer these services not only through the traditional telegraph and telephone infrastructure but also through satellites, microwave systems, cellular telephone systems, fiber optic cables, and cable TV networks.

The global market for telecommunications services in 1985 was estimated to be around US\$200 billion, with the international portion of the global telecommunications market comprising at least US\$6 billion. Employment in this industry was around two million in 1985 in the larger industrial countries. Employment will remain high but will not grow substantially in the coming years, at least not in the provision of services connected with the basic infrastructure. In value-added services connected with telecommunications there is likely to be rapid growth in both revenues and employment.

In addition to the revenues for telecommunications services cited above, most of which refer to traditional telephony and telegraphy (although facsimile and other services may be included), one must also consider the market for data communications. The revenues of independent telephone, satellite, and specialized carriers for the U.S. in 1985 was US\$17.8 billion and was expected to exceed US\$19.6 billion for 1986. Of the predicted 1985 European VAN market of US\$879, US\$424 million would be generated by VAN services, US\$299 million by network operations, and US\$156 million by the sale of telecommunications circuits (*Value Added Network 1980*, 1). Private VANs figure importantly in only three countries: the United States, Japan, and Britain. In most other countries, public data networks either have monopolies in this market or private VANs have not yet emerged because of small domestic markets.

## Implications for Developing Nations

The growth in revenues and employment in information technology industries is likely to provide some important opportunities for enterprises in the developing world. For the purposes of analytical simplification let us consider two basic kinds of strategies on the part of individual countries: (a) import-substituting and (b) export-promoting. Import-substituting countries will establish trade and investment barriers to protect domestic infant industries in information technology – as Brazil has done. An export-promoting country will use tax incentives, research and development (R&D) subsidies, government investments, and procurement policies to favor the rise of export-oriented information technology firms – as has been the case with Taiwan and, to a lesser extent, the Republic of Korea.

Import-substituting strategies are likely to become less and less attractive for developing countries because they tend to exclude those countries from the benefits of the rapid innovation that is taking place in information technology and particularly from the benefits of lower computing and telecommunicating costs. Import substitution has provided excellent incentives for domestic innovation in software and services, as the Brazilian case makes very clear. Computer manufacturing has grown rapidly and the number of indigenously assembled products offered increased to the point where less than half of the value of computer equipment sold in Brazil comes from foreign firms. Nevertheless, the Brazilians have had to pay a high cost for this: expensive and less-than-optimally-functional small business and personal computers, along with a lot of diplomatic harassment from the U.S. government over the trade and investment barriers that keep U.S. firms out (*Transborder Data Flows* 1983; Riding 1984; Riding 1986; Pine 1986).

Given Brazil's relatively high average income and good human capital formation, it has a chance of capitalizing on lower hardware costs to become more competitive in software and services. Brazil might do better, therefore, to encourage joint ventures and even wholly owned subsidiaries in hardware, to improve enforcement of intellectual property protection in software and to allow foreign firms to operate VANs inside Brazil while focusing promotional efforts on information services that take advantage of Brazil's centrality in Latin America.

The experience in India with the promotion of a domestic computer has been similar to that in Brazil, but, because the Indians have been willing to engage in joint ventures (except, until recently, with IBM), the cost and quality of Indian hardware compared with what is available on world markets is somewhat better than that of Brazil. India's Tata Corporation has had a long-standing partnership with Burroughs (now called Unisys since its merger with Sperry).

Texas Instruments has set up a software development center in India that is linked to the headquarters of the firm via a satellite telecommunications system.

The main idea has been to take advantage of the much lower wages of programmers in India. So far, however, this operation has not been very profitable for Texas Instruments because the productivity of Indian programmers has not been high enough. There has not been much export business in hardware because of higher prices, but software exports were about US\$26 million in 1985, mostly for applications software ("India" 1986; Weisman 1986).

Developing countries that select an export-promoting policy will continue to do better in international trade in areas where they can take advantage of lower labor or resource costs. There is a variety of market segments in which production is likely to be located in export-oriented developing countries: (a) production of simple, customized software; (b) data input from paper documents; (c) the provision of personal services via the global telecommunications infrastructure; (d) manual assembly of printed circuit boards and of smaller semiconductor-based machines and appliances; and (e) the writing of sophisticated microcomputer software applications for Third World settings.

Most of the newly industrializing countries (NICs) in Southeast Asia have chosen to follow an export-promoting strategy. Taiwan seems to have done well recently in the assembly of computer monitors, personal computer clones and add-on products. Korea has focused much of its efforts on consumer electronics, but is beginning to move into more sophisticated electronic equipment. Exports of personal computers from Taiwan and Korea had a value of around US\$600 million in 1986, up from US\$200 million in 1984 ("Clone Wars" 1986). Korea relies on large industrial groups, the chaebol, to carry out its information technology promotional programs. Taiwan and Singapore have established large government-subsidized research facilities and science parks in order to encourage technological innovation. Hong Kong is specializing in information technology services, taking advantage of its experience with internationally-oriented financial services, but it will also upgrade its manufacturing capabilities, for example in textiles, by using new manufacturing technologies made possible by the application of information technology (Haavind 1986).

Most developing countries have focused understandably on agriculture and mature technologies in recent years. Yet there is good reason for them to begin informing themselves of challenges and opportunities that will be posed by the increasing use of information technology. These industries are already changing the way in which production and distribution is organized in the mature industries and many farmers in the industrialized world are taking advantage of information technology to manage their farms and to find out what prices are available on various markets.

Most information on the new technologies in the developing world is collected and disseminated by government agencies. Only the wealthier and more industrialized developing countries are likely to benefit from these facilities. Given limited resources, it will be desirable to establish and upgrade existing

international centers for the diffusion of information about the new technologies. This role is currently played by a few UN bodies such as the Centre on Transnational Corporations (UNCTC), the UN Centre for Science and Technology for Development (UNCSTD), and the Advanced Technology Alert System (ATAS) of UNCSTD. These resources can be usefully supplemented by the use of private consulting firms.

Once governments of developing countries feel more informed about the potentialities for the application of information technology, they may want to reconsider some of the pre-existing programs and arrangements with multinational corporations. The increased competitiveness of Japan relative to the United States in semiconductors, mainframe computers, telecommunications equipment, and other industries suggests that LDCs should begin to think about making new alliances with Japanese MNCs or renegotiating earlier agreements with U.S. firms. The relative weakness of European firms in all industries with the possible exception of telecommunications equipment and data processing services means that alliances with European firms may be easier to negotiate but may have fewer payoffs with respect to providing access to the latest technologies.

## Conclusion

There is no reason for developing countries to believe that they have no stake in the diffusion of information technology. They must inform themselves about the nature of these new technologies just to preserve their existing status in the world economy. Some applications may have direct and immediate positive effects on growth, employment and exports. In particular, applications of information technology in agricultural production, distribution and marketing are likely to have rapid and direct payoffs. The reduced costs of computing and telecommunications will release government and private revenues for other productive purposes.

Other applications, particularly those which are inappropriate given the resources available to developing countries, may be extremely costly. It would be foolish, for example, for countries with high unemployment and low wages to pursue a policy of subsidizing highly automated or robotized factories. It would also be foolish for countries with strong educational systems and a good base of human capital to ignore the potential benefits of exporting services via the new telecommunications infrastructure.

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