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Wilfried Lütkenhorst*

New Technologies and Industrialization Prospects of Developing Countries

Industrial technologies are both an outcome of the industrialization process and one of its main driving forces. The introduction of new technologies can be seen as one of several important factors which directly and indirectly change the context and modes of international industrial production, thus being among the key determinants of the international division of labour. Given the accelerating pace of technological development in industry, there is an urgent need not only to identify incipient technological breakthroughs but above all, at an early stage, to analyze their short- and long-term implications for the worldwide industrialization process and to reassess the validity of crucial assumptions underlying developing countries' current industrial strategies.¹

In the advanced industrialized countries where technological developments in industry have been concentrated, new products are continuously introduced which either substitute or supplement existing products. New production processes are being applied which have higher productivity and/or different factor proportions, higher flexibility and different economies of scale. In place of some materials traditionally supplied by developing countries, new materials are being introduced. These innovations in turn lead to changes in production costs, quality, timing, etc. and thus to changes in the competitive system both at the micro- and at the macro-economic level.

As a result, adjustment pressures on developing countries have increased and so may, with some notable exceptions, their technological dependence. Obviously, the pursuance of the industrialization process will force these countries to participate in one form or another in the international technological race. With the race accelerating in speed and in costs, many developing countries will face great difficulties in following: only a few may succeed in keeping abreast in highly selected areas of technology. For the majority of developing countries, new technologies will have to be acquired from abroad rather than developed domestically. Restricted property rights and high technology transfer prices will constrain this acquisition. So will prevailing scarcities in financial resources and human skills.

Process technologies are applied in industrial enterprises with a view to increasing productivity or to responding better to other market requirements. As a means of production, they come both embodied, i.e. in the form of industrial machinery and equipment, and disembodied, i.e. in the form of know-how, experience, managerial and organizational skills. This is an extremely important point to recognize: it means that each technology – and above all new sophisticated ones – is to be seen as an integrated hardware-software package with the interaction of these two components greatly determining its costs and benefits.

Closely related to the above, it is currently to be observed that industrial services are assuming an ever greater importance. This is true in a double sense. First, new sophisticated production technologies can only efficiently be operated within an overall system of support services such as telecommunication; advanced repair and maintenance services; computer software specialists; and R&D inputs. Second, at the company level the "service content" of manufacturing is increasing, e.g. through the use of computer systems for

¹ The article discusses major issues raised in the UNIDO Expert Group Meeting on Prospects for Industrialization Policies in Developing Countries Taking into Account the Impact of Developments in the Field of New and High Technologies, held 4-7 April 1989 in Vienna. For this meeting specific case studies have been prepared for UNIDO on the industrial policy and strategy implications of recent technological advances in telecommunications (Kurt Hoffman), machine tool industries (Staffan Jacobsson), textiles and clothing industries (Kurt Hoffman), biotechnology (Martin Fransman) and new and advanced materials (Lakis Kaounides). In the paragraphs describing the new technologies the present article draws on these case studies which will soon be published by UNIDO. Thanks go to Herman Muegge, UNIDO, for a critical review of an earlier draft. This does not affect, of course, the author's responsibility for remaining mistakes or inadequacies of the text.

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design, quality control, inventory handling, etc. Indeed, "information technologies have created a symbiosis between development in the manufacturing and the services sectors".² Two brief further comments are in order in this regard. First, the services emphasized above are knowledge-based in nature and productivity-raising in their effects. They represent highly productive inputs to the production system and have nothing in common with the traditional notion of services being low-skill, low-productivity activities. Second, and following straight from the previous point, these services are directly industry-related. A recent OECD study concludes that more than 50% of all market-oriented services in OECD countries are of a directly production-related nature.³ Hence, while it appears to be true that the advanced industrialized countries are gradually becoming service economies, it is certainly grossly misleading to equate this with a trend towards a post-industrial economy. In the words of a much debated recent study: "Manufacturing Matters",⁴ i.e. a strong manufacturing base will remain the backbone of industrial development in the years to come.

Nature of New Technologies

For a term as broad as "new technologies" there is obviously no watertight definition available. What can be observed at present is that the international technology-driven competition has grown, development cycles of both new products and new processes have become shorter and comparative advantages of both countries and companies are subject to relentless change. In this overall process of industrial change some dramatic technological advances such as microelectronics and bioengineering have emerged which are commonly referred to as "new" technologies. These new technologies exhibit certain characteristics with regard to the nature, scope and direction of their impact on industrial development as briefly described below:

□ *Nature of impact.* The major new technologies are *transformational* in nature, i.e. they have drastically changed the conditions under which industrial goods are being produced. Microelectronic innovations are a case in point. Not only have they triggered off a whole wave of new products (e.g. in consumer electronics) but

above all they have had a profound impact on industrial production processes. CAD/CAM, CNC control units, CIM and FMS are but a few acronyms which have become common language in modern manufacturing.⁵

□ *Scope of impact.* Closely related to the above point, the new technologies can be characterised as *pervasive*, i.e. in their application they cut across many sub-sectors of industry (and not only industry). Conventional classifications of industrial sub-sectors and activities therefore tend to become less meaningful or blurred. This is the case e.g. in machine tool production which now includes as much electrical as non-electrical engineering and in food processing and pharmaceuticals production in which similar new biotechnologies are developed and utilized.

□ *Direction of impact.* Though implicit in what has been said so far it needs to be specifically pointed out that the new technologies tend to work in favour of increased *homogeneity* of industrial production processes. Industrial equipment will become more similar across various branches (at least regarding components such as control units, design systems, etc.). This in turn has significant implications for human resource development in general and training in particular (see below).

In the developed countries and the most advanced developing countries the introduction of new technologies entails changes in many key parameters of industrial development with far-reaching repercussions on corporate strategies, structural change, trade and investment patterns and overall competitiveness. In these areas, some traditional notions and ways of thinking will have to be buried as has become obvious for example in the debate on "flexible automation". Only 10 to 15 years ago, flexibility and automation were conceived of as antagonistic and the idea of achieving increased flexibility *via* automation would have been considered a contradiction in terms. With the advent of microelectronics-based CAD/CAM systems this is no longer true; the rules of industrial production have been partly rewritten.

Telecommunications

There can be no doubt that advances in the field of microelectronics and telecommunications occupy a central position in the incipient industrial-technological transformation taking place at present. Indeed, both areas are to be seen in a sense as the two sides of the same coin: while microelectronic equipment permeates industrial production technology, telecommunication facilities are the matching industrial infrastructure

² UNCTAD: Trade and Development Report 1988, New York 1988, p. 257.

³ Cf. OECD: Economic Studies, No. 8, Spring 1987.

⁴ Cf. S. Cohen, J. Zysman: Manufacturing Matters. The Myth of the Post-Industrial Economy, New York 1987.

⁵ CAD/CAM = computer-aided design/computer-aided manufacturing; CNC = computer numerically controlled; CIM = computer-integrated manufacturing; FMS = flexible manufacturing systems.

required to reap system or networking benefits. Computer-based systems provide a common language which – as is often said – is transported by telecommunication on the highways of the information age minimizing transaction time.

Recent technological developments in telecommunications have taken place in exchange technology, transmission equipment and peripherals alike:

- digital exchanges are being introduced which are solid-state (without moving parts) implying fewer breakdowns and less maintenance requirements than conventional electromechanical switching systems;
- transmission equipment is revolutionized by fibre optics and laser transmission systems which are superior to conventional systems in terms of greater capacity, speed, flexibility and resistance to interference;
- peripheral equipment now comprises a broad range of “intelligent” terminals and telephones, key systems, mobile radios and a variety of new office equipment.

With these wide-ranging innovations, telecommunications even more than before is becoming a critical element of any country's industrial infrastructure. Consequently, any development strategy which is dependent in any way on international linkages for finance, technology, goods and services and/or involves the local participation of foreign firms in any sector of the economy will face considerable and growing difficulties in the future if an adequate, digital-based telecommunications system is not in place.

Microelectronics

The diffusion of microelectronics is closely related with telecommunications because of important synergetic effects. Of all new technologies the industrial application of microelectronics is by far the most advanced. Microelectronic technology has been introduced in a wide range of industrial processes involving both the transfer and processing of information and the control of machinery. Leaving aside microelectronic innovations in the sphere of administration and co-ordination (office automation equipment) the two major areas of application so far have been computer-aided design (CAD) on the one hand and computer-numerically-controlled (CNC) machines on the other. This is briefly exemplified below

by the cases of the clothing industry and the machine tool industry.

So far, the *clothing industry* has shown a considerable “resistance” to automation pressure. Its central production stage, viz. the assembly of pieces of cloth, has remained largely a domain of labour-intensive operations on traditional or programmable sewing machines. However, in the pre-assembly stage, CAD systems have been rapidly advancing and are now widely used for pattern-making, grading and marking on the basis of stored “rules”. The main benefits are a quick response to changing market requirements, a shorter turnaround time in grading and marking and considerable improvements in fabric utilization.

As regards the international diffusion of CAD systems in clothing manufacturing, the overwhelming majority of them has been installed in industrialized countries: by 1985, only approx. 10 CAD systems out of a total of 700 were to be found in advanced developing countries.⁶ The same broadly holds true for CAD diffusion in other industrial sectors. It has been significant only in very few developing countries (including Brazil, Hong Kong, India, Republic of Korea, Mexico, Singapore and Taiwan) which have either promoted their indigenous electronics industry, established a domestic automobile production or moved into high-technology-based clothing exports.⁷

The *machine tool* industry has, since the 1970s, become a particularly strong producer and user of NC and CNC machinery. For example, in the leading OECD producing countries of metal-cutting machine tools the share of NC machine tools has risen from one quarter to two thirds within just a decade (1976-86). In the same period the share of CNC lathes in total lathe production went up from one third to almost four fifths of the total. Here again, a considerable diffusion gap exists between most developed countries and the few advanced developing countries which are significant users of NC-machine tools. However, in terms of density (number of NC machine tools per employee in the engineering sector) at least countries such as the Republic of Korea and Singapore now have achieved levels of the order of 50% of the density in the UK, the USA or the Federal Republic of Germany.

These illustrative references are supported by evidence from many other fields of industrial activity. Hence, it appears safe to conclude that in the field of microelectronics there is “little basis for drawing a

⁶ Cf. K. Hoffman: *Clothing, Chips and Competitive Advantage: The Impact of Micro-electronics on Trade and Production in the Garments Industry*, in: *World Development*, Vol. 13 (1985).

⁷ Cf. R. Kaplinsky: *Micro-electronics and Employment Revisited: A Review*, ILO, Geneva 1987.

general conclusion that (the developing countries) are closing the technological gap with the industrially advanced economies".⁸

Biotechnology

Biotechnology and new and advanced materials are very much in an incipient stage as far as their industrial applications are concerned. Hence, their implications for future patterns of industrial development are less clear-cut and more difficult to assess.

Biotechnology can be defined as the use of biological organisms (or their constituents such as cells and DNA) for the transformation of inputs into commercial outputs. In this sense, evidently, biotechnology or bioprocessing has a very long history ranging from fermentation to, more recently, the introduction of new plant varieties within the so-called Green Revolution. Around the mid-1970s, however, a "new" biotechnology took off. Scientific breakthroughs (mainly in recombinant DNA and cell fusion) have provided new powerful tools which in turn have greatly enhanced the potential of biotechnology for commercial applications. The new techniques enabled new combinations of genes to be created and the functions of biological organisms to be modified.

In general, however, the translation of scientific and technological advances into commercial applications (products or processes) has not lived up to initial expectations.⁹ Only a few marketable products have so far been created from the "new" biotechnology, *inter alia* because lead times for product development, including testing and approval, tend to be very long and often unexpected problems emerge in the process of scaling-up. Examples of commercial biotech-offspring include the anti-cancer agent interferon, human insulin and growth hormones in the field of pharmaceuticals as well as tissue culture, sugar-substituting sweeteners and the cloning of oil palm plants in the area of agro-industry.

The latter two developments are already having substantial effects on the international sugar market and on the vegetable oil market. The gradual substitution of non-sugar sweeteners for sugar has contributed to a further oversupply and low prices in world sugar markets; high productivity oil palms will lead to shifts in cultivation (e.g. away from rubber into palm oil because of higher yields) and may eventually also result in price decreases for all vegetable oils.

⁸ R. Kaplinsky, *op. cit.*, p. 63.

⁹ Cf. K. Venkataraman: Biotechnology for Development: The Hard Road to Fulfillment, in: Development and South-South Cooperation, Vol. III, No. 5, December 1987.

New Materials

New and advanced materials are another high tech field of great significance which is expected to develop its full impact on industrial development and competitiveness towards the late 1990s. Increasing attention is now being paid to recent scientific and technological developments which have led to the creation of highly engineered advanced materials. These comprise a number of distinct yet connected clusters of materials such as engineered plastics, advanced ceramics, composites, advanced metallic alloys and superconductors.

The quintessence of progress made in such interlinked fields as physics, mathematical modelling, computer science and advanced instrumentation is that material scientists can now intervene directly at the microstructure of materials. Consequently, it is less and less the availability and properties of specific materials which constrain the development of end products. Rather, one can now in many cases start from the required properties and performance elements of a product and then develop and process tailor-made materials for the particular application. From this, a vastly accelerated rate of materials and product innovation follows as well as rapid obsolescence in existing products and processes, and reduced life cycles for new materials. No single material will dominate the market for long periods, as used to be the case in the past.

Furthermore, it is likely that the materials which will dominate industry in the 21st century, will be "materials systems". Composite and laminate materials systems tailored for specific applications and environments will gradually displace monolithic or homogeneous materials, such as metals.

The early incorporation of such materials into new products and processes confers higher value added, leads to improved competitive positions and accelerates market penetration. Hence, a successful advanced materials sector will increasingly contribute to maintaining or acquiring international competitive advantage. Many governments have already recognized the potentially harmful effects on output, employment and trade of falling behind in advanced ceramics, polymers and composites.

Future Industrial Development Patterns

Based on the brief analyses provided above an attempt can be made to arrive at some more general inferences. These will – sometimes implicitly – be shaped primarily by developments in microelectronics

and automation technology which have left their mark already quite firmly on international industrial structures and economic relations.

First, the introduction of new technologies is bringing about a change of the major determinants of global industrial competition. The implications of this change for developing countries have been and will continue to be profound. In many branches of industry comparative advantages based on the intensive use of low cost labour are being eroded or lost due to progressive automation in industrialized countries. A further implication is the tendency of the raw materials intensity of industrial production to decline¹⁰ thus jeopardising the long-term development prospects of raw materials producers and exporters.

At the same time, it appears that a certain technology obsession – coupled with doomsday predictions for the developing countries – which was prevalent in the early 1980s, is now giving way to more realistic and differentiated assessments. It has become clear that the barriers for adoption of new technologies have been underestimated whereas the immediate impact of their diffusion in specific sectors has been overestimated. This is not to say that the current changes in the international division of labour are to be belittled; however, the sometimes feared “relocation back North” of industrial capacities has so far not taken place on a massive scale¹¹ – although it can be observed that the strong redeployment wave of past decades from North to South is now tapering off. This means that the time needed by all actors to adjust to the new technological setting can be used by developing country governments to design appropriate policy responses and measures.

Second, and particularly important for the design of policy responses, it needs to be recognized that the new automation technologies in developed countries have been introduced for different reasons in the various industrial branches and often at a different diffusion pace in companies within the same industrial branch. The most obvious motive, given the nature of factor endowments in industrialized countries, has been the pressure to reduce production costs. In the high-wage context of developed countries, automation can result in reducing the total unit cost of production by saving labour and increasing the labour productivity.

However, the cost argument has often been complemented – and sometimes indeed been superseded – by other considerations. The two most significant ones have been product quality and flexibility of production. Product quality is the overriding concern e.g. in the manufacturing of precision tools and

professional instruments. In these areas the use of CNC-machinery has effectively become an industrial standard. The use of conventional machinery would inevitably lead to exacting requirements and close tolerances not being met, rejection rates being comparatively high and eventually competitiveness being lost. Flexibility has become a must in many industrial branches such as metalworking and engineering products (where approx. 80% is small batch production) and particularly in garments manufacturing where more frequent fashion changes demand flexible adjustment and quick response.

Indeed, this emphasis on flexibility, quality and a built-in capacity to quickly adjust to changing customer needs can be said to constitute the central characteristic of the new technologies. This explains why organizational innovations have to go along with the introduction of new hardware. The much heralded Japanese success has at least as much been caused by new management styles as by new machinery: quality circles, group technology, just-in-time inventory planning and multi-skilled production workers are some of the basic determinants.

Third, and directly linked to the flexibility issue, economies of scale are gradually being eclipsed by economies of scope.¹² In the past, automated industrial equipment was dedicated to a very specific task such as, for example, the production of a specific component. Changes in this dedication were either impossible or involved extremely time-consuming and costly adjustment of the equipment. In this context of high minimum efficient sizes of production, high volumes of standardized products were required to achieve sufficiently low unit costs: this is the essence of economies of scale. With the application of microelectronics, however, automation has become programmable or flexible. This implies that the trade-off between automation and flexibility is less sharp than it used to be. CNC machinery can be programmed to perform a variety of tasks, e.g. producing different machine components or assembling different products. This flexibility permits the move from one-product to multi-product manufacturing. To recover high investment costs it is no longer required to have large

¹⁰ This is partly due to more efficient materials utilization in the context of CAD/CAM systems and partly due to biotech-induced substitution effects and the advent of new and advanced materials.

¹¹ This is the clear result of the most comprehensive empirical study so far undertaken on the subject. The study covers the investment behaviour of Federal Republic of Germany companies in the following industrial branches: textiles, clothing, shoes, precision instruments, optics and electronics. Cf. R. Jungnickel: *Neue Technologien und Produktionsverlagerung*, Hamburg 1988.

¹² Cf. S. Cohen, J. Zysman, *op. cit.*, chapter 10.

production series of the same product but to efficiently utilize the equipment for flexible small batch production of a variety of products: this is the essence of economies of scope.

Fourth, the emergence of new technologies has tended to be accompanied by increased entry barriers for new companies seeking to start production in the industrial branches concerned. Such barriers refer first of all to the access to, and the ability to operate, the new technologies; further to capital requirements, R&D capacities, marketing networks and other factors. Entry barriers appear to be less of a problem in the field of biotechnology which is very research-intensive yet not particularly capital-intensive. Hence, many developing countries possessing the core scientific capabilities and a supportive overall industrial infrastructure – two exacting conditions, to be sure – will be able to enter the biotech market in specific fields. The situation is different, however, with regard to the production of flexible automation equipment where the barriers for new companies are tremendous. Advantages of great size apply in areas such as financing, research and development, marketing and distribution which are of eminent importance. A forceful corporate concentration process is underway in these branches in most developed countries both at the national level and increasingly crossing national boundaries.

Crucial Role of Industrial Policy

Developing technologies is one thing, achieving industrial competitiveness is another. The former provide opportunities and powerful tools to achieve the latter. However, transmission mechanisms are needed to translate technological potential into actual economic benefits. This is where economic policy in general, and industrial policy in particular, enter the picture. They influence the forms and conditions, the costs and benefits of applying new technologies.

The speed of generating and diffusing new technologies and the efficiency of applying them depend on a broad range of coherent policies. System advantages are essential to fully reap the benefits of sophisticated production technologies. Apart from system requirements at the company level this refers to:

□ system requirements at the level of an industrial branch or the industrial sector as a whole: industrial networks need to be established to provide for crucial input-output links and complex interconnections including a number of high-tech related industrial services;¹³

□ system requirements at the level of the economy as a whole: meeting these requirements is essentially a policy task and will have significant repercussions on the efficiency of lower level systems (industrial sector, branches and companies). Key elements of these overall system prerequisites are a harmonious interplay of private and public sector institutions; effective co-ordination between research and industrial sector needs; human resource development efforts in line with prospective industrial-technological trends; the provision of adequate amounts and forms of industrial finance, etc.

Given the broad array of policies which impinge upon technological innovation and, in turn, on industrial competitiveness, important implications can be discerned for the determinants of a country's comparative advantage. With high technology products being increasingly traded on an intra-industry basis, comparative cost advantages have lost their "political innocence". The high-tech areas of international trade which are rapidly gaining significance are determined neither by the availability of natural resources ("Ricardo goods") nor by relative factor endowments ("Heckscher-Ohlin goods"). Trade in high-tech products has been said to be the sphere of "arbitrary comparative advantage".¹⁴ This means quite simply that the patterns of specialization emerging now in particular areas of industrial production are not primarily the result of factor endowments and relative factor prices but more the result of political intervention: "In a very real and immediate way, a nation *chooses* its comparative advantage."¹⁵

This applies not only in the stricter sense that specific lines of technological development are given priority and are deliberately promoted/subsidised. It also applies in the broader sense that, in view of the increasing significance of human capital as a factor of production, a country's educational system and entire social infrastructure determine its overall competitiveness more strongly than ever before. This is a situation where the opportunity costs of refraining from political action are ever greater; a premium is placed on the earliest possible promotion of potentially competitive technologies and products.

National policy-makers will find themselves in a formidable dilemma situation: often there is

¹³ "Advantage in a national economy is embodied not simply in the capacities of specific firms but in the web of interconnections that establishes possibilities for all firms." (Ibid., p. 102).

¹⁴ Cf. W. Cline: 'Reciprocity': A New Approach to World Trade Policy, Washington 1982.

¹⁵ R. B. Reich: Beyond Free Trade, in: Foreign Affairs, Vol. 61 (1983), p. 782.

considerable pressure to take policy decisions (e.g. on the introduction of an advanced telecommunications system) as early as possible since in the course of time policy will become more and more constrained by technological imperatives. This implies, however, that policy decisions often are to be taken in a state of highly insufficient knowledge. While this dilemma can never be entirely eliminated, it could obviously be reduced by early access to knowledge about technology options. A close monitoring of international technological trends thus is essential.

Development Climate

The ability to apply new technologies is not so much determined by measures which are specific to the various technologies involved but rather by the overall entrepreneurial, managerial and technological capabilities of a country. Such capabilities develop over time; they are usually built up in the course of the industrial development process. Well-designed and coherent industrial policies can play a major role in this process; at the same time, even good resources and skill endowments can be ruined by bad policy.

Admittedly, the required concentration on creating a conducive overall development climate is a difficult task in times of economic crisis and the concomitant external and internal pressures which many developing countries are facing at present. Yet the question is if the isolated introduction of advanced technologies in specific areas can yield broader benefits unless it is sustained in the long run by an overall atmosphere of innovativeness and entrepreneurship. Essential elements in this are:

□ *Stability and continuity.* Frequent policy changes tend to generate a feeling of insecurity on the part of economic actors and prevent the formation of stable long-term expectations so crucial for the willingness to undertake long-term industrial investments.

□ *Strategic vision and policy commitment.* A central role to be played by the government in developing countries is to design an industrial strategy, indicate sectoral priorities and formulate objectives with a view to providing guidelines for company decision-taking. Experience has shown that a strategic vision coupled with a corresponding policy commitment is required to encourage private risk-taking.

This "strategic vision" is not at all to be equated with rigid economic planning. It can be applied to quite

different economic systems. The important point is to provide an overall direction and orientation for private decisions which often involve long-term, costly and risky commitments.

Human Resource Development

There is an increasing awareness now that it is the education and skill level of the labour force which largely determine a country's competitive strength and resilience, its capacity to adjust to new sophisticated technologies and to reduce the economic and social costs of the adjustment process. This has been a clear lesson from successful countries, both developing and industrialized. It is now widely recognized that the successful industrialization of the East Asian newly industrializing countries has been largely caused by the early priority given to the development and upgrading of human resources. Investments in expanding and improving secondary and higher education have taken a large share of public expenditures. A cornerstone in their human resource development strategies have been efforts to organize an efficient country-wide vocational training system. Indeed, the quality of vocational training more than anything else is the decisive factor in coping with technical change and in applying new technologies. Even countries with a strong scientific elite will meet difficulties in diffusing new technologies unless they have given equal priority to their vocational training system.

The utilization of new technologies based on computers and micro-electronics is rapidly gaining in significance. This has the effect of making production systems much more similar across various industrial branches than they have been hitherto.¹⁶ The implications of this tendency for a rational organization of vocational training are far-reaching and call for increased co-operation between industry and government.

Under the conditions of increasing convergence of industrial technologies, training for industrial activities that make use of the new technologies can clearly yield economies of scale in the sense that a general technical training can easily be adapted for use in specific industrial branches. This implies that sooner or later industry will obtain benefits in strict cost terms through participating in general training courses in the use of new technologies. The financing of such training could, of course, come both from industry associations and the public purse; the benefits for government would be those of supporting industry in its efforts to remain internationally competitive.

¹⁶ Cf. UNIDO: *New Industrial Technologies and Human Resource Development*, in: *Asia: Some Selected Issues*, UNIDO/IS.611, 19 February 1986.

Furthermore, this type of training tends to maximize the mobility of semi-skilled staff and thus create more opportunities for dynamizing the industrial sector as a whole. This point is especially relevant given the emphasis in many, particularly Asian, developing countries towards the creation of supporting industries and close networking of service and producing enterprises. For the most part the smaller firms which grow up to meet the needs of more complex industrial structures are created by people who previously acquired industrial experience through working in already established larger enterprises. It might be expected that this kind of pattern will also be observed in relation to new technologies in the coming years.

A high level of general technical training thus appears to be conducive to strengthening the position of smaller firms. The same is true for a standardized system of examinations and certificates.¹⁷ The more technical competence is visible from standard certificates the more will inter-firm mobility be encouraged and the less important will be internal labour markets. This would again favour smaller companies in their recruitment of skilled labour.

Small and Medium Enterprises

Small and medium enterprises (SME) have a very important role to play in any country's industrial development. They are a major supplier of industrial employment and a crucial element in industrial networking, e.g. as specialized producers of parts and components which otherwise would need to be imported. Furthermore, it has increasingly come to be recognized that SME are a valuable and significant source of technological innovation. Examples abound that the existence of efficient SME adds to the resilience and responsiveness of a country's industrial sector whenever challenged by external shocks (such as drastic price changes, changing consumer preferences or new production technologies).

Accordingly, there is evidence that above a certain minimum threshold smaller companies tend to be more dynamic innovators than bigger ones. At the same time, many new technology areas are characterized by high entry barriers in areas such as research and development, finance, marketing, distribution channels, etc. The implication is that the high potential of SME in developing or utilizing new technologies can only materialize if it is strengthened by a number of joint

support functions. These could range from information services (including market research) to joint research programmes, the formation of export consortia, collective bargaining with suppliers of production inputs, joint negotiation with financial institutions, etc. Many examples for such initiatives can be found in industrialized countries in terms of regional initiatives of smaller companies either in the same industrial branch (e.g. clothing manufacturers in Italy) or across different branches of industry (e.g. the Fosieby industry group in Sweden).

While the organization of SME co-operation along these lines is essentially a task for the enterprises concerned and would require their continuous commitment and active participation, government policy can play a valuable catalytic role in this regard. For example, training and awareness courses could be organized to draw attention to new technological options and seed money could be provided to initiate viable forms of co-operation.

It is noteworthy in this context that the Republic of Korea – long known for its emphasis on large industrial conglomerates – in the early 1980s switched to a policy of promoting SME.¹⁸ The reasons given for this remarkable policy swing related above all to weaknesses in the production of more sophisticated industrial components (e.g. electronic instrumentation and control systems) on which the country has remained highly import-dependent.

Institutional Support

Institutional aspects have been emphasized above in connection with the organization of vocational training and regarding technological and other support extended to SME. Indeed, it is hard to overestimate the role played by an efficient institutional network in promoting the development and diffusion of technologies in developing countries.

On the one hand, experience shows that competitive pressure in open markets is among the most powerful mechanisms for inducing changes in products and processes and responding to opportunities offered by new, more efficient technologies. On the other hand, in many developing countries only insufficient information is available on the nature and range of new technologies on offer as well as on the terms and prices of acquisition. Furthermore, the developmental role of new

¹⁷ Cf. H. Ergas: Does Technology Policy Matter?, in: B. R. Guile, H. Brooks (eds.): *Technology and Global Industry. Companies and Nations in the World Economy*, Washington 1987.

¹⁸ Cf. W. Lütkenhorst: *Industrial Development and Industrial Policy in the Republic of Korea – with Special Emphasis on Engineering Industries*, in: W. Klenner, et al. (ed.): *Trends of Economic Development in East Asia*, Berlin 1989.

technologies typically implies disparities in the perceived private and social returns from their introduction. Government policy and public institutions thus are needed to complement and reinforce the market mechanism. Some of the more important institutions are discussed below.

Collecting and assessing information is one essential area. In view of the skills required for the related activities, the costs involved and the relevance of specialized technology information for a wide range of industries, many developing countries have established centralized technology information agencies often as a joint government-private sector effort.

Obviously, another important area calling for institutional measures is the gradual building up of domestic R&D capacities. While in most developing countries public research institutes and laboratories exist, their research orientation leaves much to be desired. More often than not, research programmes follow academic basic research interests which remove them from the more immediate needs of their country's industries (or, for that matter, of other productive sectors of the economy). What is often lacking is the close interaction of R&D institutions and industry. Industrial companies are to be encouraged to demand research services; universities and other research institutions in turn should pursue more industry-related research. The lack of such co-operation appears to be a result partly of traditional attitudes, partly of weak communication links

between the actors concerned and partly of the overall lack of integrated industrial production systems in many developing countries. Transfer agencies – i.e. agencies concerned with the commercialization of research results and the design of industry-relevant research programmes – could play a key role in overcoming some of these barriers.

In this context, following the experience of developed countries, the establishment of so-called science parks could yield substantial benefits for some more advanced developing countries which have already acquired certain capabilities in research-intensive industrial production.

Finally, an important though often neglected institutional requirement is an effective system of industrial standards and quality control. Standardization results in the reduction of transaction costs, particularly for decentralized industries; it is crucial for any production of high-tech components and absolutely indispensable if these are to be exported. It has been argued in fact that in the case of Japan the early introduction of national certificates linked to industrial standards has encouraged enterprises to adopt firm-level quality control systems which in turn has rendered possible the successful expansion of the subcontracting system.¹⁹

¹⁹ Cf. C. J. Dahlman: Impact of Technological Change on Industrial Prospects for the LDC's, Paper prepared for the World Bank Seminar on Technology and Long-Term Economic Growth Prospects, 16-17 November 1988 (mimeo).

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Rasul Shams

INTERESSENGRUPPEN UND ANPASSUNGSKONFLIKTE IN ENTWICKLUNGSLÄNDERN

Fallstudie I Türkei

The number of developing countries which have signed agreements on structural adjustment with the IMF and the World Bank has increased rapidly in the eighties. At the same time, the discussion on the conflicts involved in such adjustment programmes has intensified considerably. Against the background of the belief that the success or failure of programmes, the way in which they are implemented, as well as the period of time in which they can be politically supported, are decisively determined by the activities of interest groups, the example of Turkey is subjected to an empirical analysis.

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Acquisition of New Technology

Throughout this article reference has been made to developing countries, sometimes as generators of new technologies, sometimes as users of new technologies. The question if an individual country should rely on imported new technology or should seek to develop and produce advanced technology domestically indeed touches upon a key industrial strategy decision. The answer depends entirely on the specific country and the specific technology in question and would have to take into account numerous demand and supply related factors, such as size and structure of domestic demand; the potential to tap export markets; skills required and available for product development and subsequent manufacturing; competitive situation and prices in the world market; economies of scale and of scope; and many others. Nevertheless, in what follows some comments of a more general nature are offered.

The experience of many countries has clearly demonstrated that the efficient assimilation, adaptation and diffusion of imported technology can yield substantial long-term benefits. Furthermore, it does not preclude the later domestic development of the same or even more advanced technologies. Accordingly, the sequential aspect in absorbing technology needs to be stressed. The external sourcing of advanced technology may be considered a logical first step. As these technologies are increasingly diffused and utilized in a country's industrial sector, they create both learning effects and a broader market which also domestic producers will subsequently seek to tap.

An important issue to be considered in this context is the trend towards increasing specialization and intra-industry trade worldwide. Given that any concept of total self-sufficiency in high technology areas would be anachronistic, to what extent is it reasonable to favour domestic production over imports? Is there a trade-off between rapid and efficient diffusion on the one hand and the generation of domestic production capabilities on the other? For example, some advanced developing countries have indeed achieved higher self-sufficiency ratios in the production of NC machine tools than most industrialized countries. What are the implications for user industries²⁰ and for the industrial development process as a whole?

The Technology Gap

While many of the economic implications of new technologies are still subject to debate there are some indisputable truths as well. Among these is the fact that the impact of the incipient technological revolution will

be felt in one way or another by all developing countries regardless of their level of development or their economic system. Not all, however, appear to be well equipped to respond adequately to the challenges facing them and only a few are in a position to generate frontier technologies themselves.

In particular, the present mix of industrial production has significant implications for both technological adjustment pressures and technological adjustment capacities. Developing countries producing a diversified range of industrial products for different export markets will find themselves permanently forced to adjust products and processes to changing quality requirements, price and cost structures. In these cases, high adjustment pressure and the need to acquire comparative advantages will itself contribute to the gradual build-up of adjustment capacities. Conversely, countries whose industrial activities are dominated by resource-based goods (natural comparative advantage) are typically facing a lower pressure towards technological upgrading and, consequently, are not stimulated to innovate. If these countries are confronted with sudden and drastic technological changes (as may increasingly be the case due to the development of new materials), they will hardly be prepared to meet the resulting challenges.

This situation may lead to the following scenario. The more advanced developing countries endowed with efficient promotional institutions and highly skilled human capital are given powerful new tools to increase their competitiveness (by combining their wage cost advantage with the latest machinery) and may even gradually "catch up" with the industrialized countries. At the same time, many other developing countries (the least developed countries in particular) would further fall behind in the industrialization race. For instance, there are indications that foreign direct investment in manufacturing will concentrate even more than in the past on relatively few leading developing countries.²¹ In consequence, the poorer developing countries will find themselves in a vicious circle: left aside by foreign investors because of their not meeting the requirements for technologically more advanced production, they will be largely excluded from the only realistic source of technological upgrading, viz. foreign investment.

If the scenario outlined above really applies, then a

²⁰ A negative impact could be higher prices (as compared to the world market) and a relatively narrow range of available types of machinery.

²¹ Cf. W. Lütkenhorst: Export Processing Zones: Challenges from New Trends in Foreign Direct Investment, in: *INTERECONOMICS*, Vol. 23, No. 5, Sept./Oct. 1988.

situation of increasing technological gaps will result. And this may in effect be particularly the case between developing countries. Moreover, the accentuation of R&D disparities could induce additional "brain drain", further depriving the poorer developing countries of their already limited human resources.

This is not to deny that possibilities for technological leapfrogging do exist in some areas and also least developed countries can avail themselves of these opportunities. Advances in telecommunications are a case in point. Given that (a) a highly efficient telecommunications system has become a basic element of a country's industrial infrastructure and (b) the introduction of such a system is not a continuous process but takes place only in discrete intervals, there is no choice but to jump to the most advanced equipment available. In general, however, the potential for technological leapfrogging has tended to be overestimated. Jumping into high-tech areas does not provide a solution to a lack of skills and weak supporting infrastructures; it is further complicated by vested interests and sunk investments which in most industrial branches are more relevant than in the area of telecommunications.

International Co-operation

To promote and/or respond to technological changes in industry in the 1990s will require, more than ever before, substantial financial, organizational, managerial and research & development resources which go beyond the capabilities of single companies and often even single countries. A pooling of resources and sharing of experience are required in many areas to both coordinate and enhance national technological efforts. In the developed countries the trend towards joint programmes, projects and institutions in selected high-tech areas is becoming ever stronger. For instance, the European Communities (EC) have in recent years initiated joint technology research efforts in telecommunications (Research and Development in Advanced Communication Technologies for Europe, RACE), major industrial technologies (Basic Research in Industrial Technologies for Europe, BRITE) and biotechnology (Concertation Unit for Biotechnology in Europe, CUBE).

Likewise, international co-operation may contribute to strengthening the position of the developing countries in the international system. Co-operation potential exists both among developing countries and between developing and industrialized countries.

The regional and sub-regional level appears to be a logical starting-point for co-operation among developing

countries, in particular where economic co-operation and integration arrangements already exist such as the Association of Southeast Asian Nations (ASEAN), the Andean Pact, the Gulf Council for Economic Co-operation (GCC) or the Southern African Development Co-ordination Conference (SADCC). The ASEAN countries for example adopted a Plan of Action on Science & Technology for Development as early as 1981 with manufacturing industries, transportation and communication being among the priority areas. Furthermore, efforts are underway to arrive at a harmonization of ASEAN industrial standards. In general, technology-related regional co-operation among developing countries can cover a broad range of issues. These would include, *inter alia*, the joint monitoring of emerging trends in key technology areas; efforts at establishing joint telecommunications systems (e.g. satellite communication) or at least technical compatibility for countries in the same sub-region; exploring the potential for technology specialization schemes; or joint approaches at regulating specific technology areas such as bioengineering. Among the many advantages of such regional co-operation efforts would be a visible political commitment by member governments to promote specified priority areas of new technologies as well as increased market transparency for companies already involved or interested in these areas.

Conclusions

It has been demonstrated in this article that in a number of different areas generic new technologies are being introduced in industrial production which together partly redefine the parameters and forms of the international industrial division of labour. The implications for the position of the developing countries have been shown to be far-reaching. They comprise, however, both threats and opportunities. In any case, early doomsday predictions foreshadowing the exitus of whole industrial branches in developing countries have been proven wrong.

New technologies cannot work miracles. Neither do they automatically re-establish the overall industrial superiority of developed countries nor do they provide across-the-board opportunities for developing countries to leapfrog into a bright high-tech future. Technological innovation does not provide ready-made solutions to any country's industrial development. It generates tools, however powerful they may be, to increase productivity and improve human well-being. Whether the inherent potential of technological advances is translated into successful industrial development is largely a question of economic and social organization: policy matters.