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FOSTERING TECHNOLOGICAL DYNAMISM: EVOLUTION OF THOUGHT ON TECHNOLOGY CAPACITY BUILDING AND COMPETITIVENESS

Summary of the review and analysis of the literature

Report by the UNCTAD secretariat

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Preface

1. In accordance with the work programme of the Ad Hoc Working Group on the Interrelationship between Investment and Technology Transfer adopted at its first session (25-29 January 1993) and endorsed by the Trade and Development Board at its second executive session, the UNCTAD secretariat has undertaken a comprehensive analytical review of the literature on technological capacity-building and on the role of technology in the international competitiveness of nations and their enterprises.

2. A preliminary version of the review has been prepared largely by Professor Dilmus James, University of Texas, while he was working at UNCTAD. It has also benefited from inputs by Dr. Norman Clark, University of Sussex, Dr. John Enos, Oxford University, Mr. Andrew Hall, University of Sussex and Dr. Martin Fransman, Institute for Japanese-European Studies, who have also provided comments. The review is now being revised and will be published as a United Nations sales publication in the coming months.

3. The present report constitutes an extensive summary of the above-mentioned review. The literature that has been examined in preparing the review and the present report has been reproduced as background document UNCTAD/ITD/TEC/12.

Introduction

4. Technology and technological change affects productivity, amount and composition of output, levels of employment, skill profiles of the workforce, degree of competitiveness and trade flows. In the longer term, technology has a bearing on cultural values, social relationships and configurations of political power. It is, then, little wonder that the process and effects of technological advance continue to attract increasing attention among scholars, decision makers and practitioners in the laboratory or at the point of application. The analytical review undertaken by the secretariat deals with two subsets of these concerns: (i) how can countries, in particular developing countries, acquire and gain mastery over technology, including the organization of production processes, that is relatively new to them? and (ii) how do technology transfer and the accumulation of technological capacity affect competitiveness at the enterprise and national levels? The literature discussing these issues is vast. In this study, an attempt is made to focus on selected literature that has a direct bearing on the question of technological capacity-building and competitiveness. Although the agricultural sector is by no means ignored, technological capacity-building is analysed mainly in reference to the industrial sector. A special section is also devoted to the particular concerns of the least developed countries.

Chapter I

Evolving attitudes regarding technology, capacity-building and competitiveness

The neoclassical position

5. Until quite recently, orthodox neoclassical economists have tended to take technological progress for granted. In their microeconomic analysis, the production function, depicting all combinations of inputs for producing a given amount of output, is taken to be the centre of the firm's technological knowledge. Inventions and discoveries are generally considered as exogenous factors which create a pool or shelf of readily available technology in the public domain from which firms can choose. Thus, in neo-classical analysis, typically the acquisition of knowledge is assumed to be costless or at most incurring only a modest one-off expense. The element of time is ordinarily de-emphasized by presupposing instantaneous acquisition of technology. When the analysis occasionally focuses on generating technology de novo, the analogy with an ordinary investment decision is very close; that is, the firm compares the cost with prospective returns, both properly discounted, and weighs the probabilities of success or failure. Very often the analysis assumes perfect competition, which means, among other things, that the entrepreneur is omniscient about the market for inputs including technology. Relative product and factor prices constitute the core-data dominating decisions by the firm.

6. Since the late 1950s, mainstream economics has gradually come to recognize the important role of technological change in the process of economic growth. However, until very recently, the economic analysis of the origin, pace and direction of technological change has been largely ignored, or examined only within a highly reductionist and abstract framework. During this period, the focus of study centred on the ex post consequences of introducing new technology and to a great extent this remains so today.

The "developmentalist" position

7. Of the different schools of economists that have diverged from the neo-classical position, the "institutionalist economists" have always considered technology as a core element in economic development, but they have not been influential in forcing the technology debate into the field of development economics. Similarly, the impact in this respect of both the "structuralist" and the "dependency" schools has been minimal despite frequent references to the importance and desirability of technological progress in their writings. However, during the late 1960s and early 1970s, some development economists, referred to as "developmentalists" for the purposes of this study, began to sense that the very levels of abstraction and restrictiveness of the assumptions that had lent elegance and broad applicability to orthodox economics were limiting its usefulness in understanding the process of technological change. They began treating technology transfer and technological innovation within a political economy context and as an endogenous analytical variable and, therefore, a major element in determining economic growth and socioeconomic development. This was also a period when

many large developing countries established regulations governing technology imports and the national science and technology councils. It is obvious that there was some dissatisfaction concerning the manner in which technology was being analysed and the existing institutional mechanisms used for acquiring technology. Thus, the period from 1965 to 1975 can serve as a benchmark for identifying major differences in past and present treatment of technological change relating directly or indirectly to technological capacity-building and competitiveness.

8. In the past, there was heavy emphasis on transfer of technology rather than its internal generation in developing countries. Although developmentalists saw some room for expanding domestic innovational activities in developing countries, the brunt of the discussion on this issue revolved around acquiring technology from abroad and gave little recognition to endogenous technological capability.

9. At this stage, most writings on technology tended to focus on the technology transfer process and, in particular, the imperfections in the existing channels for transferring technology. There was also a widespread belief that technologies developed in mature industrial countries were ill-matched to the conditions, i.e., factor endowments, market sizes, and basic needs of the masses, in developing countries. This outlook meant that more weight was given to the choice of suitable production techniques. In this respect, transnational companies were viewed as the main channels for transferring technology under market conditions. However, the role and effectiveness of these enterprises in transferring technology was widely criticized. It was alleged, for example, that they provided technologies which were unsuitable for developing country conditions and, moreover, they charged higher prices even when the marginal cost to them for supplying already existing technology was zero or very close to it. Another complaint levelled at transnational enterprises was that technology was often transferred as part of a package or bundle tying technology to finance, managerial know-how, marketing capabilities and frequently with contractual provisions not advantageous to the purchaser. Thus, in part because of these experiences, the literature has tended to concentrate on monopolistic elements in the market and the cost to technology buyers. This, in turn, has had a major influence on some policy makers as reflected by the establishment, in a number of developing countries, of regulations governing technology imports. It should be noted, however, that the thrust of the literature and policy prescriptions has been directed at "defensive" measures to remedy defects in the international market for technology rather than positive actions designed to foster indigenous technological capability. Furthermore, during this period very little attention was focused on the technical learning process at the firm level.

Intervening events and the current "developmentalist" position

10. Several events and trends contributed to the evolution of the developmentalist position. These include, first, the rise of the East Asian super-exporters which aroused interest in learning about the origins and determinants of technological change in developing countries; second, a growing number of studies on innovational activities in mature developed countries which greatly advanced the understanding of how technological change

comes about; third, the recognition that many firms in developing countries did innovate, a few of them being able to undergo major technological transformations; fourth, the curiosity about the non-convergence of country growth rates led to a fresh interest in the detailed mechanics of technical learning and the process of technological capacity-building; fifth, the liberalization of much of the world economy has placed technology in the spotlight as countries exhibit a growing preoccupation with achieving and maintaining international levels of competitiveness; and finally, over the past three decades technology has become much more prominent in various economic theories, including international trade theory, the product-cycle theory, and more recently, the technology-gap literature in which technological change is considered an endogenous factor in the analysis.

11. Due partly to the above factors, over the past several decades attitudes towards technology and technological change have changed significantly. First of all, with the emergence of alternative sources of technology transfer, the former preoccupation with monopolistic imperfections in the international technology market and the associated call for regulations on technology imported by developing countries has waned. Second, while obtaining technology from abroad remains important to most developing countries, technology transfer is now seen primarily as a means of accumulating internal technological capacity rather than an end in itself. In addition, the problem of choosing the most appropriate technology has been far less conspicuous in recent literature with the emphasis shifting from the choice of technology to what a firm does with it after securing it. What is more, the recognition that incremental innovations at the firm level can increase the productivity of installed capacity and the fact that productivity levels can vary widely even among firms in the same industry using similar technology has contributed to a decline of interest on the initial choice of technology. Regarding actual and latent innovational abilities in developing countries, the new consensus is that domestic innovation, R & D activities and science and technology capability, up to a point, complement rather than substitute imported technology.

12. In short, therefore, the current focus is on taking advantage of opportunities for complementing local technological capabilities with technology obtained either as part of investment flows or through other conduits for technology transfer. At the same time, there has been a growing recognition that the enterprise is an extremely important entity for accumulating technological capacities in developing countries. The way technology is perceived has also evolved. It is viewed as a complex product and its development and assimilation demands interaction between various sectors in the economy. In this respect, the modern view of technological advance is at considerable odds with a linear thesis. Instead of an inevitable sequence from basic research through directed basic research, experimental design, applied development to pilot project and full-scale production, each stage often influences the others in a multidirectional fashion. Furthermore, there is a rich and complicated network of linkages through which various agents transmit and receive technical information.

13. The "developmentalists" have never been comfortable with the historical analysis of conventional economics. Indeed, there has been a growing consensus among development economists that the nations that are now attracting more

robust flows of technology are the ones that have taken prior actions to upgrade their domestic science and technology base through establishing incentives and an economic environment conducive to innovation developing adequate levels and categories of human resources and providing appropriate institutional, infrastructural and real-services support. Furthermore, they are able to endogenize and gain more benefits from the imported technology. This highlights the importance of the historical development of technology both at the enterprise and national level, a fact that serves as an incentive to begin putting one's scientific and technological house in order.

14. In addition to the foregoing shifts in emphases, or in some cases, fundamental changes in the way certain aspects of technology and development are viewed, there is significant interest in the current literature on the actual and potential impacts that newly and emerging technologies might have on developing countries. Significantly, low-income regions are not being completely neglected in these areas.

Chapter II

Technological capacity-building

A. Technological capacity-building (TCB) in developing countries by enterprises

15. Over the years, research on several industries has convincingly demonstrated the ability of enterprises in developing countries to innovate by using in-house know-how and resources. While most often such innovations are based on incremental improvements, and while ordinarily an individual change adds only slightly to efficiency, the cumulative effect can be a powerful source of enhanced productivity. Experience has shown that some enterprises in developing countries are capable of more significant technological learning and even major infusions of technology. Naturally, all enterprises do not show a proclivity or capability for innovation; however, there has been a sufficient number that do, thus drawing more attention to the process of enterprise-level learning.

16. One useful framework for examining enterprise-level technical learning is the concept of the "learning ladder". Each rung in the ladder depicts the progression in the learning process, starting from the ability to recognize an opportunity for technological input, the capacity to seek and select the appropriate technologies, the ability to adapt to local conditions, the skill to modify technologies, the know-how to generate new processes and products, and finally, the capacity to undertake R & D at the enterprise level. In reality, however, this progression is not inviolate and the available evidence indicates that there is a discontinuity in the learning process which makes it particularly difficult for most enterprises to go beyond the modification stage.

17. More detailed investigations into technological capacity-building at the enterprise level have revealed additional complexity. For instance, there is a profound influence on technological behaviour depending on the type of industry within which an enterprise operates. Sources of technology, direction of technological effort, the opportunity and room for technological manoeuvring are evidently conditioned by intersectoral differences.

Intra-enterprise learning

18. The neo-Schumpeterian school of economics, which has made the most effective attempt to address the question of how the enterprise uses and integrates technology within existing knowledge, has found it necessary to transcend the restrictive assumptions surrounding neo-classical versions of innovation. A major building block is the proposition that some technology, whether embodied in capital equipment or conveyed through licences, patents, books, word-of-mouth, etc., is often "tacit" or not fully codifiable.

19. The difficulty of codifying all technical knowledge is the primary reason why viewing technology as a commodity is misleading. While some technical information can be fully transmitted by word of mouth, printed matter or observation of practitioners, many forms of important technologies incorporate various degrees of tacitness requiring post-acquisition effort on the part of

the receiving enterprise. A second fundamental aspect is that enterprise-level learning tends to be "localized" by centring around deviations from known modes of production and searching for rules that have been successful in the past. Also, it tends to be cumulative in the sense that past learning experiences pave the way and condition the directions for future technological undertakings.

20. As a consequence, mature firms can have diverging paths of search and innovation, a result consistent with observed differences in intra-industry productivity levels. More importantly, given a few plausible assumptions, multiple equilibria outcomes are possible for enterprises depending on their past learning efforts and the technological and economic environment. Unfortunately, this includes the possibility of being locked into a low innovation situation.

Linkages

21. While some interest in backward and forward linkages among productive entities in developing countries appeared in the early literature, it was not until the 1980s that attention began to be drawn to the various channels through which enterprises in developing countries could access technical information. These learning mechanisms, many of which to one degree or another combine interpersonal relations with commercial activities, have become increasingly appreciated as a key element in capacity-building. Among the most common linkages described in the literature are: (i) subcontracting and other sourcing mechanisms; (ii) work force mobility; (iii) equipment suppliers; (iv) user-producer relationships; (v) linkages with R & D and other supporting institutes; (vi) consultancy services; (vii) Informal linkages; (viii) strategic alliances which may involve linkages with government, university or private R & D institutions; and (ix) intra-enterprise linkages.

The State sector

22. The available evidence on the role of the State sector in accumulating technological capability shows rather a mixed picture. While there are several cases of public enterprises that have accumulated considerable technological prowess, there are also others that have exhibited only moderate success and still others where the record has been dismal.

Small and medium enterprises

23. Small and medium-sized enterprises (SMEs), in developed countries are receiving a great deal of attention, perhaps because of the dynamism this sector has exhibited over the past decade. Unfortunately, however, relatively little is known about technological progress and the process whereby technology is acquired and mastered by SMEs in developing countries, particularly as regards the larger SMEs of the formal sector.

Linkages to external sources

24. Among the most obvious observations that can be made about enterprise-level technological capacity-building in developing countries is that foreign sources of technical learning are extremely important to the enterprises in

these countries. Firm-level acquisition of technology involves, to some extent, technology from abroad and frequently the technical information secured from foreigners is crucial for continued technological progress of the receiving enterprise. Every type of linkage discussed above frequently has an international connection and involves investment flows. In particular, direct foreign investment is a common conduit through which learning linkages can be activated.

25. Experience shows that building technological capability under developing country conditions is not easy. In many cases it has not been possible to acquire technological capacities that go beyond learning passively from production activities. The success of technological capacity-building depends on deliberate efforts backed by favourable industrial policy. As can be deduced from the experiences of successful countries, a proactive approach to enterprise-level technological capacity-building appears to be a prerequisite to achieving technological dynamism.

B. National measures for technology capacity-building in developing countries

26. Although the literature on technological capacity-building has recently begun placing greater emphasis on the enterprise level, a nation's technological capacity-building or competitive position is just the sum of individual firms' technological capabilities. Technologically progressive enterprises operate within a rich network of interconnections between themselves and other institutions. In addition, the general economic environment plays a significant role and as is the case with enterprises, history counts for nations as well. This can be seen, for example, in the different evolutionary paths that various developed countries have taken in terms of science, technology and education.

Macro-economic policies and technological capacity-building

27. Bearing this in mind, what are the specific conditions at the national level that can facilitate technological capacity-building? Three sets of conditions are identified in the literature. The first concerns conditions that are not specifically directed at science and technology policy as such but are deemed desirable for the overall operation of the macroeconomy. Adequate economic growth, political stability, stable prices, high levels of employment and a favourable balance of payments all fall into this category. Other helpful conditions include a dependable and predictable legal system and a general economic atmosphere that rewards enterprises' initiatives and innovative efforts. In this context, access to global technologies is connected with intellectual property rights and a healthy exposure to competition. The later can spur entrepreneurial and innovative energies and talents.

The institutions for technological capacity-building

28. A second set of conditions involves institutions and infrastructures that target technological capacity-building. The possibilities include a high-placed science and technology institute and/or a national council of science and technology set up specifically to formulate technology-related

policies and give guidance to national efforts relating to technological capacity-building. In this connection, the entire educational apparatus, both formal and informal, can play a central role in providing the institutional base necessary for building local technical skills. Moreover, intelligence services can be provided by agencies that gather and make available information on technologies, production, marketing, finance, investment opportunities, and the domestic and global economy. The availability of such data will not only reduce transaction costs for individual firms attempting to acquire information on their own but will also raise the amount and quality of information readily available to them.

29. Other types of support infrastructure include R & D institutes, engineering consulting services and extension services. Often R & D institutes tend to be State-funded, but even in cases where they are not, the State can play a constructive part in encouraging the development of private R & D activities. Extension services can be directed to testing of materials, advising on standards and quality control, counselling domestic firms on negotiations with foreign counterparts regarding joint ventures, licensing arrangements and other similar activities. Although not universally accepted, initiatives such as industrial parks are thought by most to be an effective way of boosting local technological capacity through increased linkages and communications between domestic firms and locally located foreign firms. Other less frequently used measures to induce local research capability include enriched salary incentives for selected R & D projects, tax rebates for R & D activities and tax levies to support R & D.

Specific policy instruments

30. A third set of conditions involves policy instruments that can be used to encourage technological capacity-building. These include import licensing, the foreign exchange allocation system, price controls, concessional credit schemes, investment grants or subsidies, preferential tax treatment, protection through tariff and/or quota measures, and tax exemption on imported capital goods and intermediate inputs. The procurement system of government agencies and State enterprises can also be fashioned to support innovative sectors and new product development.

31. These instruments can be focused on specific sectors or producers, a characteristic that renders them highly controversial. Past experiences show, however, that in order to be effective, these instruments must be applied with consistency and persistence. An agreement needs to be reached on performance criteria with the sectors, industries or enterprises that are being targeted and progress must be monitored. Moreover, the evidence available suggests that it is inadvisable to try to use these types of targeted instruments for other purposes than TCB (e.g., increasing employment, solving balance-of-payments problems, redistributing income, etc.), because the dynamics of cumulative learning can be dampened under these circumstances. Finally, it is widely believed that science and technology policy should be in harmony with trade, industrial investment and employment policies, although beyond a general exhortation, the specifics have so far received only scant treatment.

32. In summing up, therefore, it should be stated that while the literature is liberally sprinkled with descriptions of various policy and institutional conditions necessary for building a technological base, there is a dearth of solid analytical and evaluative material on how effective many of them are in promoting TCB. There are, however, three exceptions: R & D institutes, human resources and intellectual property rights.

R & D institutes

33. Over the years, developing countries have made concerted efforts to boost their science and technology capability and develop indigenous R & D capacity. Despite these accomplishments, however, there is overwhelming evidence to suggest that many research institutes in developing countries are operating far below their potential. There is no question that the central problem with the research system in developing countries is the anaemic contribution that R & D activity provides the productive sectors within these nations. This deficiency is attributed primarily to the weakness of linkages between R & D units and producing enterprises. This shortcoming is at the core of the problem, although there are also deficient linkages in other areas; there is, for example, little organic dialogue among researchers, agriculturists, industrialists, financial institutions, consultants and government decision makers.

34. A number of studies on this subject have also uncovered a variety of problems at the institute level regarding the selection, maintenance and use of laboratory equipment and the sub-optimal allocation of key researchers' time. The literature, furthermore, describes difficulties with the choice of research projects which tend to be too small to attain a critical minimum threshold of resources devoted to individual projects and are, in the aggregate, too heavily concentrated in basic research. Unstable funding for R & D is another difficulty widely mentioned in the literature.

Human resource development

35. Human resource development is one aspect of social development which has received considerable attention and support in developing countries. This is, to an extent, due to the direct link that exists between the development of human resources and the building of technical capability.

36. The literature identifies at least four major trade-offs in developing human resources for technological capacity-building. The first is related to the controversy involving the proper role and balance of secular and religious authorities in providing education. Second, there is the conflict between suffering the costs of "brain-drain" and allowing educated citizens to choose their own destiny. Third, for a given education budget, there is a trade-off between provision of low-skill and high-skill education; in practice, it has proved easier to expand university education than secondary education, although this has been questioned on economic grounds. Fourth, there is the problem of finding a proper balance between acquiring technology from abroad and gearing human resource development to endogenization vis-à-vis generating technology de novo domestically. Several studies have stressed that to a

certain extent these activities can be complements rather than substitutes; if so, the question one ought to ask is how can the educational system in developing countries be designed to achieve the necessary balance?

Intellectual property rights

37. The 1980s saw heightened interest in the international aspects of intellectual property rights (IPRs). Developed countries' interest in this topic is attributed to three factors: (i) the rapid growth of international trade in knowledge-intensive goods and services in recent years; (ii) the new opportunities created by global economic liberalization for exploiting proprietary technologies, and (iii) the improvement in the technological capacity of some developing countries which has increased the risk of imitation of technologies developed in mature industrial economies.

38. The concern shown by developed countries, along with the fear of retaliatory actions against nations thought to have weak IPRs, has forced developing countries to take a closer look at the overall economic consequences of providing more secure protection for intellectual property. In addition, there is evidence to suggest that as developing countries accumulate more advanced technology, some are becoming increasingly conscious of the benefits of protecting their own intellectual property.

39. The benefits to developing countries from strengthening their patent protection identified in the literature include access to information disclosed in patents, stimulation of domestic research, enhanced technology and foreign direct investment inflows, easier access to markets in developed countries, and the stimulation of more R & D globally.

40. Possible costs include the expense associated with administering and enforcing the new regulations, increased payments for proprietary knowledge, and higher domestic prices in the short run due to anti-competitive elements associated with IPRs. Restrictions on copying could also have an impact on employment, foreign exchange earnings, industrial output and the process of learning through imitation or "reverse engineering". It must be stressed, however, that the conceptual and empirical investigation of the effects of IPRs on developing countries is still in its infancy. There is little agreement as to the net effect of the benefits and costs just mentioned and some believe that IPRs should be lax for LDCs and become stronger as one moves toward the NICs.

Chapter III

Technology, competitiveness, industrial policies

A. Enterprise-level strategies for attaining and maintaining international competitiveness

The conceptualization of the firm

41. In the literature discussing international competitiveness, one definition of a firm which is receiving increased prominence is the conceptualization of the firm as a collection of core "competences". Core competences are those abilities which give the firm a competitive advantage and facilitate the realization of value. Thus, the condition of being competent is equated to that of being competitive. Accordingly, the corporate strategy or policy priority of managers is to identify the firm's core competences and to concentrate on developing them in order to improve competitiveness. However, the proponents of the "competence" concept stress that core competences cannot be acquired quickly or easily or at lower cost or transferred to others, and it is precisely this feature that makes them a source of competitiveness. A firm is able to earn an economic rent from those competences which are in short supply and cannot be readily and inexpensively emulated by would-be competitors.

42. The above concept of competence has important implications for the conceptualization of corporate strategy since a firm is constrained in what it can do by its competences and the limitations it faces in acquiring and accumulating them. This view, however, is in strong contrast to the "voluntarism" evident in much of management literature, where the impression is often given that the key to success lies in managers developing an appropriate strategy. The "competence approach", on the other hand, suggests that although strategy is constrained by competence, good strategy is based on identifying and enhancing distinctive competence. The strategic imperative for management, therefore, is to identify simultaneously the firm's distinctive competences and the markets in which these competences can be used to earn satisfactory economic rents.

43. The literature is now beginning to tackle questions on how competences emerge, accumulate, or yield value, i.e., how they are organized, and what factors need to be taken into account in their organization. So far, most of the work that has been done in this area relates to some notion of "bounded rationality". The term refers essentially to the constraints that limit the individual's ability to process information, implying logically that individuals have no option but to make decisions on the basis of the information they have processed, rather than on the total amount of relevant information in existence. However, while bounded rationality is an important consideration to take into account in organizing competences, there are many other factors that need to be explored in a more systematic way if we are to better understand and, therefore, design the forms of organization that are appropriate for the development and exploitation of competences.

Organizing the accumulation of competences

44. At the firm level, the important question is whether a firm needs to be subjected to the pressures of a competitive environment in order to develop competitive core competences, and if so, what kind of "competition" is necessary? In this respect, it is important to distinguish between competitive "pressures" and competitive "incentives" because of their different effects. It is argued that while competitive incentives carry the promise of the firm and (some or all of) its members being better off, competitive pressures carry the threat of being worse off. Whenever greater weight is attached to being worse off, competitive pressures will have a greater impact on a firm than competitive incentives.

45. Literature concerning the firm has traditionally dealt with firms operating in developed-country markets which, under international trading practices, are usually relatively open so that competitive pressures may, in both factor and product markets, come from other firms producing domestically or from imports. In this context, the very concept of core competence implies the existence of significant competitive pressures. The situation in many developing countries, however, with smaller markets and often significant trade barriers, is very different.

46. Much of the earlier literature on the NICs has argued that their superior performance resulted from their introduction in the 1960s of a trade regime that approximated free trade. More recent literature, however, has pointed out that both Japan, in earlier periods, and the NICs have eluded many of the precepts of neo-classical thinking. This has led to a growing body of literature on how manufacturing-based and export-oriented trade policy was used by these countries to create the incentives necessary to accumulate competences while fostering the competitive pressures needed to ensure that these competences are "competitiveness compatible".

47. The above discussion on the importance of competitive pressure for the accumulation of core competences makes it implicitly clear that in order to understand the processes that go on within the firm (such as the development of competences) it is necessary to understand the environment or context within which the firm exists. Accordingly, an analysis of the interior of the firm requires simultaneously an analysis of its exterior or, as sometimes referred to, its "selection environment". The latter refers to the sum total of factors which influence growth of the firm.

B. Strategic intervention: technology, competitiveness and industrial policy

48. In the developed economies, industrial growth and international competitiveness usually depend on access to new technologies and the capacity of different countries to sustain their lead in innovation and technological development. It is therefore not surprising that since the early 1950s much of the discussion on technological capacity-building and competitiveness (at the government and academic levels) has centred around the impact of policy, that is, whether or not an active industrial policy is necessary to achieve technological leadership and improve the competitiveness of national companies.

49. Basically, the debate has been between two elements: on the one hand, those who argue for minimum intervention and believe that far from stimulating technological development and inducing competitiveness, strategic intervention by means of industrial policy stifles competition; and on the other, those who advocate an active industrial policy to support technological development and competitiveness.

The non-interventionist position

50. According to non-interventionists, the type of industries and technologies developed should be determined not by government policy but by the market. Following neo-classical economic doctrine, they argue that the role of the government should be confined to creating the right conditions for competition and the market to function properly. Competition between firms is believed to be highly desirable because it leads to efficient production at a minimum cost and creates an environment conducive to technological change and innovation. Consequently, anything which interferes with competition is viewed as undesirable.

51. Following this logic, it is further believed that collusion and/or cooperation between firms invariably constitutes a threat to competition. Firms, it is argued, have an interest in colluding in order to restrict competition (whether their collusion is explicit or implicit). While this will benefit the firms affected by pushing up prices and possibly increasing revenues and profits, it is the consumers of their products who will lose. Thus anti-trust regulations have been prominent in the United States and other developed countries such as the United Kingdom and Germany, being intended to minimize the opportunities for inter-firm collusion or cooperation.

52. Indeed, the differences among industrial-policy approaches in Japan and other major industrialized countries are reflected in the differing level of importance attributed to laws regulating competition. In Japan, inter-firm cooperation in the field of technology and marketing is not only tolerated but also encouraged through forward-looking industrial and research policy. The central objective is to identify strategic industries, key technologies and potential markets for public assistance through direct and indirect measures. Many attribute the Japanese success to this approach.

53. Non-interventionists argue, however, that the Japanese model will not work in the Western-style market economic system, pointing out that it would restrict the role of the market. Moreover, even if adopted as a strategy, accurate predictions with regard to the development of key industries or the identification of successful markets are not as easy and straightforward as claimed by some pro-interventionists. Mistakes are possible and if investment decisions are made on the basis of wrong forecasts, commitments by entire branches of industry can turn out to be bad investments. Thus Japanese-style strategic intervention by means of industrial policy to foster technological development is seen by some observers to be inappropriate and unworkable in the developed economies of the West.

54. Another argument used in recent years to reject strategic intervention by means of industrial policy concerns the globalization of production, growing foreign direct investment and the expansion of cooperation or alliances

between firms of different countries. It is estimated that during the 1980s the world stock of foreign direct investment doubled, reaching over a trillion United States dollars by 1990. Furthermore, since the mid-1970s, there has been at least a ten-fold increase in the number of inter-firm agreements in technological cooperation, most of them between firms of different nationalities.

55. These trends, it is argued, have blurred the national origin of both products and firms, thereby severely hampering strategic intervention to assist national firms, in exclusion of other firms originating from other economies. The greater the level of direct foreign investment and cross-border corporate alliance, the argument goes, the less effective strategic industrial policies will be in enhancing the international competitiveness of national companies. Policies, even if they are targeted, accordingly tend to benefit foreign firms as well, thereby neutralizing any advantages national firms may have enjoyed.

The pro-interventionist position

56. For pro-interventionists, the issue of technological development is intrinsically linked to competitiveness. Access to new technology will enable countries to sustain their competitiveness. By the same token, however, technological dependence can lead to loss of competitiveness. Not surprisingly, therefore, calls for an industrial policy in recent years have come largely from academics and politicians who are concerned with rapid technological advancement in competitor countries.

57. In Europe, for example, there is concern about the fast development of new technologies (i.e., information technology, biotechnology, energy and space technologies) in Japan and the United States and the fact that Europe lags behind in these areas and will soon become dependent on imports from these countries. It is argued that technological dependence on key technologies such as computer memory chips can lead to loss of competitiveness not only in industries that are engaged in the manufacture of computer hardware but also in other industries where these technologies are applied. Consequently, advocates of the interventionist approach warn that without active government policy directed at these key technologies, national firms will be subject not only to unfair foreign competition but also to an irreversible weakening of their technological capacity.

58. Similarly, in the United States calls for industrial policy are linked to the perceived deterioration of that country’s industrial competitiveness, especially in comparison with that of Japan. The source of this problem is the continuing relative erosion of American strength in high-technology industries.

59. In summing up, therefore, the available evidence suggests that although many developed countries have used industrial policy at one point or another, either to protect/preserve old industries or as a response to new industrial problems, only a few have used it consistently. In recent years, however, the loss of competitiveness arising from new technologies has forced most developed countries to focus on to a set of principles that broadly favour strategic policy intervention in key sectors. In the case of developing

countries, on the other hand, the industrial policy debate has revolved around the infant-industry argument and in particular the question of how and for how long emerging industries should be protected.

C. Strategic intervention: the debates over infant-industry protection and industrial policy

60. Arguments for and against infant-industry policy are too numerous to include in this summary. However, two important points arise from this debate:

61. First, few would recommend the old style import-substitution industrialization model as a long-term route to acquiring technological capacities. It has been demonstrated that costs of the import-substitution industrialization model were extremely burdensome: agricultural and traditional export sectors suffered; excessive capital intensity was encouraged with detrimental impacts on employment and income distribution; import-substitution industrialization became import-intensive; underutilization of capacity was common; and the protected "hothouse" environment did little to encourage efficiency.

62. There are some authors, however, who argue that the problems accompanying ISI have little to do with import-substitution industrialization per se. They point out that the problems are related to external factors and the way governments manage (or mismanage) import-substitution programmes. In this respect, reference is often made to the fact that virtually all industrial nations developed their manufacturing sectors behind protective barriers in their early stages.

63. Another generalization that can be made is that despite widespread acceptance of the virtues of a healthy export sector and heavier reliance on market forces by most developing countries, the literature reflects a major revisionist trend away from the pure forms of neo-liberal policy prescriptions that prevailed at the beginning of the 1980s.

64. Thus, as reflected in both literature and real-world policies, there is widespread dissatisfaction with both import-substitution-industrialization and a pristine form of neo-liberalism as a means of accumulating technological capability. Between these two poles, however, the number of possible permutations for strategic interventions is somewhat daunting. In its simplest form, the objective of infant-industry policy is to temporarily shelter young, high-cost domestic industries from mature, low-cost competition from abroad to provide time for the protected national industry to gain the technical expertise to lower costs to an internationally-competitive level.

65. This approach for intra-industry learning has been roundly criticized on several grounds. It has been argued, for example, that it is not easy to predict which industries have the capability of becoming low-cost in the foreseeable future. Moreover, it is pointed out that since the world technological frontier is likely to progress, the infants are chasing a moving target which means a more rapid cost reduction is needed or a more extended

period of incubation is required. In addition, the private sector is capable of sufficient foresight to pick winners and cash in on future gains after an initial period of losses.

66. There is also a political-economy argument which says that in actual application, the argument for infant-industry is misused to disguise unjustified avoidance of international competition and also that the protection granted very frequently is kept in effect long after an industry reaches adulthood. Furthermore, the perception that protection is de facto long term may blunt incentives for acquiring the technical learning to become globally competitive. These practical aspects led, even those who recognized the validity of the infant-industry argument, in principle, to become very discouraged about its actual employment.

67. Although some developmentalists have defended the validity of temporary protection for stimulating intra-industry learning, pointing out that in a developing-country context the private sector may be excessively averse to taking risks, inadequately informed or unable to obtain funds because of imperfect financial markets, this more constricted version no longer enjoys widespread support. There is, however, a general agreement that the existence of benefits that spill over into segments of the economy beyond the protected industry are a prerequisite for defending intervention on behalf of immature industrial activities. There is also the suggestion that, since R & D and most other innovational activities require time, involve risk and absorb resources, and since, in the early stages of accumulating experience in generating technology, such undertakings are likely to be high cost, there may be a case for fostering domestic TCB through protecting technology-related efforts as well as sheltering the production of final output.

68. What has been the result of infant-industry protection policy? More concretely, it can be said that infant-industry protection is very difficult to bring off successfully. The record is strewn with cases where results clearly did not warrant the sacrifice. Second, frequently the period of time required for the successful maturation of some infant industries can extend to decades. Although there are some difficulties involved in specifying a precise beginning and maturation of an infant industry, there are reasons to suspect that the required length is growing as technologies become more complex.

69. In this connection, two important lessons drawn from studies on these issues are worth mentioning. First, it is a mistake to cut off access to outside technology when the world technological frontier is moving very rapidly. Second, a key concept in the whole process is <u>selectivity</u>. There must be some selection of products or product areas to target.

70. The question of governments' ability to learn and shift policies accordingly is an issue which has received greater attention in the literature. In this respect, the evidence emerging from the newly industrializing countries has shed considerable light, especially as to why infant-industry protection is a risky business and why the period from infancy to maturity can be so lengthy. The evidence obtained suggests that there are a number of balancing acts and intricacies involved. Among other things, they require learning to ease up on purely regulatory functions and shift to a more

positive, handmaiden-oriented or nurturing position. For many governments this may not be easily accomplished. There is also the matter of degree, and as always, selection, with regard to how much and what kinds of technology to import. In addition, conditions will change through time requiring sensitivity and subtlety in responding to them. The difficulties inherent in government learning may go a long way in explaining why countries that have already attained a semi-industrial status seem to have a better chance at carrying an infant industry through to maturity. For the vast majority of developing countries, this is additional cause for not taking the initiation of an infant-industry lightly and, on a case-to-case basis, to weigh carefully whether suffering the costs of market failure might not be the wisest course.

Chapter IV

Technological strategies for the least developed countries (LDCs)

71. Turning to the issues faced by the LDCs, our knowledge about workable technological strategies becomes increasingly inadequate. The review of literature on the general technological situation in the LDCs and poor regions in other developing countries brings out the well-known constraints they face: low level of human resource development; inadequate infrastructure; low demand for technology resulting from small and weakening manufacturing sectors, small market size, reliance on relatively capital-intensive production processes, policy bias towards large-scale enterprises, and the tendency for domestic production to duplicate imports, a condition which has been characterized as "import replication", as opposed to "import substitution".

The importance of the informal sector

72. In view of its importance to the economies of LDCs, the informal sector has been the focus of a number of studies on technological behaviour. The findings contradict the notion that the micro-enterprises making up the informal sector are stagnant in terms of technology or capital accumulation. Indeed, technological capacity is manifest in diverse forms, depending on the geographic area and the consequent contextual situation in which firms operate. Technical learning and capital accumulation tend to go hand-in-hand, seeing that the accumulation of capital equipment (more expensive and complex at each stage) requires parallel learning by workers and small-unit managers - it is analogous to the cumulative nature of technical learning in larger firms.

73. In the informal sector, ideas for innovations come from many sources including imagination of the owner, friends and neighbours, and observations by informal or formal sector users or equipment suppliers. Surprisingly, while subcontracting arrangements may spur innovational activity, numerically they are not very important. The same holds for information secured from government agencies. By contrast, however, education seems to have some positive influence although training and years of experience are much more significant in explaining different incidences of innovation among firms. A great deal of this experience, both for the entrepreneurs and workers, has been acquired during previous employment in the formal sector.

What types of technologies?

74. The scant success of traditional development strategies in improving the conditions of the LDCs has led to a whole body of literature on what should be the nature of technologies or technological strategies for these countries.

75. The appropriate technology movement has given rise to a significant amount of literature. The concept, which was originally referred to as intermediate technology and gained popularity in the 1970s, has a number of definitional problems. At times the concept is couched in general terms which stress the examination of appropriateness (economic, social and cultural) in each individual situation, but this general-principle approach is so all embracing that it runs the risk of being vacuous. Another approach relies on

specific characteristics as definitional guidelines. As the emphasis of the appropriate technology school is on low-income, labour-surplus societies in which production is normally performed by small-scale units, appropriate technology, compared to conventional technology, would exhibit all or most of the following characteristics: (i) low investment cost per work-place, (ii) the employment of a relatively labour-intensive technique, (iii) the need for low to moderate skill levels and entrepreneurial capabilities, (iv) a usual mode of operation that is ecologically sound, (v) the use of a high proportion of locally available inputs and (vi) efficient operation on a small-scale basis. Naturally, the appropriate or intermediate technology would have to be superior to traditional technology in order to be a viable option.

76. It should be noted, however, that although the appropriate-technology movement can point to many individual successes, there is little evidence that it has contributed much to achieving technological dynamism. Consequently, despite its obvious appeal, appropriate technology has failed to be adopted into the mainstream as the dominant form of technology-practice.

77. The potential of the frontier technology in alleviating poverty has also been the subject of considerable literature. An approach to applying frontier technology in developing countries has been described in the literature under the term technology blending. As suggested by the term, the idea is to discover whether the combination of modern biotechnology, photovoltaics, laser applications, space satellite communications, new materials science and microelectronic innovations can be married with (not replace completely) techniques and procedures found in the village economies, SME manufacturers, the urban informal sector, agribusiness and small-holder agriculture.

78. Technology blending is distinct from appropriate technology in that, compared to the latter, blending is likely to: (i) require greater investment per workplace created, (ii) involve a larger leap in terms of skills, and (iii) require more importing of the technology. While some successful cases of blending have been reported, it is apparent that not all technology blends work well and those that do depend on a specific set of circumstances. In the context of technology capacity-building, in order for "blending" to contribute to technological dynamism, the blends must provide the basis for local innovation by seeking other feasible applications, adaptations to local situations, and further improvements and refinements. However, as initiatives with technology blending are in early stages of planning or implementation, evaluations are not yet readily available in the literature.

79. Concerning frontier technologies, a number of studies have reported on computer use and information technologies in Africa and the problems faced in the application of these technologies. Despite the difficulties noted in their application, one aspect of computer technology in developing countries that has attracted some attention concerns the so-called expert systems, which are computer programmes that, by utilizing information and reasoning techniques, try to simulate those employed by human experts. There are serious discussions and pilot projects involving expert systems are being applied to problems of developing countries, primarily to agricultural, forestry and village health care. While the use of expert-systems in developing countries has not lived up to expectations in the 1980s, their

advocates advance several reasons why efforts to continue explorations and experimentations should be encouraged. First there are expert systems in use in developed countries that hold some potential for productive applications in developing countries; second, there are already some promising expert systems in operation in developing countries.

Different institutional emphases

80. Regardless of the mix of technologies selected, they do not operate effectively in an institutional void. While literature generally agrees on the need for new approaches to the technological development in LDCs, the question of what is workable still remains.

81. The literature on what types of institutions or producing units should be emphasized for breathing new technological life into low-income sectors or countries has been an attempt to answer the above question in connection with specific sectors or regions. The various proposals include taking a new look at the potential offered by the natural-resource-based sector. It is argued that this sector, which is fairly large and relatively profitable in many African countries, is amenable to a number of improvements: technological upgrading through the application of new technologies; the establishment of a science and technology institute under the national planning commission that will not only formulate policy but will also oversee its implementation; and institutionalization of arrangements for networking among different actors involved in innovation. The central focus of such arrangements would be on innovation at the enterprise level through collaborative problem-solving involving supplier firms, university facilities, engineering consultancy firms and research institutions; a bigger role for SMEs, including those of the informal sector and in rural areas; and greater use of possibilities offered by Non-Governmental Organizations.

The common ground

82. Turning to the more general issue of the role of technology capacity-building in the process of development, there seems to be a broad consensus regarding the detrimental consequences to capacity-building and industrialization when the gulf between current capabilities and the complexity of the technology in place becomes overwhelming. It is argued that a mismatch between capabilities and the complexity of technology in place does not only lead to industrial inefficiency but also to "negative feedback", i.e., industrial experience rather than providing the stimulus for further development of learning of new skills and capabilities, which creates attitudes and interests that inhibit the full development of other sectors. Thus, pursuing technology capacity-building policy through importation of modern technologies (i.e., "technological fixes") is seen as unviable and myopic. At the same time, however, opinion is virtually unanimous, that the way out for nations, regions or sectors trapped in relentless poverty lies in technological capacity-building. While this may seem contradictory, in the light of complaints about resorting to "technological fixes", there are major qualifications that distinguish the two positions. One difference is that for the former group of authors the process of technological capacity-building is a long-term process. A second difference has to do with what is understood by the term "technological capabilities", that is, whether they are a narrowly

conceived set of technical skills and managerial practices associated with the operation of specific hardware or whether the emphasis is on the accumulation of managerial/organizational technology, i.e., the capacity to conceive a new project, select and negotiate for the technological components required, see the scheme through a construction and completion phase, initiate a continuous stream of improvements, and undertake investments in discrete improvements in technological capacity-building.

83. Furthermore, there is general agreement on the need to put emphasis on local initiative and learning by the indigenous population. Moreover, it is repeatedly emphasized that alternative learning paths have not been explored and even when the "correct" moves have been made, there has been a lack of persistence and seriousness of execution. However, advocating a meaningful and dominant role for indigenous resources should not be confused with a doctrinaire espousal of "self-reliance". The tradeoffs between long-run local learning and short-term exigencies are a matter of judgement and subject to some elasticity depending on practical and pragmatic circumstances; timing and tactics may be manipulated as long as the accumulation of domestic TCB remains the ultimate objective.

84. Not only should the initiative for innovation and technical learning be guided by local institutions, the impetus should originate in the form of demand-pull for innovations from the productive sector. The literature agrees on the pivotal role of the private sector and of the proper orientation and inspiration of local innovations. But while market incentives are vital, they are not sufficient for spurring technological dynamism in very low-income nations or sectors. This view is not surprising since some scholars make the same observation with regard to more technologically advanced countries where clearly national scientific and technological foundations are on a stronger footing than those of LDCs. In essence, relying on very rapid exposure to market-driven imperatives, in isolation, is merely another example of a "quick-fix" mentality.

85. Finally, there is general agreement that while the task of technology capacity-building in LDCs will not be easy, it is not impossible; some combination of prescriptions incorporating patience, heavy reliance on indigenous resources, cumulative learning, and endogenization of technology can begin to turn the tide in favour of technological dynamism in very low-income regions and nations of the world.

Chapter V.

Technology for agricultural development in developing countries

86. There is sometimes an unconscious predisposition among development analysts to regard technology as relating mainly to industry and by implication almost as having little to do with agriculture. Nothing could be further from the truth. But if technological factors are as important in agriculture as they are in industry, it is nevertheless true that they impinge in rather different ways. There are two broad reasons for this. First, agricultural production is inherently more unstable and location-specific than is the case with industry. This is largely because it takes place within the context of natural (biological) systems that continuously evolve over space and time. The second difference relates to the weakness of the market in allocating technological resources efficiently for the small-scale, heterogeneous type of agriculture which is typical of most developing countries.

87. For these reasons, the investment of resources designed to upgrade the technological level of agriculture (particularly for the poor farmer) has traditionally been seen as the business of the public sector, with research being conducted in centralized institutes and its results passed on to the farmer by means of a network of extension agencies. Interesting questions then arise about technological capacity-building since there is a growing realization that capacity building, if it is to be successful, should take place as close as possible to what is the enterprise equivalent in agriculture, the farm.

88. In the 1970s, the predominant mode of thinking in this area was still what was called the top-down or transfer-of-technology model. The view was that new technologies would come from the transfer of good practices from the developed countries with diffusion taking place through community development programmes. The process of diffusion was achieved through the establishment of a number of research institutions, initially through private and bilateral aid and later with multilateral aid. It was in this context that the transfer-of-technology model came very much to the fore as the correct institutional mode for agricultural development. The rationale for this approach in the post-war period was based on the widespread view that developing country agriculture was technologically primitive and that the rapid population growth rates meant a need for new technologies. Similarly it was thought that the problem was not so much one of inefficient agronomic practices as one of technologies that needed to be upgraded. Furthermore, for the first time, plant breeders started applying plant characteristics previously confined to temperate food crops - hybrid vigour and dwarfing to crops grown in tropical countries. The high-yielding varieties (HYVs) that emerged became the bedrock of what is now known as the Green Revolution.

The Green Revolution

89. The Green Revolution best illustrates the transfer-of-technology model, since the initial impetus for it did not come from the national agricultural research systems (NARS) of the developing countries but rather from two international agricultural research centres (IARCS) that subsequently became

the model for the 18 centres that now comprise the Consultative Group for International Agricultural Research (CGIAR) system. Production technologies and varieties for mandated crops and geographical regions were developed in these centres and subsequently passed on to the NARS for applied research and final transfer to farmers.

90. The impact of the Green Revolution has been one of the most discussed themes in the development literature. However, attitudes towards it have altered over time, due to the phases of technical innovation that have occurred and to the emergence of longer-term patterns in the effects observed. Historically, much of initial analysis focused on issues associated with the adoption/non-adoption of modern varieties, the suggestion being that "non-adoption", and therefore failure to benefit from modern varieties, was simply due to the ignorance of smaller farmers. Later analysis suggested that "non-adoption" was the result of the incompatibility of high yielding varieties with prevailing socio-economic patterns and that these varieties were only suitable for a specific set of favourable physical conditions. In fact, some authors have pointed out the problem was not with the technology itself, since when it could be applied efficiently it was highly successful, but that it often did not meet the diverse needs and circumstances of farmers. Part of the problem with the Green Revolution has been attributed to the centralized nature of the research institutes which were involved in the development and diffusion of the technology which did not allow for feedback from farmers, considered crucial for solving basic problems facing farmers particularly those of small farmers in poor regions. Thus, the better understanding of the issues derived from the experience of the Green Revolution has led to a growing emphasis being put on agriculture as a complex dynamical system.

The new approaches

91. More recent research findings indicate that modern strategies have often been a rather crude attempt to deal with what has now emerged as a sophisticated system of resource management; furthermore if science is to provide technology for these complex systems there must be greater understanding of them. The two best known approaches put forward as alternatives to the transfer-of-technology model are the "farming systems research" (FSR) and the "farmer-first-and-last"(FFL) models. The former which has emerged mainly from the IARCs, relies on working with farmers to identify problems and is intended to involve them to varying degrees in a process of change which takes place wholly or partly on the farm. It is argued, however, that the idea of farmers' involvement, which makes this approach a valuable method for addressing farmers' needs, renders its integration into mainstream agricultural research extremely difficult, due to the hierarchical nature of the latter.

92. This has led to the farmer-first-and-last approach, more radical in that it assigns a central role to farmer-generated knowledge. The literature provides abundant examples of farmers' innovations as well of their ability to manage complex environments in a sustainable fashion. However, despite the recognition of the value of farmer-generated knowledge, the full nature of this knowledge system, its desired institutional focus, and the extent to which it can contribute to conventional agricultural research systems are

issues that are still not fully resolved. In addition, it is unclear how the farmers' knowledge system would cope with increasingly new agricultural technologies.

New technologies

93. A counterpart to the growing appreciation of the complexity of agricultural techno-economic relations is a growing concern about the sustainability of developing country agriculture and the contribution of technology in dealing with it. Probably the most widely heralded vehicle in this sense are the competences and capacities associated with recent developments in biotechnology. The potential of plant biotechnologies for agriculture includes a diverse range of techniques which appear to offer real scope for helping solve the problems of developing countries, particularly since they provide potential "tools" to solve agronomic problems which may be highly location specific.

94. However, the scope of accelerated technological change that is associated with biotechnology is so vast and covers such an enormous range of human activities, including the agricultural sector, that it is inevitable that conflicts of interest will arise. As a consequence, a number of authors have been cautious when discussing the impact of biotechnology on developing countries. One reason why biotechnology seems to hold specific problems for developing countries, from the point of view of capacity-building, is that whereas agricultural research has in the past been in the public domain, much of the applied research in agricultural biotechnology has been undertaken in the private sector, chiefly in developed countries. Furthermore, applied biotechnology has often been the result of private sector collaboration with universities. Also, the development of this industry in developed countries is said to be connected with judicial decisions that have granted intellectual property rights to innovators over genetically engineered "forms of life". For these reasons, it is argued, access to new information on agricultural biotechnology by the scientific community in developing countries is relatively restricted.

95. The rapidity with which biotechnology innovations are produced, together with the above-mentioned concerns, have led to increasing attention being devoted by literature to policy options available to developing countries. Integration of biotechnology initiatives into existing institutions has been the policy stance of many major international agencies; collaborative initiatives with existing "pockets" of biotechnological expertise in developing country research systems have been advocated by bilateral aid agencies. At the national level, a number of developing countries have established centres for biotechnology and genetic engineering. It is argued, however, that these initiatives will still be hampered by the same mechanisms and strategies which have been identified as weaknesses in previous vintages of agricultural technology innovation; a number of authors are suggesting bridging mechanisms which will foster technology capacity-building more directly. The suggestions include the targeting of specific "windows of economic opportunity" or exploration of policy lessons from successful experiences.

Lessons to be learned

96. The main lesson to be derived from the literature is that the achievement of technological capacity-building in the agricultural sector is both important and, as in industry, rather difficult. The importance is partly due to the fact that the benefits of the Green Revolution have not impinged on particular regions and classes (especially the poorest). This leaves an economic problem to be solved. The difficulties involved in actually bringing about technology capacity-building relate to the traditional alienation of formal research activities from the real production experiences and knowledge of poor farmers. Hence, the challenge is how to create institutional structures that will both mobilize and enhance these key human resources, while at the same time permitting the benefits of scientific research to impinge where needed.

Chapter VI.

An agenda for further research

97. One encounters no difficulty in locating discontinuities in our stock of knowledge regarding the accumulation of technology capacity-building and the ways technology determines competitiveness. The following suggestions, however, represent a very selective distillation of the possibilities based on the depth of our ignorance, the degree to which knowledge gaps are already being narrowed by on-going investigations, and the extent to which knowledge inadequacies or voids are considered crucial.

Technology and strategic alliances

98. Despite being a relatively new phenomenon, the tendency for large corporations to seek out strategic technology partnerships with other firms, universities, or independent research institutes has attracted considerable attention. Yet, what is unclear are the consequences that these technology alliances may have on the general accessibility of the newly generated knowledge. So far most investigation in this area has concentrated on the developed industrial countries and the NICs. Concerning the great majority of developing countries, however, a number of questions are still unanswered. Will strategic alliances affect the global distribution of technologies and the ability to mobilize them effectively? For outcomes viewed as undesirable, are there reasonable and appropriate ameliorative measures? What advantages can non-NIC developing countries offer in order to be attractive candidates for inclusion (i.e., their private firms, parastatal enterprises, universities or research institutes) in this very potent aspect of economic and technological globalization?

Science and technology policy and cohesiveness with other major policy objectives

99. While the literature exhibits an awareness of the need for coordinating technology and national policy, it is very short on concrete policy recommendations. Three research approaches for increasing the understanding of policy cohesion are suggested. First, it would be very useful to take a retrospective look at where the most extreme conflicts between science and technology objectives erupted when they were not properly integrated into the overall national policy goals. By determining the forms of these policy abrasions, some useful insights might be garnered regarding the nature of coordinating mechanisms. Similarly, an examination of national experiences of those nations that have attempted to mesh policies, covering both successful and unsatisfactory results, should yield some notions of how to carry out a properly functioning process of coordination. Third, there is a place for some theoretical work based on organizational and behavioural aspects of political economy that would at least make a start at establishing a conceptual basis for approaching the problem.

Incentives and support for innovative behaviour

100. Despite the considerable number of instruments being employed, the literature is virtually silent on how effective these instruments are in

achieving their desired objectives. Further work in this area should include the following: first, a taxonomy of these measures, with an eye toward conducting evaluative criteria; second, stipulation of the appropriate criteria for evaluation; and third the assessment of incentives and support measures. For instruments that have proved inadequate, an attempt should be made to determine whether the cause of the inadequacy was in the instrument itself or in its implementation.

Strategic intervention

101. There is feverish research, and consequently a growing literature, on industrial policy in developed countries and advanced industrializing countries. The orthodox neoclassical economists either do not accept a role for strategic intervention, or conceding the rare occurrence of market failure, they insist that government failure inherent in remedial actions will be even more damaging. In contrast, those who see a role for policy intervention argue that progress can be made through selective or strategic intervention in key industries. However, despite increasing calls for strategically focused industrial policy, the literature is still somewhat obscure on certain key issues.

102. The objectives of a research agenda in this area can be stated by a series of questions. If a nation makes the decision to foster technological dynamism through focused, temporary protection, (i) What criteria should be applied in the attempt to pick winners? (ii) What are reasonable, effective performance criteria for the targeted infants industries, and how should they be administered and monitored? What "exit" criteria should be applied, either because the fledgling has matured, or because it is deemed to be stuck perpetually in arrested development? What are the salient variables in the social, economic and political arenas that abet or impede the ability and willingness of governments to identify and react expediently and judicially to changing conditions?

Intellectual property rights, developing countries and empirical investigations

103. There is a highly sophisticated set of arguments, both pro and con, as to the effect of intellectual property rights protection on technology and innovativeness in developing countries. In addition, there is no dearth of empirical studies, although they mainly concern mature industrial countries. What is lacking are solid empirical examinations of developing country experiences with intellectual property rights protection that will, in effect, corroborate or refute the various notional positions presented in the literature. Research areas include the following: (i) in-depth sectoral and case studies analysing the interrelationships among intellectual property rights, investment flows, technology inflows and technology capacity-building; (ii) studies taking into account the various intellectual-property-right categories (e.g., patents, trademarks, utility models, etc.) and variations of the legal stipulations (e.g., ease of qualifying, breadth of coverage, duration, etc.; (iii) the different effects, if any, that intellectual property rights regimes have on countries at various levels of technological

sophistication; and (iv) the degree of manoeuvrability regarding the mix of intellectual property rights applied in the new atmosphere of a more liberalized and open world economy. These studies should focus on developing countries, since that is where the greatest deficiencies in knowledge are found; however, they should also attempt, where relevant, to estimate the varying impacts on royalty and licensing payments, which are of prime importance to geopolitical discussions over international intellectual property rights agreements.

Least developed countries (LDCs)

104. In view of the enormous gaps in our knowledge regarding technology capacity-building and competitiveness, there is a need to pursue research with regard to a number of issues. Literature on the LDCs indicates that they are especially vulnerable to infusions of technology from external sources. The most efficacious ways need to be uncovered for technology importing countries to gain enough expertise to identify desired technologies, including, of course, the associated "soft" technologies.

105. In addition, there is the question of appropriateness of the technology being imported or locally generated by LDCs. In this respect, there is an important role for political-economy-oriented research that identifies policy options available to the international community that (i) can deliver technology on more efficient concessional terms, (ii) are ambitious enough to make a palpable dent in the technological marginalization of many LDCs, and (iii) are sufficiently reasonable and attractive to serve as the basis for a broad consensus by many donor and aid-receiving LDCs.

106. Another issue concerns the appropriate types of science and technology indicators that might be useful for guiding and monitoring technology capacity-building in LDCs. Very little has been done in this regard; a completely different approach to this issue for these countries may be required.

Innovation systems

107. Although today the linear model of scientific and technological advances finds only few defenders, the question remains whether the concept of technology transfer, and even the process of domestic generation of technology, suffers from some vestigial remnants of the notion that the supply of new applied technologies is fairly inelastic with respect to scientific research.

108. The fact that there is ample literature on R & D institutes in developing countries, but far less on other sources of innovation, might be a symptom of the lingering effects of a linear syndrome. The way technology transfer is usually couched in terms of end-of-pipeline technologies may be another indication. Certainly, if one conceptualizes a spectrum of innovational activities, the flow of information and impulses promoting further innovative behaviour are not unidirectional. If the concept is extended to that of an entire innovation system incorporating all of the interconnections and

linkages through which learning takes place, a multifaceted and multidirectional flow of information and impulses materializes. If such a picture is correct, it may mean that, relative to other avenues for generating technological improvements, traditional R & D activity is overly emphasized. It may also mean that there is an unconscious excessive preoccupation with hardware vis-à-vis organizational skills and entrepreneurial talents of the human agents responsible for manipulating technological artifacts. The idea of evolutionary innovation systems is hardly a completely neglected area, but relative to the potential importance of the concept, the research effort appears to be sub-optimal.

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