EXCERPTS FROM VARIOUS ARTICLES IN RELATION TO TECHNOLOGICAL DEVELOPMENT

A. Industrial revolution (Britain)

The words industrial revolution in small letters is usually refer to that complex technological innovation which, by substituting machines for human skill and inanimate power for human and animal force, brings about a shift from handicraft tom manufacture and, so doing, gives birth to a modern economy.

The words when capitalized have still another meaning, they denote the first historical instance from the breakthrough from an agrarian economy to one dominated by industry and machine manufacture. The industrial revolution began in England in 18th century and spread from there to Europe and few areas overseas. The heart of the industrial revolution was an interrelated succession of technological changes. The material advances took place in three areas.

1. There was a substitution of mechanical devices for human skill
2. Inanimate-power in particular steel took the place of human and animal strength.
3. There was a marked improvement in the getting and working of raw materials especially in what are now known as the metallurgical and chemical industries.

Concomitant with these changes in equipment and process went new form of industrial organization. The size of the productive unit grew: mechanics and power both required and made possible the concentration of manufacture and shop and home work room gave way to mill and factory.

B. Capital goods production (America)

A particularly important way in which economic production became specialized after the industrial revolution was the development of a sector devoted to the production of capital goods─ since much of the dynamic of economic growth actually occurred within the sector.

Rosenberg considers the mechanism of this process via a series of historical studies of industrial production in USA during the 19th century. Rosenberg hypothesis may be put very simple─ what gave the tremendous push to the development of early US capitalism was the changing character of capital goods manufacture, in particular the growing concentration on the production of producer-durable-machinery, equipment tools, and other fixture which became the necessary building blocks in the later manufacture of final goods to the consumer. This represented a very specific form of the division of labour which contained within itself important characteristic of dynamic change and no where could this be seen more clearly than in the growth of machine tool production itself. Machine tools production occupied a strategic role both because their production became a locus of important technological changes and because they were use in a wide range of sectors (as well as in the production of machine tools themselves). Rosenberg maintains that tree features of the machine too manufacture were of importance.

1. **Technological convergence:** The industrial process may be regarded as one of increasing specialization and differentiation of economic production both horizontally (the production of new goods and services) and vertically (The application of the productive process). However, what is often ignored is the fact that many of the new industries used, broadly similar productive process involving a metal using technology with decentralized sources of power. Hence, for example, what was common to the manufacture of sewing machines bicycles, ships, railways, motor cars and armaments was that, they all required power driven machinery to perform a (relatively small) range of operations on metal ─ turning, boring, cutting, milling, grinding and polishing.

Moreover, the productive operations of these machines faced similar technical problems in areas such as power transmission, friction reduction, measurement and control and metallurgy (concerning e.g., the ability of metal to withstand heat and stress). Hence, heterogeneous collection of industries form the point of view of the final consumer was homogenous in terms of the technology embodied in the machinery required for production. Rosenberg defines this property as one of technological convergence and argued that it had important consequences both for the development of new techniques and for their diffusion once developed.

2. **Vertical disintegration:** The process, by which specialized machine tool firms became established was one of progressive vertical disintegration as firms spun-off from their mother firms at the outset of growing industry, often has to undertake the full range of productive operations including the design and development of necessary capital goods. As the industry develop in sized and experience, however, many tasks and functions can be sub-contracted to specialists. Rosenberg point is that, vertical disintegration became significant at that stage in US industrialization precisely because of the simultaneous growth of a large number of industries which were technologically convergent.
3. **Sequential innovation:** The importance of this form of specialization must also be seen in a dynamic sense, since in effect, the machine tool sector became a centre of continuous learning and technological improvement through technical imbalances and through applications of engineering with customer industries. What Rosenberg is at pain to emphasize is that any technological change in the construction or application of a complex capital good like a machine tool immediately create the conditions for further change in a virtually endless series of technical shift which owe more to the engineering application of the skilled mechanic than to the economic pressures of the market place.

   In this manner, then, capital goods production in general, and machine tool production in particular became the main avenue through which technological changes were introduced into the nascent industrial economy and the insight which Rosenberg US, have equal relevance today. One case of contemporary importance might be that of information technology where the advent of the micro processor shows clear similarities in terms of all the three features we have been considering. Thus the specific example of computer aided design shows how an innovation initially developed within the electronics capital goods sector has now been shown to have application in a wide variety of other industries with dramatic impact on employment patterns, prices and industrial structure. Another example might be that of the development of appropriated technology for developing countries. Rosenberg himself argues that only through the creation of their autonomous capacity for the manufacture of capital goods will poor countries acquire technologies suitable for their own purposes.

Taken together, they revolutionalized the rate and direction of industrial change in the 19th century. They can also be seen as keen characteristics of the innovation process today.

C. <u>Silicon Valley (California/USA)</u>

Lalkaka (1998) attributes the success of the silicon valley, California (a pioneer in high technology development through the clustering of firms in a geographical location) to a “culture of risk taking, competitiveness and the freedom to fail, a critical mass of professional services from lawyers and accountants, the existence of technical infrastructure, venture capital and research universities. Most contributors to the Silicon Valley literature have given, importance to the role played by Stanford University supporting the innovation and technological development of the Silicon Valley. In particular, historical role played by Fredrick Terman of Stanford University in providing opportunities to his graduate students to start business based on their findings is well documented.

One very important aspect of the Silicon Valley is the unique role played by venture capitalists in funding start ups and supporting overall business growth in the valley. For example, Aoki (2002) examined the "systematic relationship between the venture capitalists and cluster of entrepreneurial firm which served as a catalyst of technological system innovation I the silicon valley".

Kenny (2000) noted the ability of the valley's venture capitalist to adapt to new conditions despite encountering numerous failures. Technological and entrepreneurial growth in the Silicon Valley have benefitted from the supply of skilled migrant workers most of whom came from China and India. Whiles he majority of these worker are "knowledge worker" who form the bulwark of the valley's technology-base companied, many of them have risen to become CEOs and shareholders of Silicon Valley's companies. Thus a number of factors and events unique to the Silicon Valley have made it possible for the Silicon Valley to emerge as a successful case of cluster-base enterprise development. Though innovation and new technologies were important ingredients, many have argued that it is the dynamism and the entrepreneurial spirit of the companies located there that drove the valley to new height. The way business is conducted in terms of risk taking, the willingness to accept failures as well as the ability to network and collaborate with other actors in the regional system are amongst the most important factors accounting for the emergence of the silicon valley as "the high-tech Mecca" of the world (Malairaja, 2003).

The success of the Silicon Valley in California was not a top-down planning initiative by the government. The government has of course played a crucially supportive role in the early phase of the valley's development through inter-alia, the award of the defence R&D contract to silicon valley companies, that notwithstanding, the silicon valley was an essentially market rather than state-driven and it emerged mainly as a product of processes associated with a private enterprise culture.

The significance of innovation in creating technological breakthrough resulting in old industries, making way for new industries emerging is apparent in the experience of the Silicon Valley. The silicon valley evolved through 4 major technological phase: **defence, integrated circuit, computer and the internet.**

The success of the Silicon Valley in the creation of new firms, jobs and wealth and its ability to achieve global supremacy in internet, ICT and other emerging technologies led to the development of global high –tech phenomenon called "Siliconia". This phenomenon first spread to other parts of the US before making it way to Europe, the Middle East and Asia pacific regions.

In Europe Siliconia thrived in different regions, including, among others, the Cambridge high-tech area particularly known as Silicon Fee. The corridor stretching from Glasgow to Edinburg, Known as the Silicon Glen, and the Sophia Antipolis in France. The successful evolution of Silicon Fee is traced to the setting up of the Cambridge science park in 1970 by the University of Cambridge. Similar high-tech growth is observed in Munich and Stuttgart region in Germany and Malaga in Spain. Policy makers in Asia like the counterpart in Europe have looked towards the Silicon Valley model to promote high-tech development in their respective countries. Amongst the most notable are: Zhongyuanchun high-tech district near Beijing, China; Bangalore

in India; Tokyo's Bit Valley in Japan; Hsinchu region in Taiwan; Cyberport in Hong Kong; Intelligent island Singapore; and the multi-media super corridor in Malaysia. In all these regions science and technology parks, including incubators, play a pivotal role in promoting and nurturing high-tech companies especially small and medium enterprises (SMEs).
Unlike the case of Silicon Valley, most of the high-tech regions, particularly those in developing economies of Asia pacific region emerged as policy-driven initiatives. Prospects for their success in emulating the Silicon Valley experience would depend on the nature of the policy environment.

Lessons/factors affecting Silicon-Valley-Type strategies

Lessons can be learnt from the Silicon Valley experience indicates as to how best of Silicon Valley model can be adopted to the prevailing socio-economic, technical and actual circumstances in the given country. Therefore, important for S&T policy in developing emerging economies to address the factors that bear of the effectiveness of such high-tech development strategies.

1. **Locational factors:** High-tech clusters are likely to flourish in regions where the enterprise culture is well develop and where educational (university), transport, communication and other infrastructure support services are well provided the location aspect is therefore, critical for the development of technology-based companies lagging regions do not attract investment-indeed they count as areas of high investment risk. The implication of this is that, a certain level of technological and economic development has to be achieved before the Silicon Valley experience can be invoked in the development of the strategies for transition to a knowledge-based economy. Although the high-tech cluster strategy favours location of investment in developed regions, the cumulative process arising from its implementation could benefit lagging region through its spillover effects proper regulatory policy measures.
2. **Factors relating to networking and capacity building:** The clustering of firms in specific locations enhances networking possibilities are knowledge-sharing between firms through face-to-face communication. This in turn can help promote innovation. Networking however, presupposes that, physical and institutional infrastructures are provided through the process of capacity building. Short of this, structural bottlenecks would arise, resulting in networking gaps, impairing the development of innovation. Network gaps are common in many developing countries where the process of capacity development is as its infancy. In the absence of such a network system, the problem of fragmentation of industrial effort should persist; and the resulting high-transmission cost would effectively limit prospect for innovation and technological progress.

   Networking development is required not only between firms, but also between the university, industry and the government. The promotion of such an institutional partnership is central to a development policy that seeks to enhance the transfer of technology from research institutions to industries.

   Success of some high-tech clusters in the USA and Europe id attributed in part to strong links with nearby universities and research institutes. This partnership could also be extended to address various other issues affecting the region; such as labour and immigration matters, quality of education, infrastructure requirement, research grants and funding, tax policies etc. in developing countries the role of the government in capacity building is expected to bridge that gap between the university research and its application.

3. **Enhancing access to venture capital:** venture capital is crucial for funding innovation activities and for financing start-up. The source of venture capital would need to shift from central and local government (if this situation prevails) to local and foreign venture capitalists, lest continued provision of venture capital by public agency locks them in vicious circle of budget deficit and economic instability. Rather, the government would play a crucial role in the development of venture capital industry if it limit its engagement chiefly to the implementation of regulatory and fiscal policy measures that would guaranteed economic stability to prospective investors. Lessons could be learned for example, from the UK and other parts of Europe where policy was applied to create business environment to attract venture capital from the USA.
4. **The role of Multinational Corporations (MNCs):** MNCs play an important role in the development of high-tech clusters. Their important derives not from their domination of the cluster but in their contribution to the development of start-ups business and SMEs. It is important that some form of interaction is established between MNCs and local firms e.g. so that local business evolve along the supply chain learning from the experience, management know-how and technologies of MNCs. Policy measures should include the following;
   - **i.** Through a combination of incentives and regulatory measures, the government should seek to influence the behaviour of MNCs so that they will be readily disposed to interact with local SMEs.
   - **ii.** While encouraging inward investment by MNCs and SMEs policy should address the need for establishment of a network system, which will enable firms to interact, exchanging ideas and accumulating knowledge thus creating the conditions for innovations and the development of the technological capabilities of local firms. This way, MNCs can be made to play a crucial role not only in transferring technology but also in embolden it in the socio-economic system through the process of technological learning.
5. **Coping with growing pressures of globalization:** Coping with growing pressures of globalization would require countries to achieve competitiveness through technological progress. For this purpose, government would need among others to adopt policies to attract foreign venture capital and to facilitate employment of foreign skilled workers. Another aspect of the pressure of globalization on individual countries relates to their environmental responsibility. This has implication for the sustainability of the global economy and environment.

THE TECHNOLOGY DEVELOPMENT SEQUENCE

From the economic history of Japan and Korea, we deduce the technology development sequence to be as follows: operation, maintenance, repair, imitation, modification, design, and domestic manufacturing involving innovation. It should also involve the development of local skills and a selective approach that enable local craftsmen to master the adopted techniques. The introduction of a new technology must match the stages of industrialization and it must be related to available natural resources.

D. *GHANA*

Technology policy and technology development

In the foreword to the seven – Year Dev elopement Plan (1963/70 – 1969/70, Dr. Kwame Nkrumah, The President of the Republic of Ghana, Stated: The plan provides the blue-print for the future progress and development of Ghana as a nation. It is a programme of social and economic development based on the use of science and technology to revolutionalise our agriculture and industry. It was in the light of this that the Ghana Academy of Science (the predecessor of to CSIR) prepared a paper entitled "Seven – Year National **Programme** for Promotion of science", which was mainly designed to popularize science and technology.

The current situation

Over the years the Government of Ghana has established specific institution for the development of scientific and technological capabilities, research and development (R&D), and the provision of essential services. Currently, the Council for Scientific and Industrial Research (CSIR) with over thirteen institutes, the Ghana Atomic Energy Commission (GAEC) and other agencies carry out research and service activities in the country. Five Sectoral Coordinating Committees have been established with a view to providing a comprehensive overview of the science and technology sector and implementation of research programmes. Basic research is also carried on at Universities of the country.

It is thus evident that Ghana has a relevant science and technology base and infrastructure which could be developed further and funded to cope with the demands of the aspirations of a nation in dire need of accelerated growth of its economy.

Might be a good idea to make an inventory of all researchers, inventions, pilot plant demonstrations, etc. in the CSIR, other research outfits and the Universities.

Brief history of technological development in Ghana

The current state of technological development in the country is traceable directly to the adoption of ISI strategy of industrial development and the ignorance of the role of technological development in a nation's socioeconomic development on the part of Ghana's political leadership (Nkrumah excluded) since the mid 1960s.

Ghana's technology policy has been one of importing the required technologies in various forms, including capital goods and equipment, technological services such as design and engineering, service technologies, including maintenance and management. Intermediate goods, raw materials, know-how and skills for operating the installed plants were often acquired abroad.

In the 1980s Ghana established a number of institutions for dealing with different aspects of technology, but they pursued their activities in a fragmented and isolated manner. The policy making organs, the research institutions and the users of technology have always operated in isolation.

Thus the Council for Scientific and Industrial Research (CSIR) or one of its institutes has not been generally involved in giving advice or opinions in the examinations of investment proposals submitted for screening and approval to the Ghana Investment Centre. Similarly, production enterprises have rarely called upon CSIR or other research and development institutions for advice or opinion in the selection or evaluation of technology to be imported. There has always existed a communication gap between the results of research and development efforts by institutes of the CSIR and the Universities and the production of goods and services in the public and private sectors.

One of the major impediments to the use of the results of research concerns the inadequacies of appropriate institutional arrangements and of the design and engineering inputs required to develop beyond the laboratory stage. The various links in the innovative chain, namely, laboratory-level research, pilot plant investigations, commercial plant design and engineering and plant production trials, are not systematically consistent with industrial needs or are simply duplicated by technology imports from abroad, even though in selected areas, such as agriculture, certain linkages between R&D and technology users have been initiated (UN Report) Second, up to the mid 1980s no national programme for technology transfer and development had been evolved which would allow a common co-ordinated approach, including the establishment of appropriate linkages and the creation of a suitable institutionally operational environment. A technology policy document was drafted and approved by Parliament in the early 1990s detailing out the goals for technological development and the strategies for achieving each goal for the economy and for each specific sector or subsector.

The existence of that document has not affected the mode of transfer, utilization and development of technology in Ghana since the 1960s.

The current state of technology can be described as technological inertia. There is a woeful lack of technological dynamism. In their book on *Technology and Enterprise Development in Ghana*, Lall and his associates (1994) made the following findings:

i. There was a preponderant reliance on imported technology because of the undeveloped nature of the capital goods sub-sector.
ii. There was low investment capability. Most firms had been set up with assistance from parent companies, or from personnel with no lasting links to the firms, or were outright turnkey projects. In all cases, there was little in terms of transfer of investment capability and its diffusion through the sub-sector.
iii. A lot of equipment was obsolete. Many firms had started with second hand equipment; but even those that started with new equipment had done little to upgrade the equipment.
iv. Apart from the metal working and food processing firms, there was undue reliance on simple technologies whose ability to enhance technological capability is negligible.
v. There is complete absence of industrial engineering.
vi. Maintenance culture is restricted to very few firms, especially the large (transnational affiliate) firms, and even these firms drew on the parent companies for assistance - resulting in very little local build-up of this all important capability.
vii. Many firms did not know that there was a need to adjust their layout every time they shifted to different product patterns.
viii. There was low technical efficiency, even among the affiliate companies because not much effort had been invested in raising local technical expertise.
ix. Only the metal working firms showed appreciable process engineering capabilities, but then most of these firms were managed by foreigners.
x. There was little evidence of other types of capability acquisition; and there was little indigenous capability upgrading. Many firms were waiting for foreign assistance to sort out problems.

These findings are overwhelming in their indictment of Ghana's manufacturing industry. With respect to information gathering networks, available evidence shows that manufacturing firms do not have in-firm R&D policy, no R&D culture and minimal R&D activities. Some experimentation is undertaken in some large-scale enterprises (e.g. cocoa processing), but this is not formalised. There is also a weak effort demonstrated by R&D institutions in support of manufacturing industry (Lall, 1994).

Ghana comes across as lying in that phase of technological development where she has acquired only some amount of operational capability and very little in terms of process adaptation, knowledge, and experience in the production process. Capabilities beyond these are virtually non-existent.

However, it is important to note that a large mass of ingenuity is known to reside within Ghana's informal industrial sector, as documented in Smillie (1991) and other publications on the experience of the Intermediate Technology Transfer Units (ITTUs). Brew-Hammond (1995) also documents the largely successful case of technological accumulation in Ghana's electric power generation utility which is in the formal sector. These experiences suggest that some of the necessary ingredients for technological dynamism in Ghanaian enterprises may already be in place and what is needed is locate them and build on them.

Given the structure, characteristics, shortcomings and challenges facing the Ghanaian manufacturing subsector, the objectives for the development of the subsector are to:

- transform the micro/small-scale, rural/urban non-factory units into viable factory production enterprises continually upgrading itself, and capable of supplying the socio-economic needs of the bulk of the population.
- encourage a significant proportion of these micro-enterprises to become vibrant SMEs
- increase the share of manufacturing output in GDP to at least 30% by 2020.
- (within manufacturing) shift away from concentration on non durable goods production to production of intermediate goods (chemicals, for example) and certain capital goods (machinery).
- increase the share of manufactures in total exports to 40% by 2020.
- diversify exports away from primary products.
- encourage innovation in all enterprises and make them competitive in the local and international markets.
- promote education that provides the intellectual and practical skills for engineers, scientists, farm and industrial managers, entrepreneurs, government executives and technicians.
- provide uninterrupted power and water supplies to the industrial sector.

What, then, should be the objectives of innovation in national development?

The objectives of applying science and technology are to:

1. <u>lay a solid foundation for the continuous development of S+T through</u>
   (a) investment in basic infrastructure – public utilities; public works such as irrigation systems, schools, housing and hospitals; transport sectors, such as roads, railways, ports, waterways and airports; and research facilities such as laboratories and related equipment.
   (b) Acquisition and/or improvement of operational, adaptive and innovative capabilities;
   (c) Technical training programmes in schools and in companies;
   (d) The setting up of R&D for each group of similar enterprises.
2. <u>Reduce technological dependence through</u>
   (a) Cutting down significantly on technology and goods imports;
   (b) Doing away with foreign managers and supervisors of enterprises in which the state has interest;
   (c) Ensuring local repair and maintenance of all equipment and machinery;
   (d) Ensuring significant local inputs and materials in assembly and packaging firms.
3. <u>Nurture small and medium-sized enterprises through:</u>
   (a) technology incubators, export processing zones and production networks;

(b) Creating links between knowledge generation and SME development, especially engineering, technology and SME development;
(c) Creating a network of incentives and support systems, and ensuring the development of local operational, repair and maintenance expertise, and a pool of local technicians.

How are the objectives of technological development integrated into the objectives of manufacturing subsector development?

First, we have a four-pronged strategy for developing the manufacturing subsector

(1) Setting up a capital goods/machinery and equipment producing sector because this sector is of critical importance in the creation of industrial skills, the improvement and diffusion of industrial techniques, the development of innovations and the sustained growth of the productive capacity of any economy. One could consider the capital goods sector as the infrastructure for sustained industrial development.
(2) Upgrading the technologies and modernizing the micro/small-scale/urban/rural enterprises - which demands local manufacturing of simple machines and tools.
(3) Enlarging the medium and large-scale facilities and introducing sophistication and efficiency in their operations - which needs a build-up of technical engineering and managerial skills, the unpackaging, absorption and adaptation of imported technology, thus indigenizing technical progress and building sustainability into the growth of the economy.
(4) Setting up of spare parts producing and repair workshops to rehabilitate broken down heavy equipment - a situation which takes for granted the establishment of capital goods or machinery and equipment production enterprises.

A. Establishment of capital goods/machinery producing sector

Historical studies of the industrial beginnings of the present day advanced countries and even the newly industrialising countries (NICS) reveal unmistakably that the capital goods sector is of critical importance in the creation of industrial skills, the improvement and diffusion of techniques and the development of innovations; and that the growth of the capital goods sector is responsible for the sustained growth of the productive capacity of an economy.

First, technology, whether locally developed or externally acquired, can function effectively in an economy only when that economy has the requisite range of skills to correctly diagnose causes of machine breakdown, perform repair work and maintenance, modify and adapt to achieve relevant factor saving bias. These kinds of skills are produced and embodied in the capital goods industry.

Secondly, because the machinery producing industry has strong links with virtually all other industries, it is responsible of transmitting these new ideas and skills to the entire machine using sector of the economy. Moreover improvements in the productivity of the machinery producing industry reduces cost to all industries that use machinery.

Third, it is the machinery producing industry that develops machinery appropriate to the agricultural sector, with its peculiar national character, and thus improves agriculture productivity.

Fourth, a capital goods/equipment/machinery sector is necessary to support the local manufacture of simple equipment and tools, and is vital to introducing complexity and technological development into the medium and large-scale operations. *In Ghana, if policy makers are serious about rehabilitating the railway system and extending it to the north of the* *country, the multiplier effects on the economy will be far more significant if a capital goods/machinery producing sector is in place.*

Fifth, the steel industry is organically linked to the minerals and mining industries, the energy industries (as one of the most energy intensive industries), the chemicals industries, the engineering, agricultural, defence, and transportation industries. In other words, for every worker employed in basic steel production, twenty other dependent jobs are created – good for employment prospects in LDCs.

<u>The feasibility of establishing a domestic capital goods sector in LDCs</u>

There is the question of whether there is any need for establishing a capital goods sector locally i.e. whether the needed capital goods should not be imported.

<u>Arguments against the feasibility of setting up the industry in LDCs</u>

(a) the small size of the domestic market for steel and steel products
(b) the inadequacy of infrastructural support facilities, and the prohibitive cost of setting up such facilities
(c) non-availability and/or poor quality of the relevant raw materials
(d) the deficient manpower base for operating and maintaining such a technically sophisticated industry
(e) the over-riding political and economic interests of the developed and fast developing nations for whom LDCs represent a present and future market outlet for their home-based steel industries.

This make-import argument seems spurious on further examination, for

a. Without the skills relevant for the machinery producing industry, imported technology cannot be modified and adapted to reflect the factor bias of the using country i.e. without developing a local capital goods sector there can no development of local technological capabilities and imported capital goods cannot be used effectively in the economy.
b. Comparative advantage need not be present before capital goods production is put in place (static argument); comparative advantage can be created – vide Japan opting to enter into the production of high income elasticity products for which it had no comparative advantage.
c. The capital goods sector must be developed locally because it is well known that close proximity permits easier collaboration between makers and users of equipment and contributes to the possibilities of indigenous adaptation and development.
d. Moreover it encourages indigenous research and development which is essential if production is to be adapted to local factor proportions, raw materials and needs of the bulk of the population.

<u>Strategy</u>

If there are no raw materials for the capital goods industry, i.e. if the economy has no iron ore, coking coal, limestone, natural gas, it is advisable to establish a capital goods sector based on the importation of these raw materials. Japan and South Korea which are among the most efficient and competitive capital goods producers in the world are in this category. The market size problem can be ameliorated by making the industrial sector very much export-oriented.

If the raw materials exist or even if they are imported, market size considerations dictate that instead of huge integrated steel complexes, <u>mini-mills</u> may be constructed. The 'mini mills' are essentially scrap-based, and employ electric arc furnaces for steel production. The cast steel is then rolled into bars and wire-rods.

The mini-mills alternative has the advantage of

(a) reducing the high unit cost of steel production using the blast furnace route;
(b) producing steel to serve a smaller market;
(c) achieving economic competitiveness by using the electric arc furnace process for carbon steel production at lower capacities;
(d) using scrap (usually in abundant quantities) which is ideally suited for the electric furnace.

Alternatively, or in addition, rolling mills may be constructed. Rolling mills procure their billets either through importation or from the local mini-mills. Their product mix consists of reinforcing bars and wire rods.

Raw material base for steel industry in Ghana

Iron ore deposits at Oppong Manso in the Western Region, and at Shiene-Tweleba area near the Togo frontier in eastern Gonja.

Trees that produce dense charcoal substitute for coking coal planted near Beposo.

Limestone deposits at Nauli. Also, sea shells found in plentiful supply at Bator in the Volta Region are substitute for limestone.

There is a feasibility study of the iron and steel industry in the archives of the Ministry of Finance. Worth revisiting it.

B. Modernising the informal production units

Upgrading traditional technologies and products

The traditional technologies in use in the informal sector are simple, labour intensive, low cost but the level of efficiency is rather low in terms of productivity and product quality. There is therefore need for a vigorous programme of R & D activities geared towards upgrading the traditional technologies to facilitate their transfer to the modern industrial sector through the establishment of small-scale industries. The focus of policy measures is to improve techniques of production, raise the quality of traditional products, increase productivity and also diversify the range of traditional production by introducing new products.

The range of products to be encouraged include the traditional ones of processed foods, handicraft products, building and construction materials, pharmaceutical and chemical products, and energy, but must not be restricted to these since the country abounds in many raw materials from which many products can be derived.

Strategy

The economy should be dotted with industrial parks where these products can be produced.

The planning of industries at these centres, should be based on raw materials that are available in the areas. All industrial parks must be served by adequate infrastructure, especially water, electricity, a good road and railway network.

This strategy has the merit of encouraging the setting up of viable small-scale industries in the rural areas and stemming the rural-urban drift and ensuring a more equitable distribution of the national income and a balanced industrial development in all the regions of the country.

GRATIS and the regional Intermediate Technology Transfer Units (ITTU) should be manned by highly skilled personnel to provide training for small-scale industrialists to upgrade and update their management, production and marketing skills.

The National Board for Small-scale Industries (NBSSI) may be tasked to oversee the development of technology incubators, and the creation of links between knowledge generation and small-scale enterprise development, especially engineering, technology and small-scale business development, and a network of incentives and support systems.

NBSSI might also encourage the formation of industrial cooperative societies. Special training and demonstration workshops on the advantages of industrial cooperative societies may be organized for the traditional craftsmen and industrialists. Among other things, cooperative societies serve as catalysts for the integration of rural activities in farming, fishing, industrial processing and storage of primary and finished products. The societies could facilitate joint purchases or production of industrial raw materials, promotion of R & D activities leading to improvement of processing techniques, products quality and marketing methods.

Societies could also mount exhibition of products regularly in the regions to stimulate transfer of know-how and to generate subcontracting of industrial processing. They could distribute pamphlets on appropriate technology, simple machines and their uses, product quality control, opportunities and prospects of setting up small-scale industries.

S & T personnel could pay visits to the production units to assess the operations and problems of the units in order to draw up appropriate promotional measures.

B(ii) ***Modernising the informal production units: Local manufacture of simple machines, equipment and tools***

Perhaps the small scale or so-called informal sector offers the best chance of developing a viable capital goods sector. It is a sector that is forced to use and actually ends up utilizing local resources to produce goods.

The biggest output of the capital goods sub-sector of the informal sector is auto-repair but it also produces

(a) agricultural implements - ploughing harrows, planters, tillers, weeders, open and tank trailers, wheelbarrows, agricultural hand tools;

(b) food processing implements – groundnut threshers, rice threshers, maize shellers, sugar cane crushers, cassava graters, corn mills, poultry equipment; and

(c) others such as cutlasses, shovels headpans, spades; aluminium ware (pots and pans), aluminium roofing products; electrical goods – street lamps, electrical circuit components, switch boards.

The local manufacture of simple machines and tools is a vital input into the programme for upgrading traditional technologies. Machine design and construction companies should be given all the resources and necessary promotion for the manufacture of simple and appropriate machines and tools. Table 2 gives some examples of machines that are manufactured or can be manufactured locally.

Table 3. Examples of local manufacture of machines, tools and equipment

	Machinery, tools, equipment	Area of Application
1	Solar crop dryers	
2	Crop storage structures	
3	Grinding mills	
4	Sugarcane crusher	
5	Cocoa pod crusher	
6	Cassava grater	
7	Palm Kernel shell processor and burner	
8	Pressers for edible oils and fruit juices	
9	Maize husher-sheller	Small-Scale Industries

10	Fish smoking furnace	
11	Charcoal kiln	
12	Broad Loom	
13	Potters wheel	
14	Improved kiln for Boodoo, Bread, Epitsi, etc.	
15	Bee hive	
16	Tractor-drawn equipment-disc ploughs, trailers, row cultivator, land leveler, etc	
17	Hoe	
18	Brick and tile moulding machine	Building and Construction
19	Wheel barrow	
20	Spade shovel, axe	
21	Limestone kiln	
22	Concrete mixer	
23	Burnt brick Kiln	
24	Carpentry and masonry	
25	Charcoal stoves	Household
26	Well pumps	
27	Solar heaters and coolers	
28	Biogas generator	
29	Biogas stoves	

Source: Acquah (1983).

Technological Requirements for sustainable industrial growth

To facilitate the acquisition of skills, to increase the domestic production of some equipment and machinery, The Technology Transfer Centre (TTC) and the Ghana Investment Centre (GIC) should have their mandate reviewed to:

1. collect information on
   (a) domestic production of equipment, prices, quality, availability;
   (b) foreign machinery and equipment, their prices, quality, country of origin;
   (c) trends in international trade;
   (d) technological advances and marketing opportunities - the latter through the creation of research data bank covering both domestic, sub-regional and selected overseas markets – with a view to
      (i) assisting in the identification of the technological needs of the national economy, technology acquisition, and analysis of information on alternative sources of technology;
      (ii) evaluating and selecting technologies relevant to the national needs and also compatible with environmental standards;
      (iii) helping to negotiate the best possible terms and conditions under which the technology will be acquired, registered, and ratify the agreement thereof.
2. develop, organize, and monitor local raw material sourcing for industrial production and/or focus on enhancing the utilization of local resources and improving the domestic application of proven industrial technology particularly for medium and large-scale enterprises.

3. Provide a convergence of services to help nascent entrepreneurs through counseling, training, information, and access to finance. Subsidies may be justified initially, but progressively the services should be against affordable payments.
4. Advise on the importation of technology, internalization of imported technology, and identification of R&D areas for the priority sectors.
5. assist in the unpackaging of imported technology, including the assessment of its suitability, direct and indirect costs and conditions.
6. promote and assist in the absorption and adaptation of foreign technology and create the basis for the growth and development of indigenous technology, linked to national design engineering and research and development efforts.
7. help in the diffusion and assimilation of technology among its users.
8. encourage the type of technology imports which allow the acquisition of increasingly complex skills from assembly or the finishing of products to more complex capabilities involving the adaptation, improvement, design and development;
9. create technology parks as a seedbed for technology-based companies.

<u>Prerequisites for industrial development – The Technology Promotion Centres</u>

The three prerequisites for technology and industrial development are design engineering, machine tools manufacture, and skilled and varied (multidisciplinary) manpower.

<u>Design engineering</u> is the organization and application of knowledge for purposes of investment and production. In the case of investment, it is concerned with the planning and implementation of investment projects; formulation of the project, choice of the most appropriate product design and process technology, project evaluation, detailed design and engineering, procurement of plant, preparation of contract documents, supervision of construction, testing, and starting-up of new installations.

In the area of production, it renders valuable services for the operation and maintenance of the plant, the solution of management problems, and the training of personnel. When backed by R&D, they provide the necessary support for adapting imported technologies to the local environment and for creating and applying new technologies.

<u>The Machine Tool Industry</u>

Machine tools constitute a very important element of the capital goods sector, and their importance derives from their enormous impact on the productivity and competitiveness of industries to which they furnish one of the major means of production.

Machine tools are power-driven machines which work on metal, wood, glass plastics, etc. They can be categorized into two broad groups, namely,

(a) chip removing types – turning, milling, planning, shaping, drilling, boring, gear-hobbing, tapping, broaching and grinding, etc.;
(b) forming types - all types of presses, forge hammers, explosion-forming machines and welding.

An engineering industry based on machine tools and engineering design is the nucleus of heavy industry and the basis of technical progress. A heavy industry base with machine-building sector as its core will lay the foundation for endogeneous industrialization; it is only if heavy industry is built that both light industry and agriculture can be developed effectively, because heavy industry will build the machinery for them.

If we have machine factories that can design and fabricate machines, it will be a relatively simple problem to build pilot plants for testing scientific research results. It should be reasonably obvious that the results of scientific research should be introduced into industrial production only after they are fully tested at a pilot plant.

Technological capabilities acquisition

For Ghanaians to acquire capabilities beyond just operating and maintaining the machinery/equipment, a government-backed company (or a joint venture with a reputable MNC) should be established to develop Ghanaian specialty in the design and construction of capital equipment for the steel and other heavy industries within a specified time frame. The company must be involved up to the limit of its capability and resources in the design and installation of any steel or other process industries. Ideally, it could be in the role of a subcontractor to one of the major engineering multinationals – until the company develops all the expertise needed.

The foregoing suggests that it might be necessary for the Technology Transfer Centre to establish a national institution (Technology Promotion Centre) with regional centres in Accra or Winneba, Kumasi and Tarkwa to

- (i) Serve as a central engineering design and machine tools center.
- (ii) Design and build machines for industry
- (iii) Serve as a pilot machine-building factory for research work
- (iv) Carry out pilot plant investigations
- (v) Undertake the unpackaging, adaptation, and updating of imported technologies
- (vi) Encourage the establishment of private consulting and engineering design organizations.

In the medium term, the success of TPC will depend on the availability and the training of very sophisticated technical manpower, trained in the relevant fields like design engineering and machine tool fabrication. These centres must work in cooperation with excellent research universities. For this purpose, The Engineering School of the Kwame Nkrumah University of Science and Technology, the School of Mines at Tarkwa in the Western Region and the Industrial Research Institute of the CSIR in Accra or Apostle Dr. Safo Kantanka's technology outfit and proposed science university at the Winneba junction could be strengthened, funded and upgraded for this purpose. It might be necessary to bring in outside expertise at the initial stages.

The goal is to build an excellent research university to collaborate with the Technology Promotion Centres. The best staff available including foreign experts should be recruited. Departments of mathematics, physics, chemistry, material science and engineering, mechanical engineering, industrial engineering, electronic and electrical engineering, chemical engineering, life sciences, etc. should be established. It might be necessary to add graduate school of Information Technology, and School of Iron and Steel Technology later.

The Universities should pursue academic exchanges and collaborations with international institutions of higher learning especially in the fast developing countries.

Technology parks should be established to provide the infrastructure for the transfer of technology between academia and industry

The universities should be funded by individuals such as Dr. Safo Kantanka and/or consortium of banks and/or government. Each university and centre will concentrate on the human and material resources which are abundant where it is located. For instance, Tarkwa will concentrate on mining and the oil business.

Recommendations (Policies for promoting industry)

Intervene to promote the build-up of a scientific culture, of relevant research and development expertise, and of technological capacity for local industry, and technological capabilities in the working population. The interventions can take the form of

(a) Improving education, especially engineering and technical education at all levels in order to produce a skilled workforce, competent management and able professionals and researchers;

(b) Lowering the cost and the risk element of doing business by providing social and economic overhead capital, and creating an enabling environment which makes it profitable to assimilate imported technology, adapt it and begin to generate domestic technology. The enabling environment would include an efficient and transparent regulatory framework, enforcement of contracts and well-defined property rights, insurance and accounting services, development of the money and capital markets, forging of business-government relationships, information on foreign markets, technologies and their prices, etc.

(c) Encouraging the type of technology imports which allow the acquisition of increasingly complex skills from assembly or the finishing of products to more complex capabilities involving the adaptation, improvement, design and development;

(d) Putting in place mechanisms and incentives which promote research and development by local firms and technological upgrading by the small and medium sized firms;

(e) Raising the local content of production to stimulate local linkages and technology diffusion, and for encouraging firms that have been developed in the context of import-substitution activities to engage in exports

(f) Fostering enterprise development by strengthening research and development, have in place entrepreneurial promotion schemes, help to secure venture capital funds, provide training facilities in manufacturing technologies, among others;

(g) Speeding up literacy campaign in order to create a scientific, or at worst, a functionally literate community. This will aid in the diffusion of growth impulses coming from the top-down approach;