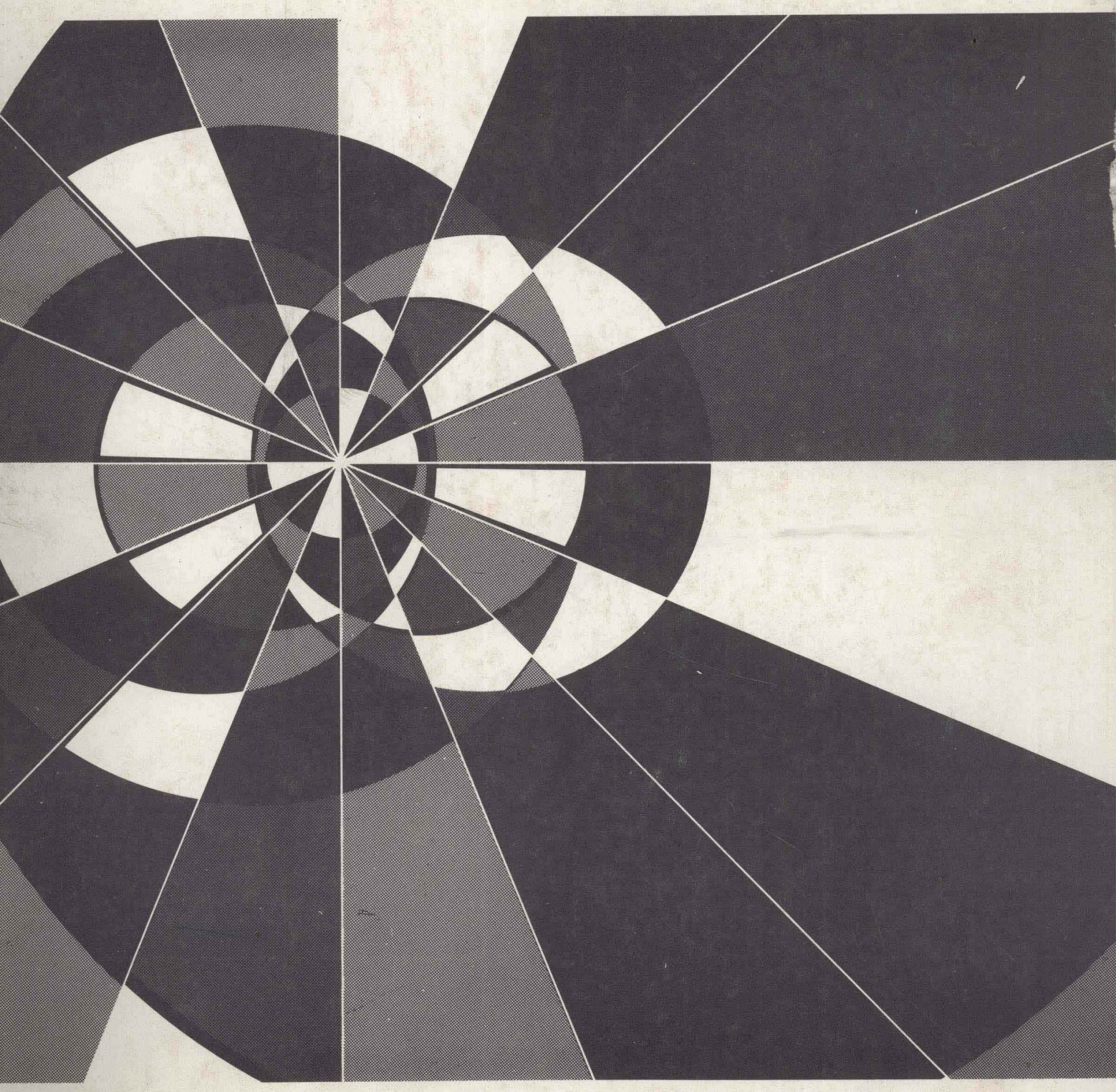
Transnational Corporations in the International Semiconductor Industry



United Nations Centre on Transnational Corporations
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United Nations

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PREFACE

In response to the mandate of the United Nations Commission on Transnational Corporations, 1/ the United Nations Centre on Transnational Corporations (UNCTC) is undertaking studies on the role and activities of transnational corporations in selected industries of special interest and significance to host countries, particularly developing countries or areas. The present report, Transnational Corporations in the International Semiconductor Industry, is one in a series of such studies.

The objective of the studies is to present an overall analysis of transnational corporations in the context of the structure, production and market characteristics of particular industries, including an analysis of the strategies and operations of these corporations, their role in world production and trade and in the development of the specific industry. The studies are intended to contribute to a better understanding of the participation and strategies of transnational corporations in those industries and to enhance the ability of host countries to establish appropriate policies, as well as improve their negotiating capability in dealing with transnational corporations.

In the above context, semiconductor production, in which transnational corporations are actively engaged both in developed and developing countries or areas, is of special importance. The present report is structured in three parts. The first part (chaps. I-IV) defines the semiconductor industry and presents the structure of the world market, production and trade in the industry. Further, it considers the economic characteristics of the different stages of semiconductor manufacturing which to a large extent define the nature of the operations of transnational corporations, notably in an international context. Thus, the first part provides a general framework for the analysis of transnational corporation operations undertaken in the body of the report.

The second part (chaps. V and VI) outlines the role of transnational corporations in the context of the structure and evolution of the industry historically and currently and examines major transnational corporations based in the United States, Japan and Western Europe. While it analyses the operations of specific transnational corporations, including products and technologies, it emphasizes the evolution of the international dimension of their operations, including foreign direct investments, technology transfer and intercorporation linkages. It also examines the main features of transnational corporation strategies, notably in response to the structural changes confronting them in the current transitional phase of the industry's development and how these condition their international operations in developed and developing countries or areas.

1/ Official Records of the Economic and Social Council, 1980, Supplement No. 10 (E/1980/40/Rev.1).

The third part (chaps. VII-IX) discusses specifically the relevance of semiconductor transnational corporation operations with regard to developing countries or areas. It purports to assess the impact of their operations on such variables as employment, the balance of payments and the technological capabilities of developing countries or areas and examines in more detail the nature and extent of their operations in the principal offshore assembler developing countries or areas. It also considers the role of independent assembly subcontractors in these countries and their relation to transnational corporations and non-transnational corporations. Finally, it discusses the overall role of transnational corporations and the prospects for developing countries or areas to participate in the semiconductor industry, distinguishing between major groups of these countries. The intent is to provide some major considerations pertaining to overall country policies on the industry and the role of transnational corporations, given the characteristics of this technically advanced industry.

Explanatory notes

The following symbols have been used in the tables throughout the report:

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

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

A hyphen (-) indicates that the item is not applicable.

A minus before a number (-2) denotes a deficit or decrease, except as otherwise stated.

Details and percentages in tables do not necessarily add up to totals, because of rounding.

The following apply throughout the text and tables:

A point (.) is used to indicate decimals.

A slash (/) indicates a crop year, a school year or a financial year, e.g., 1970/71.

Use of a hyphen (-) between dates representing years, e.g., 1971-1979, signifies the full period involved, including the beginning and end years.

Reference to "tons" indicates metric tons, and to "dollars" ($) United States dollars, unless otherwise stated.

The term "billion" signifies a thousand million.

Annual rates of growth or change, unless otherwise stated, refer to annual compound rates.

1. Semiconductor devices constitute the fundamental building blocks for the vast array of electronic systems which are finding applications in ever-widening spheres of economic activity. In the semiconductor industry, transnational corporations are central economic actors. On a world-wide basis, transnational corporations account for the overwhelming share of semiconductor production and trade and for the technologies necessary for state-of-the-art semiconductor manufacture. To a considerable extent, competition among transnational corporations determines the direction, rate and extent of development in this highly technology-intensive industry. As semiconductor transnational corporations seek to expand their markets, they play a critical role in extending the frontiers for the application of microelectronics to economic life both in developed and developing countries or areas.

2. While the present report examines the world-wide operations of semiconductor transnational corporations, it gives specific consideration to their operations in developing countries or areas. It is particularly concerned with the identifiable trends in the global semiconductor industry, the role of transnational corporations in this context and their participation in the development of the semiconductor industry in developing countries or areas.

3. Almost since its inception, the semiconductor industry has been transnational in the sense that major firms have had production abroad or at least technical links with firms in foreign countries. In the context of this industry, transnationality has performed at least three important functions historically: (a) it has provided major corporations access to foreign markets insulated to varying degrees from semiconductor imports; (b) it has enabled corporations to maintain competitive costs through the global allocation of various phases of the production process in accordance with country or regional comparative advantages; and (c) it has fostered an international diffusion of semiconductor technology. The first and third considerations relate primarily to transnational corporation operations in the developed market economies while the second relates principally to their operations in developing countries or areas.

4. The transnational character of the industry has evolved through a number of stages in response to changing economic and technological factors that have affected the costs of semiconductor production and in response to the changing competitive environment in the industry. During the first decade of the industry's existence, from the early 1950s through the early 1960s, the principal transnational corporations were United States-based merchant (or open market) semiconductor producers. A number of those producers invested in Western European countries principally to establish manufacturing or point-of-sale (POS) assembly facilities. Of those still active, Texas Instruments (TI) was the most prominent investor in Western Europe through the mid-1960s. In addition, the semiconductor division of International Telephone and Telegraph (ITT) established a strong presence in Western Europe, which has historically constituted a major telecommunications chip market. The decisions of several United States-based transnational corporations to establish subsidiaries in Western European countries was largely motivated by the restricted market access of semiconductor imports in many of those countries. For similar reasons, some major Western European semiconductor producers - notably Philips (Netherlands) and SGS-Ates (Italy) - established foreign subsidiaries or joint ventures in other Western European countries than their respective home bases. During that period, there was no

foreign direct investment in either the United States or the Japanese semiconductor industry and neither were Japanese semiconductor firms active in the Western European market.

5. A second phase in the transnationalization of the industry began in the early 1960s and gained momentum in the late 1960s. The period was marked by the commercialization of integrated circuits (ICs) and the emergence, particularly in the United States, of a number of new firms committed to mass production of ICs. Such production presupposed the rapid expansion of IC markets which mainly depended on considerable reductions in production costs. Those reductions were achieved in a number of ways. In the first instance, mass production itself resulted in substantial cost reductions through learning curve effects and the realization of scale economies. Such effects have historically been confined primarily to the production phase of front-end wafer processing. In the relatively labour-intensive assembly/packaging phase learning economies have been limited due to the relatively simple nature of the technology. With labour constituting a relatively high share of total factor costs in assembly/packaging, cost cutting took the form principally of economizing on unit labour costs.

6. Different transnational corporations have emphasized different approaches to reducing labour costs. From the start, Japanese semiconductor firms relied to a greater extent than their United States counterparts on the introduction of labour-saving automated assembly equipment in their domestic facilities. By contrast, United States firms chose overwhelmingly to invest in offshore assembly subsidiaries in developing countries or areas, beginning with Fairchild in Hong Kong in 1962. The extensive investment by United States transnational corporations in offshore assembly in the 1960s and early 1970s, combined with rising labour costs in Japan, induced a number of Japanese firms to invest in offshore assembly as well, though they have relied on it for only a relatively small percentage of their total assembly needs. United States transnational corporation offshore assembly subsidiaries have re-exported the overwhelming share of processed semiconductors for sale to original equipment manufacturers (OEMs) or distributors primarily in the United States, but also in Western Europe and Japan. Japanese transnational corporations, by contrast, have frequently integrated offshore semiconductor assembly operations with consumer electronics assembly operations in particular developing countries or areas, to serve both the local market and the export market.

7. Japanese semiconductor transnational corporations tended to rely more extensively on assembly automation than United States transnational corporations even in their offshore assembly plants. However, beginning in the late 1970s there emerged a distinct trend towards greater automation of offshore assembly on the part of United States semiconductor transnational corporations. The trend was occasioned in large degree by the intensification of competition between United States and Japanese semiconductor transnational corporations in certain strategic market segments. To match Japanese product performance, United States chipmakers have sought to achieve comparable levels of automation in order to enhance process control, improve detection of defects, and minimize operator contact with the chips - a source not only of damage in handling but also of contamination. Moreover, rising wage costs in many offshore assembly locations provided an additional incentive to automate in order to raise assembler productivity and reduce dependence on assembly labour. Finally, the transition to very large scale integration (VLSI) has made assembly automation even more essential for technical as well as cost reasons.

8. Also, beginning in the mid-1970s, semiconductor transnational corporations performed more and more final testing in offshore plants. The decision to integrate forward into testing, as well as mark and pack and shipping, was motivated in large part by the need to shorten turnaround times as well as to economize on transport costs. Also, certain changes in the United States tariff provisions governing offshore assembly resulted in the transfer of pre-assembly operations like wafer sawing and die separation, which also tend to be labour-intensive, to offshore assembly locations.

9. Except for the largest producers, Western European semiconductor firms have not generally relied on offshore subsidiaries to satisfy their assembly needs. While firms like Philips, Siemens, SGS-Ates, and AEG-Telefunken have offshore assembly subsidiaries, other Western European firms have tended to rely either on home-based assembly or on assembly subcontractors in developing countries or areas. Those firms that have opted for home-based assembly have been principally captive semiconductor producers not faced with the same competitive pressures to lower assembly costs as merchant producers. Assembly subcontractors have provided several smaller Western European firms - as well as smaller United States and Japanese firms - with an alternative to foreign direct investment in assembly capacity when the volume of their shipments does not warrant the latter.

10. The latter part of the 1970s marked the beginning of a new phase in the evolution of the international semiconductor industry. For convenience the current phase can be designated the VLSI era since the onset of very large-scale integration (VLSI) has accentuated its features; however, those features were already taking shape in the previous LSI phase of the technology. In particular, the capital requirements of competitive IC manufacture have been escalating rapidly as firms have had to invest in ever more complex and costly wafer processing equipment to handle the requirements of narrower circuit line widths and larger wafers. At the same time, intensified competition has been forcing the pace of innovation, requiring greater research and development outlays and resulting in more rapid obsolescence of existing technologies and the capital equipment embodying them. The same forces of competition have put financial strains on many corporations, especially those United States merchant IC houses with few, if any, products other than semiconductors to counterbalance the cyclical fluctuations occurring, particularly in high volume memory chips.

11. This set of circumstances has led to a proliferation of alliances, both among semiconductor firms themselves and between semiconductor and other firms - usually diversified electronics firms. Electronic equipment manufacturers incorporating more and more microchips into their products - chips, moreover, whose design increasingly dictates the capabilities of the end product - have sought to acquire greater control over chip technology by integrating backward into IC manufacture. They have offered a substantial injection of capital into cash-short semiconductor houses in exchange for access to the latter's technology. Hence, the wave of takeovers and mergers occurring during the late 1970s, which left only a relatively few United States merchant IC houses independent of equity links to other firms. In a number of cases, the acquiring firms were Western European companies seeking to close the semiconductor technology gap separating them from their United States and increasingly from their Japanese competition.

12. With the expansion of captive producers during the latter 1970s and early 1980s, captive IC production in the United States grew more rapidly than merchant production. With the shifting balance between captive and merchant production, a tier of smaller specialized firms offering a range of services related to IC

production emerged. A variety of firms offered research and development, design, mask making, silicon foundry, testing and assembly services to captive, or in some cases merchant, producers whose IC output would not justify the sizeable investment necessary to maintain state-of-the-art capability in all phases of IC production.

13. While increased specialization has provided at least a temporary solution for smaller captive and to a lesser extent merchant producers to the problem of escalating capital requirements and skilled personnel costs, high volume merchant IC producers have generally adopted different strategies to cope with the problem. In a number of cases, merchant IC houses have integrated forward into the systems field in an effort to enter higher value-added product markets. United States transnational corporations like Texas Instruments, Intel and Motorola are perhaps the outstanding examples of this trend. At the same time, large merchant firms have become more active in joint research and development and product design. A number of firms have entered into long-term technical co-operation and cross-licensing agreements. The 10-year agreement between Intel and Advanced Micro Devices (AMD) covering the former's 16-bit microprocessor family is illustrative of this trend.

14. International co-operative links between semiconductor transnational corporations are also becoming more common as each seeks technical partners that will best complement its own product and process strengths, irrespective of nationality. Thus, in CMOS, Toshiba (Japan) is co-operating with SGS-Ates (Italy), and Intel (United States of America) is co-operating with Matra-Harris (French-United States joint venture). In 64K DRAMs, National Semiconductor (United States of America) is licensing the design and process of Oki Electric (Japan).

15. Since the mid-1970s, both technological and competitive forces have altered patterns of international investment in the semiconductor industry. The pace of investment in offshore assembly subsidiaries has slowed considerably, due in large part to the growing trend towards assembly automation but compounded by the slump in world semiconductor markets in the early 1980s. The bulk of foreign direct investment by semiconductor transnational corporations has been in design, manufacturing, and/or POS assembly facilities in the major developed country markets. For technical reasons, semiconductor transnational corporations have had to place greater emphasis on foreign direct investments over exports to major markets because of the need imposed by higher and higher levels of circuit integration for closer co-ordination between chipmakers and equipment manufacturers. Besides assuring greater accessibility to foreign customers, foreign direct investment is increasingly preferred over exports as a way of circumventing tariff and other trade barriers. First, United States transnational corporations and, more recently, Japanese transnational corporations have established semiconductor facilities within the European Economic Community (EEC). Similarly, most of the major Japanese semiconductor transnational corporations have invested in United States subsidiaries, not because of existing tariff or non-tariff barriers to Japanese chip imports but because of the unwillingness of many United States OEMs to rely too heavily on foreign chip sources. In addition, such investments were motivated by a desire to ease growing trade frictions between the United States and Japan. Conversely, a number of United States semiconductor transnational corporations (in addition to Texas Instruments and Motorola) are now either constructing or planning their own manufacturing facilities in Japan. The interpenetration of United States and Japanese semiconductor transnational corporations in each other's home markets presumably serves the additional function of enabling them to monitor more closely one another's technology.

16. With regard to transnational corporation operations in developing countries or areas, the overwhelmingly large share of foreign direct investment in offshore assembly has been concentrated in fewer than a dozen developing countries or areas. Most host developing countries or areas are located in East and South-East Asia while a few are in Latin America and the Caribbean. The principal consideration in the selection of a site for transnational corporation investment has generally been the availability of low-wage unskilled and semi-skilled labour. Only the relatively labour-intensive assembly phase of semiconductor production was initially located in developing countries or areas. More recently - as noted above - many transnational corporations have added testing capacity to their offshore assembly facilities to economize on transport and inventory costs by shipping from offshore plants directly to the final markets.

17. Numerous Governments of developing countries or areas have established export processing zones (EPZs) to accommodate the operations of semiconductor transnational corporations and other labour-intensive export-oriented manufacturing concerns. In certain countries, semiconductor transnational corporations account for a sizeable share of all production undertaken in EPZs. The zones provide semiconductor transnational corporations with an industrial infrastructure, low-cost inputs such as water and electricity, as well as exemption from duties on the raw materials and semi-processed goods imported for further processing and re-export. Firms operating in such zones generally enjoy various tax holidays as well. Even in cases where semiconductor transnational corporation subsidiaries do not operate in EPZs, they frequently enjoy a special status entitling them to the same privileges as firms in the zones.

18. In those developing countries or areas that have attracted semiconductor transnational corporation investment, the most visible impact has been on employment. Most assembly subsidiaries employ several hundred to several thousand operatives, mostly female, as well as a small number of technicians and engineers, mostly male. While the direct employment effects appear sizeable, the net effect on unemployment in most developing countries or areas is relatively small. Thus, those employed in transnational corporation assembly subsidiaries are frequently new entrants into the labour force induced to enter solely by the existence of such jobs rather than workers who had previously been unemployed members of the labour force. Additionally, the indirect employment effects of transnational corporation assembly operations tend to be limited due to the virtual absence of linkages between such operations and other sectors of the local economy. The principal indirect employment effects, then, are those attributable to the multiplier effects on national income of semiconductor workers' spending.

19. Developing countries or areas are often eager to attract foreign direct investment by semiconductor transnational corporations because of the anticipated export earnings and foreign exchange their operations will generate. While semiconductor transnational corporation assembly subsidiaries undoubtedly make a net positive contribution to the trade balance and the foreign exchange reserves of the developing countries or areas where they operate, the size of that contribution is constrained by a number of factors. Most importantly, the lack of wafer processing capacity and the absence of linkages to local materials suppliers necessitates the import of the parts to be assembled and the packaging and other materials required for that assembly. Additionally, some portion of investment income generated by the transnational corporation assembly subsidiaries is repatriated abroad, constituting a drain on foreign exchange reserves. As a result of such considerations, the net contribution of semiconductor transnational corporation assembly operations to the balance of payments and foreign exchange

reserves in developing countries or areas is difficult to assess, but it is evident that gross export earnings alone of transnational corporation subsidiaries are not an accurate measure of the magnitude of the industry's contribution to a country's international payments balance and foreign exchange reserves.

20. Finally, the technology transfer dimension of semiconductor transnational corporation operations in developing countries or areas is not significant. The technologically most sophisticated phases of semiconductor production - research and development, design and front-end wafer processing - are all performed within the developed country operations of transnational corporations. Only the assembly and test operations have been transferred by transnational corporations to offshore locations, and the latter only fairly recently on a large scale. Both operations utilize technology embodied almost exclusively in imported capital equipment or, in the case of testing, in imported testing software programmes. For the most part, the assembly operator requires little training to reach peak efficiency and acquires few generalizable skills. The introduction of greater assembly automation in offshore assembly plants may increase somewhat the demand for skilled maintenance technicians and engineers in such plants, but the effect of automation on the skill level required of the assembly operative may well be negative. Since in many instances semiconductor transnational corporations have placed expatriate managers and engineers in strategic positions within their assembly subsidiaries, the potential for the transfer of managerial skills to host country nationals would also appear to be limited. Moreover, the embodied technology and disembodied technical know-how required for efficient semiconductor assembly bear virtually no resemblance to the requirements for front-end wafer processing. Thus, even the acquisition by host country national firms of managers and engineers employed within transnational corporation assembly subsidiaries seems to provide little expertise needed for the eventual establishment of an integrated semiconductor industry in developing countries or areas, incorporating research and development, design and engineering, and front-end wafer processing in addition to assembly and test.

21. In the current phase of the semiconductor industry's development, developing countries or areas would appear to have a relatively minor role to play in the context of inter-transnational corporation rivalry. With the focus of competition shifting increasingly to the areas of research and development and process technology, assembly costs diminish in relative importance. Moreover, with increasing automation, assembly labour contributes less and less to total assembly costs. Thus, the search for low wage assembly labour takes on less urgency. As for the possibility that semiconductor transnational corporations will move in the direction of offshore IC wafer fabrication, that seems remote in the foreseeable future. Only one - SGS-Ates - has done so thus far. In that case, the wafer diffusion facility it is establishing in Singapore will make CMOS ICs for digital watches. In the event that other transnational corporations make similar investments, they are likely to do so only for simpler, more mature device types and process technologies. Moreover, only those developing countries or areas possessing the requisite industrial infrastructure, supplier and service industries, and skilled labour force are likely to attract such investment.

22. Certain more advanced developing countries or areas have been able to enter wafer processing for discretes and/or ICs without direct equity participation by transnational corporations in such ventures. Here again, their local wafer diffusion capabilities have been restricted for the most part to more mature processes. Only for such processes have developing countries or areas been able to find developed country semiconductor firms willing to license their technology and

provide extensive technical assistance and training. In those developing countries or areas possessing an adequate semiconductor research and development capability, it is conceivable that the accumulation of production experience with simpler technologies could provide a basis for eventual migration to more complex technologies. The Republic of Korea semiconductor industry, for example, is upgrading its wafer processing capabilities through a variety of channels, including technical co-operation and joint ventures with transnational corporations, as well as foreign direct investment in research and development, design and prototype production in the United States.

23. Those developing countries or areas currently possessing substantial semiconductor assembly and test capacity, whether within transnational corporation subsidiaries or within independent assembly subcontractors, are likely to continue to play an active role, albeit of diminishing importance, through the next decade. While automation has caused at least one offshore assembly plant closing in the recent past and retrenchments at some others, there is no indication as yet of a significant trend away from offshore production. Many semiconductor transnational corporations have successfully automated their offshore plants and have no incentive to withdraw their investments as long as their offshore operations still offer cost savings over onshore assembly. Also, they may still enjoy various tax exemptions and other financial incentives offered by host country Governments. These factors do not preclude an eventual transnational corporation phasing out of offshore assembly but only reduce somewhat its likelihood in the short term. Should cost differentials between onshore and offshore assembly continue to narrow, offshore assembly could eventually be rendered uncompetitive. However, in the near future, rather than phasing out their offshore assembly activities completely, semiconductor transnational corporations are more likely to consolidate existing operations. While they may close individual facilities, they should be able to compensate for the reduced capacity through greater automation at remaining sites.

24. Those developing countries or areas not participating at present in any capacity in the international semiconductor industry seem to be confronted with relatively few options for such participation. While a few may still succeed in attracting transnational corporation investments in offshore assembly, for the reasons discussed above, the future extent of such investment is apt to be limited. By the same token, semiconductor transnational corporations are not likely to increase substantially - and may eventually decrease - their reliance on independent assembly subcontractors in developing countries or areas. Smaller, nationally based specialist semiconductor firms as well as captive producers in developed countries are likely to continue to rely on independent assembly subcontractors in developing countries or areas to a greater degree than do high-volume standard device producing merchant semiconductor transnational corporations. As for the establishment of an integrated semiconductor industry in developing countries or areas, the prospects seem even more limited. In those cases, however, where a thriving local consumer electronics industry constitutes a large and expanding market for discretes and simpler ICs, a local wafer fabrication capacity may be economically justified. This presupposes, however, that the local infrastructure, the supplier industries and the skill level of the labour force are sufficiently well developed to support it. Otherwise, continued import of semiconductor components, possibly for local assembly, may be the more rational alternative.

25. In general, it seems that from an economic point of view, the development of an indigenous semiconductor industry need not be considered a priority by every developing country or area, irrespective of its level of industrial development.

Rather, before promoting such an industry a country must weigh not only the potential market for the industry's output but also the local economy's resource capacity to support a reasonably efficient local semiconductor industry. Without production of at least average efficiency, the semiconductor industry could impose an unacceptably high burden on the economy's scarce resources. Thus, for most developing countries or areas, rather than viewing a local semiconductor industry as a necessary condition for industrialization, it would seem more appropriate to view industrialization as a necessary condition for the eventual development of a viable semiconductor industry. It is in this context that the overall participation of transnational corporations can best be approached in the future.

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