THE ROLE OF TECHNOLOGY IN THE PROCESS OF ECONOMIC DEVELOPMENT

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I. Introduction

This paper focuses attention on the beneficial effects ensuing from the promotion of capital goods production in developing countries. It is essentially a theoretical review of the established fragmentary literature on the subject, having the advantage of bringing the various arguments together in one compositive article. The discussion is necessarily generalized to the global context because it is obviously only outside Africa where capital goods production furrows have already been ploughed. However in deference to the primarily African readership of this journal a concluding section has been added aimed briefly at assessing the technological development strategies open to black African administrations in the post- Monrovia era.

II. Capital Goods and Industrialization

Capital goods mean different things to different people, but common to most interpretations, however, is the centrality of machinery. The capability to produce machines has been perhaps the most sought-after attribute of industrialization since the initial mechanical revolution occurred some two centuries ago. The importance of mechanical practice has regard not only to the provision of reproducible capital in the economy, thus making a substantial contribution to improvements in the productivity of labour, but, additionally, it constitutes the prime conditioning element for the achievement of dramatic increases in economic growth through the combined influences of technical change and specialization. Marx, with his usual eloquence, puts the historical importance of this relationship in a somewhat more erudite fashion:

> "As inventions increased in number, and the demand for the newly discovered machines grew larger, the machine-making industry split up, more and more, into numerous developed branches, and division of labour in these manufactures was more and more developed. Here, then, we see in manufacture the immediate technical foundation of modern industry. Manufacture produced the machinery, by means of which modern industry abolished the handicrafts and manufacturing systems in those spheres of production that it first seized upon". (Marx, 1906, p. 417).

Ever since modern industry "rent the veil that concealed from men their own social process of production" (Marx, p. 564) it has been a major goal of industrializing nations during the ensuing epochs of World development to acquire the mechanical techniques and skills necessary for the manufacture of producer equipment. But what is it about capital goods capacity that makes it such an attractive and compulsive objective in many of the industrializing states, and an essential ingredient in the initial development-push of others? What is it, furthermore, that drives relatively poor nations to invest in manufacturing capacity of high resource cost engineering items even when foreknowledge exists that locally produced equipment will cost more during the period of industrial infancy, an infancy that often-times takes on a Peter Pan-type characterization, than if the equivalent goods were purchased outright from already established producers abroad? Clearly, the rationale which provides the impulse for industrializing nations to strive for capability in capital goods production rises above any relationship between the sector's incipient growth pains and its efficiency level. Early writings on the subject failed, however, to grasp this point. Pack and Todaro (1969, p. 400) writing on the subject of technological transfer and economic development, as far back as the late 1960s, argued the case for developing countries to institute measures to encourage the growth of domestic capital goods industries but with one caveat, and that was that unit capital costs of production should be no higher than those of the advanced countries from which the displaced imports originate. Their qualification is essentially the opportunity-cost one of seeking to maximize the allocation of scarce investible resources in an under-developed economy. That the quest for efficiency, especially in the capital goods sector which is organic to the generation of efficiency in other mechanical industries, be given the economic reverence that is its rightful due requires no justification. But the pervasiveness of infant industry arguments has had the effect of neutralizing the incisiveness of the role of economic efficiency in

development, replacing it to a great extent with a plethora of other non-price based considerations[2].

These additional influences which militate for the establishment of capital goods capacity in developing countries, whilst not denying the fundamental primacy of efficiency in production, are increasingly recognized and indeed justified as being goals in their own right. The rationale for fostering an indigenous machinery manufacturing industry can be classified under a number of broad macro-economic headings, namely: faster economic growth; the promotion of externalities; the widening of technological choice; and the ability to secure the benefits of foreign trade. It will be the purpose of the discourse that follows to offer adumbration of the various issues associated with each of these.

III. The Rationale of Capital Goods Production

(i) Growth Characteristics

The notion that the machinery producing group of industries is a "leading sector" in the process of industrialization now seems to be generally established. The basis for this view is that the sector has shown a tendency to grow faster than industry as a whole. Examples abound. During the initial Five-Year Plan of the Soviet Union the investment emphasis was on heavy industry and machine fabrication in particular. The annual average growth rate for Soviet heavy industry between 1928-29 and 1937 was 17.8 per cent, with the machinery industry registering 18.9 per cent[3]. For India, over the period 1951 to 1967, the growth rate of the machine building industry was 15.6 per cent[4]. The growth of machinery output in Communist China during the period 1952-1966 was also high, amounting to 18.6 per cent[5]. The expansion of Japan's heavy and chemical industries in the post-war era proved similarly remarkable. Over the same time-span, 1952-66, the growth of machine building activity reached 15.1 per cent per annum[6]. The branches' index of production (1965=100) rose from 14.6 in 1955 to 291.6 in 1970, an increase of more than twenty times over the fifteen years. As a result, the share of the heavy and chemical industries in the total output of manufacturing industry reached 57 per cent in 1970, higher than the corresponding share in West Germany or the United States[7]. Similar trends were registered in India, where the share of machine building output rose from 4.5 per cent in 1946 to 23 per cent in 1974[8]; Brazil, where the sector's share in industrial value-added rose from 15 to 27 per cent between 1949 and 1959[9]; in Communist China where, over roughly the same

period, the machine building industry's share in total industrial output grew from 2-7 per cent to 12 per cent[10]; and, finally, in the case of Korea, where the share of mechanical engineering products in all manufacturing products increased from 5.2 per cent in 1960 to 10.4 per cent in 1970[11].

The rapid structural transformation of economies induced by the growth and development of their capital goods sectors lends credence to Rostow's assertion that engineering goods capacity is a leading force in propelling a country forward in its drive for economic and technological maturity[12]. Hoffman, (1958) in a major treatise, put forward a comparative framework for measuring the growth performance of capital goods production between industrializing nations. In an attempt to trace how the pattern of manufacturing output in developing countries is affected by the emergence and growth of a capital goods sectors. According to Hoffman, in the first stage of industrialization, net output of consumer goods industries is on the average five times that of capital goods. In the second stage, the ratio is reduced to about 2.5 to 1, while in the third stage the net output of these two groups is approximately equal. Although Hoffman's analysis is primarily concerned with capitalist countries, he interestingly had this to say on the Soviet Union:

> "The Soviet Union is, of course, the most striking example of a country which has deliberately fostered the production of capital goods industries by state action. During the first three Five- Year Plans (1928-42) investment in capital goods industries were between 84 and 86 per cent of all capital investments in industry (excluding repairs to existing capital equipment). In 1937 and 1940 the gross output of capital goods was already about equal to the gross output of consumer goods. The relationship between the net output may have been similar" (p. 100).

India was the first developing country to emulate the Soviet Union's two-sector growth strategy; and ignoring the allocation of investment resources in the First Five-Year Plan, where priority was given to the development of agriculture and the social and economic infrastructure, it has been quoted (Bhagwati, 1970, p. 8) that as a proportion of planned expenditures in industry 70 per cent were devoted to the metal, machinery and chemical industries during the Second Plan and 80 per cent during the Third Plan[13]. Thus, by 1968 India's ratio of consumers goods to investment goods in terms of gross value-added was in the order of 1.8:1[14]. To progress from the first

to the third of Hoffman's stages normally took several decades in most industrial countries. The Soviet Union, however, in just one decade had reached the third stage whilst India over a slightly longer period had only just failed to achieve the same[15]. The development experience of the Soviet Union and India gives substance to the Hirschman-Gerschenkron hypothesis[16] that contemporary industrializing countries can work their way from "last back to basic and intermediary industries"; a process that completely reverses the traditional path of industrialization which initially relies on the development of consumer goods industries[17].

(ii) Externalities

The writings of Hirschman (1958) also introduced to development economists the strategy of unbalanced growth with its associated concept of "linkage", both of which have direct relevance to the character of industrialization in the Third World. Since the doctrine focuses on the structural and dynamic forces at work in an economy rather than solely the enlargement of overall capacity, a further justification for emphasizing the development of producer goods industries can be advanced in terms of the dynamic externalities involved in the manufacture of machinery.

A major feature of the unbalanced growth strategy is the concentration of investment into those industries most conducive to transforming the economy to a higher stage. Hirschman maintains that this is preferable to dissipating scarce investment funds by attempting to advance on all fronts at the same time: "to be breathlessly climbing a peak in a mountain range is considered more important than standing poised on the crest of a ridge in the foothills". (Wilber, 1969, p. 86) Planning in the Soviet Union provides a historical example of this approach. The country pursued a "shock" strategy of bottlenecks successively created and resolved[18] a policy which has been described as "planning by campaigning"[19]. The Soviets directed large chunks of their total investment to certain industries designated as having key status by the authorities. This policy caused severe shortages and stresses within the economy which, as a consequence, created fresh bottlenecks and therefore new targets for the Soviet planners.

The level of interdependence between various industries is an important indicator as to the appropriateness of any particular "campaign". Thus, external economies would be gained by a country if it invests in those industries exhibiting high linkage effects. Hirschman documented two types of linkage: the input provision or

backward linkage effects, and the output utilization or forward linkage effects[20]. From a development perspective, it is backward linkages which have the greater stimulative effects. The advantage of an industry with high backward linkages relates to the part it plays as an inducement mechanism to the development of a feeder network of ancillary industries. If the expansion of a particular industry leads to a general increase in economic activity embracing a considerable number of basic and supplier industries then it must be classified as a key industry meriting a high priority in development. Under this criterion, the machinery branch can clearly be interpreted as a key sector. The strong backward linkage effects of the machine building industry stem from the fact that it has a high ratio of purchased inputs to the value of its total production[21].

One of the most significant effects that a growing network of linkages has on an industrializing economy is the increased intensity and diversity of the labour skills thus generated. There are various externalities associated with technological application but amongst the most important is the impact skill acquisition has on industrial advancement. In the case of the metal-working sector learning is acquired by doing and is, therefore, a cumulative function of the historical evolution and development of engineering practice. The origins of machine- making in developing countries are normally to be found in the informal artisanal workshops where all manner of repair, fabrication and modification are undertaken in extremely primitive conditions. Although the "marginalized" craftsmen possess only the most rudimentary of technical facilities their adroitness in mechanical undertaking acquired through years of accumulated experience in problem-solving situations, has enabled them to expand their activities into machinery manufacture proper. This occurred, for instance, in Ludhiana in India's Punjab region where families originally involved in repair work now specialize in the manufacture of basic machine tools against order, often constructing them literally in their backyards. Similar examples of repair shops expanding into machinery production have been quoted for Latin America[22]. Even if such a pattern is unlikely to lead today to the establishment of the extremely large machinery plants that are to be found in the advanced nations the continued contact with engineering design and organizational problems nevertheless inculcates the workforce with an expanding and deepening mechanical expertise. Moreover, as production increases and the degree of specialization is enhanced there is the possibility of profound improvements in worker productivity. This has come to be known as the "learning-curve" phenomenon[23]. Such cost-reductions have been held to emerge especially in those areas

of manufacturing activity which involve repetitivity and continuity in the work programme[24].

A company that is able to effect reductions in production costs through movement down its workers' learning curve may also be in a position to secure further increases in efficiency from the introduction of allied improvements in the organization of production. As with the learning curve concept, a fairly high level of demand and continuity of production are necessary; but these are conditions rarely to be found in the developing world where levels of demand tend to be insufficient to sustain either flow-line or series production. Even though one-off and batch manufacture continue to be the prime methods of production in such countries, there may still be opportunities (primarily in batch production where the quantities are not insubstantial) for amelioration in the organization of production. There is, for instance, the possibility for improvements in materials handling. It might also be feasible to change the lay-out of process machinery to accommodate a more ordered pattern of production so that the parts of the product advance in a logical fashion through the various stages of machining to fabrication. Moreover, the introduction of modular design, where common parts for different machine products can be identified, will help to lengthen production runs and thus increase the efficiency gains from the improved lay-out of the plant.

The discussion thus far has concentrated on the positive influences that linkages, skill-enhancement and organizational improvement can make on the operating efficiency of the capital goods sector. As a source of capital-saving in the machinery- using industries these factors are clearly of some importance. However, there is a further source of capital-saving, having regard to reducing the capital content of the machinery product in an attempt to make it more appropriate to the factor endowments of given developing countries. The possession of the ability to influence the design of machinery represents a further consideration singling out domestic capital goods capacity as a crucial strategic factor in the technological development of newly industrializing countries.

(iii) Choice of technology

The promotion of a machinery production capability has now become a sine qua non for those Third World countries intent on securing non-dependent technological development. To a very great extent the significance of the acquisition of indigenous machinery manufacturing facilities and competence bears directly on economic

considerations surrounding the appropriateness of technology. Most importantly, it allows local equipment producers to specialize in the manufacture of processes which aim at maximising the labour input of technology application whilst, at the same time, minimizing the loss in the degree of output achieved[25]. The mainspring to this approach is the view that acknowledges the existence of a fairly large pool of unemployment in many of the poorer countries and attempts to utilize the comparative inexpensiveness of this labour as a means of generating steady but sustained economic growth.

Although the appropriateness of technology in relation to the factor proportions of given developing economies has for long been advanced by development economists[26] its economic feasibility in terms of Third World nations willingly avoiding modern techniques simply does not square with the practical realities of these countries' aspirations; it also, at the same time, smacks of attempts, especially if sponsored by Western dominated international agencies, at encouraging the continuation of Third World technological serfdom. Even though such arguments give pragmatic rein to wide scale endorsement of implementing labour-intensive techniques in labour-surplus states there is nevertheless a growing consensus, even amongst the policy-makers within the peripheral countries, that the solution to the problem of unemployment will not be found merely by augmenting the size of production potential through importation of foreign technology[27]. The phenomenon of increasing unemployment occurring coincidentally with an expansion in industrial capacity has led to the realization that the promotion of manufacturing activities is not only a question of the scale of operation but also of the nature of the technology adopted for the purpose, with its consequential impact on the volume of employment[28].

Efforts to orient machinery production in labour abundant countries around appropriate, labour-intensive technology is clearly of considerable importance when it is noted that the majority of world technology exports today consist of "State of Art", capital-using equipment from advanced countries. Circumstances will arise, of course, where imported capital- intensive technology with its attribute of enhanced accuracy will need to be given priority in the establishment of selected manufacturing activities, but the creation and level of this capacity will need to be determined in the light of such considerations as the nature of the industry; the quality of output; the effective demand for the products; and the cost structure of comparative productive operations. Notwithstanding this, however, once a machinery producing base has been constructed, particular emphasis can

then be given to the design and production of techniques most appropriate to the economic conditions prevailing within the economy of a developing country. Thus a machinery producing sector offers the host country greater latitude in the choice of technology available.

The concept of "appropriateness" has evolved to encompass two different though related variants of the sense in which it is perceived.

The first view of appropriateness is one that holds direct relation to the "quality" of the technology that is available for use in labour-rich economies. Clearly, if the choice of technology is constricted to the output of the dominant capital goods sectors located in the advanced countries the opportunity to select lower quality machinery will be severely limited. Lower quality in the sense used here conforms to the principle of cost- minimization: avoiding the sophistication of the high cost, high technology of the West and instead concentrating on the appropriate aspects of simplicity and durability. The suitability of such machinery for the non-industrialized countries hinges on the belief that they harbour higher elasticities of demand for given technologies relative to those exhibited in the developed countries for the corresponding class of product. The search for appropriateness has led a number of celebrated economists to hedge towards the notion of encouraging a market for second-hand machines which, for a variety of reasons, are now obsolete in the countries where they originated[29]. Numerous ideas in this context have been mooted, ranging from the supply of specifically 15-20 year vintage models[30], thus explicitly de-emphasizing the sponsorship of primitive forms of equipment, to custom-built technology primarily intended for use in Third World environments[31].

The second nuance on the meaning of technological appropriateness argues that the only truly relevant forms of mechanical technique are those that emerge, whether copied, adapted or modified from existing designs, from within the developing world itself, being a response to the economic conditions operating in the host environment[32]. This view obviously depends on the existence of an albeit rudimentary, domestic capital goods sector to produce the equipment required. The capability to build machinery is clearly a central feature in the supply of appropriate technology, but it is also fundamental to the emergence of appropriate innovation. The development of such a sector will tend to be a pre-requisite for the introduction of capital saving, labour-intensive technologies which address the immediate problem of efficiently allocating scarce economic resources. The application of

.technology will also be appropriate from the process angle in that capital investment in the mechanical industries of developing countries will tend to fall within the parameters of standard, general purpose machinery redolent of the equipment employed in the small engineering workshops of western companies in the earlier part of this century. The significance of this technology is that it is primarily a man-to-machine mode of operation, emphasizing the artisanal abilities of the operator. Capital goods production along these lines would thus not only help to absorb the putatively prevalent pools of untapped skilled labour that exist in the developing world[33], but would also provide a potential reservoir of innovative talent that will serve the other sectors of engineering activity either directly through its mobility or indirectly through the cross- fertilization of efficiency of the innovation embodied in the techniques diffused.

(iv) Foreign Trade

The final facet of this discussion justifying the development of capital goods capacity used to be rationalized in terms of foreign exchange savings; this emphasis has shifted over recent times to focus on the more positive aspect of foreign exchange "earnings". However, it is the former consideration which occupies the minds of policy makers when initially instituting import-substitution measures for capital goods development. Countries at the threshold of industrialization are desperately keen to conserve foreign exchange resources to ensure that imports of essential materials are continuously available to fuel the industrialization-push. Thus without foreign exchange an economy is effectively "closed" to imports. In such circumstances a country without well developed metal, machinery and subsidiary industries is unable to produce a sizable quantity of capital goods and thus invest a high fraction of its income however high its potential saving propensity may be[34]. Both the Indian (Mahalanobis) and the Soviet (Fel'dman) two sector growth models operated under the assumption of a closed economy[35]. But clearly the closed economy assumption is unrealistic as in the early stages of Indian and Soviet development significant amounts of capital-goods were, in fact, imported. The problem can be resolved, however, if instead of closed economy is read foreign exchange constraint. The models now take on a greater element of reality: in an "open" economy, an upper limit to possible investment is imposed not by domestic investment capacity but by that capacity plus foreign exchange available to buy investment goods from abroad. Assuming zero local investment goods capacity, then foreign exchange availability provides the upper constraint on possible investment[36]. The case for the development of local

machine-making capacity may thus be supported on the grounds that foreign exchange to an industrializing country is a scarce resource and, once past the import-substitution phase, its use can be economized through substantial reductions in the importation of machinery.

It has been the normal strategic ploy of developing countries which have constructed the industrial base of their economies through import-substitution policies to then turn to the export market. This reorientation of development strategy is an inevitable and necessary action for most newly industrializing states and is typically the result of the initial import- substituting spurt of demand petering out on the conclusion of all easily exploitable investment avenues. Of course, such a process eventually affects all industrial sectors, and those involved in the production of capital goods provide no exception. A primary rationale for attempts by machinery manufacturers to enter export markets stems from their efforts to increase the length of production runs depressed by the local economy's low demand for durable equipment; being both a cause and effect of the high price structure of locally produced capital goods. Through the promotion of exports there will be the potential for the emergence of a "virtuous economic circle": the initial raising of demand stimulates production and the consequent rise in the scale and efficiency of manufacturing operations lead to falls in unit costs, with the possibility of further increases in demand. The fairly recent growth in the technology exports of developing countries is something novel to world trading patterns, but it is nevertheless a phenomenon that is being closely monitored by development analysts for clues to the determination of an evolving comparative advantage[37] .

Although the dynamic attributes of technology exports have not been widely articulated in the development literature most informed commentators would subscribe to the view that export activity leads to an enlargement of technological capability. There would appear to be two main reasons for this. First and foremost is the idea that the exposure of previously sheltered firms to a more aggressive commercial environment engenders a spirit of competitiveness. This relates not only to the need to reduce price levels to internationally competitive levels but also to the pressures for improvement in design. The necessity of instituting design changes has regard to the second of the positive influences promoting the precocious development of technological capability: machinery exports have a tendency to induce technological feedback. This phenomenon has been observed by Westphal (et.al. 1984) in the case of Korean machinery exports whereby the foreign customers were instrumental in imposing their

will on product design and quality control. They have also contributed to greater productivity and lower costs by suggesting changes in production processes and improvements in management techniques and production organization - all at no cost to the Korean firms[38]. It is this feature of capital goods exports that facilitates an acceleration and expansion of technological competence; it may well also, at the same time, lead to its deepening[39].

It appears, furthermore, that the scope for promoting Third World machinery exports may well be greater than for traditional exports of consumer goods and primary products. The increasingly electrical and electronic content of the consumer good exports of the newly industrializing nations have tended to attract import restrictions in the major markets of the industrialized regions. The international recession has hastened the imposition of these import controls by exacerbating the sense of nervousness already felt by western nations prior to the recession's onset and caused by the declining share of the domestic market served by local industry. Moreover, the other major traditional export of the development countries, raw materials, provides little in the way of incentive with world commodity prices being their lowest for years. Such a scenario, coupled with the fact that mechanical engineering goods are neither subject to excessive trade restrictions nor represent a potential threat, through their high labour skill embodiment, to the employment of unskilled labour in the advanced countries suggests that the contemporary international arena is conducive to the expansion of Third World machinery exports even at a time when total demand is contracting[40].

The empirical evidence substantiates this sanguine appraisal of the developing countries' trading prospects in machinery. Table 1 marshals together the data on world trade in machinery, since 1970, by broad economic region. The immediate impression obtained from analysis of the statistics is the encouraging manner in which the share of developing country exports in world trade has increased from 1.6 per cent in 1970 to 6.3 in 1982. The comparative figures for the developed countries show a fall from 87.6 per cent to 84.6 over the same period, registering a negative growth in their trade of 0.3 per cent.

That the poorer countries are becoming increasingly involved in industrialization and in the promotion of technological activity is indicated by the rising trend of machinery shipped to the Third World; the region attracting a 30.9 per cent share of world exports in 1982 compared to a base share of 21.5. Thus, the evidence indicates

Table 1: World Trade in machinery and transport equipment (SITC, revised, 7) - Values (in millions of $US, F.O.B.) and shares (%)

Year	World Trade	REGIONS OF DESTINATION: Developed Market Economies	Developing Market Economies	Centrally Planned Economies	Region in world trade	Total world trade	REGIONS OF DESTINATION: Developed Market Economies	Developing Market Economies	Centrally Planned Economies
Regions of Origin									
World Trade									
1970	89,769	59,445	19,279	10,360	100.0	100.0	66.2	21.5	11.5
1979	439,831	270,764	119,185	48,071	100.0	100.0	61.6	27.1	10.9
1980	510,934	308,282	147,860	52,527	100.0	100.0	60.3	28.9	10.3
1981	522,550	304,550	165,778	49,384	100.0	100.0	58.3	31.7	9.5
1982	509,002	298,263	157,447	49,240	100.0	100.0	58.6	30.9	9.7
Developed Market Economies									
1970	78,623	58,057	17,107	2,801	87.6	100.0	73.8	21.8	3.6
1979	376,759	255,815	103,982	15,605	85.7	100.0	67.9	27.6	4.1
1980	437,014	290,732	127,913	16,935	85.5	100.0	66.5	29.3	3.9
1981	445,620	284,712	143,504	15,060	85.3	100.0	63.9	32.2	3.4
1982	430,460	277,249	135,539	14,138	84.6	100.0	64.4	31.5	3.3
Developing Market Economies									
1970	1,431	757	633	20	1.6	100.0	52.9	44.2	1.4
1979	20,684	11,282	9,036	222	4.7	100.0	54.5	43.7	1.1
1980	27,239	13,898	12,595	573	5.3	100.0	51.0	46.2	2.1
1981	31,628	16,052	14,600	687	6.1	100.0	50.8	46.2	2.2
1982	32,136	17,442	13,570	617	6.3	100.0	54.3	42.2	1.9
Developing Africa*									
1970	61	24	32	4	0.1	100.0	39.3	52.5	6.6
1979	269	149	107	0	0.1	100.0	55.4	39.8	0.0
1980	362	231	129	1	0.1	100.0	63.8	63.8	0.3
1981	312	140	158	2	0.1	100.0	44.9	50.6	0.6
1982	315	171	142	1	0.1	100.0	54.3	45.1	0.3

Source: UN Monthly Bulletin of Statistics, Special Table D, Vol. 38, No. 5 (May 1984)
* excluding the exports of Zimbabwe.

that the Third World is not only emerging as a potential force in the World trade of technology but is also providing a growing proportion of the market for capital goods exports. Table 2 provides a closer examination of these trends and the results are revealing. Even though the share of the Third World's exports to both itself and the developed nations have remained fairly static over the period (see Table 1) its share in the total World trade to these two regions has increased remarkably. The proportion of developing country exports amongst all exports to countries of the Third World increased from 3.2 per cent in 1970 to 8.6 in 1982, recording an annual growth rate of over 8 per cent. Moreover, the newly industrializing countries' share of World exports to the developed world over the same time span rose from 1.3 per cent to 5.8, representing a 13.3 per cent rate of growth. The recession and the pursuit of de- industrialization policies in the West, has by comparison, led to declines in the share of advanced country machinery exports, relative to World exports, to both the developed and developing market economies.

Table 2: Performance of Machinery Exports by Region (1970-82)

Exports to / Exports from	Developing countries			Developed Countries		
	Value	Share	growth	Value	Share	growth
	($US mill.)	(%)	(AAG%)	($US Mill)	(%)	(AAG%)
LDCs						
1970	633 (19,279)	3.2)	8.6	757 (59,445)	1.3)	13.3
1982	13,570 (157,447)	8.6)		17,442 (298,263)	5.8)	
DMEs						
1970	17,107 (19,279)	88.7)	-0.2	58,057 (59,445)	97.7)	
1982	135,539 (157,447)	86.1)		277,249 (298,263)	93.0)	-0.4

Source: Table 1.

Note: figures in parenthesis relate to the total value of particular regions in World trade.

The capture of technology export markets has been, and continues to be, a painful exercise for the newly industrializing countries. The building up of an international marketing network and the continual struggle to overcome ingrained prejudices in terms of established trademarks and reputations have proved formidable barriers[41]. Given all these obstacles it is nevertheless evident from the above analysis

that substantial progress has been achieved. Two qualifications to this basically rosy assessment should, however, be noted. Firstly, caution needs to be exercised in the interpretation of the fairly significant growth of incursion into foreign markets that has been sustained by the developing economies. This "rapid" rate of growth represents a statistical illusion in that measurement is based on the extremely small export base prevailing. Secondly, the broad-brush treatment of classifying the Third World as one entity hides the fact that within such an area the technology export performance of particular countries varies widely. The newly industrializing states of Korea and Taiwan, for example, have made impressive progress in this respect. The countries of sub-Saharan Africa, by comparison, as Table 1 illustrates, have yet to enter the mechanical engineering stage of industrialization and this is reflected in their minuscule 0.1 per cent share of World trade in machinery; they seem, with one or two exceptions, "locked" into a pre-industrial milieu of technological activity.

IV. Africa's Technological Development

(i) The Problem

The paradox of African economic development is that policies aimed towards industrializing the countries of the Continent, and thus reducing their over-reliance on agriculture, have ultimately depended on the foreign-exchange earnings of cash crops. Although this is a major problem, it is not the only one. Market constraints such as low levels of capital accumulation, demand and hence capacity-underutilization are also important influences contributing to black Africa's doleful industrial performance.

In an attempt to rise above these difficulties, Africa's policy-makers in 1980 expressed their industrial ambitions within the framework of what came to be known as the Monrovia Strategy (after the country where it was formulated): a central theme of this Pan African approach to the ideal of integrated continental development being the promotion of capital goods production capabilities for the development of genuinely African technology[42]. Champions of such inward-directed development efforts were the experts of the international development agencies who had for long proclaimed the benefits of poorer countries employing "appropriate technology".

The effects of the Sub-Saharan droughts several years into the current decade dramatically altered the spotlight of policy, as formulated both within and without the Continent. The thrust of

developmental efforts swung firmly back in favour of agriculture. Although this shift in emphasis was dramatic it ought not to be considered final. The basis for this view is two- pronged. Firstly, efforts to improve agricultural productivity, in both farming and processing, are very much dependent on the input of machinery and for the reasons stated hitherto, it ought to be locally produced machinery. Secondly, if it is accepted that in the foreseeable future agricultural output will continue to be subject to climatic factors, then self-sustained economic development will clearly only come about through industrialization. Sooner, or later, therefore, policies relating to the fostering of indigenous technological capacity must return to the centre-stage of policy debate.

(ii) Strategic Options

The Monrovia Strategy was perhaps Africa's first collective recognition of the need to ease its reliance on the export of cash crops as the mainstay of the Sub-Saharan economies[43] through the development of domestic technological capabilities. Given the right "climate" most informed observers would agree to the correctness of this approach; the debate arises rather on the suitable strategies to be followed in achieving such an objective. Essentially, the OAU's policy was one of encouraging the endogenous growth of machine-making activities, whilst, at the same time, "de-linking" from the technology supplying industries of the advanced states. Although the ability to achieve the latter aim is problematical, and in any case dependent on the success of the former, the proposal nevertheless reflected a sense of considerable awareness and foresight of the problems the Continent faces, and will continue to face. Of major significance in this respect was the recognition that none of the existing strategies of technological development are applicable to African economic conditions.

The Western model is clearly inappropriate[44] . It is an evolutionary approach to industrial and technological development that emphasizes capital-using innovation, and, most importantly, a competitive commercial environment. The Soviet paradigm of the 1980s, by contrast, has much to commend itself to the capital-scarce African countries. The machinery producing sector was regarded as a key industry and therefore given priority in the allocation of investment funds: it was seen as the engine of growth, with capital-saving the cornerstone to the strategy. This is evidenced by the way research and development expenditure did not emphasize major design changes in the product leading to the premature replacement of

still productive equipment. The little innovation that did take place was instead geared to making the copied Western equipment of standard, general-purpose design, more amenable to long-production runs. The choice of machine model was narrow and restricted to the basic. Thus, through the achievement of economies of scale, standardization and specialization, the Soviets sustained capital-saving not only in the technical nature of the final product but also in the manner by which it was produced.

For Africa, the problem with this model is that it requires a very large level of demand to make it work. In the contemporary history of industrial development the promotion of a viable capital goods sector has never occurred in countries possessing less than 20 millions in populations; this is normal, however, for the average African country[45]. Finally, the technology development models of Japan, Korea and Taiwan feature a variety of common characteristics separting them from the experiences of their industrialising predecessors. Even though the Far-Eastern strategy was of the same style as Soviet efforts several decades earlier, there was one major difference: although these South-East Asian countries concentrated on the efficiency- inducing attributes of scale, standardisation and specialisation in the production of labour-intensive products, their output was destined for overseas markets rather than domestic ones. Here again, however, a problem exists for Africa to emulate this Far- Eastern approach. Certainly Japan, but also Korea and Taiwan, are all countries possessing a fairly long history of mechanical expertise, and albeit it was of a lower order compared to the industrially advanced nations, a sufficient standard of quality was nevertheless achieved. No such expertise exists in the Sub-Saharan countries of Africa, where even basic technological proficiency has, until quite recently, been conspicuously absent.

(iii) An African Paradigm?

In a rather belaboured and circuitous manner the discussion has come some way to revealing the sense of the Monrovia Strategy. In a world of declining export opportunity for even the established technology-producing countries, what hope is there for the fledgling capital-goods industries of Africa? Their products will be lacking quality, reputation, trade-marks, back- up services and marketing networks. Comparatively, they will also probably be high-cost and too backward in design for most other countries, even the newly industrializing ones.

The implication which stems from the foregoing discussion

suggests that perhaps the only fruitful strategy for states possessing low levels of capital and effective demand, combined with poor (trans-continental) export prospects for industrial products should, out of necessity, be one of more modest design. Its primary rationale being to foster a technological platform comprized of rural as well as urban machinery manufacturing undertakings concerned with the fabrication of basic agricultural and industrial equipment. This "Third-Way"[46] represents an approach seeking alternative, more applicable origins for the initiation of indigenous technological advancement - addressing itself to the production and adaption of mechanical techniques to meet the needs of agriculture and local industry.

A technology strategy peculiar to Africa it would not be, but suitable to its needs certainly. China did in fact pursue such a "gradualist" approach to the development of its economy during the 1950s and 1960s. Of relevance here has been the dualistic character of China's development push: "taking agriculture as the foundation and industry as the leading sector"[47]. Although, unlike African economies, China has been large enough to avoid reliance on the export of cash crops, the necessity of raising productivity in the agricultural sector has always been viewed as a priority by the authorities. The promotion of the mechanical engineering sector therefore became of strategic importance in increasing the mechanization of farming. The present status of Africa's machinery-producing sector presages little in the way of optimism that it will provide the take-off for the sort of technological development to occur as has happened in this early period of Chinese industrialization; but it should nevertheless be remembered that similar views were expressed about Korean, Taiwanese and, indeed, Communist China's prospects only some three decades ago.

Notes

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1. This study was undertaken while the author was a Research Associate at the Institute for Development Studies, University of Nairobi, thanks to financial assistance provided by the World Bank under an award from the Robert S. McNamara Research Fellowship Programme.

2. Bruton (1979), asserts forcefully that the countries of the developing world should as a matter of policy encourage the establishment of indigenous machine building capacity. However, he also admits that ..."Few formulations of the conventional, static comparative advantage argument would lead to a conclusion that a developing country should build its

own capital goods industries". (p. 47).

3. See, Matthews (1981, p. 34).

4. See, Cheng (1972, p. 228). Over the period 1961 to 1972, the growth of India's machinery sector was approximately 50 per cent higher, at 9 per cent per annum, than that for all other industry (Matthews, 1981, p. 31).

5. *Ibid.* In unison with the experience of India, during 1952-66 the growth of machinery output was 50 per cent higher than that of total output (Cheng, 1972, p. 231).

6. *Ibid.*

7. See, Okita (1980, p. 129).

8. Data drawn from United Nations Statistics in National Accounts (1976) and Table 3.1 in (Bhagwati, 1970).

9. See, Leff (1968, p. 2).

10. See, Cheng (1972, p. 228).

11. See, Rhee (1973, p.3 fn.)

12. Rostow identifies some of the "leading" industries since the industrial revolution, thus, ..." after the railway take-offs of the third quarter of the nineteenth century - with coal, iron and heavy engineering at the centre of the growth process - it is steel, the new ships, chemicals, electricity and the products of the modern machine tool that came to dominate the economy and sustain the overall rate of growth". (1959, p. 8).

13. See, Bhagwati (1970, p. 85).

14. *Ibid.*, (p. 106). The ratio applies only to value-added from the "organized" industrial sector.

15. It is interesting to note that China appears to have also passed through all Hoffman's stages in a decade. See (Maizels, 1963, p. 50).

16. See, (Hirschman, 1958, p. 111) and (Gerschenkron, 1952, pp. 7-8).

17. See, (Cheng, 1972, p. 232).

18. See, (Wilber 1969, p. 87).

19. For a fuller discussion, see (Nove, 1961, pp. 288-95).

20. "Backward linkage effect" indicates that every non-primary economic activity will induce attempts to supply through domestic production the inputs needed in the activity. Forward linkage effect" indicates that every activity that does not by its nature cater exclusively to final demand will induce attempts to utilize its outputs in some new activities. See, (Hirschman, 1958, chap. 6).

21. On this point Cheng (1972, p. 195) has this to say on the development of supplier industries of Communist China's machine- building industry ..."The backward linkage impact on input industries such as iron and steel, non-ferrous metals, rubber, glass, and plastics is fairly great. Of the total production costs in machine-building, about 60 per cent are for intermediate materials - 56 per cent for metals alone".

22. Cortes (1978, pp.13-14) in describing the development of the Argentinian machine tool industry states that it ..."evolved from the repair activities of small workshops or at the initiative of individual machine operators and metal workers, may of whom had been trained in army workshops or on the railways. In addition, a substantial proportion of the workers were Italian immigrants who had had previous training in metal working in their home country. The machines produced in the initial stages were simple lathes, grinders, presses, boring and drilling machines, copied from imported machines. Production was evidently artisanal, based on the technical ability of the firms' owners to copy the machines with which they were familiar. The production technology was very simple, in many cases using machines produced by the firms themselves. Amsden (1977, p. 220) in tracing the early development of Taiwan's machine tool industry similarly noted that ..."the earliest machine tool shops evolved to provide repair and reconditioning services to small local firms. Later such activity was superseded by the manufacture of complete units of lathes, drill presses and punching machines".

23. See, for instance, Arrow (1962, pp. 155-73); and Hirsch (1952 and 1956).

24. See, Alchian A. (1963, pp. 679-93).

25. The following statement by Pack and Todaro (1969, p. 397) is fairly typical in this respect ..."Let us state explicitly that the establishment of this ...(machine-producing)... industry is not put forth as a solution to the employment problem at the cost of decreasing the rate of growth of output through the adoption of inefficient techniques. Rather, it is proposed on the assumption that both output and employment growth can be accelerated. Specifically, we would argue that the LDCs should produce their own machinery, copying initially the earlier more labour-intensive designs of the western countries. This would provide the possibility of eliminating much of the conflict between output and employment growth while avoiding the important difficulty of designing new labour-using machinery. By duplicating earlier western equipment they would derive the benefit of controlling both the direction and speed of technical change in their own countries".

26. E. F. Schumacher published his celebrated work; Small is Beautiful, as long ago as the early 1970s.

27. The importance that African nations, through the "Lagos Plan of Action", have given to

the promotion of local capital goods capacity is superficially indicated by the fact that science and technology is the largest section in the Plan. (Atul Wad, 1984, p. 327 fn.).

28. Of course, inappropriate technology cannot solely be blamed for the problem of unemployment in the developing world. Kenya, for instance, has managed to sustain relatively high average growth rates in GDP of 5.9 per cent between 1960-70, and 5.8 per cent between 1970-82. Moreover, since independence in 1963, the country has consistently achieved per capita economic growth of around 3 per cent per annum. Recently, however, this growth pattern began to change. Things started to go awry around the beginning of the present decade. It was perhaps inevitable that with the import-substitution engine running out of steam the uncontrolled population expansion of about 4 per cent per annum, currently the world's highest, would begin to seriously bite into Kenya's economic growth. In 1980-81 the increase in per capita GDP was only 1.4 per cent. In 1981-82 there was a negative 0.4 per cent increase, followed in 1982-83 by a meagre 0.1 per cent rate of growth. (World Bank, 1984, pp. 207-73). In addition, there exists a genuine concern that the situation could further deteriorate. The basis for this anxiety has regard to the quite alarming rates of population increase that are projected: it has been forecast that from now to the end of the century Kenya's population will increase at an average annual rate of 4.4 per cent, pushing the population total from the present 19 millions to around 40 millions. (World Bank, 1984, *Ibid.*). This level of population increase has already begun to squeeze employment opportunity. The annual growth in wage employment averaged only 36,300 during the Fourth Plan Period (1979-83) (Economic Survey, 1984, p. 45). Commenting on this degree of labour absorption a government publication stated that it would not be easy to sustain that rate of job creation (Economic Survey, 1984, p. 45). With the population having increased by some three quarters of a million in 1983 alone, it is difficult to conceive the official view that the residue of job seekers will be absorbed outside the formal sector in the rural economy and in urban informal activities. It is indicative that "jobs" in the urban informal sector are increasing but at a decreasing rate: in 1982-83 the growth in employment represented 6.2 per cent which was considerably less than the 10 per cent achieved over the previous five year period (Economic Survey, 1984, p. 47).

29. See, Cooper and Kaplinsky, 1975.

30. See, Pack, 1980 - also in the World Development publication vol. 9, N°3 (1981, p. 229) of the revised paper.

31. The Intermediate Technology Group, situated in London, is primarily concerned with developing this form of technology.

32. See, for instance, (Cooper, 1980), (Bhalla, 1981, pp. 370- 80), (Burton, 1979) and (Mkandawire, 1981).

33. For an extended discussion on this issue, see, (Cooper, 1980, pp. 6-15).

34. Domar, 1972, p. 236.

35. See (Mahalanobis, 1953) on India, and (Domar, 1972, p. 151) on the Soviet Union.

36. Quoted in (Stawart, 1976a, p. 126).

37. See in particular the excellent special issue of World Development devoted to a survey of technology exports by the newly industrializing countries (Lall, 1984)

38. Cited in Westphal (1984). (Lall, 1984, p. 507). Original source (Westphal, 1981).

39. Westphal et.al. (1984) argue that ..."Export activity not only compresses the time for experience to be accumulated, it also affords a wider variety of experience in more diverse circumstances. It can thus be expected to accelerate cost reductions from learning and to deepen existing capabilities" (pp. 528-29).

40. See, (Mitra, 1979, pp. 2-4).

41. In the development of the Argentinean machine tool industry local manufacturers sought to acquire licences from foreign producers for the purpose of promoting exports; the acquisition of the trade names being seemingly more important than the transfer of the technology. See Cortes (1978, p. 16). For a wide- ranging discussion of trade-marks and technology transfer, see Stewart (1979).

42. The Lagos Plan of Action for the Implementation of the Monrovia Strategy for the Economic Development of Africa's, adopted by the Second Extraordinary Assembly of the Organization of African Unity (OAU) Heads of State and Government, Lagos, Nigeria (April 1980).

43. This is saying something very different from lowering the importance given to the agricultural sector, both in terms of raising its productivity and in improving Africa's self-sufficiency in food production.

44. India's technology development strategy is likewise considered inappropriate: through collaboration with Western partners it produces capital-using machinery, producing it - because of the lack of effective local demand - at high-cost. Moreover, weak competitive pressures in the highly regulated domestic economy ensure that technological "independence" has only been gained at the expense of design and innovational "dependence".

45. This is certainly the case for the newly industrializing countries, though for the advanced nations Sweden may represent a notable exception.

46. In this respect Wad (1984, p. 343) argues ..."The concern over technological dependence is inseparable from the concern over what constitutes an appropriate industrialization strategy and stems to some extent from a growing realization that neither the conventional capitalist nor socialist patterns are suitable for the African context and that there is a need, in Forje's words, for a "third way to development". See Forje, J (1978-79).

47. From the document "The Ten Great Relationships", presented in 1956 by Mao. Cited in Singh (1979, p.589).

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RESUME

L'on pourrait décrire à juste titre l'Afrique comme le "dernier bastion" du monde où le développement économique reste à conquérir. Il faudrait que le Continent s'industrialise tout comme cela a été le cas dans les autres régions du Tiers Monde s'il veut s'affranchir de sa dépendance quasi totale des cultures de rente et partant des conditions climatiques pour pouvoir développer son économie. Or il importe au premier chef de placer le développement endogène de technologies au premier rang des politiques nationales pour que le processus d'industrialisation soit viable.

Cet article fait un inventaire des avantages économiques tirés par un pays qui encourage le développement des capacités nationales de fabrication de biens d'équipement. Les raisons fondamentales qui poussent les pays en cours d'industrialisation à déployer des efforts pour développer leur capacité de production de biens d'équipement transcendent en général les contraintes rencontrées au niveau de l'efficacité de fonctionnement de ce secteur au cours de la première phase de son évolution. De toute évidence, la thèse de l'industrie naissante a été brandie à telle enseigne qu'elle a fini par annihiler le rôle déterminant de l'efficacité économique pour la première étape du processus d'industrialisation, lui substituant pour une grande part une pléthore de considérations non plus économiques.

L'auteur conclut son article, après avoir examiné l'une de ces considérations les plus importantes, sur une évaluation des diverses stratégies de développement technologique s'offrant à l'Afrique.