NEW TECHNOLOGIES AND INDUSTRIAL RESTRUCTURING IN SOUTH AFRICA

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1. INTRODUCTION.

As the prospects of a democratic political alternative loom in the horizon, it has become increasingly necessary to consider and chart future democratic policies that will redress the historical injustices of apartheid. Chief among these will be an alternative progressive economic strategy targeted at addressing the country's chronic economic situation. An important, indeed crucial, element of that strategy will be a progressive industrial strategy (PIS). An industrial strategy aimed at restructuring the industrial sector and launching it on a dynamic growth path.

What do we mean by an alternative progressive industrial strategy ? PIS is used here to refer to a comprehensive plan and programme of industrial restructuring whose major focus is the provision of goods and services to the people and not the accumulation of private capital. That is, a strategy geared towards the creation of social wealth, jobs for all, a safer working environment and the alleviation of poverty. In order to realise this objective, a PIS has to improve and strengthen the industrial sector, overcome inefficiencies and increase the growth potential of the sector and its sub-sectors, promote productive investment and improve its technological orientation.

This paper is aimed at raising issues relating to technology which a PIS, indeed the overall economic strategy, will have to contend with.

There are three major reasons why a technology strategy is important. First, as we move into the 1990s the knowledge-content in production will continue to increase more rapidly. Second, evidence suggest that new technologies (particularly microelectronics related technologies) are playing a significant role in global economic restructuring and in determining patterns of international competitiveness. Finally, the paper recognise that market imperfections are acute in technological generation, development and diffusion and therefore sees a central role for the state in this regard.

The term new technologies' is meant to encompasss advances in the areas of microelectronics, telecommunications, new materials and biotechnology. It is essential to note from the start that the industrial applications of these new technologies varies significantly. Microelectronics and telecommunications technologies seem to have gained widespread industrial application whilst new materials and biotechnology are still in their embryonic stages. This discussion will therefore concentrate mainly on the first two, even then with a heavy bias towards microelectronics.

2. TECHNOLOGY AND INDUSTRIALISATION.

There is a dynamic relationship between industrial technologies and industrialisation. Industrial technologies are both an outcome of the industrialisation process and one of its main driving forces. As production and industrialisation proceeds the determinants and methods of production are continuously being improved, reshaped and changed. The changes could be **incremental**, **radical** or **revolutionary** in character[1].

Incremental technical change refers to those changes occurring continuously and incorporating minor changes in product and process. Radical innovations represent significant changes in product and process. Technological revolutions involve innovations which are clearly perceived to have low, and descending cost; are in apparently unlimited supply; have pervasive applications; and a recognised capacity to reduce costs and change the quality and quantity of capital equipment, labour and produce.

It is in the context of these distinctions that the historic importance of the new technologies, particularly microelectronics technology, is to be found. Their introduction has directly and indirectly changed the context and modes of industrial production and international competition. As a UNIDO (1989) study clearly argues, in the industrially advanced countries (IACs), where technological developments in industry have been concentrated, new products or materials (computer numerically controlled -CNC- equipment, fine ceramics, engineering plastics etc) which either substitute (e.g fine ceramics for glass and porcelain) or supplement existing products. New production processes are being applied which have higher productivity and/or different factor proportions, greater flexibility and different economies of scale and scope.

3. THE NATURE OF NEW TECHNOLOGIES (NTs).

In this section I will briefly consider the impact, the scope and direction of the impact of the new technologies. There exists a general consensus that microelectronics related innovations are revolutionary in nature i.e they have radically transformed the conditions under which industrial goods are being produced. Not only have they triggered off a whole wave of new products (e.g in consumer electronics) but above all they have had profound impact on production processes. In the production of clothing for example, the use of microelectronics related technologies such as computer aided design (CAD) systems for pattern making, grading and marking enables manufacturers to respond quickly to changing market conditions. Other improvements are a shorter turnaround time in grading and marking and a considerable improvement in fabric utilisation (up to 10%). Other developments are the linking of the CAD system to a computer-controlled cutter. This offers substantial gains in the speed and accuracy of the cutting process[2].

The new technologies can also be characterised as **pervasive**. That is, in their application they cut across many sub-sectors of the industry (and have applications beyond industry). Microelectronics technology has been introduced in a wide range of industrial processes involving both the transfer and processing of information and the control of machinery. CAD and computer numerically controlled systems can be used and are used in different sub-sectors; garments, machine tools, engineering and the manufacturing of precision tools and professional instruments (e.g surgical instruments).

The pervasive nature of microelectronics seem to suggest that as we move into the 1990s there will be an increased tendency towards homogeneity of industrial production processes. Industrial equipment will become more similar across different branches, at least regarding components such as control units. This will lead to the breakdown of traditional specialisations not only in industrial classification but also in skills requirements[3].

In the above discussion reference was made to the control and transfer of information. In many ways telecommunications facilities are the matching **industrial infrastructure** necessary to reap system or networking benefits of computer-aided production. Computer-based systems provide a common language which is transported on the highways of the information age minimizing transaction time[4] (UNIDO, 1989). SA is not doing too badly in advanced telecomm technologies. In a study of the SA telecomm industry, Kaplan (1989) points out that in excess of 20% of the network is digital - higher than for many European countries[5].

The discussion on new technologies has focussed mainly on what is called embodied technologies, i.e computers, telecommunications and CNC machine tools. This has left out an essential component of the new technologies, the **disembodied** aspect, i.e know-how, experience, managerial and organisational skills as well as the structures (organisations) utilised to fully reap the benefits of the embodied technologies. Research has shown that organisational innovations - changes in firm structure, buyer-supplier relations, managerial philosophies, production organisation and the labour process - are prerequisites for a successful adoption of new electronics-based automation technologies[8]. Some researchers argue that changes at this level account for about 75% of the total accruing from flexible automation (Bessant and Haywood, 1987). The much heralded Japanese success has at least as much been caused by organisational innovations as by new machinery : quality circles, group technology, just-in-time inventory planning and production and multi-skilled production workers are some of the basic determinants. Of importance to developing countries like SA, is the fact that these changes require very little capital investment as compared to the NTs (moreover these require substantial forex as they are produced in IACs). It seems therefore that a key policy question is the prioritisation of organisational changes in industrial restructuring processes.

4. SOME CONCLUSIONS AND IMPLICATIONS FOR INDUSTRIAL RESTRUCTURING IN DEVELOPING COUNTRIES [7]

First, the use of microelectronics technologies in many sectors is bringing about a change of the major determinants of global industrial competition. In the auto industry, for example, comparative advantage based on the use of low cost labour is being eroded or lost due to progressive automation and organisational changes in the IACs. Clothing production is also beginning to be affected by this trend. This plus the tendency of the raw materials intensity of industrial production to decline jeopardises the long-term development prospects of raw materials producers and exporters[8]. In this context the tendency to revert back to primary production evident in South Africa can only mean one thing; poorer growth prospects (Black, 1989).

Secondly, we noted above that the information-content in production is increasing at a faster rate as a result of the NTs. Energy and materials intensity in production is being superseded[9]. Carlota Perez[10] (1985) points out that this stems directly from the very visible change in the general relative cost structure towards ever cheaper information handling potential through microelectronics and digital telecommunications. Because of this, already there is a faster rate of growth in information intensive services in international trade and this will affect the evolution of export markets for raw materials as well as the composition of imports. In recent years, for example, trade in patents and 'know-how' and other technological information has been growing faster than commodity trade[11].

Thirdly, in IACs the new technologies were mainly adopted in an attempt to reduce production costs. In the context of high-wage costs of these countries, new technologies had the effect of reducing total unit cost of production by saving labour and increasing productivity. If the new technologies are labour-saving, it might be argued that these would not be suitable for countries with high unemployment, or surplus labour economies such as SA. Controversy exists over the overall employment effects of new technologies. Three issues are raised in this regard. First, it is acknowledged that at the firm level the new technologies are indeed labour saving, but that this is counter-balanced at the macro-level as a result of indirect employment creating effects. Second, the diffusion of new technologies enables countries to increase their share in global markets, earning forex which can be ploughed back into production thus opening up new employment opportunities. Again the NTs give rise to new industries necessary to service the systems. Third, with the shift from cost to product characteristics as a key determinant of competition in world markets the traditional attitude of the role played by labour in comparative advantage is altered. Today it is not so much the cheapness of labour, but its education and skill level that counts.

Moreover in the light of some of the developments associated with the NTs, the cost argument seem to be superseded by other considerations. The two most significant ones have been **product quality** and **flexibility** of production. Product quality has come to the fore as a competitive factor. In the manufacturing of precision tools and professional equipment, for example, the use of CNC machinery has effectively become an industrial standard. On the other hand flexibility has become a must in many branches of metalworking and engineering products (where approximately 80% is small batch production) and particularly in clothing production where more frequent fashion or style changes demand flexible adjustment and quick response.

Fourthly, as a result of the flexibility offered by the NTs, **economies of scale** are gradually eclipsed by **economies of scope**. In the past automated equipment was dedicated to the production of specific products. Production and productivity depended on the repetitive movements of motors and workers and every change in model/style or tooling involved extremely time consuming and costly adjustment of equipment. In this context optimal production costs were closely related to high volume production of standardised products - this is the essence of economies of scale. With the application of microelectronics, however, automation has become programmable and flexible. With electronics controls it is possible to effect rapid changes in production schedules. CNC machinery can be programmed to produce different machine components or assemble different products. It is no longer necessary to produce a single product in order to recover high investment costs. This can be done through the efficient utilization of machinery for flexible small production of a variety of products: this is the essence of economies of scope. The economies of scope open great opportunities for countries with a small domestic market.

Fifthly, the NTs have tended to be accompanied by increased barriers to entry for companies and countries seeking to start production in the industrial branches concerned (e.g electronics). The barriers relate to, inter alia, the ability to use the NTs; capital requirements, R & D capacities etc.

Perhaps even more important from developing country perspective is their **overall industrial environment**. Their ability to, in any significant manner, move into the era of flexible manufacturing depends on the existence of what might be called the "technology support" structure; encompassing the skill levels of the labour force, infrastructure provision (e.g advanced telecomms) and the availability of necessary support industries (maintenance services and computer software specialists). Seemingly these considerations are starting to have an effect on the direction of foreign investments. In the 1980s, for example there has been a tendency for foreign direct investment (FDI) to shift to IACs. The share of foreign direct investment from IACs to developing countries has declined from a peak of 41.8% in 1975 to a low of 16.8% in 1986 of total FDI flows (UNIDO, 1989).

5. NTs AND INDUSTRIAL POLICY.

It needs to be said from the start that the concept of total self-sufficiency in high technology areas is not possible. Technology policies therefore have to focus on a combination of three things: **generation, acquisition and diffusion** of new technologies.

The pervasive application of electronics related technologies suggest that they can be used as a facilitating technology in upgrading existing sectors, or in new areas of focussed production. The following discussion on the generation, acquisition and diffusion on NTs needs to be constantly informed by this.

5.1 Sectoral Targeting for Technological Generation.

As pointed out above the country's ability to generate technology depends on the existence of a technology-creating system as well as its technology generating capacities. Studies on telecomms and capital goods sectors done by Kaplan (1989) suggest that SA's capacity to generate high tech systems is limited. On the other hand, some of the universities, notably Wits and UCT, and specialised research institutions in the country, seem to have a well developed scientific capacity which can be strengthened and broadened. Again industries connected with the military establishments and other so-called strategic industries seem to have a technological capacity which can be adapted on for social production.

Generating technology within the country requires a strategy of sectoral targeting mainly because it is impossible to develop leading-edge technologies in all sectors of industry. The strategy of targeting is essential in developing a dynamic comparative advantage. The experience of other countries clearly illustrate the advantages of such an approach: Japan's successes in textiles, shipbuilding, automobiles, electronics and new materials; Korea's emulation of this pattern in textiles, shipbuilding, autos and electronics; Brazil's informatics policy which shaped the emergence of substantive capabilities in electronics and software (Kaplinsky, 1990). Furthermore, the production structure of any country offers possibilities for certain policies while constraining others. In SA for example due to the dominance of mining in the economy, R&D associated with mining might be a starting point in developing an indigenous technological capability.

A key element in the strategy of targeting for technological development is the level of intra-firm spending on R&D by firms operating in the targeted sector. Intra-firm spending is not only a critical component of sectoral expenditure on R&D, it is also indispensable at the national level. State policy to encourage collaborative research will therefore be essential.

Other than the specific targeted technology or sector, there are other issues involved in deciding on whether to develop and produce advanced technology internally. The strategy also has "to take into account numerous demand and supply related factors, such as the size and structure of domestic demand; the potential to tap exports markets; skills required and available for product development and subsequent manufacturing; competitive situation and prices in the world market; economies of scale and scope; and many others." (UNIDO, 1989:22).

Often when issues relating to technology generation are discussed the tendency is to think about large scale enterprises or large research and development institutions (so-called science parks) with small to medium size firms (SMF) relegated to second place if ever considered. Evidence suggest that SMFs tend to be more dynamic innovators than bigger ones and thus are a significant source of technological innovation (Dodgson,1989). Moreover a policy aimed at expanding the employment capacity of the economy cannot afford to ignore SMFs. But in the context of NTs, the experience of "Third Italy"[12] show that in order for SMF to develop or utilise the new technologies a number of joint support structures (encouraged and supported by the state) are necessary. These could range from information services to joint research programmes, the formation of export/import consortia, collective bargaining with suppliers of production inputs and, joint negotiation with financial institutions (UNIDO, 1989).

5.2 Acquisition of New Technologies.[13]

The question of developing and producing advanced technology is closely related to the acquisition of technologies produced elsewhere. The point made above about targeting applies equally to that of acquisition. Firstly, both are about choice. Which technologies to produce internally and which to buy from other countries? Secondly, the technology-generating and technological capabilities will, to a large extent, determine assimilation, adaptation and diffusion of imported technologies.

A successful assimilation, adaptation and diffusion of NTs can be beneficial in many ways. Their introduction can stimulate the growth of related industries such as computer services, service and repair centres. Imported NTs can also create both learning effects and a broader market which can, in time, be tapped by domestic producers (UNIDO, 1989).

It needs to be said that the acquisition of technology from abroad is a demanding and complicated process. Specialised knowledge is required on the available options, their prices, properties, advantages and disadvantages. Given the cost (monetary and otherwise) involved in accumulating and processing the relevant data, it might be necessary for the state to offer these services. In many developing countries national technology registers have been established to provide the necessary information. Though this is not sufficient in itself, at least its a starting point. Again this is where the issue of networking and collaboration between firms, public and/or private, becomes crucial.

So far nothing has been said about what might be a real constraint for a democratic government: the availability of foreign exchange needed to purchase the NTs. The country's balance of payments, a depreciating exchange rate which affects the internal interest rate as well as the foreign debt will be an added constraint. It will therefore be necessary to break out of this, not only for the benefit of the technology related matters but for the overall economic strategy.

5.3 Diffusion of Technologies.

Conventionally it is assumed that market forces will ensure the diffusion of new technologies throughout the economy. The competitive environment as well as demand forces are said to enforce this. This is undoubtedly true but it is also true that private enterprises are more concerned with their individual competitive position in the market and that often they tend to disregard externalities which might impact negatively on the whole economy. It is essential therefore for the state to intervene in the diffusion of NTs.

The development of a dynamic comparative advantage through the strategy of sectoral targeting will be beneficial to the entire economy if accompanied by a purposeful policy to encourage the widespread utilisation of developed and acquired technologies. Some of the policies needed to achieve this relate to: the establishment of effective mechanisms for technology transfer between and within sectors of the national economy; interventions to ensure that imported technology operates to designed capabilities; mechanisms for adapting and assimilating imported technologies to local conditions (Kaplinsky, 1988). For example, subsidies can be used to encourage the adoption of NTs by targeted sectors.

5.4 NTs and Skills Development.

The successful generation, adoption, assimilation and diffusion of new technologies depends as much on the interventions discussed above as the capabilities of the people using them. As Kaplinsky (1988) points out, the experience of Japan and the Asian NICs has shown that an educated labour force is crucial to industrial success. The observation made above that there is a general increase in the knowledge content in technology mean that more and more a broadly skilled labour force will be indispensable. This is reinforced by the tendency towards cross-sectoral or inter-sectoral application of the NTs, like electronics control units, which militates against skill polarisation.

In the 1980s it increasingly became more evident that the development of human resources can no longer be treated as a residual. In SA where there is an alarming shortage of skilled labour, restructuring in the context of the NTs will place a heavy demand on the educational and training systems. I have addressed the question of skill shortages in relation to restructuring a future post-apartheid economy in detail in an earlier paper (Ngoasheng, 1989). Here I can only restate some of the conclusions. The starting point for such a restructuring is of course the radical transformation of the entire apartheid education structure. Second, substantial investments in expanding and improving secondary and higher education. Third, developing and upgrading the current vocational and technical training as well as the apprentice system. Fourth, as the NTs make production systems more similar across various industrial branches, the basis of much education will have to change - for example, from mechanical and electrical engineering to mechanotrics, and from narrow apprenticeships to more broadly-based craft-training.

Another important component of industrial labour force training will be that carried out by firms. Firm investment in training and retraining for the NTs will be essential for their competitive performance in the future. The current skill shortages in the country will certainly elicit a response from enterprises - public and private. Some large companies have already started to respond to the situation. Work done by NUMSA points out that training in the metal, engineering and auto industry is undertaken by few large firms through modular training schemes (Erwin, 1990). This has to be extended and broadened and the approach needs to be altered. As Erwin argues, modular training, though useful for operator upgrading, limits the skill level of artisans. In fact it reinforces the old single-skilling approach. To encourage more firms to train and retrain the labour force in the future, the state might promote such investments through either subsidies or tax rebates.

6. ORGANISATIONAL TECHNOLOGY AND INDUSTRIAL POLICY.

It was observed above that changes in disembodied technologies, that is, organisational reforms are a prerequisite for the successful adoption of the NTs. Generating, adopting, assimilating or diffusing the NTs within old forms of work and production organisation will amount to a waste of resources. The experience of the US auto industry in the late 1970s and early 1980s clearly showed that heavy investment in electronics automation technologies without corresponding changes in firm structure, managerial philosophies, production organisation and the labour process does not yield the necessary benefits. General Motors, the US auto giant, in an attempt to fight the challenge from Japanese car industry, invested well over $50 billion in a single decade in automation in new flexible automation technologies. Despite this GM's share of the US market has fallen from nearly one-half to around one third (Kaplinsky, 1990). At the point of transition therefore, it seems organisational reforms have to receive priority. Any restructuring that leaves the authoritarian structures and relations in production in tact will run into problems.

A policy programme in the light of the above will be to develop an incentive system designed to facilitate reorganisation to complement the generation, utilisation and diffusion of NTs. Kaplinsky (1988) argues that one route to this is through the employment of productive services firms who specialise in the new organisational innovations. Subsidies for the use of their services can thus be a key component of appropriate policy.

7. THE STATE, INDUSTRIAL RESTRUCTURING AND NTs.

After reading through the paper this section might appear redundant because the underlying assumption is that the state is a key actor in the process of restructuring the whole economy, technology included. This section seeks to confirm this, but more importantly to make two important points. First, is the need for stability and continuity in policy. Lack of clarity and 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 (UNIDO,1989). Stability is very essential, particularly in relation to the development of an indigenous technological capability. This much is evident from the experience of Japan.

The second point, is that the state has to provide economic actors with a strategic vision and simultaneously demonstrating its commitment to policy. The state's primary role is to design a PIS, indicate sectoral priorities (targeting) and to provide guide-lines for company decision-making (ibid). Once again the Japanese experience indicates that a "strategic vision" (that is, a notion of the country's preferred future industrial structure) coupled with a corresponding policy commitment is required to encourage private risk-taking.

FOOTNOTES.

1.The discussion on technical changes is drawn from Freeman (1984), Kaplinsky (1988) and Perez (1985).

2. In the past few weeks I have been doing a study of the garments industry in Western Cape and some of the manufacturers have introduced computer grading and marker making systems. One manufacturer has linked these two to pattern making and computer-controlled cutting systems.

3. This breakdown should be understood in the context of the current restructuring of industry (at least in the IACs) from a system characterised by single-tasking and single-skilling to one characterised by multi-skilling and multi-tasking. For a comprehensive discussion of these issues see Hoffman & Kaplinsky (1988), Ngoasheng (1989) as well references quoted therein.

4. Truworths, the giant retailer has a point of sale system which links the Cape Town head-office with 80% of its stores country-wide. According to an executive of the company this has improved their ability to plan and monitor the activities of the entire company. It has also increased their ability to respond quickly to market trends and variations.

5. In the same study Kaplan discusses a number of weaknesses and problems in relation to the industry such as the level of production, high import content of locally produced equipment, the skewed distribution of telephones, and so on.

6. For a comprehensive discussion of this point see Bessant & Haywood (1987); Hoffman (1989) ; Hoffman & Kaplinsky (1988) and references therein.

7. The following discussion draws from a study done by UNIDO (1989).

8. This decline is partly due to more efficient materials utilisation in the context of CAD/CAM systems and party due to the advent of new and advanced materials.

9. Already in product engineering there is a tendency to redesign goods to make them smaller, less energy-consuming, with less moving parts, more electronics and more software.

10. The following discussion is drawn from Perez (1985).

11. Issues related to the transmission and sale of processed information and patents constitute a significant part within the agenda of the current negotiations on GATT, the so-called Uruguay Round. For a comprehensive analyses of the negotiations as they relate to this point see Kaplinsky (1989).

12. "Third Italy" refers to the regional economy around Emilia characterised by cooperation and small firms networking and flexible specialisation practices with the local government playing a crucial supportive role.

13. The possibility to purchase advanced technology should not be seen as a substitute for developing a leading-edge indigenous technological capability. More than anything, external sources are complimentaries.

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