Thesis

By

SHITUNDU,

Joseph Louis Mark

University of
Dar-es-Salaam

An Empirical Investigation of Technical Change in Tanzania Manufacturing Industry Dar es Salaam

MAY, 1993

AN EMPIRICAL INVESTIGATION OF TECHNICAL CHANGE IN TANZANIAN MANUFACTURING INDUSTRIES

J. L. M. Shitundu

A DISSERTATION SUBMITTED TO THE UNIVERSITY OF DAR-ES-SALAAM IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

May, 1993

University of Dar-es-Salaam.

Abstract

The Tanzanian manufacturing sector has been performing poorly (low and declining labour productivities and widespread capacity underutilization) especially in the period since the late 1970s to the mid 1980s. The main hypothesis of our study is that absence of purposeful and adequate technological change, efforts and capabilities contributed partially to that poor performance.

This study has quantitatively established that very little or no technological change (Hick neutral technical change) took place and did not contribute significantly to output variation in the Tanzanian manufacturing sector. And qualitatively it has been found that in the metals and engineering firms and in the educational and technological institutions, in Tanzania, there were little or no serious technological efforts and thus very low technological capabilities persisted despite the massive technology imports which took place in the 1970s.

Since technological change, efforts and capabilities are very important factors of economic growth, their absence affected growth negatively. Therefore, this study make some few recommendations for improving the technological development and the efficient industrial performance in Tanzania viz: localisation policies be effectively monitored, the scarce resources be concentrated in few R & D institutions or else the door be opened to foreign investors, the supply of funds and skilled manpower to technological activities be increased and policies conducive to technological development be provided.

DECLARATION

By **THIS DEED** I the undersigned **JOSEPH LOUIS MARK SHITUNDU**, hereby declare that this dissertation is my own work and has not been submitted for a degree in any other University.

Signed: This 11th day of May, 1993.

TABLE OF CONTENTS

CHAPTER 5: MODEL, DATA AND METHODOLOGY

LIST OF TABLES

LIST OF FIGURES (AND GRAPHS)

LIST OF APPENDICES

Abstract

The Tanzanian manufacturing sector has been performing poorly (low and declining labour productivities and widespread capacity underutilization) especially in the period since the late 1970s to the mid 1980s. The main hypothesis of our study is that absence of purposeful and adequate technological change, efforts and capabilities contributed partially to that poor performance.

This study has quantitatively established that very little or no technological change (Hick neutral technical change) took place and did not contribute significantly to output variation in the Tanzanian manufacturing sector. And qualitatively it has been found that in the metals and engineering firms and in the educational and technological institutions, in Tanzania, there were little or no serious technological efforts and thus very low technological capabilities persisted despite the massive technology imports which took place in the 1970s.

Since technological change, efforts and capabilities are very important factors of economic growth, their absence affected growth negatively. Therefore, this study make some few recommendations for improving the technological development and the efficient industrial performance in Tanzania viz: localisation policies be effectively monitored, the scarce resources be concentrated in few R & D institutions or else the door be opened to foreign investors, the supply of funds and skilled manpower to technological activities be increased and policies conducive to technological development be provided.

ACKNOWLEDGEMENT

Throughout the preparation of this dissertation I received valuable intellectual, moral and material support from different people. Indeed, I owe special thanks to my two supervisors, Prof. BENNO NDULU of the Department of Economics, University of Dar-es-Salaam (currently with AERC in Nairobi) and Prof. ARNE BIGSTEN of the Department of Economics at the University of Gothenburg (Sweden). The two supervisors read the drafts and offered many useful insights, comments and suggestions which greatly improved both the form and content of my dissertation. My two supervisors were always a source of encouragement and inspiration and without their help and constant warm cooperation this work would not have materialized.

Many thanks should go to Prof. LENART HJALMARSSON, of the Department of Economics at the University of Gothenburg, for his very useful scholarly comments (especially on my four chapters, viz: 3, 4, 5 and 6) which helped me to be on guard on various theoretical and methodological issues of technical change. Also I am very grateful to MARIO C. ZAJAN of Department of Economics at the University of Gothenburg, for reading, commenting and offering very useful suggestions (especially on my two chapters, viz: 7 and 8) which helped me in various issues of technological efforts and capabilities. Many thanks should also go to Prof. MBOYA BAGACHWA of the Economic Research Bureau at the University of Dar-es-Salaam for reading and commenting on my earlier draft (chapters 1,2,3 and 4). My colleague, TIMOTHY NYONI also deserves many thanks for helping me in various computer work and for his academic criticisms and comments on my study.

I would like to thank my employer the University of Dar-es-Salaam for sponsoring my study. Also I am very grateful to Prof. ROBERT MABELE, the Director of the Economic Research Bureau; and Dr. AMMON MBELLE, the Head of the Economics Department at the University of Dar-es-Salaam and other academic and non-academic members also of the two institutions, for their unmeasurable support which helped me to complete this dissertation.

Various sources of funds have greatly facilitated my study. I would like to thank the African Economic Research Consortium (AERC) and the Council for the Development of Social Research in Africa (CODESRIA) all for providing me with funds which enabled me to carry out research and expedite the initial and final data processing, updating and write-up work. I deeply appreciate the financial support from the Swedish International Development Agency (SIDA) which funded my study leave in Gothenburg for coursework and writeup. Many thanks and deep appreciation should also go to ULLA OLOFSSON of the University of Lund who very efficiently managed the Dar-Lund exchange Programme and made my stay in Sweden comfortable. Also I wish to thank EVA LENA NETH JOHANSSON of the University of Gothenburg for her assistance and help during my stay at the university of Gothenburg. I really appreciate the facilities and good working environment accorded to me at the university of Gothernburg.

I would like to thank MSANCHI MBEYE a Secretary at the University of Dar-es-Salaam for her efficiency in typing which contributed much to the completion of this dissertation.

Finally I would like to thank my parents, relatives and family for their contribution and support throughout my study. My father MARK R.D. SHITUNDU and mother FELISTAS O. NAMBUYU constantly encouraged me and prayed for the completion of this work. My brothers WILFRED, JOHN, WILBROAD and RICHARD, too, gave me their moral and material support during my study. To ISABELLA, my wife and our daughters MAGRETH and CHRISTINE, I express my deep gratitudes for their understanding and enduring when I was away undertaking this work: research, writing and general preparation of this dissertation. Their encouragement is very much part of this effort.

However, any error or shortcoming in this work remain solely mine and should not be ascribed to any of the above acknowledged people or institutions.

ABSTRACT

The Tanzanian manufacturing sector has been performing poorly (low and declining labour productivities and widespread capacity underutilization) especially in the period since the late 1970s to the 1980s. Our study is one of the several studies which attempt to explain that poor performance. In our study it has been principally hypothesized that in addition to severe shortage of foreign exchange other factors such as absence of serious, purposeful and adequate technical change contributed to that poor preformance.

The reviwed theoretical and empirical analysis of technical change show that technical change is a very important factor of economic growth (productivity growth) in both developed and developing countries. However, in the developing countries, incremental technical change rather than the Schumpeterian "major breakthroughs" are more common. And the key concepts used in analysing such incremental technical change are "technological efforts" and "technological capabilities". The reviewed experiences of some relatively successful developing countries (some Asian and Latin American countries as well as some few cases in Africa) indicate that countries which undertook some serious, purposeful and adequate technological

efforts to acquire, use and manage technological capabilities are more successful in getting efficient industrialization. A majority of developing countries (Tanzania included), however, have not undertaken enough such efforts and are experiencing poor industrial performances.

This study has thus investigated and confirmed that in the Tanzanian manufacturing sector there were little or no serious technological efforts despite massive technological imports in the 1970s. Therefore, very low technological capabilities persisted in the sector with low and declining labour productivities and widespread capacity underutilization. Several factors contributed to this, and they include lack of effective S & T policy, limited (in some cases passive) local participation in technological activities due to inadequate skilled manpower, funds and facilities; weak planning, poor implementation of the BIS and the role of foreigner investors; lack of coordination and relatively too many, small and weak created technological institutions. In general, Tanzania does not seem to have learnt from the experiences of relatively successful developing countries in this regard.

The creation of COSTECH in 1986 together with the establishment of the Ministry of S & T and Higher Education may help Tanzania to have an effective S & T policy and also be able to learn in certain cases from the relatively successful developing countries in the promotion of technological development. Moreover, it is important to increase funds allocated to technological activities, strengthen educational and technological institutions and possibly to concentrate on few technological institutions for efficient utilization of the very scarce but neccessary resources (skilled manpower, funds and facilities) and thus be able to effectively promote technological development and achieve better industrial performances in the sector. Alternatively and subject to further studies the existing technological institutions should be scrapped off and the door be opened to foreign investors.

CHAPTER I

INTRODUCTION

1.1 Background to the Problem

In the early 1960s many African countries became independent and most of them, Tanzania included, sought to undertake industrialization as a way of confronting underdevelopment. Sutcliffe (1971) and Rweyemamu (1973) among other development economists had a notion that industrialization is a necessary condition for overcoming underdevelopment in the less developed countries (LDCs).

Wangwe (1979) and Adei (1987) noted that many LDCs, following economic development theories of the 1950s resorted to import substitution programs. They did so by attracting direct foreign investment mainly from the Trans-national Corporations (TNCs) which could provide capital, management and technical know how for their import substitution industries.[1]

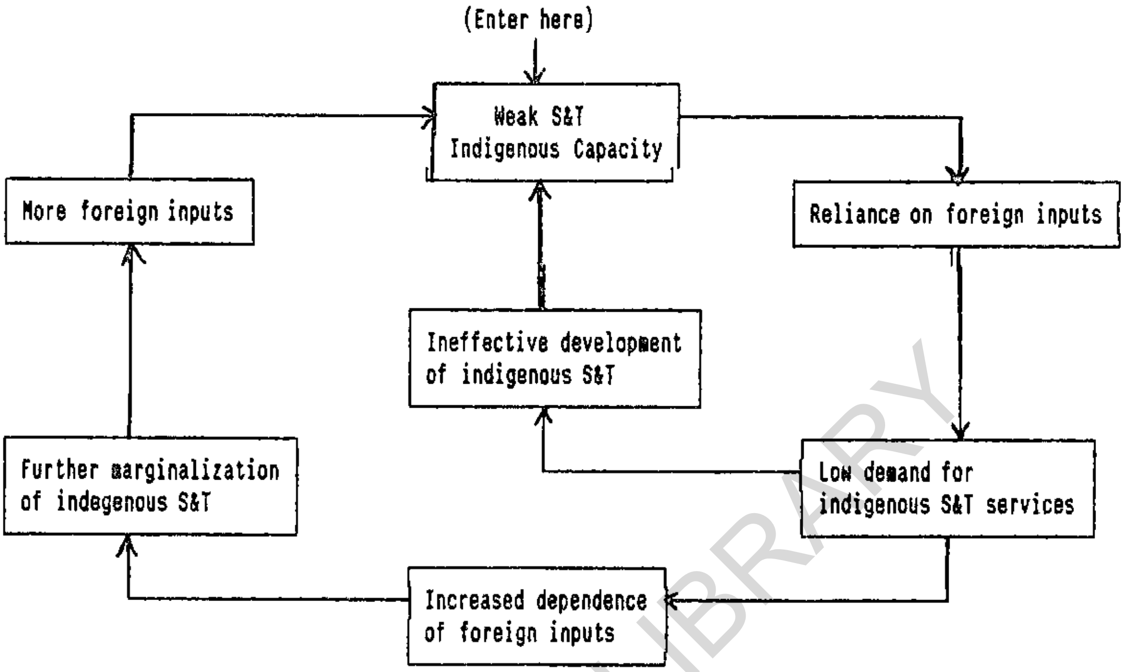
Wangwe (1979) further pointed out that such import substitution in LDCs started with consumer goods industries, involving a transfer of consumption technologies being tied

[1]See, for example, Kuznets (1954) Hirshman (1958), Chenery (1960), Sutcliffe(1971) and Rweyemamu(1973).

to the transfer of unmodified and unadapted technology embodied in the imported capital goods. In that case, Adei (1987) noted that many LDCs failed to achieve technological advancement and economic prosperity through the import substitution industrialization. And in addition that such LDCs have been experiencing economic crises in terms, of repayment of external loans and servicing of import substitution industries.

UNIDO (1982, 15) noted that, generally the TNCs contributed little to the development of technological infrastructure in the LDCS, which were thus caught in a "Viscous circle" of technological dependence as is summarised in the following figure:

Figure 1.1: The Viscous Circle of Technological Dependence



Note: S&T = Science and Technology

Source: UNIDO (1992, 15, pg. 9)

No-where are the disparities between the industrialised countries and LDCs more marked than in the crucial area of technological development; that technological dependence is almost total as is shown in Table 1.1 below:

Table 1.1: Selected Indicators of Technological Capacities

Indicators	Developed Market Economy Countries	Eastern Europe (Incl. USSR).	Developing Countries Africa	Asia	Latin America
R&D Scientists & Engineers 1973 (% of World Total	55.4	32.0	1.2	9.4	2.0
R&D Expenditures 1973 (% of World Total)	66.5	30.6	0.31	1.63	0.94
Share of Exports of Machinery & Transport equipment. 1976 (% of World Total)	86.9	9.5	0.04	2.6	0.68
Developing Countries Imports of Machinery & Transport equipment 1971 (% of World Total)	90.3	4.2	N/A	5.1	N/A

Source: UNIDO (1982, 15 pg. 4).

From Table 1.1 we see that developing countries in general are at very low levels of technological development as they possess only 12.6% of global stocks of scientists and engineers who are engaged in R&D, and of these the majority are concentrated in few Asian and Latin American countries. In addition developing countries account for only 2.9% of global expenditures on R&D and only 3.3% of global exports of machinery and transport equipment, while they import almost 95% of all their machinery and transport equipment from developed countries. This in turn signifies the high technological dependence of LDCS on developed countries.

The high technological dependence tends to affect negatively LDCS in terms of the high costs involved in importing technologies and also in terms of undermining attempts by LDCs to strengthen their own capacities of research and technological development. This is especially the case where little or no local efforts are made to utilise imported technologies in building local technological capabilities. Unfortunately, as the literature review chapter of this study reveals, many of the LDCs have not undertaken seriously such local efforts.

In addition there has been disillusionment about the operations of the TNCs (noted since 1960s) with respect to local technological development. In some LDCs such disillusionment have led to restrictions on foreign investment and even to nationalization of foreign owned companies. However, as Adei (1987) noted, such restrictive and nationalization actions did not automatically bring technological advancement to most such LDCs. Therefore, instead of taking such actions some other LDCs have been taking advantages of foreign experiences through various forms of technological imports. The literature review chapter indicate that such LDCs have in general, been much more successful than the former.

Following such failures and successes among different LDCS, there have been changes in analysing technological change issues in LDCs. Fransman (1983), noted that since the late 1970s there has been a rather fundamental shift in the focus in many studies of technology in LDCs. That is, whereas previously, most studies focused very much on questions relating to the transfer and choice of technology, increasing attention has more recently been given to the process of technological change within LDCs, and that what is mainly being examined is what happens when technology is imported, assimilated and improved upon in LDCs.[2]

The Neo-classical economists as well as their critics agree that technical change and the forms that it implies constitute the main source of economic growth.[3] Venkataswami (1974) noted that in the advanced countries technical change has been identified as the most dominant factor for economic growth; and that for LDCs it offers the best hope of economic development.

In addition, Fransman (1982) explained that in recent years there has been a growing volume of literature dealing with the various forms of technical change that take place in LDCs. The point is that the various forms of technical change that take place in LDCs are of great importance and that they are not similar to the major breakthroughs of the Schumpeterian kind on the frontiers of knowledge which take

---

[2]For details see Fransman and King (1984)

[3]See the theoretical review chapter of this study

place in developed countries.[4]

In analysing technical changes in LDCs a key concept that is widely used in much of the literature is the "Technological capability".[5] A few semi industrialised LDCs have succeeded in building their technological capability to the extent of being exporters of technology and thus have managed to change the nature and extent of technological dependence.[6] Such successful countries include Argentina, Brazil, Mexico, South-Korea, India, Singapore, HongKong and Taiwan.

However, the majority of the LDCs are quite far away from achieving that success. At best, for such countries, they can only learn from the experiences of those successful LDCs. One of the basic lesson is summarised by Kaplinsky (1984, pg. 420):

> "These technical improvements do not arise as manna from heaven, nor are they automatic consequence of learning by doing. Rather they arise from the conscious application of Science and Technology in production".

---

[4]See the theoretical review chapter of this study

[5]For the definition of the concepts, see the theoretical review chapter of this study

[6]See the literature review chapter of this study

Other lessons are summarised in the literature review chapter of this study. However, it is emphasized by the above quotation that technological change in LDCs may come only with some deliberate and purposeful efforts.

Different circumstances or factors have led to different successes or failures in the process of acquiring technical capability in different LDCs. What is required is for each country to measure the costs and benefits of doing particular technological efforts. Dahlman and Westphal (1982) argued that it is not valid to argue that since LDCs obtain most of the technological knowledge from advanced countries rather than by creating it themselves, then technological efforts have only minor role to play in the process of industrial development.

Bell, Ross-Larson and Westphal (1984,) found that various infant industries in LDCs generally experienced relatively slow productivity growth. These authors argued that the poor performance (slow productivity growth) is due to the absence of sustained efforts to acquire and use the capabilities necessary for continuous technological change, and that the evidence shows that the accumulation of technological capability is not accomplished through costless and automatic learning by doing but rather through conscious efforts to develop a technological strategy, to invest in resources for technological changes and progressively to accumulate technological changes. Thus the absence of technological efforts and technological changes can explain partially the poor performance of industries in LDCs.

Perkins (1983) noted that the serious economic problems faced by Tanzania are common throughout LDCs. Indeed much of the experiences of import substitution strategy and the role of TNCs as briefly explained above, applies to Tanzania as well.

Bank of Tanzania (1982) and Skarstein and Wangwe (1986) explained that by the late 1970s and the early 1980s the industrial performance was very poor in Tanzania. The poor performance of manufacturing industries in Tanzania could be shown by a volume index for the manufacturing sector. Unfortunately, such an index is currently not available. (Work on its compilation started only in 1985). Therefore the only available alternative is to use the contribution of the sector to GDP at constant prices and supplement it with the trend of production in some selected industries. These are summarised in Tables 1.2

Table 1.2: Output Trends in Tanzania Total Economy, Agricultural and Manufacturing Sectors (1976 Prices) (Shs. Million)

Year	Total GDP	GDP Annual Growth	Agricultural Sector			Manufacturing Sector		
			Total Output	% in GDP	Annual Growth	Total Output	% in GDP	Annual Growth
1964	12600		6300	50.0		1,040	8.3	
1965	13000	3.2	6200	47.7	-1.6	1200	9.2	15.4
1966	14700	13.1	7090	48.2	14.4	1400	9.5	16.7
1967	15500	5.4	7090	45.7	0.0	1500	9.7	7.1
1968	16200	4.5	7350	45.4	3.7	1700	10.5	13.3
1969	16600	2.5	7400	44.6	0.7	1800	10.8	5.9
1970	17300	4.2	7700	44.5	4.1	1900	11.0	5.6
1971	17900	3.5	7600	42.5	-1.3	2100	11.7	10.5
1972	19100	6.7	8200	42.9	7.9	2200	11.5	4.8
1973	19600	2.6	8300	42.4	1.2	2300	11.7	4.6
1974	19900	1.5	8000	40.2	-3.6	2400	12.1	4.4
1975	20900	5.0	8600	41.2	7.5	2400	11.5	0.0
1976	21700	3.8	9050	41.7	5.2	2800	12.9	16.7
1977	21800	0.5	9200	42.2	1.7	2600	11.9	-7.1
1978	22200	1.8	9000	40.5	-2.2	2700	12.2	3.9
1979	22900	3.2	9100	39.7	1.1	2800	12.2	3.7
1980	23400	2.2	9400	40.2	3.3	2700	11.5	-3.6
1981	23300	-0.4	9500	40.8	1.1	2400	10.3	-11.1
1982	23400	0.4	9600	41.0	1.1	2300	9.8	-4.2
1983	22900	-2.1	9900	43.2	3.1	2100	9.2	-8.7
1984	23700	3.5	10300	43.5	4.0	2200	9.3	4.8
1985	24300	2.5	10900	44.9	5.8	2100	8.6	-4.6
1986	25100	3.3	11600	46.2	6.4	2000	8.0	-4.8
1987	26400	5.2	12100	45.8	4.3	2100	8.0	4.8
1988	27500	4.2	12600	45.8	4.1	2200	8.0	4.6
1989	28400	3.3	13200	46.5	4.8	2400	8.5	9.1
1990	29400	3.5	13600	46.3	3.0	2600	8.8	8.3

Source: Selected Statistical (1987), and Economic Survey (various).

According to Table 1.2, the Tanzanian manufacturing sector recorded high annual growth in the 1964-1976 period with the exception of the slow down in the 1973-1975 period (due mainly to the first oil price shock in 1973/74). This trend changed in the period from the late 1970s to the mid 1980s with some fluctuations and even negative annual growth rates. This was mainly due to reduced foreign exchange availability as a result of second oil price shock and the Amin war both towards the end of the 1970s. However, since 1986, there was implementation of the Economic recovery programs (ERPI and ERP2) and this improved the foreign exchange availability to the sector; and hence there was, since 1987, a slight improvement with some positive annual growth for the sector in the period 1987-1990.

As shown in Table 1.2, the annual average growth rate of GDP (at 1976 Prices) dropped from 5.5% during the period 1965-1970, to 3.2% during the period 1970-1980, and to only 1% during the 1980-1985 period. However, it recovered to 4.1% during the period 1987-1990. And the annual average growth rate in the agricultural sector dropped from 3.6% in the period 1965-1970, to 2.3% during the period 1970-1980. It recovered to 3.1% in the period 1980-85 and further improved to 4.1% in the period 1987-1990. However the annual average growth rate of the manufacturing sector dropped badly from 10.7% in the period 1965-1970 to 4.0% in the period 1970-1980 and to -4.6% in the period 1980-1985. However, it recovered to 6.8 in the period 1987-1990.

The share of the manufacturing sector value added (at 1976 prices) to GDP which was 8.3% in 1964, rose to the maximum contribution of 12.9% in 1976 and even in 1978 was still high, that is 12.2% (due to coffee boom); and thereafter it dropped to 8.6% in 1985, to 8% in each of the years 1986, 1987 and 1988 and recovered to 8.5% in 1989 and to 8.8% in 1990. This trend observed in the manufacturing sector in Tanzania, is associated with a more or less similar trend of the Tanzanian economy in general and of the agricultural sector, in particular. This is because the Tanzanian manufacturing sector depends on the agricultural sector for foreign exchange to import industrial inputs. This is especially so because most of the Tanzanian manufacturing industries are of import substitution nature rather than export oriented. They are unable, currently, to earn by themselves, enough own foreign exchange. The poor performance of the manufacturing sector can also be seen in Table 1.3.

Table 1.3 Production in Selected Industries in Tanzania

Industrial Goods	Unit	1974	1978	1980	1982	1985	1986	1988	1990
Textiles	(000' sq.m)	86400	835000	88000	56100	N/A	61900	64300	63300
Beer	(000 litres)	63700	85800	63600	64200	75800	65200	53000	45000
Cigarettes	(000,000 pcs)	4700	4100	4700	4700	2700	2700	3000	3700
Cement	(m.tons)	296000	272000	286000	370000	376000	435000	591000	664000
Petroleum	(m.tons)	75300	590000	617000	505000	520000	370000	438000	337000
Iron Sheets	(m.tons)	26000	30200	17300	16000	21700	8200	14700	N/A
Blankets	(000 pcs)	N/A	1060	790	750	650	480	570	440
Fishnets	(000m: tons)	460	230	110	60	100	120	160	150
Aluminium	(m.tons)	3700	4000	4000	3100	2400	1500	2600	2500
Sisal ropes	(m.tons)	29500	31400	29900	10300	10400	19200	18500	20200
Pyrethrum Extract	(m.tons)	150	60	50	40	40	40	44	40
Wheat Flour	(m.tons)	34200	87900	33700	32100	38900	39800	39900	12100
Canned Meat	(m.tons)	4700	760	1200	390	130	110	170	30
Batteries	(000 pcs)	48000	70900	79200	59500	44100	27000	242000	21000
Shoes	(000 pairs)	2800	6400	4100	2200	1300	1400	570	N/A
Rooled Steel	(m.tons)	8600	16400	18400	12300	11300	11400	10500	N/A
Chibuku	(000 litres)	6200	15200	13400	15700	N?A	13000	15200	17400
Konyagi	(000 litres)	N/A	N/A	490	770	680	930	1170	N/A
Fertili-zer	(m.tons)	N/A	N/A	N/A	N/A	N/	47000	6000	17400

Source: Bank of Tanzania, Economic and Operation Reports

Table 1.3 presents production of goods that had priority in foreign exchange allocation in their production; and so these industries had relatively better chances of performing better. However, the general trend observed falls within the explanations given above for Table 1.2.

1.2 Statement of the Problem

Several studies have explained the poor performance in the Tanzanian manufacturing industries. Such studies include among others, Wangwe (1976, 1979 and 1983), UNIDO (1982, 15), Perkins (1983), Ndulu (1986) and Mbelle (1988). All these studies with the exception of Perkins (1983), cite capacity underutilization as the main cause of poor performance. They also argue that the main factor attributing to capacity underutilization is the lack of adequate foreign exchange for the required intermediate input imports.

These studies however, do not rule out the possibility of other factors accounting for the poor performance of the manufacturing sector. Lall in Stewart, Lall and Wangwe (1992) holds the view that, generally, industry in Africa (Tanzania included) faces problems related to policy environment, low level of capabilities and poor infrastructure in addition to the severe foreign exchange shortages. In that case, Mbelle (1988), for instance, suggested that efforts to increase foreign exchange earnings at the economy level should be supplemented by foreign exchange saving, through increased efficiency and technical progress, among other efforts.

On the other hand Perkins (1983), argued that the technological choices which were made throughout the economy since independence in 1961, aggravated the nature and number of the Tanzania's economic difficulties. Parkins's (1983) study therefore identified those aspects in Tanzania's implicit technology policy which were hindering Tanzania's industrial development. He concluded that the use of technically and economically inefficient capital and import intensive technologies did probably cause a serious waste of scarce capital, foreign exchange and skilled labour. Perkins's (1983) study also revealed the very low levels of technological capability in terms of being able to understand and to influence various imports and choices of technology. This confirms that there are other factors, apart from capacity underutilization, which have been contributing to the poor performance in Tanzanian manufacturing industries.

This study, then, has investigated one such other factor, namely the lack of technological change, which have been contributing to that poor performance. In other words, we argue that the poor performance in the Tanzanian manufacturing industries may be explained partially by lack of technological change which in the case of developing countries, is explained by the lack of or too little technological efforts in trying to acquire, build and use technological capability. The problem of lack of technological capability in Tanzania is also summarised in the following:

> "Our total dependence on imported machinery and spareparts, the speed at which such things as imported vehicles, factory machines and electricity and water supplies equipment, break down or become useless, is directly related to illiteracy in technical skills in a technological age. We cannot hope to develop a modern nation unless we tackle this problem".
>
> J.K. Nyerere (Daily News, September 15, 1988).

As is revealed in the theory and literature review chapters of this study technological efforts and technological capabilities are key concepts used in studying technological changes in a developing country like Tanzania. It is in this light that this study attempts to explain the poor performance of the Tanzanian manufacturing industries with the hope of identifying some of the conditions, factors and policies which have affected negatively the process of acquisition, building and use of technological capabilities in Tanzanian manufacturing industries.

1.3 Objective and Significance of the Study

The main objective of this study is two fold: First, to establish that little or no technical change has taken place in the Tanzanian manufacturing industries for the period 1966-1990. In addition, through quantitative and qualitative analysis we explain some conditions, factors and policies which have been hindering technological change in Tanzanian manufacturing industries.

The second objective of this study is to explain some of the theoretical and methodological problems involved in conceptualising and measuring technical change in a developing country like Tanzania. Teitel (1981), noted that the theory of technical change is inadequate and insufficient in both developed countries and LDCs. Due to problems such as lack of adequate and accurate data and presence of market imperfections, among others; the problem of measuring and understanding technological change has been found to be quite accute in Tanzania; as is the case with other developing countries.

The importance of this study arises first from the fact that we are studying one of the acknowledged important factors of economic growth. Goldsmith (1970), Venkataswami (1974), Enos (1962) and Teitel (1981) among others, have confirmed this.

While technological change may not be the most important factor, in LDCs, its role as an agent of economic growth cannot be over-ruled. Dahlman, Ross-Larson and Westphal (1987), noted that inventing new products and processes is not at the center of technological development in LDCs. Instead, the acquisition of capabilities needed for efficient production and investment should be at the center.

Other authors such as Bell, Dahlman, Lall, Fransman, Katz, Pack, Kaplinsky, Teubal, Teitel, Sahal, Sercovich and Ross Larson have confirmed the importance of technological capability in semi-industrialised LDCs.[7] They note that it helps in managing effectively the importation of technology and also in assimilating, modifying and adapting imported technology to local conditions. Bell et al (1982) and Katz and Ablin (1979) noted that some of the benefits of such effective management of technology include raising the efficiency of techniques of production and productivity in general.

Tanzania, however, is not one of the semi-industrialised LDCs, and so, such benefits from technological capability are not observed at present. So the importance of this study in this respect to Tanzania can only be expected in the important lessons which can be learnt from the experiences of

[7]See the literature review chapter of this study

semi-industrialised LDCs. We are quite aware that the course by which some of the LDCs have succeeded in building up technological capability cannot be generalised to all other LDCs. That is, there are many problems of a more specific nature, which confront different countries as they embark upon the processes of building their technological capability. In UNIDO (1982, 15, pg. 103), it is noted that there is no simple way for defining the best course of action for the development of indigenous technological capability. This fact, however, does not rule out the possibility of learning, in some aspects, from the experiences of semi-industrialised countries. Much more optimism in this case is built on the success of Kenya's textile industry, Zimbabwe's iron and steel industry and Mauritius's garments industry. These cases appear to have benefited from lessons arising from the experiences of the newly industrialised Asian and Latin American countries as explained in the literature review chapter.

The other importance of this study can also be seen in the choice of the period covered by this study, that is 1966-1990. This period includes the year 1967, in which Tanzania proclaimed the Arusha Declaration, which officially set the country on a course of "socialism and self-reliance". Nationalization of some industries and some of the other sectors took place on the basis of the policies that were specified in the 1967 Arusha Declaration.

UNIDO (1982) argued that domestic technological capability is essential in LDCs to enable them overcome their excessive technological dependence on the industrialised countries. And that technological capability is a particularly important component of self-reliance development as desired, for instance, in the Arusha Declaration (1967).[8] And for the case of nationalization, Adei (1987), cautioned on carrying it without proper consideration and efforts for the subsequent development of indigenous technological capability.

The period 1966-1990 include also the 1978/79 war. After the 1978/79 war up to mid 1980s; Tanzanian industries faced more serious foreign exchange shortages; and thus a drastic reduction of intermediate input imports. Wangwe (1979), found that there were some important innovations and designs activities in some engineering industries in Tanzania in the period up to 1978. With a more serious situation (severe foreign exchange shortages), unlike in the pre-1978/79 war, this study has investigated how some Tanzanian industries and technological institutions reacted or

[8]For definition of Technological self-reliance see UNIDO (1982, 15, pg. 11)

responded to the crisis, in terms of innovations and designs in an attempt to reduce the impact of reduced industrial intermediate input imports. Moreover, such an investigation has helped to establish the continuity or discontinuity of the activities observed by Wangwe (1979). This is because acquiring technological capability is supposed to be a continuous process.

Lastly, we cover a 25 year period. Kaplinsky (1984), argued that a period of between 3 to 6 decades is required to build the necessary technological capabilities (of course this differs among different economies). Dahlman, Ross-Larson and Westphal (1987) argued that it takes 10 or 20 years to acquire the full range of production capabilities. It is therefore not too much to expect some technological capabilities in Tanzanian manufacturing industries for the period 1966-1990, given correct and deliberate efforts.

The importance of this study may also be seen in the choice of the area of study; that is, the manufacturing sector and the metals and engineering sub-sector and technological institutions. Sutcliffe (1971) Rweyemamu (1973) and Wangwe (1979), argued that the manufacturing sector can play a very important role in the economic development of an LDC like Tanzania. Moreover, as it will be explained in chapter two of this study, Tanzania is basically an agricultural country. [9] However, it is the Tanzanian manufacturing sector which uses a larger part of foreign exchange, despite the fact that it contributes less than the agricultural sector in terms of foreign exchange earnings in the country. For this reason it has been important to study the manufacturing sector in an attempt to suggest ways of making it earn more foreign exchange and save by reducing its foreign exchange consumption. This implies helping manufacturing sector to perform better, and we believe that technical change or capability can contribute positively to this.

In as far as the choice of the metals and engineering sector is concerned, it has included the International Standard Industrial Classification (ISIC) three digit groups; 371 & 372, 381, 382, 383 and 384, that is; basic metals, fabricated metal products, machinery except electrical, electrical machinery & apparatus and transport equipment.[10] Most of the studies as reviewed in the literature review chapter of this study seem to argue that the capital goods sector is an essential though not sufficient factor for technological development in LDCs.

---

[9]See also Table 1.2 of this chapter.

[10]See chapter 7 for the covered individual metals and engineering firms

Wangwe (1979) has explained in detail the differences between the capital goods sector and the engineering sector. However, while most of the reviewed studies have used the capital goods sector, we are using the metals and engineering sub-sector[11] . This sub-sector perform a similar role as that by the capital goods sector in industrial development. In addition the capital goods sector in Tanzania is still too small. Our interest, then is to investigate whether the Tanzanian metals and engineering sub sector has (or has not) played the role of being an important factor in the acquisition of technological capability in Tanzania. That role is supposed to be expected because as Wangwe (1979) argued, the engineering sector has more important industrial activities and possesses relatively higher linkages and also can more easily help in the modifications and adaptation of imported technology. The engineering sector also has more learning opportunities and effects in regard to some technological changes.

Lastly, the importance of this study is seen in its contribution to the expansion of literature in Tanzania and to the exposition of theoretical and methodological problems involved in conceptualizing and measuring technical change in

---

[11]The Tanzanian capital goods sector include ISIC three digit groups: 381, 382, 383 and 384.

a developing country like Tanzania.

1.4 Hypotheses

Pack and Westphal (1986), among others have argued that industrial strategy is a matter of managing technological change to achieve dynamically efficient industrialization. With this view in mind, this study hypothesises that besides other factors like foreign exchange shortages; absence of serious technological change, efforts and capabilities have contributed to the poor performance of the Tanzanian manufacturing industries. Based on this main hypothesis of this study, the following have been investigated:

(i) What technological change, efforts and capabilities, if any, was undertaken in the Tanzanian manufacturing industries and technological institutions for the period 1966-1990. The nature and impact of such technological change, efforts and capabilities are analysed.

(ii) the conditions under which such technological change, efforts and capabilities took place. It is argued for example that different conditions require different kinds of technological efforts. In this case, for instance, technological efforts towards building up skills are different from those technological efforts which are made towards improving industrial performance.

In this sense, we have investigated how some industries responded to shocks such as strictness on importations and lack of spare parts. This led us to the question of sustainability which is a very important concept of technological self-reliance.

(iii) The establishing and utilization of technological institutions which function and provide services towards promotion of technological development in the Tanzanian manufacturing industries also have been investigated. The nature and impact of functions and services of such technological institutions have been evaluated.

1.5 Limitations of the Study

A basic limitation of this study is the severe constraint of data and especially so for the case of measuring capital input. Although we have tried to explain how we estimated the capital stock in section 5.1:3 (iv); this is only a relatively better estimate, which has helped to minimize rather than solve all the problems associated with measuring capital input. Other authors have used a similar measure satisfactorily through.

Associated also with the severe data constraint in Tanzania, as is the case in most LDCs, is the fact that in as far as quantitative estimation and analysis of technical change is concerned, this study has used only average Cobb-Douglas production function model. Such an average model is unable to capture fully the technical change measurement and analysis; at best it has only given us crude indicators or rough estimates of technical change which thus has to be interpreted with much caution. To minimize this deficiency, however, this study has supplemented the quantitative analysis with the qualitative analysis.

Another limitation, is that not all factors affecting technological efforts and hence technological capability are taken into account. Other factors such as the microeconomic factors require detailed firm level studies which essentially use engineering as well as economic informations. This omission of microeconomic factors may be interpreted in terms of limitation with respect to operational application and policy implications. So conclusions and policy implications arising from this study should be taken only as partial and that in order to be operational they need be supplemented by the findings from other studies in this field.

Apart from the methodological limitation noted above, there are also some theoretical limitations which are noted in the theoretical review chapter of this study. It is noted that the theory of technical change has many variant views and is still being developed to accommodate some of the realities and observations found in LDCs. This study has not succeeded in offering such a complete theory of technical change. At best it has tried to summarise different views with the hope of exposing some progress and problems in this field.

And lastly this study is limited in the sense that it covers mostly one sector, the metals and engineering sub-sector (in addition to the manufacturing sector as a whole). However, it is hoped that the metals and engineering sector has reflected some of the important issues or problems expected in the process of acquiring technological capability in other manufacturing industries as well. In addition, the reasons and advantages of studying the metals and engineering sub sector by this study have been briefly explained above.

1.6 Structure of the Study

This study consists of nine chapters. The first chapter which is an introduction has summarised the study. It, has given the background and problem area of the study; the objective and importance of the study; the general guiding hypothesis; the limitation of the study and the structure of the study.

Chapter two is a general overview of the development of the Tanzanian manufacturing sector. This chapter has concentrated on issues associated with the growth, structure and performances and on the policies and institutional infrastructure and some other economic problems affecting technological efforts and capabilities in Tanzanian manufacturing industries.

Chapter three is a literature review. It has reviewed some technical change measurement in both developed and developing countries. In addition it has reviewed issues of technological capabilities in semi-industrialized developing countries, and also has reviewed Ghana and Tanzania as examples of LDCs which have not succeeded in building technological capabilities and cases in Kenya, Mauritius and Zimbabwe which are relatively much more successful in Africa. And finally, we have summarised the chapter and highlighted some of the important lessons which unsuccessful LDCs can learn from the semi-industrialized developing countries, as well as from the three relatively successful African cases.

Chapter four, is a theoretical review of the measurement and conceptualization of technical change especially in developing countries. This chapter is more of a survey of different theoretical views rather than our own contribution to the development of technical change theory.

Chapter five, is on model, data and methodology. In this chapter we have explained the details of the model, data requirements and estimation procedure used in quantitative estimation of technical change in the Tanzanian manufacturing sector as a whole and in its ISIC 3 digit industrial groups. The limitations of this procedure have been noted and thus used as a basis for shifting to qualitative analysis. The qualitative analysis have been used to estimate and analyse technological capacities and efforts in some individual firms in the Tanzanian metals and engineering sub-sector as well as in the Tanzanian educational and technological institutions which are directly involved in technological development in Tanzanian manufacturing industries. Also the limitations of the qualitative analyses have been explained.

Chapter six presents the results of the quantitative analysis, while chapter seven provides the results of the qualitative analysis for a few individual manufacturing industries in the Tanzanian metals and engineering sub-sector. Chapter eight has the results of the qualitative analysis for the Tanzanian educational and technological institutions which are directly involved in the technological development in the Tanzanian manufacturing industries.

Chapter nine, finally summarises and concludes the study and give some general partial recommendations arising from the study.

CHAPTER 2

THE DEVELOPMENT OF THE MANUFACTURING SECTOR AND THE METALS AND ENGINEERING SUB-SECTOR WITH RESPECT TO TECHNOLOGICAL DEVELOPMENT IN TANZANIA 1961 - 1990

2.0 Introduction

In this chapter we will review the development (trends) of Tanzania's manufacturing sector and metals and engineering sub sector in particular in an attempt to introduce some of the conditions, factors and policies which have affected negatively the acquisition, development and use of technological capabilities in Tanzanian manufacturing industries.

2.1:0 The Growth and Performance of the Manufacturing Sector and the Metals and Engineering Sub- Sector in Tanzania

2.1:1 Trends of Value Added, Wage Employment and Investment[1]

The contribution of total manufacturing real value added to total real GDP was about 11.0% in 1970. It increased slightly to 12.1% by 1978, and there after fell

[1]Figures in this section (2.1:1) have been calculated by the author using data from various issues of Survey of Industrial Production, Economic Survey Ministry of Industries and Trade, Annual Budget speeches. 1976 prices.

to merely 8.0% in 1985. In this case then the objective of raising (growth) the share of manufacturing value added was not so impressively achieved.

Manufacturing average annual growth of real value added for the period 1970-1974 was 11.2%, 13.1% for 1974-1978 and dropped to -5.5% for 1978-1985 and to -10.2% for the period 1985-1989. Within the manufacturing sector the consumer goods industries such as Food and Textiles continued to contribute more in terms of value added. The contribution of the metals and engineering sub-sector to the total manufacturing value added was 9.1% in 1970, while that of the textiles sector was 22.2%. However by 1989 the figures were 13.7% and 15% for the metals and Engineering sub-sector and the Textiles sector respectively. At the same time, in the period 1970-1974, the annual growth rate figures were 23.9% for the metals and Engineering sub-sector and 3.1% for the Textiles sector. However, in the period 1985-1989 there was a decline to -14.4% and -10.1% for the two sectors respectively. The evidenced faster growth of the metals and engineering sub-sector in the 1970s contributed to structural change the Tanzanian manufacturing sector which was prior to dominated by consumer goods industries. Yet industries in the food sector and the petroleum refineries and chemicals sectors continued also to contribute highly to Tanzania's GDP.

Within the metals and Engineering sector, the Iron, Steel and non-ferrous metals (ISIC 371 & 372) and the Transport equipment (ISIC 384) appear to have relatively higher contribution of value added. The transport equipment sector deals mainly with the assembling of motor vehicle bodies. However, the sector of fabricated metal products except machinery and equipment (ISIC 381) appear to have increased its share also. The contribution from that sector (ISIC 381) was 3.0% in 1974 and 5.2% by 1985.

In 1970, the Food and Textiles sectors had the highest contribution to manufacturing employment, with their contribution being 31.3% and 32.0% respectively. The metals and Engineering sub-sector contributed only 6% to manufacturing wage employment. At the same time total manufacturing sector contributed 12.8% in 1970 to economy's total wage employment. In general in the period 1970-1974 there was increased wage employment in most of the manufacturing sectors and only a few sectors recorded negative rate in wage employment for the period. Such sectors include; the Footwear sector (322), the Furniture and Fixtures (332), the Iron and Steel and non ferrous metals sector (371 & 372) and the miscellaneous (390).

In the period 1974-1978, all the manufacturing sectors recorded positive growth in wage employment. Moreover, in terms of share of wage employment by the sectors to manufacturing sector, and that of manufacturing sector as a whole to the economy's total wage employment there was little change. For example, by 1978, metals and Engineering sub-sector had increased its share to manufacturing sector, to 11.6% and the Manufacturing Sector as a whole had increased its share to economy's total wage employment to 19.6%.

In the period 1978-1985, however, the situation changed. In most of the sectors, negative annual wage employment growth rates were recorded. While the Food and the Textiles Sectors continued to contribute more, the metals and Engineering sub-sector's contribution to manufacturing total wage employment declined, for instance, in 1985 to 10.9%; and continued to decline though slightly, in the period 1985-1989 for both the Textiles and the metals and engineering sub-sectors.

Thus while the trend of real value added was generally declining and negative in certain cases, the trend of wage employment was generally rising and positive throughout .

The trend of manufacturing investment indicate that in the period 1970-1974, most of the manufacturing sub-sectors recorded positive annual growth. The metals and engineering sub-sector's investment average annual growth was 1.0% while that of the manufacturing total sector was 8.7%. And the share of the metals and engineering subsector's investment was 11% in 1974 while that of the manufacturing sector to economy's total investment was 16.4%.

The period 1974-1978, saw massive investment in the Tanzanian manufacturing sector. The metals and engineering sub-sector's investment average annual growth, for the period 1974-1978, was 128.7% which was higher than that of the total manufacturing sector which was 30.9%, but still higher than in the previous period 1970-1974. This situation enabled the metals and engineering sub-sector's share of investment to total manufacturing to increase to 30.2% in 1978, while that of the manufacturing sector to economy's total investment increased to 24.3%. This higher investment growth achieved in this period (1974-1978) was after the first oil crisis in 1973/74, which brought severe shortages of foreign exchange. So the high manufacturing investment were made possible only through external financing either through loans or grants as Wangwe (1983), Ndulu (1986), and Skarstein and Wangwe (1986) also noted. What is not clear at this stage is how the issues of technological development were treated in such massive foreign investment which implies import of foreign technology. This aspect is further discussed later in this study.

In the period 1978-1985 there was a much more severe shortage of foreign exchange especially following the second major oil price rise in 1978 and the 1979 Amin war.

At the same time less and less foreigners were willing to provide external financing and as such investment growth in some manufacturing industries recorded negative trends. The metals and engineering sub-sector recorded -5.8% investment growth while the manufacturing sector as a whole recorded only 2.4%. This in turn reduced the share of the metals and engineering sector's investment to manufacturing sector to 15.1% in 1985 and the manufacturing sector's investment share to economy's total investment fell to 12.2%. However, in the period 1985-1989 there was a slight improvement due mainly to economic recovery programmes.

In general, it is noted that Tanzanian manufacturing industries (sectors) have been experiencing rising wage employment levels, massive investment expansion especially in the period 1970-1978, falling investment growth and falling growth rates of value added in the 1980-1985 period and slight recovery in 1985-1990 period. Such a situation have resulted in lower capacity utilization and falling labour productivity especially in the period since the late 1970s to the early 1980s.

2.1:2 Capacity Utilization Rates and Labour Productivity Trends

Table 2.1: Capacity Utilization Rates in Tanzanian Manufacturing Industries (% ages)

	1976	1981	1982	1983	1984
Textiles	83	48	41	30	35
Cement	72	35	28	18	27
Beer	84	75	56	57	50
Cigarettes	77	71	80	64	61
Paints	63	27	13	7	12
Fertilizers	40	51	10	20	39
Shoes	67	29	21	19	14
Tyres & Tubes	86	32	53	43	34
Bicycles	-	9	2	-	-
Leather	66	41	32	31	31
Hoes/Ploughs	84	83	53	90	113
Corrugated Iron	58	33	47	54	53
Blankets	14	12	12	10	10
Garments	-	27	25	-	-
Batteries	57	81	76	39	39
Iron & Steel	41	55	43	30	33
Bags	37	53	35	48	36
Sugar	-	75	53	-	-
Containers	121	41	35	32	30
Chibuku	53	65	76	91	69

Source: Ministry of Industries.

**Table 2.2: Labour Productivity in Tanzanian Manufacturing Industries
Gross Value Added per Employee
(000' Tshs. 1976 Prices)**

ISIC	Activity	1970	1974	1978	1982	1986	1988	1989
31112	Food	14.3	18.5	14.5	14.4	4.7	6.0	3.4
313	Beverages	147.2	30.7	50.0	49.3	18.8	16.4	14.8
314	Tobacco & Cigarettes	37.5	24.1	15.9	14.3	23.0	23.0	20.9
321	Textiles	14.8	11.5	14.4	7.4	5.5	5.7	3.9
322&24	Footware	17.6	15.1	18.1	12.3	6.4	5.2	3.2
323	Leather products	51.8	63.2	20.5	17.2	2.8	5.9	4.9
331	Wood products except furniture	8.7	8.3	10.9	8.5	10.0	7.3	6.2
332	Furniture & Fixtures	44.5	17.0	5.3	7.8	8.2	4.7	4.2
341&42	Paper Products, Printing & Publishing	29.9	33.1	34.3	19.1	14.5	10.9	9.9
35123	Petroleum, Refineries & Chemicals	60.7	68.1	37.0	30.0	31.7	40.6	38.1
355	Rubber	26.5	45.1	26.4	37.7	71.6	34.5	30.1
356	Plastic Products	23.6	57.3	35.8	30.0	46.6	25.0	26.7
36129	Non-Metallic Mineral Products	23.6	21.9	22.9	22.6	17.5	13.9	12.0
371-72	Iron, steel and Non-Ferrous metals	34.4	48.1	83.2	5.7	32.5	29.9	23.4
381	Metal Products except Machinery	34.4	20.0	28.0	27.3	18.8	29.9	23.4
382	Machinery except Electrical	28.3	16.9	35.3	11.1	8.6	16.0	13.8
383	Electrical Machinery	28.3	37.7	30.6	22.8	46.3	16.0	13.8
384	Transport Equipment	33.6	36.1	14.2	24.2	27.9	44.9	39.2
390	Miscellaneous	5.6	26.5	26.5	12.6	53.6	3.2	1.4
	Engineering & Metals Sub-Sector	32.4	29.7	30.2	23.3	32.1	29.5	25.9
	Total Manufacturing Sector	21.4	21.4	19.3	16.8	13.2	14.1	13.0

Source: Calculations by the author using figures from survey of Industrial Production

From Tables 2.1 and 2.2, it is seen that capacity utilization rates were low and falling for most of the industries. But in the 1970s, labour productivity more or less remained on relatively higher levels in the manufacturing sector as a whole and in the metals and engineering sector. However, there after in the total manufacturing sector it fell to 13,200 in 1986 and to 13,000 in 1989. For the metals and Engineering sub-sector it was 32,400 in 1970, 29,700 in 1974, 30,200 in 1978, 32,100 in 1986 and 25,900 in 1989. (Labour productivity figures in Tshs).

One explanation to the falling labour productivity rates in the late 1970s and 1980s is the foreign exchange shortages which affected negatively importation of several industrial inputs. This is also reflected by the lower capacity utilization rates in that period. However, relatively higher productivity rates are seen in the metals and engineering sub-sector for the same period and this tends to confirm the previous observation by Wangwe (1979), that there were, in the engineering sector, some survival oriented innovations and designs activities which consequently helped to maintain relatively higher labour productivity. But it should be noted that such activities were isolated and on a small scale, and seemed to be temporary as they did not significantly raise the engineering sector's contribution to manufacturing value added or to their exports.

2.1:3 Export Performance

Table 2.3: Tanzania's Exports by Industrial Origin (Percentages)

	1971	1973	1975	1977	1978	1979	1980	1981
Total Exports	100	100	100	100	100	100	100	100
1 Agriculture	67.9	76.5	76.0	84.7	80.8	74.8	68.9	77.2
2 Mining Quarrying	12.5	8.0	7.3	3.3	6.7	6.5	7.9	10.1
3 Manufacturing	19.6	15.5	16.6	12.0	12.5	18.7	23.2	12.7
31 Food, Breverages, Tobacco	6.9	6.4	5.8	4.0	3.9	3.9	5.4	4.9
32 Textiles	2.6	3.3	3.6	3.0	3.5	7.9	8.5	2.9
33 Wood, Wood Products	0.5	0.6	0.3	0.2	0.3	0.2	0.2	0.3
34 Paper and Products	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.6
35 Chemicals	8.9	4.8	6.6	4.3	3.2	5.0	5.8	1.0
36 Non-Metal Minerals	0.1	0.1	0.0	0.1	0.3	0.3	0.3	0.1
37 Basic Metal Industries	0.1	0.1	0.1	0.1	0.2	0.5	0.6	0.2
38 Metal Manufacturing	0.4	0.2	0.1	0.3	1'.1	0.9	2.1	2.6
39 Other Manufacturing Industries	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1

Source: UN, Year book of International Trade Statistics (1977, 1982 and 1985 Issues).

From Table 2.3, it is seen that the agricultural sector accounted for more than 70% of total exports for the period 1971-1981. Within the same period manufactured exports continued to be far less and accounted for less than 22% in most of the years. And within the manufacturing sector it is mainly three sub-sectors which accounted for a larger export share; these were the Food, Beverages and Tobacco (ISIC 31), the Textiles (ISIC 32) and Chemicals (ISIC 35). However the Chemicals sub-sector's export included exports of petroleum products from the oil refinery whose production is based on crude oil which thus tended to exaggerate the true value of the manufactured exports.

On the other hand the metals and engineering subsector's (ISIC 37 & 38) manufactured exports was very small. This situation indicate that to a larger extent the Tanzanian manufacturing sector has not been successful in shifting significantly towards export orientation, and as such, most of the manufacturing industries are still of the import substitution nature mainly producing consumer goods. And while there has been some expansion in the metals and engineering sub-sector, it still remains small and there is no evidence that the sector received any special promotion in terms of its growth and technological development. As such Tanzania continues to rely less in terms of innovations and designs and equipment requirements from the local metals and engineering sub-sector.

2.1.4 Dependence on Foreign Technology

Table 2.4: Gross Fixed Capital Formation (1976 Prices)

Year	Gross Fixed Capital Formation (Tsh. Million)	GFCF/GDP (% ages)	The Share of Equipment in GFCF (% ages)
1964	1724	13.8	46.1
1967	3079	20.3	44.6
1970	4590	27.1	52.8
1973	4844	25.3	34.7
1976	5159	23.8	50.1
1979	6400	28.0	60.2
1980	5615	24.0	51.8
1981	5806	24.9	55.5
1982	6052	25.8	55.6
1983	4042	17.7	61.8
1984	5891	24.9	69.6
1985	7221	29.7	76.4
1986	7007	28.0	71.3
1987	9144	34.7	66.6
1988	8823	32.1	61.2
1989	6721	23.7	63.4
1990	6946	23.6	61.2

Source: National Accounts of Tanzania (Various Issues) and Economic Survey (various).

From Table 2.4, it is seen that, the levels of gross fixed capital formation was quite high and increasing in the years between 1964-1970. The share of gross fixed capital formation (GFCF) to gross domestic product increased from 13.8% in 1964, to 27.1% in 1970. Later, it fell a little to 25.3% in 1973, and to 23.8% in 1976. It rose again, reaching 28% in 1979, but fell again to 25.8% in 1982. However, thereafter it rose again and continued to remain high for the period 1986-1989. Within the GFCF a larger proportion (share) was the equipment which according to Table 2.4; its (equipment) lowest share in GFCF was 34.7% in 1973 and the highest share was 76.4% in 1985; and by 1990 it was still as high as 61.2%.

Most of the equipment could have been expected to come from the local capital goods sector or metals and engineering sub-sector, but the contribution of this sector in terms of value added and wage employment is not very large, indicating that the size of this sector in Tanzania is still very small. For this reason then, among others, most of the equipment used in Tanzania is imported and hence indicating high technological dependence on foreign sources.

Table 2.5: Tanzania's Composition of Imports
(% of Total Imports)

Year	Capital Goods	Intermediate Goods	Consumer Goods	Miscellan-eous Imports	Total Imports
1964	29.2	31.6	36.0	3.2	100
1967	42.5	33.8	20.2	3.5	100
1970	45.2	5.5	15.1	4.2	100
1973	43.2	38.4	14.0	4.4	100
1976	40.4	37.1	18.6	3.9	100
1979	54.7	37.1	8.2	-	100
1982	43.8	37.2	18.8	0.2	100
1985	35.6	43.1	21.2	0.1	100
1986	47.2	32.7	20.1	-	100
1987	53.1	30.2	16.7	-	100
1988	34.1	42.8	23.1	-	100
1989	39.2	45.3	15.5	-	100
1990*	40.8	47.7	11.5	-	100

Notes: * = Estimates

Source: Bank of Tanzania, Economic and Operation Reports (various issues).

The share of capital goods' imports has therefore continued to be high in Tanzania, and this, in general terms, indicate the high level of foreign technological dependence. On the other hand this also supports the above observation that it is the consumer goods manufacturing sectors, such as Food and Textiles and others which dominated the Tanzanian manufacturing sector in terms of both value added contribution and wage employment share. As such, in terms of percentages less consumer goods were imported as compared with the capital goods or intermediate goods, as shown in Table 2.4 above.

2.2:0 Policies, Institutional Infrastructure and other Socio-Economic Factors related to Technological Development in Tanzanian Manufacturing Industries

During the colonial period (prior to 1961) Tanzania's manufacturing industries performed mainly two tasks. First, they processed primary products for export and secondly, they produced very simple consumer goods mostly for the small urban population (not more than 5% of total population). There were few manufacturing industries existing in 1961 including 6 companies which were owned by Trans-nationals. The other smaller companies were owned by Asians and Europeans both nationals and foreigners.

At independence in 1961, the level of Tanzanian industrial development was very low. There were around 220 establishments, employing at least 10 people and only very few employing over 50 people. Fixed assets were very small and only very few had investment of above Tanzanian shillings 200,000. Total manufacturing employment was about 20,000 people and the manufacturing sector as a whole contributed only about 4.3% of GDP.[2]

However in the first three year plan (1961-1964); acting on the policies (quick returns from investment) recommended by Arthur D. Little (1961) and the

[2]See Bank of Tanzania (1982)

World Bank (1961), more import substitution (for simple consumer goods) manufacturing industries were to be established. Rweyemamu (1973) noted that in the period 1961-1964, the government (of Tanganyika) gave some financial assistance to the industries through the Tanganyika Development corporation and also created favourable conditions and policies such as publicising existing investment opportunities and designing a tax incentive structure to attract foreign capital or investment. In all these industrial policies however, no consideration of technological development was taken into account.

Since the first Five Year Plan (1964-1969) there was, in general, continual expansion of the Tanzanian manufacturing sector.

In 1967 Tanzania announced her political objectives in the Arusha Declaration. It was vigorously stated that Tanzania was to build a socialist and a self-reliant state and the major means of the economy were to be nationalized; these included banks, import and export trade, some manufacturing industries and marketing bodies, among others.

However, while aspiring to be self-reliant is a good thing, to achieve it is a different thing altogether, and it requires deliberate and qualified efforts. It seems the Arusha Declaration did not give enough attention or consideration to the concept of technological self-reliance.

It has been noted in chapter one of this study that it is very difficult to be economically self-reliant without being technologically self-reliant. Moreover, the concept of technological self reliant does not mean cutting off from outside world. Instead technological self-reliance mean to be able to master technology itself and this could best be achieved by learning from the experiences of others too. Thus nationalization was a wrong strategy to begin with because it reduced the chances of learning from others. Adei (1987) noted that the concept of nationalization has to be taken with caution.

Also partly as a result of nationalisation policy there was growing public involvement in economic activities in Tanzania. Thus, the share of the public sector in the Tanzanian manufacturing sector increased both in terms of contribution to the manufacturing value added and manufacturing employment. For instance, in 1966 the share of the public sector in manufacturing value added was 5% while the share of public sector in manufacturing employment was 16%. In 1970 the figures were 26% and 32% respectively. These shares grew and remained high. By 1980 the figures were 37% and 50%

respectively.[3]

The period 1969-1978 and especially 1974-1978 saw massive investment expansion in the manufacturing sector (new projects). At the same time the implementation of the Basic industrial strategy and the role of foreign investors contributed substantially in this respect which essentially led to the expansion of the public sector in the Tanzanian manufacturing sector. However, Perkins (1983) noted that the Tanzanian planning authorities (despite that large proportion of public sector in Tanzania) did not put much emphasis on technological issues in approving the establishment of new industrial plants or projects. The levels of Tanzanian participation or influence on technological choices in many project contracts, and in technological training was thus very low if not ignored in most cases.

To sum up, there was very little attempt by both foreign investors and Tanzanian planning authorities in fostering technological development in Tanzanian manufacturing industries. This problem together with other problems such as severe shortage of foreign exchange and lack of adequate skilled managerial and technical manpower increased the possibility of ignoring or failure to build technological capability in Tanzania. With a

[3]See Bank of Tanzania, Economic and Operations Report (various issues).

much more severe crisis of foreign exchange shortages in the period of the late 1970s to the early 1980s, the situation worsened and thus further hampered efforts in fostering technological development.

Even the Structural Adjustment Programme (SAP 1982) and the national Economic Survival Programme (NESP 1981 and 1982) concentrated much more on foreign exchange issues and on structural imbalances. Technological issues were again ignored and became almost over-shadowed by the need to solve foreign exchange crisis. The Economic Recovery Programmes (ERP1 1986 to 1989 and ERP2 since 1989) too, did not address the problems related to technological development.

Moreover, since independence (1961) Tanzania has lacked an effective Science and Technology policy. In fact it was not until the early 1980s that the concern for having an effective Science and Technology policy was seriously raised in Tanzania. On the recommendations from the National Seminar for Science and Technology Development in 1984, the Tanzanian government prepared a document on Science and Technology policy in 1985; and later on, the National Commission for Science and technology (COSTECH), formerly known as the National Scientific Research Council (NSRC), was established by the act of parliament in 1986.

COSTECH is an umbrella organisation resulting from some efforts which have been put into building the technological institutional framework in Tanzania, that is the establishment of sectoral institutions for science and technological development. So within the industrial sector apart from the general role played by the COSTECH there are many established technological institutions some of which are analysed in chapter 8 of this study. These forms the first category of the Tanzanian technological institutional framework.

The Second category within the Tanzanian technological institutional framework in the industrial sector involve some engineering firms of which some are analysed in chapter 7. And the third category in the Tanzanian technological institutional framework is the educational institutions such as the University of Dar es Salaam's Faculty of Engineering and the Dar-es-Salaam Technical college which are also analysed in chapter 8.

CHAPTER 3

LITERATURE REVIEW

3.0 Introduction

The theoretical questions of technical change and productivity were also dealt with by earlier economists such as Adam Smith in the Wealth of Nations (1776) and Joseph Schumpeter in Theories der Wirtschafliche Entwicklung (1811). However, as Zuscovitch (1986) explained, it was not until the period of post World war two economic growth and the work of Abramotiz (1956), Kuznets (1954) and Salter (1966) that economists began seriously to study the relationship between technical change and economic development.[1] Since then, several authors, using various prevailing approaches have investigated and measured technical change.[2] So various forms of technical change have been analysed in both developed and developing countries.[3]

This chapter is divided into four main parts. The first part is an introduction to the chapter. The second part is on various measures of technical change. The

[1] See also Kendrick's (1961, 1973), Salter (1966) and Schmookler (1966)

[2] For Various prevailing approaches of measuring Technical Change, see also Gold (1977)

[3] See Chapter 4 for various forms of Technical Change

third part is on issues of technical capability in developing countries with examples of some developing countries which have succeeded or failed to build technological capability. The fourth part has summarised the chapter and noted some lessons which unsuccessful developing countries can learn from successful developing countries in issues of technological capability.

3.1:0 Measures of Technical Change

3.1:1 Use of Functional Forms

The problems involved in measurement of technical change have led to the emergence of different approaches of measurement of technical change which can broadly be categorized in four main groups.[4] The first group uses econometric estimation, the second group uses index numbers and the third approach applies non-parametric methods using linear programming. The first two approaches are briefly explained in this section 3.1:1. The fourth group use input and output indicators of technical change and is briefly explained in section 3.1:2.

Various econometricians have described technical change with a simple time trend as part of the econometric estimation of the production or cost function. Several

[4]Baltagi and Griffin (1988) note that the first three approaches are summarised by Diewert (1981)

studies have used the simple time trend as directly representing technical change. Such studies include Intrilligator (1965, 1982), Brown (1966), Lydall (1968), Sato (1970) and Venkataswami (1974); among others.

Most of the above cited studies are based on the Cobb-Douglas production Function (CD) and/or the Constant Elasticity of Substitution (CES).[5] These production functions were also successfully used by Solow (1957, 1959) and Arrow, Chenery, Minhas and Solow (1961). In general it can be said that most econometric studies in the 1950s used CD function, while in the 1960s the trend seem to have shifted in favour of the CES function.

There are, however, a number of limitations associated with the application of such function forms. These are explained in chapter 5 of this study. The noted limitations (in chapter 5) instigated some economists to look into other alternative measures of technical change. Some of the alternatives are mere developments within the econometric approaches of measuring technical change, and yet others are shift-overs to other different approaches such as use of index numbers and use of input output indicators.

In view of the problems related to inadequate data in Tanzania, other more complicated approaches such as those arising from the developments within the econometric

[5] See also Chenery (1949), and Furubotn (1965)

approach, the frontier production function analysis, the engineering production function analysis and the input-output (linear programming) analysis of technical change have been avoided in this study.[6] In this sense, with respect to quantitative analysis, we have in this study applied econometric estimation of average CD function whereby time trend is introduced to represent at least a crude or rough measure of technical change.

The failure of the use of functional forms to measure correctly technical change, instigated further, some economists to try other approaches. This has been especially important for developing countries. In this case the qualitative analysis of input and output indicators of technical change is explained in section 3.1:2 below.

3.1:2 Input and Output Indicators of Technical Change

The input and output indicators of technical change are sometimes used together or separately and in some cases qualitative or quantitative analysis or both are employed. In this section we have reviewed some of the studies which have used these indicators.

To start with, Fransman (1985) and Teitel (1987) noted that, in general, input indicators include: total

[6] For some advanced and complicated approaches see Forsund and Hjalmarsson (1987) and Chenery (1949).

expenditure on research and development, science and technology personnel (training: in most cases represented by number of personnel with say university degrees in science and engineering, utilization of scientists and engineers in research and development work) and years of experience in producing the particular products and related products.

And the output indicators include: output itself, patents and exports especially technology exports; and others such as Noble prizes and number of scientific papers published, quoted or referred to in the national and international literature.

Among some studies which have used these indicators include that by Mansfield (1968) on some few USA manufacturing industries. The results he obtained indicated a significant effect of an industry's R & D spending on its measured rate of technical progress.

Leonard (1971) carried out a study on 16 industries groups in USA for the period 1960-1967. His results confirmed a positive role by R & D in generating industrial growth (output) and in addition he concluded that self (company or industry) financing R & D spending had a much larger impact than government's, upon both growth of industry output and growth of output per worker. Also Shaw and Leet's (1973) study on 21 USA manufacturing industries from 1948 to 1968 confirmed that R & D expenditures led to productivity advance.

However, it has been discovered that different indicators sometimes give different results. This was confirmed by Leonard (1971) and Pavitt (1982), among others. As a result of this, various authors have tried to isolate the relative contribution of various indicators and such efforts have helped to bring out the difficulties inherent in these kinds of measurements, analyses and implications for assessing various indicators. Therefore in measuring any indicator, much depends on choosing representative variables and that the use of different indicators should not be generalized for all situations among different countries.

Lall and Mohammed's (1983) study analysed for the periods 1976-1977 and 1977-1978, various enterprises in industries in India and the USA. The main result was that R & D was an important determinant of technology exports.

On the other hand, Teitel's (1987) study concentrated on international comparisons on input indicators. He concluded that there was sufficient discrepancy in terms of equality of coefficients and statistical significance of explanatory variables to warrant separate fits for developing countries and for developed countries. In other words, he rejected the use of average coefficients, on equal terms, for all countries.

Fransman (1983, 1985) summarised some of the problems associated with the use of such input-output indicators. First, he asserted that in the case of output indicators, it is extremely difficult if not impossible to weigh patents in order to aggregate them, and that for various reasons most innovations in LDCs are often not patented as noted also by Wangwe (1979) and Wangwe and Luvanga (1990). In addition, it is noted that patents do not capture fully the incremental forms of technical change which are more common in LDCs. Further, Rosenberg (1982) noted that output indicators fail to capture quality improvements. And finally it is noted that the use of exports (or technology exports) indicators have a problem in the sense that exports (or increased exports) may result either from factor cost differences or from successful technical change; and that to the extent that the former is the case, exports may be an inadequate indicator of technical change.

Input indicators of technical change also have some limitations. Fransman (1985) noted that if input indicators are used alone rather than together with other measures such as output (in the case of productivity) they may be misleading since they bear no direct relationship to output. Moreover, it is the output of the input indicators rather than the input indicators themselves which are more important. In other words, for instance, not all engineers and scientists or money allocated to R

& D activities are fully utilized for the purpose. In addition, input indicators fail to capture the contribution of other inputs into the technical change process. And finally, as Teitel (1987) noted, there are some difficulties in applying the indicators of the quality and quantity of the scientific research carried out in LDCs, mostly because few of such works are published internationally.

On top of the above noted problems, both Lall and Mohammed (1983) and Teitel (1987) argued that severe limitations of data in LDCs make it difficult to construct many and correct indicators and for carrying out proper testing of their influences on technical change. Therefore, the input and output indicators may not be the best measures of technical change. However, they certainly give a general indication of technological change (capability) of a firm, industry or country. And this may be much more important for LDCs where traditional measures of technical change as discussed above in 3.1:1 fail to capture fully some of the aspects of different forms of technical change (incremental) which are more common (LDCs). Mclean and Round (1978) noted that some issues like the learning effects cannot easily be captured by traditional measures. In this case then it becomes better to supplement qualitative (interpretative) analysis to traditional measures, especially if one is analysing technical change (capability) in LDCs. Fransman (1982) explained that within this framework there have been a growing volume of literature on technical change (capability) in LDCs. Some of such studies are reviewed in the following section.

3.2:0 Technological Capability in LDCs

3.2:1 The Experiences of Semi-Industrialized Asian Countries

In this section we review the experiences of South Korea, Hong Kong, Singapore and India in building up and use of technological capabilities. That is, in the 1960s foreign investment followed the South Korean Foreign Capital Promotion Law (passed in 1960) which regulated both direct foreign investment and the acquisition of technology.

Amsden and Kim (1982) in Fransman (1985) explained that in South Korea in the 1960s there were little licensing for foreign technology imports because of the restrictions on the levels of royalties and on the length of contract periods and exclusion of export restriction clause.

It is noted also in Fransman (1985) that South Korean technological development took place mainly in the 1970s and the 1980s when the above noted restrictions were liberalised. In general the 1970s and the 1980s liberalisations led to an increase in both the number of contractual agreements and royalty payments (licensing increased). Direct foreign investment, too, especially in sectors such electronics, oil refining and fertilizers increased substantially. And in other sectors such as ship building and integrated steel mill; turnkey arrangements, machinery imports and licensing were used in acquiring foreign technology.

At the same time, South Korean nationals played a significant and active role. This is noted by Dahlman and Westphal (1982). Thus for instance, training both locally and internationally was taken seriously. Dahlman, Ross-Larson and Westphal (1987) argued that, one way in which acquisition of technological capabilities was accelerated in South Korea was through starting the study, training and practice well in advance of the start up of the new project. Such preparations for instance helped South Korea to produce her first world class tanker only 30 months after breaking ground for the shipyard.

Dahlman and Westphal (1982) argued that also selectivity (in use of foreign resources) accelerated South Korean process of acquisition of technological capabilities. For instance that, South Korea managed to produce world standard capital goods by venturing in industries for which process technology is not product specific; so that the initial achievement of mastery permitted the copying of foreign products as a means of enlarging technological capabilities. Such industries included mechanical engineering industries and textile machinery.

Dahlman and Westphal (1982) and Fransman (1985) explained that the export activity also played a very important role in the South Korean process of acquiring technological capabilities. In this regard, for example, South Korea acquired information almost costlessly, which were diffused through various ways by the buyers of their exports (indirect stimuli). This, it is argued helped to increase production efficiency, changing production designs, upgrading quality and improving management qualities. This is what Westphal, Rhee and Pursell (1984) called the importance of information feedback provided by users to firms in the export sector. Rosenberg (1982) referred it as "learning by exporting". In fact Westphal, Rhee and Pursell (1984) and Westphal (1984) found that this process was a very important source of product improvement and in certain cases of process improvement in South Korea.

The government policies and actions also helped in the South Korean process of acquiring technological capability. Balassa (1982) in Fransman (1985) argued that South Korea (and Singapore and Taiwan) had a better export performance because she (South Korea) avoided a bias against export and primary activities, and instead provided broadly equal incentives to most exports and ensured the stability of the incentive system. In fact, the South Korean government discriminated in favour of export activities. Pack and Westphal (1986) noted that the South Korean government did not practice neutrality in its incentive policies. And that it also discriminated in its treatment between established and internationally competitive industries versus new infant industries that were deemed worthy of promotion.

In South Korea, therefore, infant industries (set changing from time to time) benefited from protection (tariffs), credit preferences and various forms of tax inducement. But when such infant industries matured, they were exposed to international competition by entering the export sector. And when such protective and incentive policies failed to help a desired infant industry's creation, a public enterprise was established. For example it is noted that the first producers of fertilizers, petrochemicals, refined petroleum products and steel mill were such public enterprises.

Fransman (1985), summarised the above, by noting that South Korea used a combination of carrots (protection and subsidies) and sticks (incentives) contingent on export performances to promote both technological and industrial development.

Further, Dahlman and Sercovich (1984) argued that the willingness to undertake very high investments in technical human capital formation and some expenditure on R & D contributed greatly, in addition to the above noted factors, in the acquisition of technological capabilities in South Korea.

As a result (partly) of successful acquisition of technological capabilities, it is noted that, South Korea is now quite developed in plywood, textiles, construction works, ship building and cement production. That is, it produces more of these and exports them. In addition South Korea now exports technology mainly through exports of construction works, projects and some technical services.westphal,

And finally Westphal (1982) and Westphal, Rhee, and Pursell (1984) argued that the South Korean experience show that selective intervention need not be inimical to successful industrialization. Instead it did accelerate the rate of industrial growth, with little if any, compensating loss in efficiency. As noted above, it fostered the rapid achievement of international competitiveness and the fast expansion of output. However, Pack and Westphal (1986) noted also some costly mistakes arising from that selective South Korean policy.[7] But they argue that such mistakes are not a sufficient reason to condemn that policy.

[7]One of such mistakes was over investment in heavy engineering industries. For details of other mistakes, See Pack and Westphal (1986).

policy.

Singapore is another Asian country which is reviewed in this section. Fransman (1983) investigated the promotion of technological capability in the capital goods sector in Singapore. He noted that since the mid 1970s the government of Singapore made specific efforts to encourage economic growth. That is, there was a move away from policies of import substitution, towards export oriented policies. At the same time, machine production was given special priority (income tax relief). And in addition export incentives, attractive low costs (labour costs) and efficiency of labour together with favourable infrastructure, access to the markets of the East Asian countries and domestic political stability made it possible for increased inflow of foreign investment in Singapore.

Balassa (1982) noted that both wholly foreign owned firms and joint ventures contributed greatly to capital accumulation in Singapore. And that, in general, Singapore's government instituted a near free trade regime (did not provide protection and did not provide subsidized credits as in South Korea); and thus allowed for competitive pressure (export market) which required improvements in products. This was also helped by information feedback from machine users in foreign markets.

Finally, it is noted that other factors such as increase in real wages, additional investment incentives and the expansions of training and education facilities, also accelerated acquisition of technological capabilities in Singapore.

Such efforts and capabilities in Singapore, led to increase in output of machine tools and the growth of the capital goods sector in the 1980s. Fransman (1983) emphasised also the positive role of Singaporean nationals. That is, local machine producers produced less complex products, and possessed in-house capability for product change something which was not exhibited by the foreign firms which regarded Singapore primarily as a production location while leaving in their home countries or elsewhere technological change functions such as design improvements.

Hong Kong is the next Asian country to be reviewed. According to Fransman (1982), Hong Kong had a comparatively narrower manufacturing base (as compared to countries such as South Korea and Singapore, among others) in terms of sub-sectoral specialization. And that the capital goods sector was also comparatively of less importance to the rest of manufacturing sector, in terms of the contribution to manufacturing value added and employment. Such state of the capital goods sector was probably the result of the almost complete absence of government intervention in the capital goods sector and in the industrial sector in general, (unlike in South Korea and Singapore). In that sense, Little (1979) referred Hong Kong as a "perfect free trade regime".

Fransman (1982) found that capital goods firms in Hong Kong enjoyed an international competitive advantage and that this was possible because the firms had succeeded in introducing product innovation. He also noted that the firms managed to withstand the pressures of an exceptionally competitive environment because the firms were producing cheap (at competitive prices) and lower quality machinery which were meant for lower income market. And, the firms also provided servicing and repair facilities to local customers while most of the foreign competitors did not provide such services.

The Hong Kong local firms were also producing (located) near the markets, and so they enjoyed lower transport costs. They (local firms) also had access to second hand equipment which were cheaper, easier to repair and simpler to operate; thus in general resulting in lower running costs. The local firms thus did maintenance and repair work on their machinery and equipment, and did not produce any substantial modification or adaptation. And also because the local firms did not use the machines they themselves produced, they did not achieve process technological change, which is a further reflection of the simple level of their technological capability. This fact is also reflected in Hong Kong's simple machinery and embodied technology exports. Unlike other semi-industrialized countries, Hong Kong did not export turnkey projects, licensing and consultancy agreements, and did not enter into agreements for the purchase of foreign technology such as licensing and purchasing of turnkey plants and equipments.

Finally, in this section we review the experience of India. Fransman (1983, 1985), Lall (1982) and Dahlman and Sercovich (1984) explained several reasons as to the success of India in building technological capability. Chief among such reasons is the wide protection and promotion given to the process of learning at different levels.

Lall in Fransman (1985) concluded that on the basis of Indian experience it can be argued that in some situations the protection of local knowledge creating capabilities may be justified. The other reason, is the advantages of comparatively (in comparison to developed countries) lower labour costs, in India, in carrying out embodiment activities and in providing technical services. This applies mainly to construction and engineering firms and it helped India in the production and export of computer software as well as engineering consultancy.

The other reason is the deliberate efforts by firms to modify and adapt their product process or organizational techniques to make better use of local resources, save capital, improve energy balances or meet particular local needs. Such deliberate efforts helped Indian firms which had older (no longer available in developed countries) technology to export renovated textile plants to African countries.

India also put emphasis on the use of its abundant resources. India's well developed technical base and its very large absolute stock of scientists and engineers (high investment in human capital formation) made it possible for the government of India to greatly promote the development of local consulting and engineering services and of local research facilities, thus giving India a large local R & D infrastructure. In addition, the Indian government promoted the development of specific priority sectors such as power generation and textiles.

On the other hand Dahlman and Sercovich (1984) noted that India (unlike South Korea) practiced very restrictive policies towards the inflows of foreign technology.[8] Thus, India encouraged, promoted and protected indigenous technological capabilities, resulting in a broad based, diverse and complex capital goods sector, as is noted by Lall (1984a, 1984b) and Fransman (1985) among others. The

[8]For more comparisons between India's and South Korea's experiences, see Keller (1991).

development of the capital goods sector was also helped by India's large market size (protected but with local competitions).

In addition Kaplinsky (1984) noted that the institutionalization of technical change (scientific capability) ensured a sustained period of technical progress in some other sectors such as the sugar industry.

It is noted, however, that only in few certain cases foreign technology was imported, and that in such cases Indian nationals were quite active in manoeuvring in order to get technology that was adaptable or was already adapted to local conditions. Dahlman, Ross- Larson and Westphal (1987) noted that the Hindustan Machine tool Company in India managed to get a Swiss joint venture partner who was ready to supply or design for them new technology which was suitable to local environment; and also which was to provide a tremendous amount of training in India and in Switzerland.

Due to technological efforts, and capabilities, India succeeded to a certain extent in raising industrial production and exports of goods and technology. Dahlman and Sercovich (1984), for example, noted that India is now developed in power generation and distribution, with its electrical equipment manufacturing firm (BHEL) said to be ranking among the largest and most integrated in the world. And Lall (1982) and Fransman (1982) noted that

India exports turnkey projects, consultancy services and some direct foreign investments and licenses. However, in terms of efficiency, Keller (1991) noted that India performed very poorly when compared to South Korea, because of its (India's) excessive protective policies which obstructed competition which is in turn a basis for efficiency. Thus Keller (1991) concluded that the case of India and Korea indicated that technological capabilities was a necessary but not a sufficient condition to efficient industrialization.

3.2:2 The Experiences of Semi-Industrialized Latin American Countries

In this section the countries to be reviewed are Brazil, Argentina and Mexico. Teitel (1984) noted that technological activities in the Semi-Industrialized Latin American countries led to the adaptations of imported technologies as well as to the development of new products and processes.

To identify the various factors which helped these countries to successfully build up technological capability, several authors such as Dahlman and Fonseca (1978), Dahlman and Westphal (1982) and Bell, Ross-Larson and Westphal (1984), used the explanation on the creation and development of the Usiminas Steel plant in Brazil.[9]

---

[9] "Success" here is a relative concept amongst developing countries and not between developing and developed countries as in Blomström and Meller (1991) which compare Scandinavian and Latin American Economic Development experiences

It is argued first that many of the characteristics that made the Usiminas successful are the same in most other industrial sectors in most LDCs. The Usiminas firm started in the late 1950s, with the local entrepreneurs and authorities aiming at obtaining greater value added from the country' abundant iron exports.

However, the Brazilians lacked the technology and experience to set up and operate such a plant as Usiminas. So, as they commissioned feasibility studies on the firm, they also sent teams to visit foreign steel plants in order to get first hand experience of different processes and equipment.

At the same time they (the Brazilians), solicited offers from foreign producers of different technologies, ending up with a joint venture with Japanese steel makers and steel equipment suppliers. The Brazilians worked closely with the Japanese from the beginning and so learnt many aspects of the design, equipment selection, installation, construction, start up and operation of the plant. And there was also a lot of training in Japan.

After three years of technical training and production experience under the Japanese, the Brazilians took operational responsibility of the plant. However, that occurred during a financial crisis (due to recession in steel demand) and also when the plant had reached its rated capacity. So the only way the firm could break even was to expand, but because of the financial crisis, the firm's expansion was constrained by the lack of capital. So the firm resorted to stretching the capacity of its blast furnace and steel making sections.

As a result of the above noted efforts, it is noted that over the ensuring six years, the capacity of those sections (Blast furnace and steel making sections) was more than doubled; with almost no additional investment in equipment and no additions to the work force. Thus the plants total factor productivity was also more than doubled.

It is noted that key to the above explained success, was the expansion and specialization of the internal technical support infrastructure (engineering and information department). In addition, plant personnel were sent abroad for courses and practical experience in specific problem areas which were encountered.

As the plant's specialised personnel gained more understanding of steel production, they made more (minor) adaptations and increased performance. In this way a research center within the firm was created and was used in solving some operational problems. Also applied product and process research were carried out and some of it led to the development of new products and processes.

Later on the Usiminas plant expanded its engineering staff and carried out some plant expansion and designed and procured some capital goods. In this way the engineering department was transformed into being a subsidiary to manufacture capital goods for steel industry and also managed to export some of such capital goods and technical services (including training) to neighbouring countries. In this way Usiminas plant attained international competitiveness. Maxwell (1977, 1982) noted more or less similar success for the Argentinean Acida Steel Company at Rosario. However, Teitel (1984) noted that while Usiminas was a public enterprise, Acidar was a private one. Therefore, it is possible, in both public and private enterprises to build and develop technological capabilities, other things being equal.

Teitel (1984), Katz (1984) and Bell, Ross-Larson and Westphal (1984) noted other more factors which contributed in the acquisition of technological capability in Latin American countries. Such activities include; the market structure, firm and entrepreneurial factors, availability of skilled human resources, protective and other government policies.

Teitel and Sercovich (1984) argued that while Latin American countries may have taken excessive protection, that did not act as an obstacle to technical change activities. Tayler (1981) and Teubal (1984) too, noted the presence of protection in Latin American countries. They noted that in most cases the import of embodied technology was prohibited in the event of the availability of national "similars". In addition, as Dahlman (1982) noted in the case of Brazil, investment incentive schemes favoured the purchase of locally produced capital goods; and so helped to develop the local capital goods.

And finally, as Dahlman, Ross-Larson and Westphal (1987) noted also, that the Brazilian government imposed requirements on multinational automobile companies to increase the local content of their products. This helped in the development of the machine tool industries. And in addition to extensive training, Dahlman and Sercovich (1984) noted that the abundance or scarcity of particular resources gave a challenge to develop related industries and technologies.

In general terms, Dahlman and Sercovich (1984) noted that Latin American countries relied more on direct foreign investment, foreign licenses and imports of disembodied technology as channels for the acquisition of foreign technology. Studies like Katz (1978), Katz and Ablin (1979), Lall (1979, 1982 and 1984a), Dahlman and Sercovich (1984), Westphal and Rhee (1982), Fransman (1985), Teubal (1984) and Teitel (1984); noted that there was substantial increase in the production of consumer and capital goods and in the exports of technology from these

Latin American countries.

It is noted in this case, for instance, that Brazil exports turnkey projects mainly in the fields of steel and alccholic and distilling. Argentina exports turnkey projects mainly in the fields of food processing, chemicals and glass. And Mexico exports turnkey projects mainly in the fields of food processing and oil exploration. In addition, all these countries export direct foreign investment, consultancy, licensing and various combinations of capital goods (embodied technology) and technical services.

3.2:3 Review of Studies on Ghana and Tanzania

This part deals with Ghana and Tanzania as examples of LDCs which have not been successful in building domestic technological capability. Industries in such countries have not yet matured in the sense of being internationally competitive, and that in such countries the gap between the existing practice and the world technology frontier is greater.

Ghana, a West African country, gained its independence in 1957 (being the first black African country to achieve independence), only about 10 years after India's independence in 1948. As noted above India has now successfully acquired technological capability, while according to Adei (1987) Ghana has not. Ghana like many other LDCs sought to overcome underdevelopment through industrialization (mainly import substitution industries), but registered poor industrial performances.

Adei (1987) noted that among the reasons for Ghana's poor industrial performance is the lack of technological capability and severe foreign exchange shortages. In addition Adei (1987) noted some of the factors which contributed to lack of technological capability in Ghana's industries. First, that since independence Ghana lacked effective government machinery to draw up effective science and technology policies or to effectively implement them in case they existed.

Secondly that, imports of technology were not monitored to ensure an effective transfer of imported technology. Third, that nationalization was carried out without proper considerations and plans to fill the technical services gaps created by the expatriates who left, and created by the cut offs by former parent companies. And that, even some local experts created a gap by leaving, partly due to deteriorating services conditions after nationalization.

Fourth, that during and even after nationalization the government of Ghana did very little to provide resources and personnel for the nationalized industries; and more notably neglected or gave very minimal considerations to technological issues.

Adei (1987) further argued that while nationalization accords a country the opportunities to develop technological capability, to be successful in that aspect, it is important to put some appropriate and deliberate efforts. Such efforts, it is argued include creating effective science and technology policy, availability of trained manpower to man various industrial activities and creation and fully utilization of technical institutional support machinery.

Adei (1987) made some partial policy recommendations and conclusions and suggested that these be used only as hypotheses for further studies. He asserted that it is too much of a risk for LDCs to venture into nationalization without proper assessment and plans for the development of technological capability which he argued is supposed to be the most crucial responsibility of a government. Adei (1987) findings and suggestions may as well be relevant to Tanzania, especially taking into consideration that both countries ventured into nationalization and also both have not been successful in the process of building technological capability.

Among the few available studies in Tanzania in the field of industrial development and technological problems are: Wangwe (1979), Wangwe and Luvanga (1990), Mlawa (1983), Perkins (1983), Alange (1987) and Wangwe in Stewart, Lall and Wangwe (1992). Wangwe (1979) found that there were some simple designs and innovations activities in the engineering sector in Tanzania for the period up to 1978. Such activities were mainly in response to problems brought about by foreign exchange shortages which affected negatively the importation of industrial raw materials and intermediate inputs.

It is noted that where such designs and innovations activities occurred, they helped to boost or to maintain the levels of industrial performances from falling much more down. For the post 1979 period, Ndulu (1986) noted that there were a relatively smaller decline in manufacturing output compared to the decline in capacity utilization and intermediate import supply. And that this was only possible because of substitution of labour and domestic material for capital and imported inputs. However, it is not clear whether, such activities as confirmed by Wangwe (1979) and Ndulu (1986) were mere short term, sporadic and uncoordinated responses to foreign exchange shortages. It is doubtful whether such activities were part of deliberate and purposeful efforts to acquire technological capabilities.

Mlawa (1983) found a negative productivity change in the textile industry in Tanzania for the period 1973 to 1979. Summarising Mlawa's (1983) results, authors Bell, Ross-Larson and Westphal (1984) argued that there were very little "training" in Tanzanian textile industry, which as a result contributed partly to the absence of technical change in the industry and hence the observed very low or negative productivity changes.

On the other hand, Perkins (1983), found that even in the state owned Tanzanian industries (about half of Tanzania's industries were state owned) issues related to technology were neglected in both the pre and after 1967 nationalization, and that there was no effective technological policy.

Alänge's (1987) study was concerned with issues related to technological capabilities in the Tanzanian Small Scale Industries (SIDO). He noted that severe foreign exchange shortages in the early 1980s, affected the supply of raw materials to various firms. In this regard, first Alänge (1987) acknowledged that scarcity of raw materials and other inputs affected positively the process of "learning" and thus stimulated the search for alternatives and for new products and markets.

Alänge (1987) found that some small scale industries in Tanzania searched actively for local raw material sources and developed new products that increased the utilization efficiency of some of the imported raw materials as well as of the local raw materials. However, Alänge noted also that severe foreign exchange affected negatively technological capability build up. This was in terms of missed production " experience" due to interruption in production because of shortages of imported inputs.

Wangwe and Luvanga (1990) argued that the Tanzanian capital goods sector is very small and negligible such that it has not contributed much in the process of acquiring technological capability. And that this was due to the shortages of skilled manpower in the science and technological occupations. They also argued that factors such as the general decline in economic growth, together with poor infrastructural development, very little resources (funds, manpower and facilities) being allocated to R & D activities and lack of a clear and effective technological policy and lack of coordination among various technological agents and institutions and industries (production units) have also contributed to that failure.

Wangwe in Stewart, et. al (1992) found very low levels of technological efforts and capabilities in the Tanzanian cement, farm implements, sugar and textiles industries. He also noted a continual high degree of technological dependence on foreign sources. He attributed this to some roles of foreign investors and to the limited local participation in technological activities in addition to the problems noted in Wangwe and Luvanga (1990).

3.2:4 Review of Relatively Successful African Experiences.

It is not only the experiences of Ghana and Tanzania which indicate that industrialization in Africa has been very deficient with cases of stagnation and even deindustrialization in the 1980s. In fact according to Lall in Stewart, et. al (1992) industries in most of the African countries had very low levels of technological capabilities with a consequent failure to initiate and manage industrial ventures efficiently together with the heavy dependence on foreigners and imports. There were also many inappropriate technology decisions, low capacity utilisation, low and declining productivities and the non-existence of manufactured exports.

However, according to Lall, there are few successful experiences in African industries which show that failure, though widespread, is not inevitable. Accordingly, then, this section reviews briefly the three successfull experiences in Mauritius, Kenya and Zimbabwe.

To start with, in Mauritius since the mid-1970s four factors are important. First, there was a high level of human capital development. Secondly, from the 1970s macroeconomic policies favoured export-oriented industrialization. Thirdly, companies from Hong Kong, anxious to diversify their location, took advantage of these (first and second) favourable conditions. And fourthly, local (Mauritians) entrepreneurship was also very active (with close links with India) and was responsible for half of the manufactured exports. These four factors helped Mauritius manage to develop a garment industry which thus diplaced sugar as the island's biggest export. In other words, we note that the ability of Mauritian enterprises was supplemented by investors from Asia, to set up garment exporting facilities to the advantage of its export orientation. The technology involved was simple to master, but the organisation of production and export marketing required skills and enterprise lacking in many other African countries which were now made availlable in Mauritius by foreign investors.

And with respect to Kenya, its textile industry achieved a high degree of technological capability, with substantial and prolonged infusions of skills from experienced technicians from India. Relying also on local capabilities especially by white settlers, Zimbabwe managed to set up an integrated iron and steel mill (ZISCO) which was quite efficient and was state owned and highly protected. In sum these three relatively successful African cases indicate that in African countries with more developed capabilities or access to foreign capabilities, the results have been comparatively better than in others. And this may be a source of optimism for other African countries (including Tanzania).

3.3:0 Summary of the Literature Review

In view of the disadvantages and advantages of various reviewed methods of measuring technical change and also in view of the severe data constraint in LDCs, this study uses both the quantitative and qualitative analyses such that they complement each other.

This chapter also has reviewed extensively the experiences of both the successful and unsuccessful LDCs in technological capability issues. In this case, this chapter has highlighted some of the important lessons which unsuccessful LDCs like Tanzania and Ghana can learn from the relatively successful LDCs like the semi-industrialized Asian and Latin American countries as well as from the few African cases.

To start with, the basic lesson is that while technological change (capability) can raise productivity, it (technological capability) does not come automatically, cheaply or easily from passively importing technology nor does it come merely from experience. In view of limited resources (skilled manpower, facilities and funds) and differences in potentialities (natural resources) then , strategic selectivity is quite important. Therefore, specific and appropriate technological efforts are neccessarily needed.

Technological efforts in this context include training of adequate manpower in various specific technological fields or activities; establishing and utilising effectively technological institutions; establishing and supporting (priority) specific dynamically technological industries such as engineering or capital goods industries. In addition, it is also important to have an effective technological policy so as to coordinate, influence and guide technological development. In this case the provision of specific protections, incentives and penalties can help, influence and affect the way countries or firms adopt and use technology.

In most of the reviewed studies respective national governments intervened in various forms in the process of acquiring technological capability. However it has been argued that the level of the government intervention depend on specific and different circumstances among countries. For instance it has been noted that there was almost no government intervention in Hong Kong as compared to other semi-industrialized countries. In addition it has been observed that there were more protective measures in the relatively import substitution oriented countries of Latin America than in the relatively more export oriented Asian countries. In both cases technological capabilities were acquired. Wangwe (1983) noted that the learning effects leading to innovations and designs are present in both the export oriented countries and the import substitution oriented countries. However, for efficient industrialisation the export oriented and less protective countries have been much more successful, as is also confirmed by keller (1991).

Also the experiences of semi-industrialized countries, reveal that acquiring technological capability is a long term process which requires progressive, purposeful, deliberate and conscious efforts. That mere nationalization is not enough in this process. In the case of Tanzania, nationalization made matters worse. However as different experiences of semi-industrialized countries show, there is no one uniform approach to this process. What is important is for each country, firm or industry to analyse and evaluate the cost and benefits of each action and lesson in relation to its particular circumstances and resources. On the other hand, however it is wrong for unsuccessful LDCs to expect to be successful in this process by ignoring all of these lessons. In other words, such lessons may be quite important. Much more optimism on the part of Tanzania and other unsuccessful African countries may arise from the few successful African cases which appear to have benefited from such lessons.

And finally, in almost all the reviewed cases, the positive role of the " nationals " has been particularly important in the acquisition of technological capabilities. While foreign investors have been quite important in the importation of foreign technology, effective utilisation of such imported technology crucially have depended on the active positive roles played by the " nationals ". This is especially the case in involving themselves in formal training and on the job training such that they increase their participation in pre-investment, investment, production, maintenance activities and other technological activities, and so progressively accumulate technological masterly (capability).

CHAPTER 4

THEORY

4.0 INTRODUCTION

> "The weakness of present understanding of the reasons behind the differential growth puzzle is in part due to lack of facts. But it is due at least as much to lack of theory that will enable us to knit together and give structure to what we know and extend our knowledge beyond particular facts. While there has been a considerable volume of research by economists, other social sciences and technology, that ought to bear on the differential productivity puzzle, that research is not well connected. This makes review, much less integration, of what is known quite difficult. More important, it means that knowledge, is in the form of categories of semi-isolated facts, rather than a connected intellectual structure".
>
> Nelson and Winter (1977c).

While bearing in mind that above noted central problem in the construction of a theory of technical progress, this chapter will review some of the progress that has been made in the attempts to construct such a theory. Thus we review the neo-classical and Schumpeterian views of technical change; the Neo-Schumpeterian view of technical change the view on management of R & D in Developed countries, and the Development Economists view of technical change. And we will also briefly define the concepts of technology, technical change, technological capability and technological efforts.

4.1:1 The Structure of the Original Neo-Classical View of Technical Progress

Sahal (1981) and Nelson and Winter (1974) among others, argue that the neo-classical economic theory of growth and capital is the basis of the neo-classical production function concept of technology. And that the neo-classical economic theory of growth and capital derives mainly from the theory of the firm and production in a competitive industry.

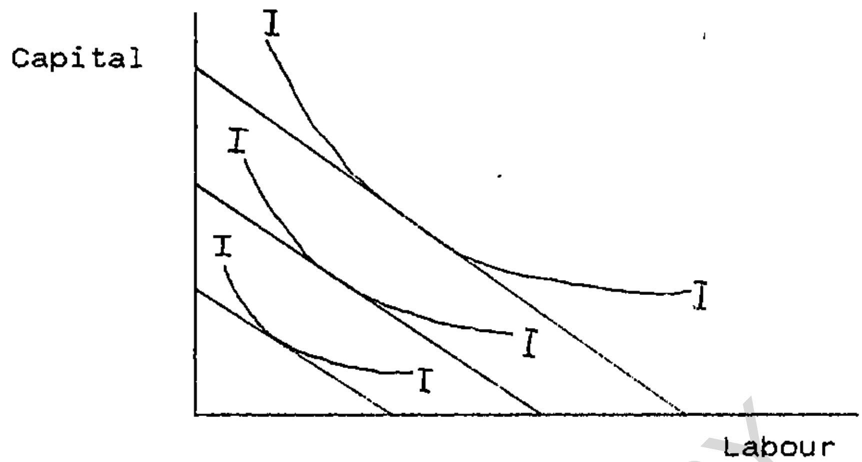
Under the neo-classical conception firms are assumed to be facing a set of alternatives regarding the inputs and outputs they use and produce. So firms choose in order to maximise profit, for instance, given external conditions facing the firm. In addition, the sector is assumed to be in equilibrium in the sense that demand and supply are balanced on all relevant markets and no firm can improve its position given what other firms are doing. Other things being equal, growth in this case may occur only when factors of production are expanded or made more efficient. Briefly changes in product demand, factor supply and technological conditions may result in growth.

The neo-classical model assumes that all firms have uniform access to state of the art technology, and define "technical change" within the framework of the production or cost function analysis. Solow (1957) gave a mathematical representation of technical change.[1]

---

[1]For details see Chapter 5.

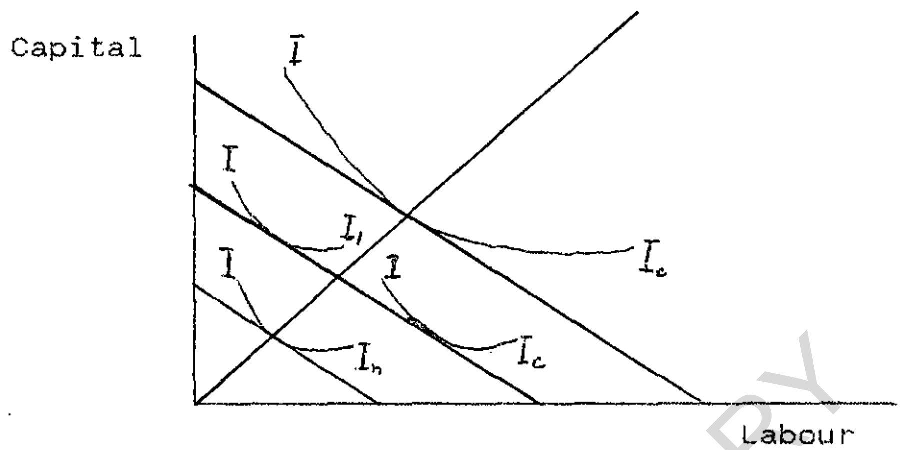
Figure 4.1a: The Original Neo-Classical Technical Change



In Figure 4.1a, any change in the proportions of the inputs employed due to changes in their relative prices, that is factor substitution, corresponds to movements along the isoquant. In contrast, changes due to development of new techniques correspond to a shift towards the origin of the isoquant. The implication is that advances in technical knowledge (technical progress) enable the firm to produce the same amount of production with less factor inputs. In others words, technical progress is shown by a shift in the isoquant towards the origin, rather than by movements along an isoquant.

The neo-classical framework also has different types of technical change, as is indicated in Figure 4.1b below.

Figure 4.1b: The Original Neo-Classical alternative types of Technical Change



In Figure 4.1b, II_0 represent the original isoquant. II_1 represents the result of a labour-saving technical change and IIc the result of a capital-saving technical change. And II_n represent a neutral type of technical change (it affects all techniques equally). Alternatively, technical change is labour saving if it raises the marginal product of capital relative to that of labour at a given capital - labour ratio utilized in producing a given output, and conversely for capital saving technical change. In this case neutral technical change is defined as not being biased in either labour saving or capital saving technical change direction.

Using a CD production function, and mathematical representation, Allen (1973) summarised three neutral technical progress (λ) at rate m, as follows:

(i) $Q = K^{\alpha}\bar{L}^{1-\alpha}$ where $\bar{L} = e^{mt}L$

such that $\lambda = m(1-\alpha)$ which is Harrod's neutral technical progress. This is labour augmenting in the sense of increasing the performance of labour.[2]

(ii) $Q = \overline{K}^{\alpha} L^{1-\alpha}$ where $\overline{K} = e^{mt}K$

such that $\lambda = m\alpha$ which is Solow's neutral technical progress, which is capital augmenting.[3]

(iii) $Q = \overline{K}^{\alpha} \overline{L}^{1-\alpha}$ where $\overline{L} = e^{mt}L$ and $\overline{K} = e^{mt}k$

such that $\lambda = m$ which is Hick's neutral technical progress which occur when the production function shift over time by a uniform upward displacement of the whole function.[4] It is equally labour augmenting and capital augmenting or simply a combination of Harrod's and Solow's neutral technical progress.

On the other hand, Brown (1967) uses an index say B, of the rate of technical progress, say R, to describe the course of technical change (its bias):

$$R = \frac{\partial \log F}{\partial T}$$

$$B = \frac{\partial}{\partial T} \log \frac{\partial F/\partial K}{\partial F/\partial L} = \frac{\partial}{\partial T} \frac{F_K/F_L}{F_K/F_L}$$

[2]See Harrod (1939)

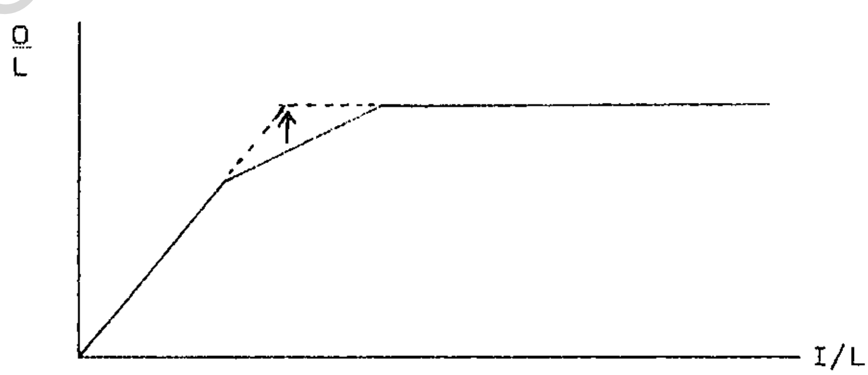
[3]See Solow (1957)

[4]See Hicks (1963, 1981)

He showed what happened to the marginal rate of substitution between K and L for fixed K and L as the level of technology changed. In that case Hicks neutrality meant $B = 0$. And $B \gtrless 0$ indicated non-neutrality (bias), either capital saving or labour saving.

Salter (1966), Atkinson and Stiglitz (1969), Allen (1973), Intrilligator (1982) and Stewart (1978) noted that "embodied technical progress" involve augmentation in the effectiveness of factor inputs due to various possible improvements in their quality or efficiency over time. That is, earlier techniques are assumed to be technically less efficient (using more of both inputs in relation to output produced). Atkinson and Stigltz (1969) in particular discussed the localized nature of part of technical progress consisting of improvements in techniques already in use, as shown in Figure 4.1c below:

Figure 4.1c: Atkinson and Stiglitz Localized Technical Progress



Where O = output, L = Labour input and I = Investment.

Allen (1973) noted that in considering embodied technical progress, the assumption of labour or capital being homogenous is dropped and so capital becomes essentially a mixed stock of different vintages, according to the date of installation in the past. That is, machines of different vintages, differ in kind and because of embodied technical progress, new machines are more productive than older (if similar) machines. For labour input, men of different vintages (distinguished by age and training) differ in kind. That is men of current vintage are more productive than those of earlier vintages. If we take machines and labour as substitutable, and assume a smooth production function, capital embodied technical progress, for example, is up to the time the machines are installed and not beyond.

The production function concept of technology has several difficulties which are summarised later in this chapter. Due to such difficulties, Kaldor presented a technical progress function in an attempt to replace the production function. Kaldor (1957) argued that the connections among production, investment and technical change cannot be expressed by any kind of reversible relation between inputs and outputs, but can be described by what he called "technical progress function". Later on, Allen (1973) distinguished two versions of Kaldor's technical progress function.[5]

The first is Kaldor's non vintage model in which technical progress represent disembodied technical progress under constant returns. The second, being Kaldor's vintage model with a technical progress function which relate to technical change in the embodied form. Later on, Kaldor and Mirlees (1962) refined the notion of Kaldor's technical progress function. The Kaldor-Mirlees version restricts the technical progress function to a vintage model of production and asserts that the rate of change of output per man as between last year's equipment is an increasing concave function of the rate of change of investment per man as between those employed using last year's and current year's equipment.

On the other hand, Arrow (1962) in his paper on "learning by doing" technical progress argued that the concept of "embodied" in capital goods was meant to reflect the idea that advances in technical knowledge can affect production only when they are designed into new capital goods through gross investment. With such a view, more investment means higher productivity. But even with this, the accumulation of technical knowledge is assumed to be autonomous. In other words, what happens in production itself has an important effect on the generation of new knowledge about production. Something

[5]See Kaldor (1957).

like learning or exploration may occur.

Arrow's particular assumption was that technical change grow out of " experience " and that accumulated experience is measured by cumulated gross investment. This was in line with Kaldor's technical progress function which attempted to capture the idea of endogenous generation of technical knowledge. Arrow's ideas were later on generalised and extended by Levhari.[6]

4.1:2 The Weakness and Strength of the Original Neo-Classical Structure of Technical Progress.

Fransman (1985) noted that the first problem of the original Neo-Classical view is the implicit assumption that there is a single decision making centre within a firm. That such a centre makes profit maximising decisions on the basis of the given technology and array of factor and product prices; and that such decisions are automatically and successfully implemented within the firm. The problem here, as Nelson (1981) noted, is that the firm is in fact a "social system "which may be resistant or unresponsive to management commands. So, in this regard, it is necessary to understand the organisational complexities of the firm, which together with other factors do influence technical progress and other decisions within the firm.

[6]See Levhari (forthcoming)

The second problem noted by Fransman (1985) arises from the assumption that the "state of technical knowledge" is given to the firm. Or as Kaplinsky (1984) put it, that firms are assumed to have "uniform access to state of the art technology" or to have "perfect information". However, Kaplinsky (1984) contrasts such assumption with the view of the "dependency school" which he argued, assume that there is uneven distribution of technological capability and proprietory rights over technology which in turn underly the technological inequities between developed countries and LDCs.

On the other hand Fransman (1985) argued that the assumption of "uniform" or "given" technology, does ignore the fact that a good deal of technical knowledge is firm specific. And that this makes the acquisition of technical knowledge an uncertain process, which is therefore costly. In this case, the neo-Classical assumption of "uniform" or "given" technology, tends to shift the attention away from the process of acquiring technological capability, which is central to the process of economic development in LDCs.

The third problem, is that, in the Neo-classical analysis there is very little or no concern with the causes (as opposed to the consequences) of technical change. Even in Hicks (1963) where it is argued that " invention delivers the set of impulses to economic growth" invention is assumed to be exogenous to the economic system or if endogenous its determining mechanism is not explained.

In addition no explanation is given on the other determinants of technical change which Hicks (1981) called "secondary invention"; apart from the influences of changing factor prices.[7] Teitel (1981) argued that technical change is not merely a response to the existence of inducements to "look for innovations"; (induced by changes in relative prices) but that, it is, more a necessary answer to the presence of constraints and bottlenecks which have to be removed so as to accomplish production. This view is further pursued later in this chapter.

Rosenberg (1982) noted that other "social determinants" of technical change have to be considered also. In this regard, Teitel (1984) argued that it is wrong to think about technical change (particulary with respect to LDCs) as implying that technical decisions are in some sense independent of production and investment decisions. And that, an explicit allocation of money and manpower is necessary to accomplish technical change, which it is argued, is endogenous rather than exogenous to the economic system.

[7]The Analysis of Technical Change or of innovations as being induced by changes in relative prices, was first proposed by Hicks (1963) and still constitute the core of the neo-classical metaphor. See also Binswanger (1974)

The other problem in the original Neo-classical structure, is the use of a "production function concept". Sahal (1981) noted that Kaldor developed a "technical progress function "because, it was impossible, in the original neo-classical model, to distinguish a shift in the production function from a movement along it. However, Blaug (1963) noted that, the technical progress function, like the production function, failed to isolate the economic from the purely technical factors. And that as such the original neo-classical analysis lacked a conceptualisation of "technology" per se. In addition Nelson and Winter (1974) noted that the original neo-classical structure lacked adequate explanation of the "innovation" and "imitation" concepts.

There is also a problem in measuring the variables in the "production function" mainly because of the extreme heterogeneity of both inputs and outputs (aggregation problem). In the original neo-classical structure, the "residual" was simply labelled "technical change". It is argued by Nelson and Winter (1974) among others, that the "residual" includes also other unexplained factors such as economies of scale. Despite this problem, however, several studies use the "residual" and argue that it gives a general indication of technical change.

Following the original neo-classical structure of technology, several authors have carried various researches with the aim of establishing better analysis of the sources and effects of technical change (or progress). In this sense the neo-classical structure has acted as a stimulant to further research and analyses on technical change.

Nelson and Winter (1974) noted that such studies have been done by economic historians such as Usher, Landes, Habakkuk, David, Temim and Rosenberg; and by students of industrial organization and technical change, especially those interested in invention and innovation per se, these are for example Schmookler, Jewkes, Sawers and Stillerman, Maclaurin, Peck, Grilliches, Mansfield and Freeman. Some of these authors are in harmony with the original neo-classical structure and others are quite discordant. In this regard then, as Nelson and Winter (1977) noted the theory of the original neo-classical has been robust in the sense that it continues to survive and spawn a considerable amount of research on economic growth.

4.2:0 The Original Schumpeterian View of Technical Progress

One of the earliest treatments of technology was the work of J. Schumpeter in the early 20th century. The Schumpeterian work was essentially a "heroic entrepreneur theory of innovation.[8] Fransman (1985) noted that with the exception of Schumpeter, among the neo-classical, there

[8]See Schumpeter (1934)

was very little concern with the causes rather than the consequences of technical change. In that case, Mansfield (1968, 1970) noted that Schumpeter separated the concept of invention and innovation and that the innovator whom Schumpeter termed "entrepreneur" or "new Man" was the central actor in transforming inventions into innovations.

Schumpeter's entrepreneur was thought to be a visionary who had to struggle heroically against obstacles such as a lack of interest and skepticism upon the use of the new machinery and also compete for markets. In other words, entrepreneur (firms) worked in competitive environment which was characterised by struggle and motion or as Nelson and Winter (1974) put it, "a dynamic selection environment, not an equilibrium one" like in the original neo-classical theory.

According to Schumpeter, the most important actors were the innovating entrepreneurs (firms) which served as the vehicles for action or the real drivers of the system. That is, large firms (entrepreneurs) took risks to innovate, made profits and made further innovations and investment. Other firms were compelled by competition to follow suit in innovation or to imitate so as to achieve higher profits.

However, Sahal (1981) noted that, while the notion of innovation was central to Schumpeter's analysis, it was essentially an exogenous variable. That is, that technical change had important repercussions of an economic nature but no essentially economic causes. In addition, Schumpeter used the production function concept which as seen above has its weaknesses.

Despite the above noted weaknesses, Fransman (1985) noted two important aspects arising from Schumpeter's stress on competition. First, that it is necessary to examine a firm in relation to other firms producing for the same markets. In other words, it is invalid to focus attention solely on the individual firm as a unit of analysis as was the case in the original neo-classical theory. Second, that every firm is "compelled" to change by the fact or threat of cheaper and/or "better" products from competing firms. Rosenberg (1976) distinguished such "pressures" from "incentives" to change. In summary, Nelson and Winter (1974) argued that the role of competition is better characterised in the Schumpeterian analysis than in the equilibrium analysis of original neo-classical theory. In addition, Schumpeterian analysis is credited also for considering the concepts of "innovations" and "inventions" and "imitation". However, the original Schumpeterian analysis centred on major breakthrough technical change unlike the neo-Schumpeterian analysis which considers both the major breakthrough and incremental technical change.

4.3:0 Patents and Chronologies of major Innovations

According to Sahal (1981) some sociologists, economists and historians developed further the ideas of Schumpeterian view on technology and started conceiving technology in terms of the number of events. They argued that the uniqueness and novelty of the event is of crucial importance. Thus accordingly, the concept of "innovation" carried the connotation of something "novel". In such a view, changes in an already existing technique are generally excluded.

Within this view, a number of variables are considered to be direct measures of technical change. These include change in the number of patents, articles and abstracts in various indices, the number of engineers and the professional grade staff in R & D activities; among others. The most widely employed are the patents (especially in developed countries) and chronology of major innovations.

The drawbacks to the use of patents have been noted in the literature review chapter. It is argued that patents give no information on "innovation" and so tend to exclude the process of development and diffusion of technology involved. Second, not all inventions (especially minor innovations or incremental technical change in LDCs) are patentable. Third, patent statistics fail to reflect the varying technical and economic importance of different inventions.

On the other hand, the use of chronologies of major innovations also have a number of problems. First, the procedure of assigning dates of occurrence of major innovations is inherently unsatisfactory in the construction of such series. Second, an index of major innovations, as may be assigned, take into account merely the initial or short term development of technology leading only to its commercial introduction. Such indices have no bearing on the long term development of technology such as new designs. Third, the construction of such indices lack a formal theoretical basis for distinguishing "major" from "minor" innovations. They only rest on assumption that a major innovation is a vehicle for minor innovations.

Sahal (1981) noted, however, that despite their shortcomings, patents and chronologies of major innovations provide a good starting point to a somewhat more direct measure of technical change (at least in comparison with the original neo-classical production function concept). Yet, on the other hand, both the patents and chronologies, are not good enough for analysing the process of technical change in LDCs. In addition, they describe merely the changes in the number of techniques and not changes in the techniques themselves.

4.4:0 Summary of the Neo-Schumpeterian View

The Neo-Schumpeterian view considered both incremental and major technical change; unlike the original Schumpeterian view which considered only major technical change. Fransman (1985) noted that several authors have considered the significance of "incremental technical changes"; for examples Gilfillan (1953) Usher (1954), Enos (1962) and Hollander (1965), all for developed countries and Katz (various), Dahlman and Fonseca (1978), Maxwell (1977, 1982), Lall (various) and Teitel (1984) all for LDCs.

Fransman (1985) noted further that, apart from the emphasis on "incremental" technical change, other features of the Neo-Schumpeterian view are true to the original Schumpeterian view. However, it should be noted that the Neo-Schumpeterian view is concerned above all with the process of economic change, as opposed to the neo-classical analysis of equilibrium state.

Accordingly, the technical change is central to the process of economic change. Technical change in this case is initiated either by the "entrepreneur" as in the original Schumpeterian view, or by R & D departments of larger firms as in the neo-Schumpeterian view.

In sum, firms, are assumed to use technical change to improve products and processes, as a major weapon in the competitive struggle, through introducing new innovations, defending their positions or imitating other successful firms. The result from such a situation is a continuous series of disequilibria, as changes and adjustment to changes occur. This implies, as Zuscovitch (1986) noted that technical change plays important role in the long term process of economic development. However this arguement is not sufficiently taken into account even by the neo-Schumpeterian view of technical progress.

The incorporation of technical change in the long term process of economic development brings a need to have an explicit theory of the dynamics of technologies development. In an attempt to do so, authors like Rosenberg (1976, 1982) and Nelson and Winter (1977, 1982) began incorporating the structural effects of technical progress into their economic theories.

Other authors who have used the neo-Schumpeterian view are Mansfield (1968, 1970), Freeman (1982), Freeman et. al (1982), Dosi (1982), and Kenney (1986). The incorporation of long term structural effects of technical progress is emphasised here also in view of the fact that neither Abramovitz (1956), Kuznets (1954) and Salter (1966) all of whom treated technical progress only as a general and undifferentiated factor (exogenous), nor Schmookler (**1966**) who treated technical progress as endogenous factor, did consider the long term structural effects of technical progress.

Fransman (1985) noted that in the neo-Schumpeterian view, "uncertainty" also played a central role. That is, the outcome of investment in technical change was considered to be uncertain so that some firms took the risk to invest while others did not. Consequently some firms succeeded and grew while others declined and sank. The process of economic growth was then conceived as the sum total of all these events.

As Fransman (1985) observed, few attempts have been made to formalize the Neo-Schumpeterian approach; with the notable exception of the simulation models constructed by Nelson and Winter in their "evolutionary approach".[9] And Mansfield (1968) argued that Schumpeter never reviewed the innovation problem statistically. From these problems and others, Fransman (1985) argued that few would claim that the Neo-Schumpeterian analysis offers an adequate explanation of technical change.

Fransman (1985) agreed that certain central aspects of the technical change process have been identified by the neo-Schumpeterian and other noted views, but that such central ideas together with other economic, socio-political and cultural aspects have not yet been rigorously welded into an acceptable theory of the determinants of technical change.

[9] See Sahal (1981), the simulation model represent a particular case with the evolutionary theory in the same sense that a model with a CD production function, neutral technical change represent a particular member of the class of neo-classical models. However, a simulation model does not use a production function in the same sense as the neo-classical.

Rosenberg (1982), too, noted that the present understanding of the social determinants of technical change is not adequate. All these arguements, imply that the neo-Schumpeterian view lack a theory which would give structure to individual innovations and thus the technological foundations of the dynamics of economic development. On the other hand, however, the neo-Schumpeterian view give the foundation for further analyses of technical progress.

4.5:0 Evolutionary Theory

According to Nelson and Winter (1982) the first major commitment of the evolutionary theory is to a "behavioural approach" to individual firms. And that it is assumed that a firm at any time operates largely according to a set of decision rules that link a domain environmental stimuli to a range of responses on the part of firms. That, unlike the neo-classical theory that attempt to deduce such decisions rules from maximisation on the part of the firm, the behavioural theory simply takes them (decision rules) as given and observable.

In addition the behavioural theory insists on variation from case to case depending on the purpose of the search (inquiry), and also the focus is on the decisions of single large firms, sector or economy. And finally, among the rules in the individual firms, the most prominent are those that involve deliberate, goal oriented "search" or problem solving ability.

Nelson and Winter (1974) noted that "search" may either be stimulated by problem solving attempts or they may simply be institutionalized (such as R & D), and that the strategy and direction of search is to a certain extent influenced by the market prices, information concerning the decision rules of other firms and by exogenous change in relevant knowledge. The evolutionary theory also involves an explicit analysis of the economic selection mechanism (basing on profitability). All these, it is argued provide a basis for the discussion of a distinctive entrepreneur function.

The behavioural approach it is argued, offers a systematic framework for a Schumpeterian analysis of the competitive process. In addition the aspect of improvability of procedures is also important in the behavioural approach. And finally the search and problem solving orientation make analysts, aware of the differences in technological development so to at least explain or characterise such differences.

4.6:0 Management of R & D and Appropriate Technology

Based on the strength and weaknesses of the neo-classical, schumpeterian, neo-schumpeterian and evolutionary theories two groups of technological change analysts have developed. In general in the two groups, technology is best understood in terms of certain measurable functional characteristics of the phenomenon under consideration.

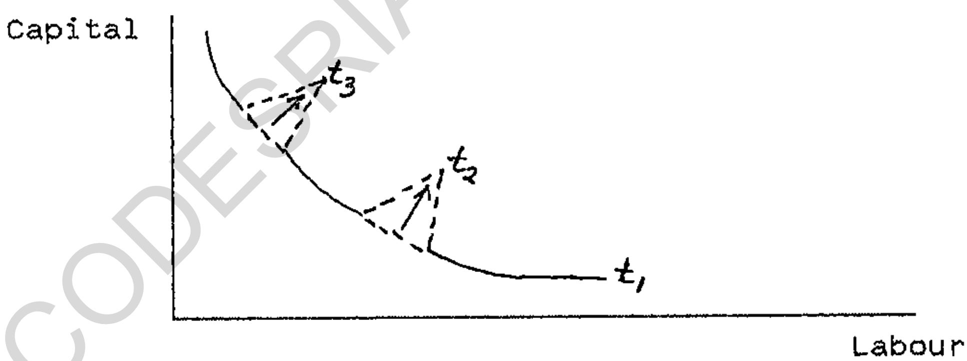
According to Sahal (1981) the two groups which developed simultaneously, may not necessarily have been aware of each others work. The two groups are: the development economists, who are concerned with the problems of appropriate technology in LDCs; and technology analysts, who are concerned with the management of R & D in developed countries. In general, both group regard technological change in terms of certain bottleneck factors such as availability of resources.

4.6:1 The Development Economists

Sahal (1981) argued that the development economists view of technology developed mainly from two arguments. First is the disatisfaction with the neo-classical framework which essentially emphasise only factor substitution and the relative price ratio. The argument is that other factors which are excluded or ignored may in certain cases be even more important than those which are included. For example, some of the most important possibilities of substitution may not be at all between labour and capital. They may be between skilled and unskilled labour, initial costs and maintenance costs, new and second hand equipment, among other examples.

The second argument is that techniques of different vintages may exist side by side. This is especially the case in LDCs where it is common place to employ the most up to date equipment together with autmoded techniques. It is argued that under such a situation it is unrealistic to assume the existence of a smooth isoquant. This is because, for example, older techniques may require more of both labour and capital per unit of output rather than less of one at the expense of the other. And this does not correspond to either a movement along or a general shift from a production function (as in neo-classical) as is illustrated in the following figure 4.6:1a.[10]

Figure 4.6:1a Representation of Techniques Dating Back to Different Time Periods t_1, t_2 and t_3



Source: Sahal (1981)

The typical neo-classical form of production function does not apply to such cases. Implicitly, then, the neo-classical production function is somehow unsuited to problems of appropriate technology in LDCs which entails

[10] See also Hjalmarsson (1973).

a situation as represented in figure 4.6:1a above. This therefore calls for redefinition (especially with respect to LDCs) of the concepts of technology and technical change as they are presented later in this chapter.

4.6:2 Analysts of management of R & D

According to Sahal (1981) the view of technology by this group, began with the analysis of the expenditure on military R & D (in the advanced countries) which increased in the years after the end of the second world war. That is, while at first they (analysts) were concerned with the capability of military technology, they later on included questions of internal organizational and external marketing factors in the management of R & D in the civilian sector of the economy.

Within this view of technology, major studies include Mansfield (1961, 1968, 1969, 1970, 1980); Leonard (1971); Pavitt (1982, 1984) and Levin et al (1984). Mansfield (1969, 1970) for example defined the concept of R & D and distinguished "innovations" and "inventions". He argued that "basic research" is the original investigation which is directed to the discovery of new scientific knowledge, while "applied research" aims at practical and commercial advances. And that "development" is a technical activity concerned with non-routine problems encountered in translating research findings into products and processes. However there is no clear line between R and D, although they are by no means the same.[11] In addition Mansfield (1970) noted that "invention can occur in either the R phase or the D phase. And when an invention is applied for the first time it is called an innovation. The innovator in this sense, is a firm that applies the invention first and is willing to take the risk involved in introducing new product or process innovations.

4.6:3 Advantages and Limitations of the View of Technical Progress in Sections 4.6:1 and 4.6:2

According to Sahal (1981), the view of technical progress in sections 4.6:1 and 4.6:2 include the following major advantages: First it considers both the major and minor innovations. And that this is particulary important for LDCs where minor technological changes are more common. Second, unlike in the neo-classical analysis, emphasize is also put on changes in product characteristics. Third, a number of important implications for a wide variety of problem areas, are considered and as such it is significant for analysis of such problems as appropriate technology in LDCs and management of R & D in advanced countries. In this case issues such as the "diffusion of technology" by such authors like Zuscovitch (1986); Arrow's (1962) "learning by doing" and Rosenberg's (1982) "learning by using" are well considered.

[11] For more details and definition, see UNESCO Statistical Yearbooks.

In summary, the view of technology in sections 4.6:1 and 4.6:2 offers a hitherto lacking conceptualization of technology per se; and that this is an important (prerequisite) step in understanding a variety of interrelated problem areas and policy issues related to technology and technological change.

However, the view of technology in sections 4.6:1 and 4.6:2 has its limitations. According to Sahal (1981) there are at least two major limitations. First, data on changes in functional characteristics of technologies over the cause of time are typically lacking. Second, analysis of such a view cannot easily be applied to an aggregate level of technological activity. The argument in this case is that while the functional measures of technology, where applicable, are evidently far more useful than the less direct approaches, these (functional) measures are of very little help in a situation where one wants to compare the performance of different industries, or sectors or economies.

Sahal (1981) also noted that, all the reviewed views of technology have problems and advantages. The neo-classical approach, for example, which specifies technology in terms of the process of production fail to provide a direct measure of technological changes. And on the other hand the technology view which use patents and chronologies of major events provide a relatively direct measure of technology but lacks a conceptualization of the production process. And yet lack of adequate and accurate data makes it difficult to apply it successfully. And finally although the technology view in sections 4.6:1 and 4.6:2 is by and large, free from some of the above noted limitations (because it is tied to the actual engineering basis of innovative activity), it is not easily applicable to an aggregate level of analysis. However it offers a better conceptualization of technological changes (minor) in LDCs. Due to these problems and advantages these different views and approaches should best be used to complement each other.

Lastly, Sahal (1981) argued in "a principle of technological guide posts" analysis, that the origin of a wide variaty of innovations in any given area lies in a creation pattern of design which remains unchanged in its fundamental aspects long after its conception. Two features of such a pattern are explained. First that technological progress is seldom a matter of radical breakthroughs. Rather, it is a result of synthesis (culminating from prior advances). Second, that it seems that the greater the variety of tasks to which a design has been adapted, the more likely it is to serve as a guide to the general direction of technological progress.

In this case then, technological progress constitute an evolutionary system in which the role played by the accumulation of relevant knowledge is very important. But the process of learning (accumulation of knowledge) tends to be localized (specific technology) and hence the very concept of a production function representing an almost infinite array of techniques sharing a common state of knowledge seems not to hold well. In this case, it is argued that technological progress seem to be one of evolution of the production function rather than mere shift of a production function.

4.7:0 Definition of Key Concepts

In this section the following concepts are defined; Technology, Technological change, Technological capability (mastery) and Technological efforts. It is recorgnized that there are no, single universely agreed definition for each of these concepts. Different authors emphasise different aspects, but here we will present briefly some key elements in each concept.

4.7:1 Technology

Alange (1987) noted that the word "technology" is derived from the Geek words "techne" (technique) and "logs" (knowledge). Thus "technology" means " the knowledge of technique". Dahlman and Westphal (1982) however, define "technology" as a collection of physical processes which transforms inputs into outputs, together with the social arrangements which structure the activities involved in carrying out such transformations. However, different authors focus on different aspects.

Adei (1987), for example centred his definition on aspects of "knowledge", that is that "technology is knowledge", and thus he defined technology as the sum of knowledge, skills and methods related to the production, distrubution and consumption of goods and services including their organization. Teitel (1984) on the other hand put the focus on technology as "information" while Dahlman and Westphal (1984) centred their definition on "method" for doing something. And that using such a method require three elements, namely; information about the method, the means of carrying it out and some understanding of it. These requirements lead to issues of technological capability which is defined below.

In summary, Dahlman and Sercovich (1984) explained that "technology" consists of technological knowledge, prodecural methods, and organizational modes to transform inputs into output. Several authors adopt more or less such a definition. Among such authors are: Bell, Ross-Larson and Westphal (1984), Cooper and Sercovich (1971), Dahlman and Westphal (1982) and Teitel (1981, 1984), Stewart (1978), Sahal (1981), Fransman (1983, 1985), Dahlman, Ross-Larson and Westphal (1987), Alange (1987) and Adei (1987).

4.7:2 Technological Change

Fransman (1983, 1985) noted that "technological change" refers to the introduction of new ways of transforming inputs into output, including the production of new or altered products (improvements in the quality of output). And Teitel (1981, 1984) noted that in advanced countries, technological change, consists mainly of cost-reducing improvements in production processes and the creation of new products. That is, according to the neo-classical theory of growth, such technological changes (innovations) are induced by changes in relative prices as Hicks (1963), Binswanger (1974) and others explained.

However, it is argued that while such technological changes may also in some instances be of interest to LDCs, they do not exhaust all types of technological changes which take place under the conditions of protection, price distortions (market imperfections) and various input constraints or bottlenecks which prevail in LDCs. In this sense, then, technological change, as Nelson and Winter (1977) argued is not merely a response to the existence of inducements to "look for innovations" (major technological changes), but more a necessary answer to such conditions which prevail in LDCs. And that such conditions in LDCs have to be removed so as to accomplish production better.

Within these arguments, Rosenberg (1976) observed that technological changes in LDCs consist mainly of adopting imported technologies to local environment and factor supplies. And that in this sense most of technological changes in LDCs are of incremental types (minor technological changes).

Teitel (1984) noted that such tchnological changes in LDCs result from deliberate and appropriate "technological efforts" as is defined later in this chapter. However, it is noted that such technological changes in LDCs aim at using different raw materials, scaling down plant sizes, diversifying the product mix, adapting the product design, use of simpler and lower capacity machinery, stretching out the capacities of existing equipment, or simply aiming at meeting changes in demand market conditions and supply constraints.

With such a definition of technological changes in LDCs, Fransman (1983) noted that within the LDCs, therefore the concern is on what happens when technology is imported, assimilated and improved in LDCs. In other words it is the "technological efforts" and "technological capabilities" to carry out such "technological changes" which have to be examined more.

Finally, the definition of technological changes in LDCs as explained above, focus on the process itself of "transforming" inputs into outputs. Or in other words on what goes on inside Rosenberg's (1982) "black box" into which inputs go and out of which outputs come. This is more or less addressing to issues of technological capabilities, in as far as the LDCs are concerned.

4.7:3 Technological Capability

Bell, Ross-Larson and Westphal (1984) and Lall (1992) defined "technological Capability" as the ability to make use of technology. Westphal (1982) and Dahlman and Westphal (1984) used the term "mastery" in the same sense as "capability'. Technological capability, in this respect, involve capability in the acquisition and modification of technical information; and in the adaptation of it to local product markets and factor supplies. It also involve creation of new technical information. In other words, technological capability is essential for effective transfer (import) of technology, for choices of appropriate technologies, for effectively operating processes and producing products and for management of changes in products, processes and the procedural and organizational management in industries.

Adei (1987) explained that "technological capability" can exist at firm, industry or country level. He argued that at firm level, technological capability is reflected in the ability to undertake successfully the functional activities, such as planning, production, maintenance and marketing and in problem identifications and solution design. At industry level or national level it is reflected by the sum total of people with the required skills, the stock of knowledge (technical), the tools and instruments and the institutional framework for technological changes. And almost all authors in the field of technological capability in LDCs seem to agree that, it is the "technological efforts" which underlies the success or failure in the process of acquiring technological capability.

4.7:4 Technological Efforts

Dahlman and Westphal (1982) and Bell, Ross-Larson and Westphal (1984) more or less defined "technological efforts" as a consicious exertion to use technological information and to accumulate technological knowledge to choose, assimilate, adapt, or create technology. That is technological efforts is required to acquire technological capability as defined above.

Dhalman and Westphal (1982) summarised all these, that "technological mastery" (capability) is the effective use of technological knowledge, through continuing "technological effort" to assimilate, adapt and/or create technology. And that to be successful such technological effort have to be deliberate, purposeful and continuous as they are neither easy or costless.

4.8:0 Conclusions of the Chapter

The conceptualization of "technology" by different theorists as presented above have resulted to a better analysis of technical changes in LDCs. It have been explained that much of technical changes which take place in LDCs are "minor" innovations (incremental types of technical change), rather than major innovations.

However, while acknowledging much of the efforts and analyses done in this field, it should be noted that the work of coordinating various views and facts so as to arrive at a more acceptable theory of technical change is still at its infancy stage. The conceptualization of the concepts "technology" and "technological change" so far have helped to focus on issues of "technological capabilities" and "technological efforts" in LDCs. This is an important step and this study follows such trend of focus.

The second main issue is that of measuring technological change. It has been pointed out that the neo-classical approach offers an indirect way of measuring technical change, while use of patents and chronologies of major events offers a direct approach. Each of these have advantages and disadvantages as they have been explained above. The technology view in sections 4.6:1 and 4.6:2 however offers a more complicated way of measuring technical change especially because it requires detailed engineering studies.

In view of severe data constraint, this study uses the neo-classical approach of measuring technical change with the aim of getting only some general indication. And in addition this is complemented with qualitative analysis which mainly has helped us to analyse "technological efforts" and "technological capabilities" with respect to the manufacturing industries in Tanzania.

CHAPTER 5

MODEL, DATA AND METHODOLOGY

5.0 Introduction

The empirical analysis of this study is carried out in three parts: the first part involves quantitative analysis of technical change in the Tanzanian manufacturing sector as a whole and in its ISIC 3 digit manufacturing industries groups. The details of the model, data and methodology employed in this part are explained in section 5.1, and its results are presented and analysed in chapter 6.

The second part involves qualitative analysis of technological efforts and capacity at firm level in some industries in the Tanzanian metal and engineering subsectors. The details of the data and methodology employed in this part are explained in section 5.2, and its results are presented and analysed in chapter 7.

The third part involves qualitative analysis of the technological functions and services of some institutions which are directly related to the technological development in the Tanzanian manufacturing industries. The details of the data and methodology employed in this part are explained in section 5.3, and the results obtained are presented and analysed in chapter 8. The analysis of this third part when combined with that of the second part above, indicate the level of technological efforts and capacity at national level, in as far as the Tanzanian manufacturing industries sector is concerned.

5.1 Technical Change in Tanzanian Manufacturing Sector and in its ISIC 3 Digit Groups

5.1:0 Introduction

In this section we have estimated the regular average Cobb-Douglas (CD) production function which involves the traditional time-trend representation of technical change.

5.1:1 Measure of Technical Change: Use of Time Trend

It has been noted above that technical change can be analyzed and estimated using production functions. One such type of technical change is a shift in the production function over time, reflecting greater efficiency in combining inputs. If such technical change occurs without changing the marginal rate of substitution between the inputs, it is called neutral (or Hicks neutral) technical change.

According to Intrilligator (1982), from a production function

$$Q = f(L, K, t) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

or $Q(t) = f(L(t), K(t), t)$

where Q, L, K and t is output, Labour, capital and time respectively, we can have the following CD function

$$Q = (A_0 e^{mt}) L^{\alpha} K^{\beta} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where Q, L, K and t are as defined above in (1), A is the scale parameter which is increasing exponentially over time; m is the rate of neutral technical change (which in the case of a Cobb-Douglas function is constant) α and β , are the estimated elasticities of output with respect to L and K and are also constant in the case of Cobb-Douglas function.

The exponential time trend term in (2) thus accounts for neutral technical change where, as noted, m is the rate of technical change. Therefore, m represent a trend increase or decrease of productivity over a period.

5.1:2 Data Sources and Collection

In this first part of the empirical analysis of this study, we have used secondary (published) data, for the Tanzanian manufacturing sector as a whole and for its ISIC 3 digit groups. We collected data mainly from the Central Statistical Bureau publications such as: Economic surveys (various), Survey of Industrial production (various), National Accounts (various), Survey of Employment and Earnings (various) and the 1978 Census for Industrial Production. Other sources of data included NDC annual and Accounting Reports (various), Ministry of Industries and Trade and Bank of Tanzania (various publications).

5.1:3 Data Requirement

Derivation of Time Series Data

To estimate the production function, for the Tanzanian manufacturing sector as a whole and for its ISIC 3 digit groups, we needed data on output, Labour input and Capital input over time. We thus derived these series for the period 1966-1988 as is described below. In addition, however, we described the associated data which are used in the analysis, viz: Capacity measure and Real Wage Rate.

5.1:3 (i) Output Series

The production function defines the relationship between inputs and outputs in physical terms. The various sources we have mentioned above give data regarding products in monetary terms and only in some few cases in physical terms as well. We could not use physical output data due to inavailability of such data in many cases and also due to tremendous difficulties involved in aggregating numerous heterogeneous products produced by each industrial group and by the manufacturing sector as whole. Instead we have used the Gross Real Value Added measure of output (in monetary terms) which are obtained by deflating the current prices value added series. The 1976 GDP deflators are used. The gross value added series are used rather than the net value added series mainly to avoid the inaccuracies which may have been involved in estimating depreciation. The unit of measurement is the Tanzanian shilling.

5.1:3 (ii) Labour Services

Initially we obtained the number of employees (annually) for the Tanzanian manufacturing sector as a whole and for its ISIC 3 digit groups; for the period 1966-1988. Annual labour Cost Values were obtained by multiplying annual total wages and salaries by the annual total employees. The annual labour cost values were deflated by the 1976 average Earning Index (Paasche's Index) to obtain the deflated annual labour cost values.

We could not use the man-hour data for labour input, because in most cases such data are not available. And also we could not use "operative" instead of total employees because in several cases "other employees" are mixed with "operatives" thus making it impossible to have precise figures of 'operatives' only.

5.1:3 (iii) Wage Rates

Annual total wages and salaries are deflated by 1976 GDP deflators and divided by the number of employees to obtain Real Wage Rate series for the Tanzanian manufacturing sector as a whole and for its ISIC 3 digit groups for the period 1966-1988.

5.1:3 (iv) Capital Input Series

In the theory and literature review chapters of this study we noted that there are serious difficulties in defining and measuring "capital", and that there is no one universally agreed way of measuring capital. For statistical purposes different measures of capital have been used by different authors. For instance while some authors use the existing machines as a proxy for capital inputs, very few use energy (electricity) consumed as a proxy for capital input. Others like Ndulu (1986) have used the perpetual inventory method to estimate capital stock series.

In this study we have used the pertual inventory method for estimating capital stock series for the period 1966-1988. We have followed most of the procedure used by Ndulu (1986) with some few differences which are explained below. It should be noted that this method involves two major steps; first the capital stocks are estimated separately and second, the capacity utilization rates are estimated so as to arrive at utilized capital stock. The importance of capacity utilization arises because of its very significant influence on actual output in contrast to what is supposed to be at the frontier.

Initially we estimated the incremental capital output ratios (ICORs) by use of net investment series (deflated by 1976 implicit fixed capital deflators). For all the manufacturing industrial cases covered in this section as mentioned in section 6.0 of this study, the estimated ICORs for the period 1966-1972 were found to be reasonably stable and hence the incremental and average capital output ratios were assumed to be the same that is for 1972 the ICORs = CORs; and so in each of the industrial cases the year 1972 were adopted as a base year, that is, from the CORs, the capital stock for that particular year 1972 were obtained in each case. With the capital stock of the 1972 base year for each case we proceeded with the application of equation (3) below to estimate the capital stock series. The same equation was used by Ndulu (1986):

$$K_i = (1 - s)K_{t-1} + I_{t-1} \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where s is the depreciation rate (which in our cases ranged between 4% - 6% and hence for consistency we used a 5% average as a depreciation rate). I is gross fixed investment constant at 1976 prices and K is estimated 1976 price capital stock series.

Having estimated the real capital stock series, we have, unlike Ndulu (1986), not used intermediate imports figures to estimate capacity utilization rates. Originally, our study intended to use the inverse of ICOR variations (percentage changes of productivity investment) to capture changes in capacity utilization (CU), since ample evidence exist that variations in net actual output have been dominated by cyclical factors affecting capacity utilization inspite of continued reasonable investment levels.[1] It should have been the case for Tanzania also. The percentage variation in CU were intended to fill the gaps in the series of actually observed capacity utilization obtained from Ministry of Industries as well as the IBRD study for 1984.

However, there were large disparities between the percentage changes in investment productivity series and

[1] Lance Taylor and B. Ndulu are also in favour of this view.

the actually observed capacity utilization rates. So this procedure was also dropped. Instead we used average capacity utilization rates calculated (by us) using figures from NDC publication (various) and Bank of Tanzania (various) to fill in the very few gaps. In that case capacity utilization index was constructed for each of the covered industrial case and was subsequently used to arrive at utilized capital stock which is used in the analysis in chapter 6.

5.1:4 Methodology:

Estimation of average Cobb-Douglas Production Function with Time Trend Variable

In this section, for purpose of quantitative analysis of technical change in Tanzanian Manufacturing sector as a whole and in its ISIC 3 digit groups for the period 1966-1988, the production function (2) in 5.1:1 is re-expressed as follows:

$$LQ = a_0 + \alpha LL + \beta LK + mt \quad \ldots\ldots\ldots\ldots \quad (4)$$

where $a_0 = LA_0$ = Natural log of A_0

LQ = Natural log of value Added in real terms (1976 Prices).

LL = Natural log of deflated labour costs (1976 Prices).

LK = Natural log of utilized estimated capital stock in real terms (1976 Prices).

a_0, α and β are parameters to be estimated

m = is the rate of neutral technical change.

t = time trend.

The ordinary least square (OLS) is used for estimation and its results are reported in 6.2.

5.1:5 Limitations of the Procedure used in 5.1

Estimating technical change by use of production function analysis is subject to a number of problems. First, with regard to equation (1) in 5.1:1, which is also re-expressed as equation (4) in 5.1:4, it is assumed that there exists a production function relating manufacturing output to capital, labour and a given parameter (A) which stands for other factors (residual) including technical change. The problem here arises because the residual includes many factors and it is not easy to tell whether the estimate include technical change as well, or whether the estimate include only technical change besides other factors in the residual such as improvement in industrial organization, external economies or economies of scale. In equations (1) and (4) it is assumed that the residual contains a time trend only which represent technical change. With the above argument this may not be all that true.

Another fundamental problem associated with the production function analysis and estimation of technical change is measurement errors due to inadequate or inconsistent data. Problems of aggregation and appropriate measures of capital and labour are numerous and especially in the case of Africa (Tanzania included) where data inconsistency and other weaknesses are widespread. We do not claim to have solved this problem, but in the case of measurement of capital input, for instance, we have adopted a method which we believe has given us fairly reasonable estimates. And also due to poor and inadequate data we only applied a simple model as in 5.1 rather than the complicated models which otherwise could have given us better estimates and analysis of technical change. Better but somehow complicated models which require immense and accurate data are therefore not used.

Finally, another fundamental problem of the approach in 5.1, is that it does not explain the elements of policy or circumstance, national or international that underlie the measured and analysed technical change. Nelson (1981) and Shaaeldin (1989) also have discussed this problem.

Notwithstanding these problems or limitations, the approach used in 5.1, have provided an analytical framework which has yielded rough preliminary estimates of the contribution of labour, capital and the residual (technical change). After, all, this crude and rough results have been taken as a starting point for a search for further analysis and measurement of technical change. In that sense, we have proceeded with qualitative analysis and estimation of technological efforts and capacities in some Tanzanian manufacturing industries and technological institutions (sections 5.2 and 5.3).

5.2 Technological Efforts and Capacities in Some Industries in the Tanzanian Metal and Engineering Sub-sectors

5.2:0 Introduction

In this section 5.2, we intend to analyse qualitatively the input output indicators of the technological efforts and capacities in some industries in the Tanzanian metal and Engineering sub-sectors. The individual industries involved are mentioned in chapter 7. The reasons for choosing such metal and engineering industries are explained in chapter one of this study.

5.2:1 Data Sources and Collection

In this second part of empirical analysis of this study, we have used both secondary and primary data for the industries concerned. The main sources of data used in this part are: with respect to secondary data, the Central Statistical Bureau and the ministry of Industries and Trade.

And with respect to primary data, the principal researcher and research assistants visited the concerned industries and gathered some of the required data which were available. This was done through use of questionnaire forms. Some questionnaire forms were filled in by several different officers in respective departments in the industries covered. More data and information were obtained through interviews which were guided by other questionnaire forms. In general the interviewed personnel included, for each industry, production managers, personnel managers, accountants, engineers, planning managers, marketing managers and in some cases the general managers.

5.2:2 Data Requirements

The secondary data were mainly required for performance analysis of the individual firms. In this case the data collected included: annual gross output and value added series, annual employment and enumeration series, data on assets, such (fixed assets) as machinery, buildings, transport equipments and on depreciation figures. Data for inputs by type and source, for materials, energy consumption and in some cases data on installed capacity and number of days worked with the number of shifts and hours worked. The period covered in this case is at least some few years before and after the economic crisis of the late 1970s and early 1980s which Tanzania faced; depending on availability of such published data. This data is used for comparison of industrial performances for the pre-crisis era, crisis era and after the crisis (presumably after 1985).

In terms of primary data, we required data for investigating technological capacity in the industries concerned. Such data include: the number of technical employees with their qualifications, experience, whether local or expatriates and the shortages; the state of machines and equipments; the problems faced such as input supply, breakdowns and spareparts availability, shortage of skilled manpower, water and power cuts; and data on industrial performances in terms of organization, engineering, production and financial aspects which are related to technological capacity (development). Also data on the level and amount of R & D if any and on other services associated with technological capacity. In most cases, such primary data is available only for a period from 1985 to 1990. This is because most industries destroy their data after 2-5 years. Although inadequate, such primary data, indicate the limited efforts made on building technological capacity especially in view of the experiences of the economic crisis period. That is, to try to investigate to what extent the industries had learnt and were taking positive technological efforts in confronting some of the problems which affected their performances; so as to be able to sustain and improve their production levels, productivity and capacity utilization.

5.2:3 Methodology

In this section the methodology is concerned with two main issues: First, the analysis of industrial performances, and second, the measurement of technological capacity and efforts.

5.2:3 (a) Labour Productivity and Capacity Utilization Indicators of Industrial Performances

The performance indicators used in this section are the

$$\text{labour productivity} = \frac{\text{Output}}{\text{Employee}} \quad \text{and}$$

$$\text{Capacity utilization Rates} = \frac{\text{Actual Production}}{\text{Installed Capacity}}$$

5.2:3 (b) Measures and Impact of Technological Capacity

Adei (1987) noted that there are some difficulties in specifying technological capacity indicators. However, he further noted that, Girvan (1981) provided a useful summary of attempts to specify technological capacity mainly at national level rather that at the firm level. And that Farrell (1979) specified some elements of technological capacity at the firm level. Basing on these two cited studies and in addition by basing specifically on Adei (1987) study, our study has gathered some evidence which indicate the level of technological capacity at firm level and at national level. We have adopted two complimentary approaches (Static and Dynamic) in measuring technological efforts and capacities in the surveyed Tanzanian firms.

5.2:3 (b)(i) Static Analysis of Technological Capacity

In this case the qualitative analysis of the qualifications, experience and number of employees, state of machines and equipment, inputs and organizational structure is carried for the period. The main interest here is to establish the existing technological capacity (stock) in the concerned industries and make some comparisons of those stocks. The main problem of this approach is that it involves only some (limited) aspects of technological capacity, that is only the potential and not how much that potential has done or is doing. To overcome this deficiency, the second approach is also considered below in 5.2:3 (b) (ii).

5.2:3 (b) (ii) Dynamic Analysis of Technological Capacity

Adei (1987) noted that in a dynamic setting, technological capacity must be manifested in the successful performance of technological functions. That certain functions, viz: Organization technology, production technology, Financial technology, Engineering technology and Marketing technology are vital for the continual operation of the firm and hence performance indicators for such functions are partial indicators of technological capacity. In other words, technological capacity, is in this case, measured by qualitatively appraising the ability to undertake these vital functions in terms of human and material resources at the disposal of the firm (industry). This will indicate how much is done by the firm in terms of technological capacity. It is noted that successful performance of technological functions in the industries concerned reflect and also depend on technological capacity (stock) explained above in section 5.2:3 (b) (i).

5.2:4 Limitations of the Procedure used in 5.2

The approach used in 5.2 has some limitations. The main problem associated with this approach arises from the poor and inadequate data which thus made it difficult to construct many and much more correct indicators and for carrying out proper testing of their influences on technical change. Lall and Mohammed (1983) and Teitel (1987) noted this problem too. In most of the surveyed firms, we used mainly input indicators such as the number of engineers and technicians. The problem in this case, is that output indicators are not adequately used together with such input indicators. At best in our case, output indicators are reflected in the very few technological functions which the local technical and managerial manpower performed in the surveyed firms. Since very little was performed, then the output indicators themselves are inadequate.

In addition this approach also failed to indicate the effective utilization of the available engineers and scientists. It should be noted here that effective utilization of such technical personnel depend also on other factors not revealed by the input indicators themselves. In other words as noted in 3.1:2 input indicators fail to capture the contribution of other inputs into the technical change process.

However, even that small combination of output and input indicators of technological change (capacity) did at least indicate the low level of technological capability of the firms covered in Tanzania. And this is much more important for a developing country like Tanzania, where as noted in section 5.1:5 traditional measures of technical change fail to capture fully aspects of incremental technical change which could be expected to be much more common. So, even though, the input and output indicators of technological capacities and efforts may not be the best measure of technical change, they give a relatively much more realistic measure of technical change as compared to the method used in 5.1; as far as our study in Tanzania is concerned.

5.3 Evaluation of the Functions and Services of Some Tanzanian Technological Institutions

5.3:0 Introduction

The basic industrial strategy (BIS) (1975-1995) in Tanzania emphasizes the development of basic industries, basic in the sense of (i) using domestic resources to meet the basic needs of the people, and (ii) activities which establish the foundation of a self-sustaining economy. This is more or less similar to self-reliance objectives of the Tanzanian Arusha Declaration (1967). In this, part we are mainly concerned with issues related to (ii). Talking on (ii) then, is talking on self-reliant development.

We argued elsewhere in this study that the key element of self-reliant development is technological self-reliance. The core problem of a strategy aimed at promoting technological self-reliance is two fold: It involves on the one hand, the selection and management of imported technology; and on the other, the stimulation of indigenous technological capabilities. In this study we are concerned with this second aspect.

Kuuya (1977) argued that developing countries and Tanzania in particular does not have the necessary economic structures that could allow for self-generating and self-sustaining technological developments. He further asserted that:

> "What Tanzania needs are well-staffed research institutions and workshops where our scientists, engineers, designers etc., can indulge in serious productive work, hopefully with the end result of a new invention. Therefore institutions should be set up to carry inventions a stage - their practical application to the problem solving in the country".

While we agree with Kuuya's assertion, it is noted that there is no simple method of defining the best course of action for the development of indigenous technological capabilities and so care must be taken in attempts to establish and utilize such technological institutions.

In this case then we are concerned with technological efforts (establishing and utilizing technological institutions) which may not necessarily contribute directly to improvement of industrial performances in the short run but could contribute to acquiring or to building up of technological skills (national technological capability) with a long term objective of attaining technological self-reliant development. The establishing and effective utilization of such technological institutions in Tanzania is therefore a very crucial step in realizing the self-reliance objective as specified in the Arusha Declaration (1967).

5.3:1 Data Sources and Collection

In this third part of the empirical analysis of this study; data were collected mainly by visiting the concerned institutions and interviewing the relevant authorities. Most of these institutions have been established long time after the establishment of the Arusha Declaration (1967) and its adopted nationalization policy. So most are parastatals. It would be interesting to assess such technological efforts with respect to promotion of technological self-reliance.

This part; involved visiting and collecting data from the following institutions which are related to manufacturing sector, viz: TEMDO, TISCO, TIRDO, MEIDA, MEIDA maintenance services, IPI of the University of Dar es Salaam, the Faculty of Engineering of the University of Dar es Salaam and Dar es Salaam Technical College.

5.3:2 Data Requirement and Methodology

In assessing the above named technological institutions we have identified the functions performed by the institutions, the means at their disposal and their potential for change and development. The list include promotional and service institutions and we hope that their activities involve implicit policy and impinge on a variety of ways on the process of technological development. In this sense we have thought more in terms of functions and services they (institutions) perform rather than in terms of institutions per se, since ultimately it is here that the major interest lies. This approach requires the specification of such functions and services and its correlation with the potential offered by the available institutions. In this case we have the following:

(i) Provision of Technical personnel (Engineers and Technicians): The Faculty of Engineering and Dar-Technical College are covered.

(ii) Promotion and Coordination of the development of specific sector (Metal and Engineering sub-sectors): Meida.

(iii) Creation of Preventive maintenance centres: Meida maintenance workshop.

(iv) Provision of Local Industrial Research, Consultancy and Designs Services: TISCO, TIRDO.

(v) Provision of Spares, Research and

Consultancy IPI of the University of Dar es Salaam.

(vi) Briefly the role of S & T Commission and the newly established ministry of S & T and Higher Education.

In terms of data then, in assessing such institutional capabilities, we have gone beyond the number of technical personnel and expenditure incurred; to qualitative evaluation of the output of the institutions. We have also investigated the possibilities of strengthening such institutions, extending the scope of their activities, and issues of contracts, cooperation and coordination locally and internationally.

While section 5.2 have dealt mainly with investigation of technological capacity at firm (industry) level; to have a more realistic picture of the state of technological capacity at national level (the Tanzanian manufacturing industries sector); analysis of 5.2 above have been supported by analysis in this section 5.3 which investigate technological capacity in institutions which are mainly intended to serve the manufacturing sector in as far as technological development is concerned.

5.3:3 Limitations of the Procedure used in 5.3

Most of the problems explained in section 5.2:4 are applicable to section 5.3 as well. However, it should be noted in addition that the technological institutions explained in section 5.3 are to a large extent "producers" of the incremental technological change. The consumers of such technological change are the firms some of which are explained in section 5.2. The problem here is that the approach used in 5.3 has mainly concerned itself with the technological capacity of the covered technological institutions, little information was revealed on the impact of such technological institutions in the technological development in Tanzanian manufacturing industries. This was mainly the problem of lack of adequate data on feedback from their (technological institutions) customers.

Inspite of such problems the approach used in 5.3 have helped to indicate technological capacity at national level, that is, when analysis of 5.2 and 5.3 are all considered then a much more realistic picture of technological efforts and capacities in Tanzanian manufacturing industrial sector is presented.

CHAPTER 6

PRODUCTION FUNCTION ANALYSIS OF TECHNICAL CHANGE IN TANZANIAN MANUFACTURING INDUSTRIES

6.0 Introduction

It is noted in chapter 5 that the empirical analysis of this study is carried out in three chapters. In this chapter (6), we have carried out only the first part. The second and third parts of empirical analysis are carried out in chapters 7 and 8, respectively.

In this chapter (6), seven industrial cases have been covered: The Tanzanian manufacturing sector; the Metals and Engineering sub-sector (ISIC 371-72 & 381, 382-83 and 384); Textiles (ISIC 321); Footwear and other wearing apparel (ISIC 322, 324); Metals (ISIC 371-72 & 381); Assembly and Repair of Machinery (ISIC 382-83); and Transport Equipment (ISIC 384). Initially, we intended to cover also, Food (ISIC 311 & 312); Leather (ISIC 323) and Rubber (ISIC 355), but we dropped these three cases for reason(s) explained in 6.1.

The sample period in this chapter is from 1966 to 1988. However, the Chow Test confirmed the existence of a structural break in the sample period, particularly starting from 1981. Accordingly the computed F* Ratio was found to be greater than the critical value of F at 0.05

level in most of the covered industrial cases. We have carried out estimations for the sample periods 1966-1980 and 1981-1988 separately, even for the few cases which indicated absence of structural break in the sample period. This is mainly for consistency.

This chapter is divided into the following sections, viz: section 6.0 is on introduction. Section 6.1 is on estimation of capital input; Section 6.2 is on estimation of technical change, that is, the Hicks neutral technical change. And section 6.3 summarises and concludes the chapter.

6.1 Estimation of capital input

The analysis in this chapter is subsequent to a reasonable estimation of capital input. In chapter 5 we noted the difficulties involved in estimating capital. In this chapter 6, we have only minimized rather than solve completely such problems. We have estimated capital stock series and then constructed capacity utilization indices to arrive at utilized capital stock series which are then used in our analysis.

We initially estimated the incremental capital output ratios (ICORs) for the covered industrial cases, as they are shown in Table 6.1

Table 6.1: Incremental Capital Output Ratios (ICORs) for the covered industrial Cases; 1966 - 1988

Year	Textiles	Footwear	Metals	Machinery	Transport	Metals & Engineering	Total Mfg. Sector
1966	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-
1968	3.9	3.6	2.3	2.7	2.0	2.2	3.0
1969	2.9	4.1	1.2	2.3	1.3	1.5	2.2
1970	2.8	2.2	1.3	2.8	1.5	1.7	2.5
1971	3.7	2.7	1.6	2.1	1.3	1.5	2.8
1972	3.8	2.7	3.1	1.5	1.5	2.3	3.2
1973	9.8	9.1	5.3	1.3	1.3	2.7	2.3
1974	8.4	1.8	2.7	1.7	1.7	2.3	3.4
1975	2.7	2.0	2.5	1.2	2.1	2.2	2.7
1976	2.9	4.1	4.9	1.0	4.2	3.8	5.2
1977	1.3	2.5	4.2	0.7	9.6	3.7	6.2
1978	1.2	45.9	15.9	1.5	4.1	8.5	10.1
1979	2.1	31.0	-136.0	215.5	5.5	22.5	99.0
1980	-7.0	-2.9	-3.6	-2.3	9.0	-4.9	-7.7
1981	-1.4	-39.4	-2.9	-3.9	10.4	-4.8	-6.3
1982	-1.5	-160.7	-724.7	-5.7	-17.7	-16.4	-9.3
1983	-1.8	-64.3	13.5	23.2	-17.2	588.9	-75.2
1984	11.0	-6.3	3.5	18.3	-22.5	14.8	-19.0
1985	-2.0	-1.4	29.8	3.5	-13.9	29.6	-39.4
1986	-16.7	-1.7	-25.5	-131.1	7.8	26.7	-51.7
1987	-34.5	-3.0	18.5	-7.15	-3.8	-8.6	109.4
1988	-	-	-	-	-	-	-

Source: See Tables 1-7 in Appendix 6.1

Table 6.1 indicates that in each of the covered industrial cases, the ICORs were stable (relative small variations) in the period 1966-1972. For instance, in the case of Total Manufacturing sector during the period, the ICORs varied from 2.2 to 3.2 with an average of 2.7.

Since the ICORs were reasonably stable, then the incremental and average capital output ratio were the same (ICOR = COR). Hence for 1972 the ICOR = COR = 2.7 and this was used to compute base year (1972) capital stock, which was in return used as a basis for estimating (using perpetual inventory method) capital stock series for the other years in the sample period 1966-1988. A similar procedure was used in the case of other industrial cases.

As for the cases of Food, Leather and Rubber, the ICORs in the period 1966-1972 showed very large variations and hence they (ICORs) were unstable. In this regard, we failed to estimate the base year capital stock, since ICORs were not equal to CORs. As such, estimations of capital stock series were not carried out in the three industrial cases. Therefore, the three industrial cases were dropped from the analysis.

The negative ICORs since the late 1970s in Table 6.1 indicate that additional capital was not being effectively utilized in the production processes. Ndulu (1986) and Bukuku (1988) obtained more or less similar results in Tanzania's manufacturing sector and Tanzanian economy, respectively. Massive investment took place in Tanzania's manufacturing sector in the period of the mid 1970s to the late 1970s. However, later, in the period of the late 1970s to the 1980s there was serious foreign exchange shortages in Tanzania. This contributed partly to the less effective utilization of the massive investments and hence very low industrial production. All these explain the observed negative ICORs.

From the Ministry of Industries and Trade, we obtained capacity utilization figures for the years 1975, 1977 and years 1978 onwards. As for the period 1966-1972 we assumed like Ndulu (1986) that capacity utilization rates were more or less 100%. There were thus gaps for few years in the early 1970s and 1976. We intended to fill in the gaps by use of percentage changes in investment productivity (the inverse of ICORs) to estimate capacity utilization. However, the large disparities between the investment productivity and the actually obtained capacity utilization rates prompted us to drop the method. Instead we used the average capacity utilisation figures from Bank of Tanzania (various) and NDC publications (various) to fill in the few gaps. We therefore constructed capacity utilisation rate indices which were used to arrive at utilized capital stock series.

In this chapter, we have used utilized capital stock (KU) rather than total estimated capital stock (K). This is on the assumption that estimated capital stock was not being fully utilized. According to Table 1 in Appendix 6.2, all the coefficients of unutilized capital stock (Ke) were too small and too insignificant (t-test). That means the unutilized capital stock (Ke) was unimportant and had zero marginal productivity in each of the concerned industries. Ndulu (1986) and Bagachwa (1992) also found that marginal productivity of unutilized capital was zero in Tanzanian manufacturing industries. Thus, in this chapter we have dropped out unutilized capital (Ke) from the analysis.

6.2 ESTIMATION OF TECHNICAL CHANGE:

Use of Time trend (Tim)

The type of technical change being estimated in this section refers to Hicks neutral technical change. Equation 4 in section 5.1:4 has been used. For the sample period 1966-1980 results obtained are presented in Table 6.2.

Table 6.2: Estimates of the Production Function in the concerned Manufacturing Industrial Cases 1966-1980 (Time Trend Variable included)

Industrial Cases	Const.	LKU	LL	Tim	Ad.R	DW	F	df
Textiles	1.494 (0.24)	0.243 (1.263)	0.630 (1.196)	0.039 (0.905)	0.941	1.825	39.041	9
Footwear	2.888 (0.541)	0.312 (0.566)	0.427 (0.907)	0.027 (0.333)	0.762	2.744	8.988	7
Metals	3.430 (1.328)	0.007 (0.041)	0.719 (3.450)	0.063 (1.594)	0.949	1.650	88.510	11
Machinery	1.890 (0.767)	0.456 (1.912)	0.302 (1.247)	0.086 (2.457)	0.964	1.593	87.088	9
Total Manufacturin g Sector	4.051 (1.280)	0.353 (2.856)	0.343 (1.055)	0.036 (1.578)	0.980	1.828	162.722	10

In Table 6.2, the coefficient of determination adjusted for the appropriate degrees of freedom was .94 and above in four cases. Thus, 94 percent or more of the variation in the value of output in each of the four cases was explained by labour, capital and time trend (Hicks neutral technical change), in the sample period 1966-1980. And in footwear the Ad.R was .76. An F-test show that in each of the five cases, the regression was highly significant at 5% level. Therefore, the adopted average Cobb-Douglas production function provided good fit to the data for the sample period 1966-1980.

The sum of the labour and capital coefficients was less than unity in each of the five cases; that is between .7 for total manufacturing sector and .9 for Textiles. This suggests that each of the industrial case, was characterized by decreasing returns to scale in 1966-1980. However, the Titner's (1952) F-test in Koutsyiannis (1977) showed that the sum of the unrestricted coefficients of labour and capital in each of the five cases, do not depart significantly from unity thus indicating the existence of constant returns to scale.

The coefficients of labour, capital and time trend had positive correct signs in all cases. Variation in output in each of the concerned industrial cases, in the sample period 1966-1980, was thus positively explained by labour, capital and time trend (Hicks neutral technical change). But in some cases the coefficients were insignificant. For instance, labour was positive but insignificant in footwear. It was less significant in

Textiles and in Machinery (significant at 30% level only) and total manufacturing sector (significant at 40% level only). In the metals, however, labour was very significant at 1% level while capital input was insignificant (significant at 30% level only). It was significant, however, in machinery at 1% level and in total manufacturing sector at 2%.

The coefficient of time trend (neutral technical change) in each of the five cases was positive but small ranging from 0.027 in footwear to 0.086 in machinery. Specifically, it appears that, Textiles for instance, experienced some neutral technical change in the period 1966-1980, which was 0.039, indicating that the rate of neutral technical change(m) was 3.9% per year. That is, with no increase in labour or capital, output in Textiles would grow at the rate of 3.9% due to neutral technical change. However this rate (m) in the case of Textiles was found to be quite insignificant (t-test) in this period 1966-1980).

A small but insignificant neutral technical change (with 2.7% rate) was also noted in the case of footwear. For the cases of metals, machinery and total manufacturing sector, small but comparatively more significant (t-test) neutral technical change was noted in the period 1966-1980. Thus, during 1966-1980, neutral technical change contributed, though quite small, positively and significantly (t-test) to the growth of output in the cases of metals, machinery and total manufacturing sector.

Table 6.3: Estimates of the CD Production Function in the Concerned Manufacturing Industrial Cases 1966-1988 (Time Trend Variable included)

Industrial	Const.	LKU	LL	Tim	Ad.R	DW	F	df
Footwear	-1.864 (-0.455)	0.407 (1.405)	0.877 (4.146)	-0.075 (-3.182)	0.808	2.298	23.126	18
Metals	0.919 (0.564)	0.307 (1.833)	0.658 (3.424)	-0.004 (-0.237)	0.864	1.457	47.545	19
Machinery	0.892 (0.255)	0.599 (1.834)	0.311 (1.590)	0.007 (0.239)	0.896	1.993	46.168	18
Transport Equipment	3.135 (1.245)	0.195 (0.732)	0.526 (3.951)	0.023 (1.049)	0.896	2.127	46.200	18
Metals & Engineering	3.643 (1.374)	0.281 (1.250)	0.441 (2.890)	0.004 (0.304)	0.954	1.999	84.231	17
Total Manufacturing Sector	-3.198 (-1.039)	0.782 (2.932)	0.432 (1.768)	-0.005 (-0.451)	0.947	1.868	94.644	18

In Table 6.3, the Ad.R was .90 and above in five cases. Thus, 90 percent and above of the variation in each of the five cases, in the sample period 1966-1988 was explained by capital, labour and time trend (neutral technical change). In the footwear, the Ad.R was .81.

An F-test, shows that in each of the six covered cases, the regression was highly significant at 5% level, thus confirming that the adopted average Cobb-Douglas production function provided good fit to the data for the sample period 1966-1988 also.

The sum of the coefficients of labour and capital was greater than unity in two cases, thus indicating existence of increasing returns to scale. The sum was less than unity in three cases, hence suggesting existence of decreasing returns to scale. And in one case, the sum was approximately equal to unity, thus indicating existence of constant returns to scale. But Titner's (1952) F-test shows that the sum of unrestricted coefficients of labour and capital which ranged from 0.7 to 1.3, do not depart significantly from unity thus indicating existence of constant returns to scale in the covered cases for the period 1966-1988.

The coefficients of labour and capital during 1966-1988 period, had positive correct signs in all cases. The labour coefficient was significant in each of the six cases. The capital coefficient, however, was significant in five cases and insignificant in the case of transport equipment. And the time trend (technical change) coefficient was positive in only three cases and negative in the other three cases. The rate of the observed neutral technical change was also quite small in each of the case.

The small neutral technical change that occurred in some cases in the period 1966-1980, declined in the period 1966-1988 (Tables 6.2 and 6.3). For instance, machinery in the period 1966-1980 had 8.6% rate of neutral technical change which was also significant (t-test). But in 1966-1988 it declined to only 0.7% and was quite insignificant. In Metals the rate of neutral technical change which was

6.3%, positive and significant in the period 1966-1980, declined and became small, negative, that is, - 0.4%, and insignificant, in the period 1966-1988. And in total manufacturing sector, the rate of neutral technical change which was 3.6%, positive and significant in the period 1966-1980, declined and became small, negative, that is - 0.5% and insignificant in the 1966-1988 period.

In Transport equipment and in metals and engineering sub-sector, in the period 1966-1988 there was positive but very insignificant neutral technical change. Only in footwear, in the period 1966-1988, neutral technical change was significant but negative. Thus, except for footwear, in all the other cases, the impact of neutral technical change on output growth in the period 1966-1988 was quite negligible and unimportant. It was noted that neutral technical change did not contribute significantly to variation in output in footwear in the period 1966-1980. But in the period 1966-1988, about 7% of the fall in output in footwear was due to neutral technical change retrogression.

6.3 Summary and Conclusions

The empirical analysis in this chapter (6), involved seven industrial cases (6.0). An F-test in each of the covered industrial cases have shown that regression was statistically significant and hence the adopted Cobb-Douglas production function provided a good fit to the data for the two sample periods, 1966-1980 and 1966-1988.

The approach adopted in this chapter, largely attributes the residual of the growth of output over that of factor inputs, to technical progress. However, the other factors behind this source of growth could be vindicated, including scale economies. But the Titner's (1952) F-test indicated the existence of constant returns to scale in all the industrial cases covered in this chapter, for the two sample periods, and so vindication of other factors becomes less of a problem.

In addition, we have in this chapter, corrected the estimated capital stock for capacity utilization changes, which in the case of such short time series data could account for the bulk of the observed growth residuals. Therefore, capacity utilization indices were constructed and hence we obtained and used utilised capital input in our production function analysis.

When the sample period was extended to cover the period 1966-1988, neutral technical change (time trend) declined, and hence was very small and insignificant in most cases, and was even negative and insignificant in some of the cases. In Footwear only, neutral technical change (time trend) was negative and significant, thus contributing to fall in footwear's output. In general, therefore, very little if any, neutral technical change (time trend) occurred in the covered industrial cases. In some cases technical change retrogression occurred although not significant except only in footwear.

According to chapters of theory and literature review, in developing countries, what is more important is what happens when technology is imported. The question here then is, what happened to massive industrial investment (imported technology) in the 1970s in the covered Tanzanian industrial cases. The experiences of the 1980s in the covered industries, appear to indicate that very little if any, technological efforts and capabilities supported the massive technology imports, hence the noted problems of the falling industrial output, declining labour productivities and low capacity utilization. However, the production function analysis adopted in this chapter do not tell us much about the technological efforts and capabilities.

The production function analysis as in this chapter is thus inadequate in terms of analysing technical change in a developing country like Tanzania, mainly, because of its failure to capture the technological efforts and capabilities. In addition the production function analysis is faced with measurements problems especially in view of the severe data constraints which are quite common in developing countries, Tanzania included. The results in this chapter have therefore to be interpreted with much caution. At best they are mere general indicators rather than being accurate estimations of technical change.

In an attempt to complement the results obtained in this chapter, this study proceeds with qualitative analysis of technological efforts and capabilities in some firms in the Tanzania's metals and engineering sub-sector and in some technological institutions in chapter 7 and 8 respectively.

CHAPTER 7

ANALYSIS OF TECHNOLOGICAL EFFORTS AND CAPACITIES IN SOME METALS AND ENGINEERING FIRMS IN TANZANIA

7.0 Introduction

In this chapter, we intend to analyse technological efforts and capacities of some metals and engineering firms in Tanzania. Specifically the following firms have been surveyed: Ubungo Farm Implements Ltd. (UFI in ISIC 3811); Steel Rolling Mills Ltd. (SRM in ISIC 3710); Metal Box (T) Ltd. (CMB.P.(T) in ISIC 3819); National Engineering Company Ltd. (NECO in ISIC 3829) and Manik Engineers Company (Manik in ISIC 3823). And the time period covered, though with some variations amongst firms, has in general been between the early 1970s and 1990.

In this chapter the analysis is in three main parts. The first part is on firm's industrial performance in which labour productivity and capacity utilization are analysed for each of the surveyed firms. This first part is intended to be only as a background analysis. And it is noted that, the magnitudes of productivities an capacity utilization rates used, may not be quite accurate mainly on account of the poor quality of data. In spite of this weakness, it is expected that they will give us a general idea about the direction of the industrial performance of the surveyed firms.

The second part is on the analysis of the technological capacities and efforts in the surveyed firms. In this regard, static analysis on the state of manpower and of machinery is done on the surveyed firms. In addition, dynamic analysis on what has been done in terms of the technological functions is also carried out.

The third part is on the factors which have been inhibiting the technological capability build up and efforts in the surveyed firms.

In summary, chapter 7 is divided into the following sub-sections: 7.0 is on introduction; 7.1 on industrial performances; 7.2 on static and dynamic analysis of technological capacities and efforts; 7.3 is on factors inhibiting technological capability build up and efforts in Tanzanian manufacturing firms and 7.4 summarises and concludes the chapter.

7.1 Industrial Performance Analysis in the Surveyed Firms

In this section, the indicators used to analyse industrial performances in the surveyed firms are the labour productivity and capacity utilization rates.

In principle "efficiency" is a concept which denotes the relationship between the quantity of inputs used in production and the output generated as a result. If the same quantity of inputs are used in such a way that a higher ouput is generated or if the same quantity of output is generated by employing a smaller quantity of inputs, then efficiency is said to have increased. From this very broad definition of "efficiency" different empirical results may be obtained depending entirely upon how "output" and "inputs" are defined.

7.1:1 Labour Productivity

One of the most common measures of efficiency used by economists is the labour productivity measure. Perhaps its major attraction is that it is calculated with such ease, provided one can secure some reasonable estimates of output and labour input.[1] In this chapter, labour productivity is defined as real gross value added per employee. The calculated labour productivity series for each of the surveyed firms is shown in Table 7.1.

[1]See Merrett, S. (1971)

Table 7.1: Labour Productivity in the Surveyed Industrial Firms 1971-1990

	Ubungo F. Implements		Steel Rolling Mills		CMB.P.(T) (Metal Box)	National Engineering Coy	Manick Engineers
Year	RGVA/Emplo-yee (ooo'Tshs)	Actual Tons/Employ	RGVA/Empl. (000'Tshs)	Actual Tons/ Empl.	RGVA/Empl. (000'Tshs)	RGVA/ Employee (000'Tshs)	RGVA/ Employee (000'Tshs)
1971	N/A	N/A	N/A	36.4	N/A	N/A	N/A
1972	27.5	4.7	N/A	40.4	N/A	N/A	N/A
1973	16.2	2.0	N/A	39.6	N/A	N/A	N/A
1974	20.2	2.4	N/A	34.8	N/A	N/A	N/A
1975	25.6	2.4	109.6	77.6	31.8	9.4	9.7
1976	18.5	4.2	94.9	84.4	35.8	10.6	5.3
1977	N/A	2.8	35.4	67.4	23.6	11.7	4.7
1978	29.3	2.6	N/A	N/A	N/A	N/A	N/A
1979	25.0	2.4	37.5	60.8	28.6	20.2	13.3
1980	N/A	N/A	30.1	48.4	34.8	N/A	5.3
1981	14.1	3.8	25.4	50.2	N/A	N/A	10.2
1982	13.5	2.5	10.7	37.4	N/A	N/A	4.7
1983	35.7	4.4	28.2	26.7	N/A	N/A	13.3
1984	47.7	5.5	0.3	22.9	12.1	29.8	5.0
1985	36.4	3.9	19.7	32.6	10.8	11.6	23.2
1986	N/A	5.0	26.2	30.7	17.0	13.3	16.7
1987	N/A	4.7	75.5	25.8	N/A	12.7	18.6
1988	N/A	N/A	71.2	27.8	N/A	N/A	N/A
1989	N/A	N/A	N/A	28.2	N/A	N/A	Nil
1990	N/A	N/A	N/A	24.0	N/A	N/A	N/A

Note: RGVA = Real Gross Value Added (1976 Prices)

Source: Calculated using figures, from Tables 7.1 to 7.5 in Appendix 7.1.

Table 7.1 indicate that, in general labour productivity in each of the surveyed firms tended to rise in the years up to the late 1970s. But in the period since the late 1970s to the mid 1980s it tended to decline. And in the period of the late 1980s it peaked up. Looked more closely, however, this general trend appear not to have been uniform among the surveyed firms. Labour productivity rose, peaked and declined at different time periods and with different magnitudes. For instance rising labour productivities in the 1970s reached peak in UFI in 1978 when it was TShs. 29,300 per employee; in SRM in 1975 when it was TSh. 109600 per employee; in CMB.P. (T) in 1976 when it was TShs. 35,800 per employee; in NECO in 1979 when it was TShs. 20,200 per employee and in Manik in 1979 when it was Tshs. 13,300 per employee.

Declining labour productivities in the period between the late 1970s and the mid 1980s reached its lowest level in UFI in 1982 when it was TShs. 13,500 per employee; in SRM in 1984 when it was only TShs. 300 per employee; in CMB.P. (T) in 1985 when it was TShs. 10,800 per employee and in Manik in 1982 when it was TShs. 4,700 per employee. For NECO, data for the period 1980-1983 are not available. However, in the late 1980s in the surveyed firms, labour productivity appear to be rising slightly.

The noted differences in the trend of labour productivities among the surveyed firms were due to differences in the availability of foreign exchange for imported raw materials, inputs and spare parts; to differences in the availability of water and electricity; to differences in inflexibility in variation of labour input and to differences in the levels of technological efforts and capacities.

7.1:2 Capacity Utilization

In this section, lack of adequate data has forced us to analyse capacity utilization rates at firm level rather than at various production lines within each of the surveyed firms. Since in each of the surveyed firms new production lines and new machineries have been added at different times, it is, therefore, difficult to compute capacity utilization rates on the basis of production lines.

From firm's own sources we obtained capacity rates which in the case of UFI was the ratio of actual production to planned production. And for the rest of the surveyed firms the obtained capacity utilization rates were the ratio of actual production to installed capacity. In all the surveyed firms there were gaps in the provided capacity utilization rates. To fill in the gaps, we computed the two capacity utilization ratios accordingly in line with the type of ratio used by each particular firm. It is noted here that the two ratios of capacity utilization rates give different results and meaning and hence are not comparable over time. The ratio of actual to planned production give relatively higher rates than the ratio of actual to installed. In this case planned production may be a poor reflection of rated capacity, since planned targets take into account various constraints the firm faces with respect to capacity utilization. However, in the absence of adequate data, we have been forced to use, in the case of UFI only, the ratio of actual to planned production to at least indicate roughly the direction of capacity utilization. The capacity utilization rates for the surveyed firms are shown in Table 7.2

Table 7.2: Capacity Utilization Rates in the surveyed Industrial Firms

	Ubungo F. Implements	Steel Rolling Mills (SRM)	SRM	CMB.P. (T)	NECO	Manik Engineers
Year	Actual Tons Planned %	Actual Tons Planned %	Actual Tons Installed %	Capacity Rates* %	Capacity Rates* %	Actual Units Installed %
1971	N/A	53.8	43	N/A	N/A	36
1972	N/A	60.6	48.5	N/A	N/A	60
1973	63.2	57.9	46.3	N/A	N/A	88
1974	73.6	73.7	73.7	N/A	N/A	76
1975	78.8	104.8	94.8*	50*	N/A	45
1976	91.0	118.8	100.0*	63.2*	N/A	25
1977	N/A	98.1	82.4*	63.2*	N/A	23
1978	61.1	99.6	83.4*	72*	N/A	79
1979	68.0*	93.7	92.8*	70*	75*	85
1980	N/A	99.4	94.3	N/A	52*	88
1981	60*	89.8	80.0*	60*	63*	74
1982	31*	85.1	60.0*	41*	63*	26
1983	75*	63.1	45.5*	37*	N/A	48
1984	92.0*	54.6	39.4*	35.5*	N/A	24
1985	65.2*	79.3*	57.2*	30*	N/A	10
1986	90*	75.3	56.3*	30.0*	N/A	6
1987	75*	63.7	40.0*	35.7*	N/A	11
1988	70.0*	69.9	52.0*	27*	N/A	11
1989	N/A	69.8	52.3	N/A	N/A	Nil
1990	115.4+	60.9	N/A	N/A	N/A	5

Notes: + = For hoes production only.

Source: Except for those with * all calculations are based on figures in Tables 7.1 - 7.5 in Appendix 7.1.

*: Figures from Company's (firm's) unpublished reports.

Table 7.2 indicate that in general capacity utilization rates were rising in the 1970s, declining in the period between the late 1970s and the mid 1980s and slightly improving in the late 1980s. For instance in years 1972-1973, SRM was operating at below 50% capacity. Later, the rate rose to 73.7% in 1974 and to 94.3% in 1980. In CMB.P. (T) capacity utilization which was 60.2% in 1976, rose to 72% in 1978. A more or less similar trend was observed in the case of the other surveyed firms in the 1970s. Although in the 1970s we note the rising capacity utilization rates, but clearly the figures in Table 7.2 indicate that even in the 1970s there were capacity underutilization.

Capacity underutilization in the 1970s was caused by several general and specific (to the firm) factors. The general factors were frequent machinery breakdowns; lack of spare parts; shortage of water, electricity and raw materials and lack of engineering facilities and qualified manpower.

The specific factors include for instance in the case of SRM, that in the early 1970s the firm faced lack of demand for its products as customers preferred corresponding imported Japanese products. In the case of UFI too, lack of demand for its products in 1971-1972 resulted in excess stock of hoes such that it was forced to reduce production and undertake some diversification of production. And in the case of Manik the noted fluctuating capacity utilization trend in the 1970s was due to variations in weather and crops which thus affected demand for maize mills. In addition the fluctuations were due also to customer's preference for imported milling machines whenever they were available.

In the surveyed firms in the period of the late 1970s to the mid 1980s the noted general causes of capacity underutilization intensified. Specifically, foreign exchange shortages became worse and thus gravely affected importation of intermediate inputs, spares and raw materials. Therefore, capacity undertulization declined drastically. For instance, declining capacity utilization reached its lowest level in SRM in 1984 when it was only 39.4%. It was only 30% in 1986 in CMB.P. (T) and 6% in 1986 in Manik. Even in the case of UFI capacity utilization continued to decline in the 1980s and reached the lowest level in 1982 (31%).[2]

In the case of NECO, according to the Daily News of May, 3, 1989 the firm's foundry shop was capable of smelting 400 tonnes of iron a year, but it hardly handled 100 tonnes a year thus reflecting very low, 25% capacity utilization. In particular there was low demand for NECO's products because customers preferred imported spareparts especially under the trade liberalisation policy in the 1980s. This partly affected demand and hence production of smelt iron which is used in the spares fabrications.

[2]Figures in bracket are not comparable to others. UFI's rates are the ratio of actual to planned production.

In the period of the late 1980s there were mixed experiences in respect to capacity underutilization in the surveyed firms. For instance in SRM, capacity utilization rose to 56.3% in 1986, declined to 40% in 1987 and rose again to 52.3% in 1989. Compared to 1984, that is 39.4% those were improvements although they were still below the levels attained in the years before 1982. In CMB.P. (T), too, capacity underutilization improved slightly to 35.7% in 1987 but declined to 27% in 1988. In Manik capacity utilization recovered slightly to 11% in 1987 but declined to 0% in 1989 when there was no production due to over-stocking from unsold previous products (machine mills and Basement frames).

The shortages of foreign exchange was one of the main causes of capacity underutilization in the surveyed firms in the period of the late 1970s to the mid 1980s. In 1978, for example Manik applied for foreign exchange of equivalent to TShs. 2 million and were granted the same amount by the Bank of Tanzania. But in 1988 they applied for the equivalent of TShs. 20 million and were granted nil. It has been noted that the implementation of the ERP1 and ERP2 since 1986/87 improved the availability of imported raw materials and other inputs financed mainly from import support funds. However this, as the case of Manik reveals, benefited only some of the manufacturing firms. Bank of Tanzania (1988) confirms this and in addition argues that even in the case of resulting improved capacity utilization rates, in the late 1980s they were still far below the rates attained in the 1970s and also were below the stipulated average under the ERPs of between 60% to 70%.

7.2 Static and Dynamic Analysis of Technological Efforts and Capacities in the Surveyed Firms.

In this section, technological efforts and capacities for the surveyed firms are analysed. This involve static analysis on the state of manpower and machines. Mainly, efforts to recruit and train the technical and managerial manpower are investigated. In addition, it involves dynamic analysis, in which case, analysis is undertaken on what the technical and managerial manpower is doing in terms of the technological functions (5.2:3 (b) (ii)). In this section (7.2), however, concentration will be on manpower rather than on machines due to availability of data and to the fact that skilled and experienced manpower is a key component in initiating and performing such technological functions.

7.2:1 Static Analysis

7.2:1(a) State of Manpower

In this section, we analyse recruitment and training issues as related to the trends in levels of employment and in localisation in the surveyed firms. We also analyse the technological capacities of their technical and managerial employees. Differences in efforts to recruit qualified employees, to understudy the expatriates and in effective training programmes result in differences in the levels of built capacities in terms of trained and experienced technical and managerial manpower.

7.2:1(a) (i) Employment trends

In general, in each of the surveyed firms, the total number of employees has been rising in the period between the early 1970s and 1990. In the case of UFI total employment trends for the period are shown in Table 7.3.

Table 7.3: Ubungo Farm Implements Ltd. (UFI) Levels of Employment 1972 - 1990

			Nationality						
Year	Production Staff (Operatives)	Professional Managerial Adm. Staff Technicians & Clerical (Others)	Tanzanians	Expatriates	Total Employees	Total Establishment	Vacancies	Localisation %	On Training
1972	191	42	229	4	233	N/A	N/A	98.8	N/A
1973	221	135	352	4	356	N/A	N/A	98.8	N/A
1974	221	128	345	4	349	N/A	N/A	98.9	N/A
1975	237	132	365	4	369	N/A	N/A	98.9	N/A
1976	193	214	403	-	407	434	27	99	N/A
1977	N/A	N/A	N/A	4	403	432	29	N/A	N/A
1978	249	169	414	4	418	426	12	99	18
1979	236	218	450	-	454	495	41	99.1	N/A
1980	N/A	N/A	599	-	599	621	22	100	284
1981	448	198	646	-	646	N/A	N/A	100	N/A
1982	401	248	649	-	649	N/A	N/A	100	N/A
1983	473	167	640	-	640	N/A	N/A	100	N/A
1984	447	176	623	-	623	N/A	N/A	100	N/A
1985	426	201	627	-	627	N/A	N/A	100	N/A
1986	430	236	666	-	666	675	6	100	67
1987	517	211	728	-	728	775	47	100	54
1988	531	223	754	-	754	N/A	N/A	100	N/A
1989	611	199	810	-	810	N/A	N/A	100	N/A
1990	630	205	835	-	835	N/A	N/A	100	N/A

Note: The non-operatives technicians, are those technicians in other departments (in the firm) which are not directly engaged in production.

Source: Firms' unpublished records.

Table 7.3 indicate that the total number of employees in UFI rose from 233 in 1972 to 454 in 1978 and 835 in 1990. The operatives had a greater rising share than the non-operatives (other employees) indicating priority to recruiting employees who are directly involved in production. The noted rising employment levels has been due mainly to expansion programme under which two new production lines were installed since 1980. Earlier there was only one production line.

Table 7.4: Steel Rolling Mills Ltd. (SRM). Levels of Employment 1971 - 1990

			NATIONALITY						
Year	Production Staff (Opera times)	Profes sional Manage rial & Adm. Staff Technicians & Clerical (Others)	Tanzanian	Expatri ates	Total Employ ment	Total Esta be.	Vacan cies	Local isati on %	On Trai ning
1971	93	25	103	15	118	N/A	N/A	87.3	N/A
1972	93	27	111	9	120	"	"	92.5	"
1973	85	32	113	4	117	"	"	96.6	"
1974	166	46	208	4	212	"	"	98.1	"
1975	96	39	131	4	135	"	"	97.0	"
1976	82	63	142	3	145	"	"	97.9	"
1977	109	41	147	3	150	"	"	98.0	"
1978	N/A	N/A	N/A	N/A	N/A	"	"	N/A	"
1979	213	93	303	3	306	"	"	99.0	"
1980	293	97	387	3	390	"	"	99.2	"
1981	150	190	337	3	340	"	"	99.1	"
1982	165	176	339	2	341	"	"	99.4	"
1983	174	181	353	2	355	"	"	99.4	"
1984	177	181	N/A	N.A	358	"	"	N/A	"
1985	180	185	N/A	N/A	365	"	"	N/A	"
1986	180	188	368	-	368	"	"	100	"
1987	186	184	370	-	370	"	"	100	"
1988	190	187	377	-	377	"	"	100	"
1989	194	177	371	-	371	"	"	100	"
1990	199	182	381	-	381	"	"	100	"

Note: See Table 7.3, why technicians are not included in operatives.

Source: Firm's unpublished records.

Table 7.4 indicate that total number of employees in SRM rose from 118 in 1971 to 306 in 1979 and was higher for the rest of the period. By 1990 it was 381. In the period between 1971 - 1980 the share of operatives in total employees was rising more than that of non-operatives. But in the period 1981 to 1986 the share of non-operatives in total employment was rising more than that of the operatives. In the period 1987 to 1990 the share of operatives was again rising more than that of non-operatives, although the share of non-operatives continued to be quite high when compared to the period 1971-1980. Therefore in SRM, there were mixed experiences in terms of priority given to recruiting employees who are directly involved in production.

Table 7.5: CMB.P.(T) Ltd. Levels of Employment: 1970-1986

			NATIONALITY						
Year	Production Staff (Operatives)	Professional Managerial & Adm. Staff Technicians & Clerical (Others)	Tanzanian	Expatriatee	Total Employ.	Total Establishment	Vacancies	Localization %	On Training
1970	234	77	287	24	311	N/A	N/A	92.3	N/A
1971	266	77	319	24	343	N/A	N/A	N/A	N/A
1972	287	33	300	20	320	N/A	N/A	N/A	N/A
1973	316	54	358	12	370	N/A	N/A	96.8	N/A
1974	244	70	302	12	314	N/A	N/A	N/A	N/A
1975	284	66	344	6	350	361	11	98.2	11
1976	269	63	324	8	332	N/A	N/A	N/A	N/A
1977	277	62	336	3	339	N/A	N/A	N/A	N/A
1978	273	70	338	5	343	N/A	N/A	N/A	N/A
1979	317	95	406	6	412	495	83	98.5	19
1980	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1981	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1982	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1983	326	77	N/A	N/A	403	N/A	N/A	N/A	N/A
1984	274	92	N/A	N/A	366	N/A	N/A	N/A	N/A
1985	308	150	N/A	N/A	458	N/A	N/A	N/A	N/A
1986	N/A	N/A	365	1	366	494	128	99.7	4

Note: See Table 7.3, why some technicians are not included in operatives.

Source: Firms Unpublished records.

Table 7.5 indicate that total number of employees in CMB.P. (T) Ltd. has been fluctuating without a definite trend. For instance, there were 311 employees in 1970, while there were 370 employees in 1973, 314 in 1974, 350 in 1975, 412 in 1978, 403 in 1983, 458 in 1985 and 366 in 1986. There were frequent resignations on the part of several employees in important posts in the firm, such as accounts, production engineering, maintenance engineering, stores, security and technicians posts. Reasons for frequent resignations were not given by the firms officials. However, because the posts involved are among the most important posts in the firm, the firm (CMB.P. (T) Ltd.) continued to recruit other employees. Resignations on one hand and recruitment efforts on the other explain the fluctuations in levels of employment at different times. And throughout the period 1970-1986, the share of operatives in total employment was higher than that of non-operatives, thus indicating priority in recruiting employees who are directly involved in production.

A more or less similar fluctuating employment trend is indicated in Table 7.6 which show the employment trends in NECO for the period 1971-1987.

Table 7.6: National Engineering Coy Ltd. Levels of Employment 1971-1987

			NATIONALITY		
Year	Production Staff (Operatives)	Professional Managerial & Adm. Staff Technicians & Clerical (Others)	Tanzanian	Expatriates	Total Employees
1971	109	55	158	6	164
1972	98	55	147	6	153
1973	154	95	244	5	249
1975	245	57	300	2	302
1977	245	111	345	11	356
1979	196	119	N/A	N/A	315
1981	N/A	N/A	N/A	N/A	N/A
1982	N/A	N/A	N/A	N/A	N/A
1983	N/A	N/A	N/A	7	N/A
1984	190	110	N/A	N/A	300
1985	185	107	N/A	N/A	292
1986	219	130	N/A	N/A	349
1987	267	81	N/A	N/A	348

Note: See Table 7.3, why some technicians are not included in operatives.

Source: Firm's Unpublished records.

Table 7.6 indicate that total employment in NECO was rising in the period 1971-1977, declining in the period 1979-1985 and thereater rising again. The firm's officials did not give reasons for the fluctuating trend. The share of operatives in total employment was higher than that of non-operatives for the whole period 1970-1986. This indicates priority in recruiting employees who are directly involved in production.

Table 7.7 **Manik Engineer Level and Capacity of Employment 1971-1990**

			NATIONALITY				
Year	Operatives	Others	Tanzanian	Expatriates	Total Emplo.	Total Establ.	Vacancies
1971	11	1	11	1	12	20	8
1972	15	1	15	1	16	20	4
1974	15	1	15	1	16	20	4
1975	13	1	13	1	14	20	6
1976	12	1	12	1	13	20	7
1977	10	1	N/A	N/A	11	20	9
1978	10	1	N/A	N/A	11	20	9
1979	15	4	N/A	N/A	19	20	1
1980	21	3	N/A	N/A	24	N/A	N/A
1981	21	4	N/A	N/A	25	N/A	N/A
1982	26	1	N/A	N/A	27	N/A	N/A
1983	22	1	N/A	N/A	23	N/A	N/A
1984	18	1	N/A	N/A	19	N/A	N/A
1985	14	1	N/A	N/A	15	N/A	N/A
1986	14	1	N/A	N/A	15	N/A	N/A
1987	14	2	N/A	N/A	16	N/A	N/A
1988	N/A	N/A	N/A	N/A	16	N/A	N/A
1989	N/A	N/A	N/A	N/A	13	N/A	N/A
1990	N/A	N/A	N/A	N/A	14	N/A	N/A

Source: Firm's unpublished records.

In the case of Manik, Table 7.7 show that the total number of employees was fluctuating without a definite trend for the period 1971-1990.

According to firm's officials, the fluctuating employment trend indicated in Table 7.7 is in line with the fluctuating production trends mainly on the basis of fluctuating demand for the firm's products. In the period 1971-1990 the share of operatives in total employment was higher than that of non-operatives indicating priority in recruiting employees who are directly involved in production.

7.2:1(a) (ii) Localisation trends

In general in the period 1970-1990, UFI, SRM and CMB.P. (T) achieved remarkable localisation in employment. For instance in Table 7.3, when UFI started production in 1971, localisation was 98.8% with 4 Chinese expatriates. According to the technological agreement between the Chinese and Tanzanian governments, the 4 Chinese expatriates were assigned local (Tanzanians) counterparts to understudy them, right from the beginning. This partly contributed to achieving 100% localisation by 1980. The complete localisation in UFI was possible also due to firm's efforts in recruiting qualified manpower; to firm's effective training programmes and on the job training. In addition, the simple technology supplied by Chinese to UFI was easily and competently managed.

In the case of SRM, as shown in Table 7.4 when production started in 1971, localisation was 87.3% with 15 expatriates. But by 1983 it was 99.4% with only 2 expatriates and by 1986 it was 100%. The technological agreement between the Tanzanian National Development Corporation (NDC) and Daniel and Co. of Italy did not contribute much to achieving complete localisation in SRM. Apart from this, the other contributing reasons for UFI's complete localisation are true also in the case of SRM.

In Table 7.6, CMB.P. (T) which started production in 1948, had by 1970 achieved 92.3% localisation with 24 expatriates. This rate rose to 98.2 in 1976 with 6 expatriates and reached 99.7 with only one expatriate in 1987. This localisation was achieved mainly because of the firm's efforts in recruiting qualified manpower, in training and in experience acquisition for its local employees. The relationship between CMB.P. (T) Ltd. and CMB.P. (UK) Ltd. does not seem to have contributed much in the localisation process in CMB.P.(T) Ltd.

In the case of NECO, in the period 1971-1983 there was not much achievement in localisation and the trend was fluctuating. In 1971 localisation was 96.3% with 6 expatriates. It was 99.3% with 2 expatriates in 1975 and in 1977 it was 96.9% with 11 expatriates. Failure to localise completely during the period 1971-1983 was due to lack of locals to understudy the expatriates. For instance 5 out of 7 German expatriates in 1983 were engineers, but there was no single local engineer to understudy any of the German expatriates. The technological agreement with the West Germany did not include the issue of "understudying" in the technological assistance package to NECO. Furthermore, even if there was opportunity to unpackage the technology package and assuming qualified local manpower were available, it would still take quite a long time in the case of NECO, for the qualified local manpower to competently manage the imported technology. This is mainly because of the much more complex nature of the engineering activities, like "designing" involved in the NECO's production activities.

In the period 1985-1990 NECO managed to recruit local engineers. The number of local engineers in NECO increased from 5 in 1985 to 11 in 1990 and the number of expatriates fell from 5 in 1983 to only 1 in 1989 (Table 7.11 below). In addition NECO acquired an experienced production manager in 1990. To sum up localisation in NECO started picking up by 1985.

Table 7.7 above indicate that between 1971 and 1976 there was only 1 expatriate in Manik. Localisation in Manik was 91.7% in 1971 and was 92% in 1976. However, due to absence of data it was difficult to know the progress on localisation in Manik in the period 1977-1990.

7.2:1(a) (iii) Capacities of Technical and Managerial Employees

Continuous recruitment of qualified technical and managerial personnel and engaging them in further training and in acquisition of experience helped some of the surveyed firms not only to raise their localisation levels but also to build up their technological capacities.

Table 7.8: Ubungo Farm Implements Ltd. Capacities of Technical and Managerial Employees 1985-1990

		NATIONALITY				
Position and/or Employment	Year	Tanzanian	Expatriates	Basic Qualifica tion	Years of Experience	Shortage
Engineers	1985	4	-	BSc. Degree	2-20	3
	1986	8	-	" "	"	-
	1987	10	-	" "	"	-
	1988-1989@	9	-	" "	"	-
	1990	11	-	" "	"	-
Production Manager	1985-1990	1	-	BSc.(Mech.E ng.) Degree	16-21	-
Techni cians	1985	13	-	Full Technician Certificate	2-13	4
	1986-1989@	17	-	"	"	3
	1990	20	-	"	"	-
Accountant / Auditors	1985	2	-	2CPA	2-20	-
	1986	4	-	2CPA, 2NAD	"	-
	1987	5	-	1CPA, 2NAD	"	-
	1988	3	-	1CPA, 2NAD	"	1CPA
	1989-1990@	5	-	2CPA, 3NAD	"	-
Marketing Personnel	1985	1	-	B.A. Degree	4-14	-
	1986	4	-	1BA, 3DBA	"	-
	1987-1990@	5	-	1BA, 4 DBA	"	-

Source: Firm's unpublished records.

Table 7.8 indicate that in 1985, UFI had 4 Tanzanian engineers all with BSc. degrees. There was a shortage of 3 such engineers. It is noted, however, that UFI had a very comprehensive manpower training programme for locals which included both short-term and long-term courses that led to the attainment of certificates, diplomas, and degrees. Special emphasis was put on courses leading to foundry technology, craftsmalnship (fitter & turner), management, accounts and mechanical engineering. This helped to raise the technological capacity of the firm's technical and managerial employees. Thus by 1990, UFI had 11 local engineers with BSc degrees and there was no shortage. In general unlike in 1985, by 1990 UFI had adequate qualified and experienced manpower in engineering (even in metallurgy), in production management, in technician posts, in accounts and internal audit and in marketing department.

Table 7.9: Steel Rolling Mills Ltd. Capacities of Technical and Managerial Employees 1980-1990

		NATIONALITY				
Position and/or Employment	Year	Tanzanian	Expatriates	Basic Qualif.	Years of Experience	Shortage
Engineers	1981	2	1	BSc. Degree	N/A	N/A
	1982-83@	4	1	" "	"	"
	1984-86@	4	-	" "	"	"
	1987-88@	3	-	" "	"	"
	1989-90@	4	-	" "	"	"
Production (Techni cal) Manager	1983-90@	1	-	BSc. MSc. Degree	7	-
Technicians	1980-84@	10	-	7FTC holders 3 Experience	over 7	-
	1985-86@	10	-	7 FTC, 3 Experience	over 7	1
	1987-88@	6	-	6 FTC, 2 Experience	over 7	3
	1989-90@	7	-	5 FTC, 2 Experience	over 7	4
Marketing Personnel	1981-1990@	6	-	Form IV	over 7 years	-
Accountants/ Auditors	1985-90@	N/A	N/A	N/A	N/A	N/A

Source: Firms unpublished records

Capacities of technical and managerial personnel in SRM in the period 1980-1990 are shown in Table 7.9 above. In 1982, SRM had 2 local engineers and 1 expatriate engineer each with a BSc. degree. Data was not available on the shortages of engineers in the period up to 1982. However, it is noted that through recruitment and effective training programmes, by 1990 SRM had 4 local engineers with BSc degrees and there was no expatriate. And in 1983, SRM got a local production manager who was an engineer with BSc and MSc degrees. By 1990 the production manager had a 7 years experience in that position. In most of the other departments in SRM (except for technicians posts) there were adequate qualified and experienced manpower by 1990.

The number of local technicians in the SRM declined from 10 in the 1980-1984 period to 7 in the 1989-1990 period. Partly as a result of this decline, the shortages of technicians in SRM increased from 1 in 1985-86 to 4 by 1989-1990. The firm's officials did not explain the reasons behind such shortage. However, in general, it is noted that SRM had by 1990 built some technological capacities in terms of numbers of the qualified and experienced technical and managerial personnel in most of its important departments.

Table 7.10: CMB.P.(T) Ltd. Capacities of Technical and Managerial Employees 1990

Position and/or Employment	Years	NATIONALITY Tanzanian	Expatriates	Basic Qualif.	Years of Experience	Shortage
Engineers	1990	4	-	3 BS.C Degree 1 Techn. Diploma	4-over 20	1
Technicians & Artisans	1990	44	-	Most FTC holders Artisans (experienced)	Long experience with CMB. (about 20 years)	-
Accountants /Auditors	1990	13	-	4 CPA, 1 ADCA 8 Accounts clerks	Long Experience (about 20 years)	-
Planners	1990	5	-	1 Form VI, 1 Form IV, 3 Assistants	Long Experience (about 20 years)	-
Marketing Personnel (Commercial Dept.)	1990	2	-	Manager CBE Diploma Salesman experience	Long Experience (about 20 years)	-
Production Manager	1990	1	-	A Professional Engineer with BSc. Degree	Long Experience (about 20 years)	

Source: Firm's Unpublished records.

Table 7.10 indicate capacities of technical and managerial employees in CMB.P. (T) Ltd only for 1990 because of absence of such data for other years. By 1990, all employees such as engineers, technicians, accountants/auditors, planners, marketing personnel and production manager were locals and there was only one shortage in the case of engineers. CMB.P. (T) had long term training programme for its local employees on an appenticeship basis. By 1990 some employees in CMB.P. (T) employees were also attending different courses in foreign institutions (in Kenya) as well as in local institutions such as the Institute of Finance Management and Dar es

Salaaam Technical College.

There have been some frequent unilateral resignations of trained technicians and shortage of training funds. These problems have minimized the firm's achievement in building its technological capacities. However, in general, CMB.P. (T) has managed to build some technological capacities in most of its technical and managerial employees.

Capacities of technical and managerial personnel in NECO, in the period 1983-1990 are shown in Table 7.11

Table 7.11: National Engineering Coy Ltd. Capacities of Technical and Managerial Employees 1983-1990

Position and/or Employment	Years	NATIONALITY Tanzanian	Expatriates	Basic Qualif.	Years of Experience	Shortage
Engineers	1983	N/A	5	5 BSc. Degree	2-12	
	1985	5	3	8 BSc. Degree	2-12	
	1986	8	3	11 BSc. Degree	2-12	
	1987	8	3	11 BSc. Degree	2-12	
	1988	8	2	8 BSc. Degree	2-12	
	1989	8	1	8 BSc. Degree	2-12	
	1990	11	N/A	11 BSc. Degree	2-12	
Production Manager	1985-88@ 1990	- 1	- -	- Experienced	- Long Experienced	1
Technicians	1986-87@	3	-	3 FTC	Some experience	
	1988-89@	4	-	3 FTC, 1 experienced	Some experience	
	1990	3	-	3 FTC		
Accountants	1984	2	2	2 Degrees, 2 CPA	Some experience	8
	1985	3	2	2 Degrees, 3 CPA	Some experience	7
	1986	10	2	3 Degrees, 4 CPA and 5 certificates	Some experience	N/A
	1987-88@	11	1	3 Degrees, 2 CPA and 6 certificates	Some experience	N/A
	1989-90@	11	-	2 Degrees, 2 CPA and 7 certificates	Some experience	N/A
Planners	1985-86@	5	2	4 Degrees, 1 CPA and 2 Certificates	1 experienced	N/A
	1987-90@	5	2	2 Degrees, 1 CPA and 2 Certificates	1 experienced	N/A
Marketing Personnel	1985-90@	-	-	-		1

Source: Firms unpublished records.

Table 7.11 indicate that by 1983, NECO had 5 engineers each with BSc. All of them were expatriates. However, through continuous recruitment by 1989, NECO had 8 local engineers with BSc as against 1 expatriate and by 1990 there were 11 local engineers all with BSc. Data on shortages of engineers is not available. In 1990 NECO got 1 local production manager who had a long experience in NECO's production activities.

The number of technicians in NECO was 3 in 1986-87 and by 1990 there was no change. However, the number of accountants increased from 2 in 1984 with 2 expatriates and by 1989-90 there were 11 qualified local accountants. There were also 5 qualified local planners as against 2 expatriates. In the period 1985-1990 NECO which required 1 marketing personnel had none. It appears in general that, NECO for the period 1983-1990 had built up some technological capacity with respect to numbers of qualified engineers, but there were very little or no such achievement with respect to technicians, planners and marketing personnel.

In the case of Manik, absence of data on qualifications, experiences and shortages made it difficult to assess capacities of its technical and managerial manpower.

7.2:1(b) State of Machinery

The Chinese designed and supplied UFI's machinery and manufacturing know-how (technology). This involved general purpose machines and hand tools technology.[3] This technology was relatively simple and hence easier to understand and master in terms of operations and maintenance. In chapter 3, it was noted that, the simplicity of technology was one of the factors to Hong Kong's success in terms of building technological capability. UFI also has a workshop for fabricating spare parts.

In the case of SRM, Daniel and Co. of Italy supplied the machineries and technology. This involved special purpose machinery in conjuction with open and losed loop automation for production of steel bars, rods and flats. However, the machines which were installed in SRM were very old. They were installed about 20 years ago in 1971 and were a model of those produced in Europe some time after the second world war. And that the production of such models was completely phased out in the 1960s to give way to new modern machines. In that case SRM faced frequent machinery breakdowns. However, SRM has its own workshop for fabricating spare parts.

The state of machines in the CMB.P. (T) indicate that some of the machines were very old (about 30 years old);

---

[3]According to Barker, Bhagavan, Mitschke-Collande (1986), the levels of machinery technology in use in Tanzania span, the whole range (Hand tools, General purpose machinery, special purpose machinery, open loop automation, closed loop automation and computer controlled production).

were not working properly and some were already written off. Therefore, there were frequent machinery breakdowns. However in 1991, CMB.P. (T) acquired some new automated machines and equipment called "the Super Wina Welding technology" for can making. These are the latest special purpose machines imported from Switzerland, United Kingdom and Germany. There are currently less machinery breakdowns. CMB.P. (T) also has its own small tool room for forging some spare parts.

In the case of NECO and Manik, data on the state of machines were lacking. The officials of the two firms failed to supply information on the state of machines of their firms.

7.2:2 Dynamic Analysis

7.2:2(a) Organization technology

The four surveyed firms, that is UFI, SRM, CMB.P. (T) and NECO, each has an organizational structure which include specialised departments such as administration, production, maintenance, engineering, accounting, internal auditing, quality control and marketing. Only in the case of NECO the weak marketing department was evidenced. In the case of Manik, there were no such specialised departments. The director who is the owner of the firm, was also a production manager and also performed some maintenance services, marketing and planning. The other employees in Manik include a secretary, foreman, assistant foreman and others.

In each of the 4 surveyed firms there is some information flow system among the departments and with some other local firms and technological institutions. For instance based on the information flow system , UFI obtains some spare parts from local engineering firms such as the Mang'ula Mechanics and Machine Tools company Ltd. (MMMT) and NECO. And SRM has contacts with TEMDO which design and manufacture machines; with TIRDO which conducts industrial research, with NECO which provide some spare parts and with ALAF (Steel Cast Plant) which supply (40%) raw materials (billets) of which about 60% is imported from West Germany, United Kingdom and Holland.[4] CMB.P. (T) obtains some spare parts from the Kilimanjaro Machine Tool Company (KMLT), and also attends workshops organized by MEIDA. As noted above, NECO supplies spare parts to UFI and SRM. And according to NDC's group companies meeting in 1989, NECO was expected together with other engineering firms such as KMLT and MMMT to strengthen their marketing efforts through a joint marketing plan by undertaking an extensive advertising campaign. In the case of Manik there is no information on its information flow system.

[4]TEMDO, TIRDO and MEIDA are some of the Technological institutions. See also chapter 8 of this study.

With respect to investment in human resources, as explained in 7.2:1(a) there were some remarkable achievement in UFI, SRM and CMB.P. (T) and only recently in NECO as well. And with respect to planning, in general, in the case of SRM and UFI more than two thirds of the planned production targets were being adhered to (Table 7.2). There is no corresponding planning information on the part of CMB.P. (T), NECO and Manik. And finally, in all the surveyed firms, there is no information on how industrial relations problems were being handled.

7.2:2(b) Production Technology

In as far as performance on production technology is concerned there was little information on only issues related to maintenance of production levels, on keeping wastage to the minimum and on substituting local raw materials.

It is only implied, for instance in the case of UFI and SRM that in the absence of foreign expatriates the successful maintenance of production levels even in the crisis period, reflect partial success in the performance of production technology. It was reported that SRM has a specialised efficient quality control department which in 1990 helped to keep wastage to the minimum, with full length production being 90%, shorts being 5%, scraps 2%

and scale loss 3%. And further, SRM has been trying to obtain its main raw materials (billets) locally (40%) from Aluminium Africa Ltd. and has a long term plan of building its own plant for production of billets.

UFI and CMB.P. (T) too have quality control departments but there was no information on their performances. Also, for all the surveyed firms information was lacking on changes in product mix and quality, and on introduction of new methods of production and on cost reduction.

7.2:2(c) Financial Technology

In the surveyed firms (except in Manik) the financial accounting was good and was audited by Tanzania Audit corporation. This was possible due to availability of qualified accountants and internal auditors. And in some cases such as CMB.P. (T) introduction of computer technology has improved the financial information record keeping. However, information was lacking on costing of products in the surveyed firms.

7.2:2(d) Marketing technology

UFI and SRM each strengthened its marketing department by employing qualified manpower and by opening up distribution zones. For instance UFI established 6 distribution zones in Tanzania to ensure effective and timely distribution of farm implements. However in all the surveyed firms information related to maintaining market shares, responding to market or demand changes, overseas sales and debt recovery was lacking.

7.2:2(e) Engineering technology

It is in the case of engineering technology that comparatively more performances are noted in almost all the surveyed firms. UFI, SRM, CMB.P.(T) and NECO, each has a workshop which is equiped by general purpose machines. The presence of these workshops together with the availability of qualified and experienced manpower has enabled each of the 4 firms to fabricate spare parts; to have capacity for some simple designs and innovations and carry out some maintenance and rehabilitations.

SRM, for example, has its own workshop which designs and produces about 70% of its spare parts. In 1989, the Mills local engineers and technicians successfully carried out complete rehabilitation of the plant using local resources and spare designed and produced at the Mills workshop. And that the Mills furnance which was almost falling into pieces was also redesigned by the local engineers to enable locally produced spareparts to be fitted and so the furnace started working well, thus contributing partially to improvement in firm's capacity utilization.

In the case of NECO, the spare parts fabricated in its workshop are not used by NECO only but also by other local firms such as UFI and SRM. In addition NECO is involved in "designing" some new systems and installing them in other local firms. Designing is a much more complex part of engineering technology and hence only very few other engineering firms such as SRM provide this service. In Tanzania, "designing" is mostly carried out in specialized technological institutions such as TEMDO.

In Manik, its director peforms some maintenance services. Manik does not produce any sparepart. And there was no information on any other issue related to engineering technology performance.

In all the five surveyed firms, however, with respect to performance on engineering technology, information was lacking on two issues, that is on retooling and on capacity stretching modifications.

7.3 Factors Inhibiting Technological Capability build up and Efforts in Tanzanian Manufacturing Firms

In section 7.2, very low technological capabilities and little or no technological efforts have been observed in the surveyed firms. Moreover, the little successful performances on production and engineering technological functions were directed mainly towards solving problems related to foreign exchange shortages such as fabrication of spare parts, rather than towards local technological development per se. As such Tanzanian manufacturing firms have not been able to benefit largely from absorption of foreign technology, increase use of technology over time and technological learning as is implied in the low and declining labour productivity and capacity utilization rates in section 7.1. In this section (7.3) we explain factors which have been responsible to this small state and extent of technological capabilities and efforts.

7.3:1 Limited Local Participation in the:

(a) Pre-investment Activities

According to Lall in Stewart et al. (1992), in general, Africa lack domestic investment capabilities. That is, there are widespread shortages of local skilled and experienced technical and managerial manpower for launching of physical investment.

In Tanzania, Barker et al. (1986), Skarstein and Wangwe (1986) and Wangwe in Stewart et al. (1992) have found that very low stock (both in relative and absolute terms) of local technical and managerial manpower have been largely responsible for the limited participation of such local manpower in the pre-investment activities such as negotiations, financing, feasibility studies, construction, design, planning, choice of technology, execution, implementation and to some extent the actual management of the projects.

To economize on the limited local manpower skill, most of the pre-investment activities in Tanzania in the 1960s and the 1970s were carried by foreign technical and managerial manpower through turnkey projects, joint ventures and agreements or aids.

In the case of SRM and NECO it was Danielli and Co. of Italy and Twentshe Overseas Maatschappy-ton of German respectively, which undertook the turnkey projects. CMB P(T) was a joint venture with the British and Kenyan Metal Box Companies. And UFI was set up through agreement between the Tanzanian and Chinese Governments. It was simply an interest free loan and no Chinese investment was involved. And an experienced Indian engineer working as an expatriate in Tanzania since the 1950s, started, with the help of foreign sources, a simple agricultural machine repair shop which later developed into a manufacturing company (MANIK) producing locally designed maize milling machines "Newman". In all these cases, there was limited local participation especially in the case of turnkey projects where foreign sources undertakes to set up a whole factory, and hand it over in a state ready for production or already producing. No advanced technology is transferred to local and the foreign source supplies all the machines and equipment (embodied technology).

Limited local participation especially in the choice of technology leaves a local country at the risk of having biases in project design, technology or location and also much higher investment costs than may be necessary. While evidence on most of these claims may be difficult to ascertain in the sampled firms, there are however, some expected problems. For example, due to limited local participation, Danielli and Co. of Italy supplied to SRM inferior technology in terms of very old and outdated machines and equipment capable only of handling as inputs, steel billets of a size smaller than the international standard, thus, creating dependence upon few foreign suppliers and a situation in which production often stood for lack of such billets.

In addition, lack of local participation in pre-investment activities leads to subsequent failure to master, adapt and improve upon imported technologies, and to the absence of linkages with potential local suppliers of investment goods. Thus valuable opportunities for technological learning and spillovers are lost. Deteriorating efficiency in the surveyed firms may thus imply that quality control is lax, maintenance is poor, layout are not improved, labour skills are not developed, processes are not adapted and cost efficiency measures are not constantly undertaken. All these are partly due to missing learning opportunities resulting from limited local participation in pre-investment activities which is in turn brought by severe shortage of required skilled local manpower.

(i) Role of Foreign Investment and Implementation of the Basic Industrial Strategy (BIS)

Skarstein and Wangwe (1986), Wangwe and Luvanga (1990) and Wangwe in Stewart et al. (1992) explain that in the 1970s, partly as a result of the role of foreign donors and implementation of the BIS, there were massive new industrial investment in Tanzania.

With the exception of Manik which continued to be a private enterprise, the rest of the surveyed firms became public enterprises following the policies of the Arusha Declaration in 1967. Thus National Development Corporation (NDC), a parastatal, was created and entrusted with the development of the public manufacturing sector in Tanzania.

Instead of consolidating the already existing industrial projects, NDC was much more pre-occupied with initiating new projects. In 1974 the Tanzanian government adopted the BIS. Implementation of the BIS under NDC resulted in very large investments in industry. Given the poor state of the Tanzanian economy, such large investments were only possible because of foreign donors who supplied machines and equipments, technology, expatriates and foreign exchange. Even in such new investments (projects), NDC tended to hand the choice of technology for the projects entirely over to foreign partner. The financial aspects of industrial investment concerned NDC more than other aspects such as technological development.

Aspects of technological development were not only ignored in new projects, but also in the already existing projects like the surveyed firms. For example in the 1970s SRM had falling capacity utilisation due to among other reasons, lack of technological competence, maintenance and operations within the enterprise. Yet SRM engaged in setting expansion programmes, something which can be said to have been a misplaced priority particularly when taking into account the importance of improving the performance and providing inputs and spare-parts for the existing plant (before channeling resources to expansion).

As noted, foreign donors played a greater role in providing massive industrial investment resources which Tanzanian's poor economy could not afford. Aid levels grew dramatically from the 1960s to the early 1980s. For example, more than 1/3 of capital expenditures in industry have been financed by aid since 1975 as compared with about 4% in the early 1970s. Industry have been by far the largest recipient of aid. Most donors financed industrial projects. Therefore, complementary to the thrust of the BIS, foreign donor aid made it possible for new massive industrial projects in Tanzania. However, given the poor industrial performance (section 7.1) it can be said that generally, foreign aid supported the inefficient over-expansion of Tanzania's industrial capacity at the expense of the much needed foreign exchange and skilled manpower allocation to recurrent needs including technological development in the already existing projects.

Foreign donors were unwilling to participate in new industrial investments unless they had a dominant say in choosing the technology (technology package). On the other hand NDC which was more concerned with the financial aspects of the projects did not concentrate in building up technological expertise among nationals who could help in unpackaging the unfavorable technology packages. As such the shortage of skilled local manpower and its implication of the local technological development continued.

(ii) Weak Planning Process

Tanzania's enterprises and/or sectoral ministries often identified the investment projects, carried little appraisal, requested foreign finance and negotiated with foreign sources. Approval by the Treasury and Dev Plan was much easier once projects had firm promises of foreign funding. And when financing was forthcoming in large amounts, managements (parastatals) ignored the planning process. In addition the planning process itself was poor due to scarcity in skilled manpower at the planning sectoral ministries.

Thus the above noted donor - induced bias in favour of new investments was reinforced at the planning stage by Tanzania's financing strategy. That is, deficiencies in the planning process have also been responsible for the proliferation of new industrial investments in the late 1970s which was at the expense of technological development in the new projects as well as in the already existing projects such as the surveyed firms.

7.3:1 (b) **Post-Investment Activities**

(i) **Technological Capability of the Workforce**

According to Lall in Stewart et al. (1992), technological capability involve three issues, the pre-investment activities of launching physical investment (7.3:1 a) and two issues in the post-investment activities, that is the provision of human capital and the undertaking of technological efforts. In this section we explain the issue of provision of human capital which Wangwe in Stewart et al. (1992) call technological capability of the workforce. This involves analysis of the factors which affect the levels, efforts and trends of localisation process in Tanzanian manufacturing firms.

Fransman and King (1984) and Lall in Stewart et al. (1992) note that human capital for industrialisation arises from the formal education, employee training undertaken by firms and past experience of commercial and industrial activities. Lall also have argued that unlike Asians and Latin Americans the indigenous populations of most Africa have little traditional experience of modern commerce or manufacturing. This together with the effects of colonial rule tended to further minimise

African entrepreneurial capabilities and hence failure to organize, set up and run modern industries, efficiently, with some considerations of technological development.

In section 7.2, it was noted that different levels of firms' efforts to recruit skilled and experienced manpower, to create skills and to further train the manpower led to different levels of localisation among the surveyed firms. In general, however, all firms achieved remarkable or even full localisation after a long time of operation of at least 10 years. Through such localisation programmes key managerial and technological functions of the firms were manned by local manpower.

However, while in the surveyed firms, localisation achievements were quite high, the corresponding failure to perform well in most of the specified technological functions (7.2) is an indication that locals had not mastered adequately the technologies and skills from the expatriates they replaced. This could be a case of premature localisation as Wangwe in Stewart et al. (1992) found in the case of Tanzanian Cement Company also.

Premature localisation may be a result of limited local participation in the post-investment learning and technological activities. This was caused by several factors such as inadequate trained manpower for understudying the expatriates or failure to utilise fully the expatriates in terms of technological learning. This is a specially the case where foreign experts were oriented towards production (output and financial targets) rather than training and technological learning objectives (effective localisation).

In addition, apart from shortage of funds, firms are always reluctant to invest heavily in training when there is a risk of their investment leaking out to other firms if workers leave. In the surveyed firms resignations on the part of technicians was noted to be common. This has minimized firms' efforts to further train their technicians.

Firm-level training is not, of course, a substitute for the education system but a complement to it. According to Lall in Stewart et al. (1992) in African economies it is imperative for governments to provide formal education for the industry which needs inputs of well trained workers, technicians, managers and engineers. And that in the present world of rapid innovation, a broad base of scientific and engineering skills becomes imperative for success as countries go beyond the simplest of industrial activities. For the case of Tanzania, this is further investigated in chapter 8. Here we only note that there is insufficient supply of technical and managerial manpower for technological development activities in the manufacturing sector.

7.3.1:(b) (ii) Undertaking of Technological Efforts

In this section we explain undertaking of technological efforts. According to Lall in Stewart et al. (1992) skills and training become productive only when combined with physical capital and technological effort which is needed to absorb new knowledge and to adapt and improve on it.

Lall (various) have noted that no enterprise can achieve efficiency, even if well endowed with skilled employees if it does not undertake conscious, directed effort to collect and assimilate new technical knowledge. A noted problem, however, is how to measure technological efforts in investment and production activities. A good but crude prox is the incidence of engineers and technicians in the workforce. In the surveyed firms such incidence is found to be quite small. Moreover, what is much more important is how much the technical and managerial manpower do. In the surveyed firms, very little or no technological efforts were undertaken.

The component of technological effort which is most easily measurable is formal R & D. This is likely to be a small part of the total effort needed in most developing countries to master imported technologies. However, it is increasingly a critical input as more complex technologies are imported. It does not appear that CMB.P.(T) have undertaken any serious technological effort to master the modern and complex technologies imported since 1990. On the other hand, as older technologies get fully mastered, local R & D becomes essential for assimilating, adapting and improving on these technologies. Despite some achievements in the case of SRM in the engineering technological functions, there is no evidence to show that other specified technological functions were fully mastered. In all the surveyed firms, apart from simple fabrication of spare parts and understanding of routine production activities, there is no evidence that locals' are gaining deep understanding of the principles of the respective technologies as part of their conscious and deliberate technological efforts.

In general, firm level R & D in Tanzanian manufacturing sector have been found to be very rare or non-existing in some cases. Where existing it is extremely small and devoted mainly to quality control, production and engineering problems especially spare part fabrication. The main limiting factors in this case have been lack of funds and severe shortages of scientists and engineers who could carry out such R & D activities. Institutions to undertake such R & D activities have been created and are discussed in chapter 8.

7.3:1 (c) Rehabilitation Activities

In the 1980s, Tanzanian manufacturing industry was pre-occupied with rehabilitation activities. According to Wangwe in Stewart et al. (1992) the main pre-rehabilitation activity, that is, identification of the nature and magnitude of rehabilitation requirements in Tanzania's industry, has involved little local participation.

Wangwe, has noted further that the same forces which inhibited local participation in pre-investment and post investment activities seem to be replicated in rehabilitation programmes. There is still a tendency to prefer foreign experts who should be more acceptable to potential foreign financiers of the rehabilitation programmes. In the surveyed firms, this holds true, except for the SRM where local manpower, using local resources completely rehabilitated the factory in 1989. Probably, the inferiority and simplicity of the technology involved in the SRM made it easier for the locals to undertake successfully the rehabilitation.

And in the case of CMB.P.(T) rehabilitation programme was driven by modernisation and output maximisation objectives, by introducing modern and complex machines in 1990. There is no evidence that considerations were made on issues related to technological learning and building of technological capabilities over time. To that extent, the rehabilitation programmes in CMB.P.(T), too, tend to reinforce the same features of dependence and low technological learning as those observed in pre-and post-investment activities.

7.3:2 **Other Factors (Macroeconomic)**

(a) The Role of the Pricing System

In this section, we briefly explain other factors which have also affected technological development in Tanzania. These include the overvalued exchange rate, rationing of foreign exchange, price controls and trade and industrial policies of protection and liberalisation.

In the 1970s, the Tanzanian government introduced several policies which affected the manufacturing sector. Public sector in the Tanzanian manufacturing sector grew substantially as a result of the Arusha Declaration (1967) policy (nationalization), the role of foreign donor, implementation of the BIS and the weak planning process. Also a system of foreign exchange rationing through administrative allocation on a firm by firm basis was introduced. This system together with the import licensing, was used to restrict competing imports and to channel foreign exchange to the importation of raw materials for industry. On the other hand, a comprehensive price control system was also established so as to protect both producers and consumers.

These set of policies (overvalued exchange rate, rationing of foreign exchange, prohibition of competing imports and price controls) together with the objective of keeping all existing industrial enterprises (public) alive by spreading the little available foreign exchange as thinly as necessary, has had major implications for the performance and efficiency of the sector. The policies were also responsible for a situation in which firms in the 1970s were having very high financial profitability while they were economically unprofitable. Thus, the most considered criteria for the massive public investment in the 1970s was commercial (financial) profitability. This was at the expense of issues related to economic efficiency and technological development.

Lall in Stewart et al. (1992) and Lall(1992) notes that the development of technological capability is extremely sensitive to market incentives especially those arising from competition. That is, competition provides the basic spur to investment in capability development, but is a double edged weapon. That is, too little competition can lead to inadequate or misguided capability acquisition while too much can wipe out firms which cannot finance the costs of capability acquisition. In Tanzania, in the 1970s the situation was that of too little competition arising from high and widespread (indiscriminate) protection. This contributed to the very low technology efforts undertaken in the Tanzanian manufacturing firms. On the other hand, the trade liberalisation policies in the 1980s did not improve the situation due to the continue presence of parastatals which are not involved in competition and therefore carry out little or no technological capability development.

7.3:2 (b) The Role of banking

Since the 1960s, Tanzania created several financial institutions or development finance banks which were expected among other things to provide loans to projects in various sectors in the economy for technological development. Thus the banks are expected to finance also technology projects, assist in untying finance from specific imported technologies and financing the technology development features of projects. According to Wangwe and Luvanga (1990) the banks and finance institutions in Tanzania have yet to meet the challenge of reorienting their own activities to consider such technology issues. In this sense the firms and technological institutions in Tanzania have not been getting bank loans (funds) for their technological development activities. This has aggravated the problem of inadequate funds for technological development activities.

7.3:3 Lack of Effective Technological Policy

(a) Lack of Selective and Strategic Intervention

The case of Korea in chapter 3, show that sëlective, often high and prolonged protection was necessary for its strategy of rapid industrial deepening led by nationally owned enterprises. Selectivity and rapid gains in competitiveness were emphasized.

However, in most developing countries and Africa in particular (with few exceptions in Zimbabwe, Mauritius and Kenya), in general, the pattern of interventions has been that of indiscriminate and permanent protection. According to Lall in Stewart et al. (1992), this kind of intervention places no premium on gains in efficiency, ignores conditions in world market, tends to ignore industrial capability building and often stifles market forces within the economy. As Lall (1987a) illustrates, the result can often be technological lags, stagnation and inefficiency. Results from our sampled firms indicate a similar trend.

In Tanzania, intervention in the economy became explicit with the implementation of the policies of the Arusha Declaration (1967), nationalization in particular. First of all indiscriminate nationalisation was carried out in the manufacturing sector without due consideration of the limited availability of trained and skilled manpower as well as of funds. That the intervention was not strategic is supported by the argument that even the created public banks were not in any way committed to provide funds for technological development in the sector. By ignoring technological development issues and more importantly by creating monopolies (parastatals) without competition, the whole strategy of building a self reliant Tanzanian economy was being defeated. Secondly, the nationalization policy appear to have scared foreign investors such that they no longer committed themselves to long term issues such as technological development of the firms. However, it is yet to be seen whether the liberalisation policies in the 1980s have helped to reduce the foreign investors' fear. The rehabilitation activities in the 1980s as noted above, have indicated that the tendency is still that of foreign finance considerations overshadowing issues related to technological development.

The formulated BIS in the 1970s, intended to reduce dependence on foreign technology, and the bulk of manufacturing investment was expected to be undertaken in industries which employ simple technologies which could be incorporated in capital goods production in Tanzania. In this context emphasis was placed on the development of the metal and engineering industries in order to create the necessary supply capacity while the choice of technologies was supposed to influence the demand side. From the sampled firms, there is no evidence that the metals and engineering sub-sector was selectively and strategically promoted despite its importance in terms of technological development as is explained elsewhere in this study. In such metals and engineering firms, too, we have noted very low technological capability and little efforts together with the related poor industrial performances in terms of declining and low labour productivity and capacity underutilization. This failure in the Metals and Engineering sector indicate that BIS was a too ambitious idea and a mistake as a strategy to begin with, given the small and very poor state of the Tanzanian economy.

7.3:3 (b) Lack of Coordination, Information and Market

Most of the surveyed firms have their own workshops in which they fabricate some own spareparts. However, NECO in particular was basically intended to be a supplier of various machinery and autoparts. In this case other firms were expected to utilize its capacity. But only about 25% of NECO's capacity is being utilized. A noted problem in this, has been lack of market either because the would be customers (other firms) are not fully informed on this source (NECO) or they are unwilling to use NECO's products especially in view of the available imported ones under the trade liberalisation policy in the 1980s.

With respect to NECO's problem of lack of demand for its products, for instance, it appears there is no specific promotional and supportive efforts or policy to make it (NECO) much more useful in terms of spare parts provision. One difficulty in such an attempt is that technologies in use in Tanzanian industries have tended to be heterogenous, (that is from different specific foreign sources) thereby complicating the coordination and management of inventories and maintenance of plants and equipments and so affecting the expected roles of such engineering firms as NECO. In the late 1970s and the 1980s, however, Tanzania made some efforts to try to minimize some of the coordination and information related problems, as is explained in chapter 8.

7.4 Summary and Conclusions

The empirical analysis in this chapter has covered 5 metals and engineering firms in Tanzania.[5] As a background to analysis, we have for each surveyed firm analysed industrial performances in terms of labour productivity and capacity utilization. More importantly, however, we have analysed firm's technological capacities and efforts. This has been done through static and dynamic analysis. We have also tried to generalize some of the factors that have been responsible for the low technological capability build up and little or no technological efforts in Tanzanian industries.

It has been noted that, during the 1970s labour productivities and capacity utilization rates were in general higher and rising. But from the late 1970s to the mid 1980s labour productivities and capacity utilization

[5]See section 7.0 of this chapter.

1980s there were some improvements which however were still less than what were achieved during the 1970s.

The implementation of the Economic Recovery Programme 1 (ERP1) policy in Tanzania in the period 1986/87-1988/89 resulted in a small improvement in the industrial performance. For example, with respect to industrial sector, there was a growth rate of 5.2% in real terms in 1988, in contrast to the persistent declines during the early 1980s.[6] However, comparatively, the industrial sector remained depressed even in the 1980s as output was still much below the levels attained in the 1970s. The implementation of ERP2 or ESAP since 1989 continued to consolidate the gains of ERP1. What is apparent is that the two programmes and the Industrial Rehabilitation and Trade Adjustment Credit (IRTAC) improved the availability of foreign exchange thereby reducing the problem of shortage of imported raw materials, spareparts, equipments and machineries. Increased availability of foreign exchange has been possible also due to the open general licence (OGL) system. However, not all firms benefited from the improved availability of foreign exchange (BOT, 1989). The idea was to benefit only firms which are economically viable.

[6] See Bank of Tanzania (1990)

It was noted in chapter three (3.3:0) that the acquisition of technological capability is a long term and costly process which require progressive, purposeful, deliberate and conscious efforts. In other words, the acquisition of trained and experienced manpower by the firm depend also on firm's purposeful technological efforts such as effective training programmes.

UFI had a favourable technological package supplied by Chinese while SRM had an unfavourable technological package supplied by Daniel and Co. of Italy. However, both UFI and SRM managed to localise fully and to build some technological capacities with respect to the number of their technical and managerial manpower. Key to their success was their purposeful and deliberate efforts in recruiting qualified manpower, engaging them in further training, in understudying the expertriates and in on - the job training.

However, for firms like CMB.P. (T) which put relatively less efforts achieved relatively less in terms of their localisation and technological capacity building. And for Manik which did not put serious efforts in recruitment and in training its manpower the achievement were quite low.

It is noted also that the simplicity of technology in the cases of UFI and SRM helped to speed up the localisation process and the building of technological capacities. However, for NECO which had a poor technological package supplied by the Germans and a much more complex engineering technology, there was delayed technological development in terms of localisation and building technological capabilities. Late but deliberate and purposeful efforts by NECO to recruit qualified manpower and to further train them appear to have helped the firm later on to get some achievements in terms of localisation and technological capacity build up.

Despite these remarkable achievements in localisation in the surveyed firms (section 7.2), there were relatively poor performances on most of the specified technological functions, thus suggesting a possibility of pre-mature localisation. To avoid this problem, Wangwe in Stewart et al. (1992) has suggested that good policies towards localisation and firm-level training should be accompanied by more concerted efforts to monitor their implementation.

In the case of UFI, SRM, NECO and CMB.P. (T) (before 1991) the machineries and equipment used were very old and, therefore, there were frequent machinery breakdowns. This required spare parts for maintenance (preventive) and repair. With the shortages of foreign exchange to import the spares the firms were forced to utilize their own workshops also. Such shortages of foreign exchange seem to have influenced the type of technological activities in the surveyed firms.

The workshops in the surveyed firms mostly use general purpose machines and handtools technology. This according to Barker et al. (1986) have helped substantial number of workers to do highly skilled jobs such as craftwork, repair and maintenance; and that therefore this contributes to Tanzanian industrial development. And that maintenance and repair work are the main fields in which Tanzanian technicians and engineers gather practical experience as far as equipment and goods are concerned. In other words this has helped to raise the technological capacities of the Tanzanian technical and managerial manpower in the manufacturing firms.

In UFI, SRM, NECO and CMB.P. (T), in terms of the technological functions (5.2:2(b) (ii)), apart from organizational technology there were relatively much more performances in the engineering technology. In each of these 4 firms a number of spare parts were fabricated. And in some of the firms some maintenance and rehabilitations were undertaken and to very limited cases there were also some simple innovations and designs activities. Wangwe (1979) also found that there were many design and modifications and spare parts manufacture in Tanzania. And Adei (1987), too, found that in comparison to other technological functions, there were much more performance in engineering technology in Ghana's timber industries. In all these cases, such technological activities were mere isolated responses to problems of foreign exchange shortages for spare parts importation rather than being part and parcel of the longterm, coordinated technological development strategies.

And with the exception of Manik, performances in organizational technology was also comparatively better than in the case of production technology, marketing technology and financial technology. For instance it was only in UFI and SRM, where there were some notable performances in marketing technology. In the case of NECO the marketing department was weak and in Manik such a department did not exist.

Besides those few noted successful performances on some technological functions, it has been observed that there are a number of problems that have contributed to very low technological capability and little technological efforts in Tanzanian manufacturing sector (7.3). Severe shortage of trained and experienced local technical and managerial manpower has been found to be a key problem. For instance there has been shortages, in different degrees, of local technicians, marketing personnel and engineers in the surveyed firms. Moreover, such personnel who are enged in R & D activities have been found to be extremely few or non existant. In addition as also Wangwe and Luvanga (1990) found shortages of technicians contributed to another related problem that is underutilization of even the few available engineers.

The shortage of skilled and experienced local technical and managerial manpower has also been a contributing factor to limited local participation in the pre-and-post-investment and rehabilitation activities in the Tanzanian industrial projects. The other contributing factors have been the role of foreign donors, implementation of the BIS and the weak planning process. All these three factors have been pre-occupied with getting foreign financing especially so in view of the small and weak Tanzanian economy together with its persistent shortages of foreign exchange. In that situation, then foreign donors has assumed a much greater role in the investment activities and thus undermining participation of local technological personnel in key technological activities. This in turn has not been conducive to promoting technological learning and building of local technological capabilities, through lost opportunities to learn or learning by doing.

The small supply in Tanzania, of local technical and managerial personnel, partially explain their shortages. Given the crucial importance of such personnel in promoting industrial efficiency and technological activities, then, Tanzania has to engage itself in massive training of such people. Lall in Stewart, et.al. (1992) argue that given the extreme scarcity of trained manpower in Africa, it may be advisable to overtrain rather than to try to set very precise targets for skill needs especially so in view of the possibility of losing some skills to the brain drain. Korea did that in the early stages. The problem of provision of skilled personnel in Tanzanian case, is further investigated in chapter 8 with respect to the Faculty of Engineering (FOE) of the University of Dar es Salaam and Dar es Salaam Technical College.

In addition to such formal education, if localisation are to be raised then firm-level training has to be emphasized together with inclusion of aspects of training (localisation) in the technology packages offered by foreign donors. Moreover emphasis has also to be put in close monitoring of the training and localisation programmes so as to avoid premature localisation and help in building up technological capability and in effective transfer of foreign technology.

On the other hand the weak planning process could be strengthened by provision of more skilled planning personnel and also emphasizing the crucial consideration of economic efficiency and technological development as other important issues (criteria) in addition to foreign financing aspect, for effecting industrial projects. The role of NDC especially in view of its practice of ignoring such issues has to be corrected or its overall role as a holding parastatal could be reduced as part of a policy which may be directed towards reducing the size of the very large public manufacturing sector which is unproportional to the very limited foreign exchange and skilled manpower resources. Such a policy of course will be in contrast to the nationalization policy of the Arusha Declaration (1967). Nationalisation, the role of foreign donor, implementation of the BIS and weak planning process contributed to the creation of a large public manufacturing sector in Tanzania.

As a lesson from successful developing countries in the areas of technological development and industrial competence, there should be selective and strategic intervention in the Tanzanian manufacturing sector. Promoting and supporting some few Tanzanian metals and engineering industries (such as NECO and SRM) could be considered as one option. Fransman (1982 , 1983), for example, argued that basic metal working skills which are found in such metal and engineering industries, and the ability to build, copy, repair or improve capital goods (even of a simple sort) is widely regarded as the seed-bed and hub of technological progress. So given such an argument and given the severe scarcity of skilled manpower and foreign exchange it would be reasonable for Tanzania not only to reduce the large size of its public manufacturing sector but also to consider critically the importance of a selective and strategic policy.

Other problems include the overvalued exchange rate, the rationing of foreign exchange, price controls, trade and industrial policies of permanent and indiscriminate protection (prohibition of competing imports through import licenses in the 1960s and the 1970s) and liberalisation in the presence of uncompeting monopoly parastatals (in the 1980s). These policies and the thin spreading of the limited available foreign exchange, local funds and skilled manpower affected industrial performances as well as contributing to the small state and extent of technological capability and efforts in the Tanzanian manufacturing sector. Some steps, however, have been taken since the 1980s. These include devaluation, trade and foreign exchange liberalisation policies and price decontrolling in most cases. In addition to this, ways should be sought to mobilize the banks to assist as expected (section 7.3:2 (b)) in the development of technological activities in the Tanzanian manufacturing sector.

Lastly there is a problem of lack of effective technological policy with respect to provision of information and coordination role. The low demand for local technological products and services (as those of NECO), are a result of the problem of lack of information and coordination as well as of poor quality and higher prices as compared to those of imported similar products.

Attempts to minimize some of these problems in Tanzania are explained in chapter 8 with respect to creation and utilization of technological institutions such as MEIDA. It is only hoped that MEIDA for instance, will help in promoting and supporting some of the Tanzanian metals and engineering industries in enhancing technological development in the Tanzanian manufacturing sector, especially with respect to the production of good quality and marketable spare parts.

In view of all these problems, then if Tanzania is to succeed in building technological capability, undertake technological efforts and achieve industrial efficiency, then it is necessary that these problems must be confronted. However, given the poor state of the Tanzanian economy it may be difficult to solve all the problems simultaneously. Probably, here, lessons from successful developing countries (including some few African countries such as Mauritius, Zimbabwe and Kenya) could be useful. That is, apart from creating conducive macro-economic environment, due emphasis should also be put in provision of skilled manpower and funds. Since such resources are very scarce in Tanzania, they have to be concentrated in few selected and strategic industries.

CHAPTER 8

EVALUATION OF THE FUNCTIONS AND SERVICES OF SOME TANZANIAN TECHNOLOGICAL INSTITUTIONS

8.0 Introduction

In this chapter we intend to investigate technological efforts and capabilities with respect to some Tanzanian educational and technological (R & D) institutions. Acccording to Adei (1987), at industry or national level, technological capability is reflected by the sum total of people with required skills, the stock of knowledge, the tools and instruments and the institutional framework of technological changes and their impact on the national technological development.

As noted in chapter 2, technological institutional structure in Tanzania can be grouped into three categories, viz: engineering firms such as NECO, and SRM; educational institutions like the faculty of Engineering (FoE) of the University of Dar es Salaam and Dar-Technical College; and institutions which engage in research and development and in promotion and coordination of technological activities such as TISCO, TIRDO, IPI, MEIDA and MEIDA Maintenance Services.

Chapter 7 partially confirmed that there were only very little isolated technological efforts and activities in the surveyed Tanzanian metals and engineering firms (the first category), and hence very low levels of technological capabilities have been achieved. Below we specifically analyse the establishment and utilization of some educational and technological institutions (second and third categories) which are directly related to technological development in the Tanzanian manufacturing sector.

These institutions have been evaluated in terms of their functions and services offered. Chapter 8, therefore, is divided into the following sub-sections 8.0 is on introduction; 8.1 on provision of skilled manpower; 8.2 on provision of local industrial research, consultancy and design services; 8.3 on provisions of spares, research and consultancy; 8.4 on coordination and promotion of the developmet of specific manufacturing industrial sectors; 8.5 on creation of preventive maintenance services; 8.6 on the role of the National Commission of Science and Technology (COSTECH) and the Ministry of Science and Technology and Higher Education. Section 8.7 summarises and concludes the chapter.

8.1 Provision of Skilled Manpower

As noted in Chapters 3, 5 and 7, the key element to the success in the technological development, at any level, is the availability of experienced and skilled manpower. In this respect then, we have investigated the role of two educational institutions in Tanzania, namely the Dar-Technical College and FoE; with respect to the process of human resource development, specifically the provision of trained mid-level technicians and engineers. Also we have investigated the provision of direct technological services by such institutions to the Tanzanian manufacturing industries.

8.1(i) Dar es Salaam Technical College

Dar-Technical College was established in 1957, and has since developed from a small technical institute training mainly technical assistants, to one currently providing engineering courses, hence providing mainly mid-level technicians. Its annual number of graduates in the period 1976-1990 are shown in Table 8.1.

Table 8.1: Dar-Technical College Capacity, Input and Output (Number of Graduates)

Year Course	FTC (1)			Diploma in Engineering (2)			Diploma in Technical Education (3)			Diploma Columns (2)+(3) (4)		
	Capa-city	Input	Out-put	Capa-city	Input	Out-put	Capa-city	Input	Out-put	Capa-city	Input	Out-put
1976	N/A	194	204*	-	-	-	-	-	-	N/A	37	34
1981	260	226	223	80	76	59	60	46	**	140	122	59**
1982	260	244	216	80	72	67	60	57	38	140	129	105
1983	260	250	233	80	80	55	60	52	41	140	132	96
1984	260	245	216	80	79	76	60	54	28	140	133	104
1985	260	256	223	80	78	68	60	43	38	140	121	106
1986	260	N/A	246	80	N/A	N/A	60	N/A	N/A	140	N/A	100
1987	260	N/A	214	80	N/A	N/A	60	N/A	N/A	140	N/A	103
1988	260	N/A	205	80	N/A	N/A	60	N/A	N/A	140	N/A	78
1989	260	N/A	266	80	N/A	N/A	60	N/A	N/A	140	N/A	70
1990	260	N/A	244	80	N/A	N/A	60	N/A	N/A	140	N/A	91

Note: N/A = "Not available"
* = The number includes 50 students for FTC (Telecommunications).
** = Students for the Diploma in Technical Education started to sit for the National Examinations in 1982.

Source: Dar-Technical College.

Table 8.1 indicate that the college have not been utilising fully its capacity in both the certificate and diploma courses. And more markedly is the low number of graduates and its slow growth. As such the college has not been able to supply adequate mid-level technicians to the industrial firms and hence the shortages of such technicians in some industrial firms.

There are a number of reasons which have contributed to the low levels of output (graduates) and capacity underutilisation. Some of the problems include shortages of classrooms, laboratories and workshop space; inadequate student accomodation; shortage of funds and more importantly shortage of local academic members of staff as Table 8.2 indicate.

Table 8.2 Dar-Technical College Number of Local Lecturers and Technicians (1990/91)

Department	Number of Lecturers with Degrees	Shortages		Number of Technicians	
	FTC + Diploma	FTC	Diploma	Present	Shortage
Civil Engineering	21	5	10	3	*
Mechanical Engineering	24	2	10	2	*
Electrical Engineering	15	4	6	3	*
Telecommunation Engineering	11	-	6	1	*
Laboratory Techncian	13	5	-	2	*
General Studies	11	-	-	-	-
Total (all Depts)	95	16	32	11	11

Note: * = Available in total number

Source: Dar-Technical College.

The shortages of local lecturers and technicians at the college as shown in Table 8.2, have been the result of poor recruitment and training programmes; mainly due to lack of adequate funds. Long-term training programmes for post-graduate (Masters and Ph.D) studies are lacking. According to the principal of the college, post-graduate training, in most cases, have depended on individual initiative for sponsorship. Only recently, the college established some "links" exchange programmes with the Mannitoba University (Canada) and the Red-River College (Canada), where some lecturers are pursuing different post-graduate studies. It appears that the college had no staff development for quite a long time. However with the recent (1990) creation of the Ministry of Science and Technology and Higher Education, the college may be strengthened to enable it play its expected role. As a short-term measure, the college makes use of part-time lecturers from NEDCO, TANESCO and some industries. The shortages of lecturers, technicians and other academic functionaries partly explain low level of research consultancies and innovations.

8.1 (ii) The Faculty of Engineering (FoE) - University of Dar-es-Salaam

The FoE was established under the University of Dar es Salaam Act of 18th June, 1970 and effectively started its operation in June 1973 with the following objectives: first, to provide education and advanced training for engineers and technical science teachers; second, to undertake research and; third, to provide expert professional services in the form of consultancy to industry, parastatals, government and other private organizations.

Table 8.3 Faculty of Engineering (FoE) - University of Dar es Salaam Number of Students

Year	1st Year Bs.C Engineering	1st Year Total University	FoE Total Bs.C Engineering	University Total Students	Graduants Bs.C Engineering	M.Sc Eng. + Ph.D (Engineering)
	Enrolled	Enrolled	Enrolled	Enrolled		Enrolled
1973/74	61	N/A	61	N/A	-	-
1974/75	89	N/A	148	N/A	-	-
1975/76	66	N/A	213	N/A	-	6
1976/77	125	N/A	335	N/A	54	
1977/78	121	N/A	385	N/A	77	13
1978/79	140	N/A	411	N/A	53	20
1979/80	160	N/A	499	N/A	91	10
1980/81	164	885	543	2586	110	8
1981/82	163	927	560	2688	113	2
1982/83	169	1057	563	2911	118	10
1983/84	179	1071	612	3077	135	20
1984/85	160	1157	637	3269	140	5
1985/86	161	1105	634	N/A	154	5
1986/87	192	N/A	612	N/A	132	13
1987/88	194	N/A	611	N/A	118	15
1988/89	171	N/A	606	N/A	119	15

Source: FoE (1990)

Table 8.3, shows that the FoE started with 61 students in 1973 and the annual intake number for first year engineering students increased almost three times by 1979/80. The number of engineering graduates increased annually. However relative to the total university intake the number declined. For instance in 1980/81, FoE had 164 students for first year courses as against 885 for total university; and by 1985/86 only 161 first year students were admitted in FoE as compared to 1105 students for total university. In addition the number of post-graduate students was low and grew slowly from 6 in 1975/76 to only 15 in 1988/89. The low level of FoE's output (engineering graduates) has thus contributed to shortages in engineers. Thus, Tanzania also lagged behind other African countries in training engineers. For example in the Daily News, Monday, October 28, 1991 it was reported that in 1987, in the field of engineering in universities, Tanzania had 664 students as against Kenya's 3,438. And those studying science were 180 and 1,772 for Tanzania and Kenya respectively.

Table 8.4: Academic Staff Statistics in the FoE

Year	Establi-shment	Staff on Post			Tutorial Assis-tants	Total Staff present	Staff on train-ing	Staff on Second-ment	Grand Total
		Tanza-nians	Expatri-ates	Total					
1973/74	28	0	7	7	N/A	7	2	0	9
1974/75	38	4	21	25	5	30	2	0	32
1975/76	44	6	21	27	7	34	7	0	41
1976/77	50	5	30	35	4	39	9	0	48
1977/78	61	10	33	43	17	60	9	0	69
1978/79	72	15	38	53	12	65	8	0	73
1979/80	74	20	36	55	N/A	N/A	27	0	N/A
1980/81	85	31	27	58	16	74	17	1	92
1981/82	N/A	31	46	77	19	96	18	2	116
1982/83	N/A	35	39	74	17	91	29	3	123
1983/84	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1984/85	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	135
1985/86	N/A	36	34	70	11	81	44	8	133
1986/87	N/A	40	38	78	9	87	52	9	148
1987/88	N/A	66	24	90	15	115	37	9	151
1988/89	N/A	N/A	13	N/A	N/A	N/A	N/A	N/A	122

Source: FoE (1990).

Despite such low level of FoE's output, it is noted that some notable efforts have been done in recruiting and training local academic members of staff as is indicated in Table 8.4 above.

Table 8.4 shows that the FoE started with 7 academic staff, all expatriates. But with the recruitment and training programmes, by 1974/75 the number of local staff went up to 4 against 21 expatriates. Until 1982/83 (with the exception of 1980/81), there were more expatriates compared to local academic staff. The situation changed by 1985/86. In 1987/88 there were 166 Tanzanians as against 24 expatriates. The number of academic staff on training also continued rising from 2 in 1973/74 to 52 in 1986/87.

The rising number of local academic staff in the FoE have made it possible for some of its local academic staff to be seconded to other places. Up to 1979/81 there was 1 local academic staff and in 1987/88 there were 9. The overall levels of academic staff in the FoE by 1989/90 is shown in Table 8.5.

Table 8.5: Levels of Academic Staff in the FoE (1989/90)

POST	TANZANIAN	EXPATRIATES	TOTAL
Professor	2	2	4
Associate Professors	6	5	11
Senior Lecturers	18	2	20
Lecturers	30	-	30
Assistant Lecturers	39	-	39
Tutorial Assistants	17	-	17
Total	112	9	121

Source: FoE

Having raised the levels of its local academic members of staff in terms of both numbers and qualifications, the FoE has thus been able to engage to a certain level in realising its two other above mentioned objectives.

In October 1985, an evalution team reaffirmed the three objectives of the FoE with strong emphasis on industrial cooperation, research and training. In the period 1985-1989 the number of research undertakings done by the FoE's academic staff increased. In 1989, major research projects were identified for implementation, viz: low cost construction materials and low cost power plants and machines improvement.

In 1989, the FoE inaugruated a Technology Development Programme (TDP) which involve tripartite agreeement between the Foe, the FoE's donors and Industrial clients. The objective of TDP is thus to suppport ways and means of enhancing the capability (professionally trained engineers and sophisticated equipments) of the FoE in contributing effectively to industrial development in Tanzania through R & D activities and provision of consulting and expert professional services to industry. The priority areas include: (i) development of solutions for the maintenance and rehabilitation of infrastructure, equipment and machinery, (ii) exploitation of local materials for design and building of machines and other equipment and construction, (iii) development of locally available sources of alternative energy (iv) development of solutions to local problems in industry, (v) development of program of industry and government sponsored researches and (vi) developmet of process for the use of local substitutes to imported raw materials.

Another development in the FoE was the establishment of the Bureau for Industrial Cooperation (BICO) in July 1990. The main objective of the BICO is to maintain the capability of the FoE in order to contribute effectivley to the industrial development in Tanzania through R & D and the provision of consulting and expert professional services. BICO, thus, coordinates all professional development programme (p & d) activities in the FoE, and also collaborates with industries in applied R & D through the above explained TDP.

With the above explained developments in the FoE, there was a notable increase in the number of researches and publication as shown in Table 8.6 and also an increase in consultancy services as is shown in Table 8.7.

Table 8.6: Faculty of Engineering - Univeristy of Dar es Salaam
Number of Research Projects and Publications (1989/90)

Department	Number of Research Projects			Number of Publications		
	Initia-ted	On-going	Completed	Under-Preparations	Submitted	Publi-shed
Civil Engineering	3	7	1	13	6	17
Mechanical Engineering	1	4	1	5	9	8
Electrical Engineering	1	12	-	8	14	18
Chemical and Process Engineering	-	4	1	2	5	5

Source: FoE (1990)

Table 8.7: Net Income from Consultancy Services in the FoE
(In Tshs, 1976 Prices)

Year	Department					
	Civil Engineering	Mechanical Engineering	Electrical Engineering	Chemical & Process Engineering	Workshop	Total
1980/81	149,173	71,821	33,874	0	22,736	277,616
1981/82	272,972	78,741	23,112	3,497	51,603	430,190
1982/83	216,498	57,686	16,125	1,673	61,941	353,923
1983/84	310,326	82,851	15,285	9,411	35169	453,041
1984/85	298,843	97,433	12,563	50,157	32,245	491,241
1985/86	190,286	65,196	14,937	27,851	52,928	346,688
1986/87	112,073	55,958	13,908	15,027	43,678	240,645
1987/88	126,547	97,759	2,726	49,135	54,538	330,533
1988/89	182,196	88,628	12,841	34,176	42,776	314,026

Note: Used 1976 GDP deflators.
Source: FoE.

The FoE, thus has developed from a small faculty concentrating in teaching in 1973/74 to a large faculty with emphasis in teaching as well as research, consultancies and services to Tanzanian industries. However, Tables 8.6 and 8.7 indicate that the number of research projects, publications and income from consultancy services is still small.

Currently the FoE has good relations with some local as well as international organizations.[1] It is only hoped that such relations have and will continue to reduce some of the problems being faced by FoE, such as shortage of funds and inadequate facilities.

[1]See Appendix 8.1 for a list of such organizations.

8.2 Provision of Local Industrial Research, Consultancy and Design Activities

In chapters 7 and that of the literature review, it is noted that for developing countries such as Tanzania and Ghana, very few individual firms have technological capability and the situation is worse, with respect to detailed engineering, design and consultancy services. In this sense establishing national technological institutions to promote and serve the needs of individual industrial firms is of great importance. In this section, therefore, we have investigated the establishment, role and utilisation of TISCO and TIRDO, as examples of such technological institutions.

8.2(i) Tanzania Industrial Studies and Consulting Organisation (TISCO)

TISCO is a parastatal organisation under the Ministry of Industries and Trade. It was set up in 1976 by an Act of Parliament. Broadly, the functions of TISCO are to provide consultancy services and advise on all aspects of industrial development in Tanzania.

TISCO is a multi disciplinary consulting organisation organized into three consulting divisions, one information centre and one division of finance and administration. The consulting divisions are: (i) industrial studies (ii) engineering consultancy and (iii) management consultancy.

TISCO has local staff with background in economics; textile technology; food and beverage technology; forestry; civil, mechanical and chemical engineering; business administration; finance; operation research; statistics; law and information. TISCO had 15 expatriates during the 1977-1988 period. But following a systematic phasing out, the last batch of expatriates left in 1988, and so TISCO became fully localized since then.

Table 8.8: Tanzania Industrial Studies and Consulting Organisation (TISCO) Number of Personnel engaged in R & D activities (1990/91)

(i) Engineers	Number	(iv) Others	Number
- Chemical	3	- Management	3
- Civil	6	- Marketing	2
- Mechanical	7	- Finance	2
Sub Total	16	- Legal Experts	2
		- Textile technology	3
		Information Technology	3
		Sub total	15
(ii) Economists			
- Industrial	4	(v) Director General (Not involved in R & D)	1
- Food & Agriculture	3	Grand Total	40
Sub total	7		
(iii) Forest based Industries			
- Forestry specialists	1		

Source: TISCO

Note: of the above 40 personnel:

- 18 + 1* have Bachelor degrees (1* is for director General)
- 19 have Master degrees.
- 2 have Ph.D degrees.

And by 1990/91 there were 40 qualified TISCO employees engaged in various R & D activities as Table 8.8 indicate.

All the above personel in Table 8.8 have local as well as foreign consulting experience ranging from 4 to 15 years. With such qualifications and experience, TISCO personnel have been able to undertake the following major assignments: sector/opportunity studies; feasibility studies; management and organisation studies; project implementation/commissioning; rehabilitation studies and spare parts manufacture/maintenance studies. While it was not possible to obtain the total number of assignments undertaken nor their precise impact; TISCO officials claimed that the results of their consultancy assignments have been in the following forms: recommendations for technology processes, recommendations on rehabilitation requirements and proposals for restructuring of existing industries. However, TISCO do not have information feedback on the impact of such recommendations. It may only be hoped that such recommendations helped the firms improve their performances. Lack of adequate information feedback data on this aspect reflect to some extent the weakness in TISCO's information division.

However, a direct impact of the consultancy assignments is the earned consultancy fees by TISCO as is indicated in Table 8.9.

Table 8.9: TISCO Consultancy Fees
(In Tshs. million, 1976 Prices)

Year	Fees	Year	Fees
1976/77	0.103	1983/84	5.567
1977/78	0.565	1984/85	5.067
1978/79	1.917	1985/86	4.426
1979/80	2.069	1986/87	3.760
1980/81	4.059	1987/88	3.689
1981/82	4.062	1988/89	3.974
1982/83	5.827	1989/90	3.973

Note: Used 1976 GDP deflators.

Source: TISCO (1990).

In Table 8.9, TISCO's consultancy fees was rising modestly from T.Shs million 0.103 in 1976/77 to Tshs. million 2.069 in 1979/80. But during the crisis period of late 1970s to the early 1980s, there was a substantial increase in the fees earned by TISCO; that is from Tshs million 2.069 in 1979/80, almost doubling to Tshs. million 4.059 in 1980/81. This increase was probably a result of increased number of clients (industrial firms) reflecting the increasing number of problems which the firms were facing as a result of the economic crisis and hence seeking for some of the above noted TISCO's services.

In the period of the late 1980s however, TISCO's fees declined and this might have been attributed partially to the relaxation of some problems following some improvements in the availability of foreign exchange under the ERP1 and 11 programmes and hence few clients requiring TISCO's services. On the other hand, however, decline in TISCO's fees might have been a reflection of the competitive situation whereby some firms (clients) opted for such services from other sources like the private consulting firms. This problem was also acknowledged by TISCO officials. The other related problem is that most of TISCO's clients had their own liquidity problems and therefore failed to pay promptly for TISCO's services hence TISCO's declining earned income.

In addition, it was found that there was very little cooperation with other technological institutions such as TIRDO, TEMDO and UNIDO. Suprisingly though, some of TISCO's objectives and functions are similar to those of FoE in section 8.1(ii); inspite of there being little or no cooperation between the two institutions. The danger of this is that there might be duplication of activities and hence wastage of resources.

8.2(ii) Tanzania Industrial Research and Development Organisation (TIRDO)

TIRDO was formed in April 1979 by the Act of Parliament. It is noted that during the second world war, East African Industrial research organization (EAIRO) was established in efforts to alleviate shortages of essential goods by promoting their manufacture in East Africa. Later on, after the war, the EAIRO continued to encourage industrial production. However, with time, the momentum built up by EAIRO was discouraged and hence declined. And also with the break up of the East African Community in 1976, the Tanzanian government, initiated the formation of TIRDO. Four Tanzanian national scientists and an expatriate, all formerly the employees of the EAIRO, based in Nairobi (Kenya), were used to form TIRDO in 1979.

TIRDO was thus created during the first phase of a 20 year industrial plan which was also in line with the United Nations resolution chartered in the Lagos Plan of Action of 1975. By this plan, member states from developing countries were required to develop institutional capabilities and human resources in support of industrial activity in order to realize the 1% share in the world industrial production by the year 2000.[2] As part of the overall industrialization strategy, the Tanzanian Government similarly established other institutions small scale industries (SIDO) in 1973; Tanzania Bureau of Standards (TBS) in 1976; industrial consultancy (TISCO) in 1976; and engineering design and manufacture (TEMDO) in 1980. The establishment of TIRDO thus logically complemented the strides already planned and taken towards the implementation of the industrialization strategy in Tanzania.

The development of TIRDO into a multidisciplinary

[2]See TIRDO (1989)

industrial research and services institute indicate the Tanzanian government determination (efforts) to further develop the technological capability in Tanzania. We have noted elsewhere in this study that, technological capability underlies technological self-reliance which in turn is a key component to a self-reliant development strategy as the one mentioned in the Arusha Declaration in 1967. It was thus, not until ten years later, since the proclamation of the Arusha Declaration that the crucial importance of technological self-reliance was at least considered.

TIRDO facilities were envisaged to provide laboratories and pilot scale plants for the development and demonstration of industrial processes. On the whole, TIRDO services were expected to assist industry directly through the provision of testing facilities and practical technological solutions to industrial bottlenecks. It was anticipated, therefore, that TIRDO would comprise a number of technological departmens dedicated entirely to specific industrial activities such as food processing; engineering; chemical processing technology; and fibre processing among others. These departments were to be supported by specialist sections having expertise that is applicable to a range of technologies. Such sections include chemical analysis and testing, engineering, instrumentation and information and extension services.

It was thus, expected that TIRDO operations would help in finding solutions of problems hindering smooth industrial performance in Tanzania. Referring to literature review and theory chapters of this study, TIRDO was therefore expected to effect incremental technological changes, that is minor technological changes.

TIRDO's mammoth task assumed the existence of both the technical structure and the experienced human resources required. At its inception, both were not readily available. It should be noted from experience, in the literature review, that a research and development institution requires twenty years or more of committed investment for an effective impact. In more than 10 years of its existence, TIRDO has mainly been concerned with the building up of its capability in terms of acquiring equipment, laboratory facilities and qualified and experienced personnel. Even then, as indicated by Table 8.10, for instance, the levels and capacity of TIRDO's personnel are not yet adequate and do not match the national expectations as explained above.

Table 8.10 Tanzania Industrial Research and Development Organisation (TIRDO) Technical Staff as at January 1989

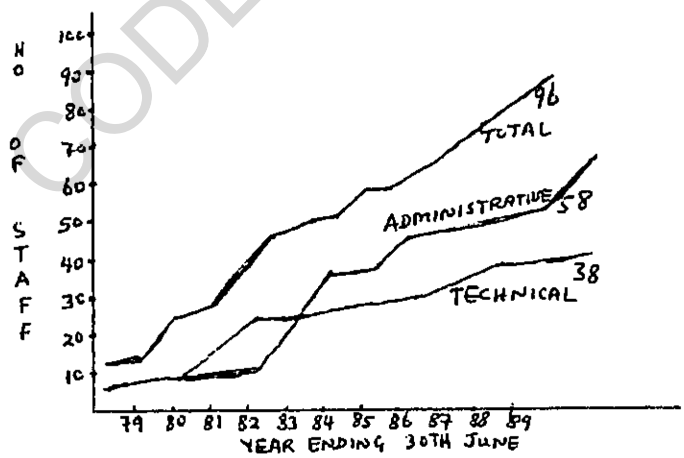
Department	Field	Number	Qualifications
1. Chemical & Food Technology	Chemist	2	Ph.D. degree
	Chemist	2	MS.c degree
	Chemist	1	B.Sc. degree
	Engineers	3	M.Sc. degree
	Engineers	3	B.Sc. degree
	Technicians	2	Technical Diploma
	Laboratory Asst.	1	Form IV
2. Engineering Department	Engineers	1	MS.c degree
	Engineers	7	B.Sc degree
	Industrial Economist	1	BA. degree
	Technicians	2	Diploma
	Technicians	1	FTC
	Senior Artisan	1	Trade Test 1
3. Industrial Information Centre	Documentation Officer	1	MA. degree
	Documentation Officer	1	BE. degree
	Industrial extension Officer	1	B.Sc. degree
	Reprographer	1	GCE
4. Instrumentation Centre	Engineers	1	MS.c degree
	Engineers	2	BS.c degree
	Technicians	1	Diploma Eng.
	Technicians	2	FTC

Source: Tirdo (1989)

As Table 8.10 indicates, up to January 1989, TIRDO had only 37 qualified and experienced technical personnel. This is obviously a very small number if at all it is to serve effectively many of the Tanzanian manufacturing industries. Although since 1983, TIRDO increased efforts to recruit more personnel, the problem is that experienced industrial R & D personnel are still very scarce in Tanzania and thus TIRDO has been forced to absorb fresh university graduates. In this regard, there are two problems: first, TIRDO has to compete with industries and other research institutions both public and private as regards terms and conditions governing manpower retention. Secondly, it takes time and further training (post-graduate) for such fresh graduates to get enough experience and adequate expertise in their specialised fields. TIRDO is only 12 years old and thus has a long way to go. Finally as graph 8.1 indicate below, even with the increased efforts in TIRDO's staff recruitment, it seems TIRDO has been recruiting more administrative staff than the badly needed technical staff. This trend has to be checked and balanced.

Graph 8.1

TIRDO
Manpower Development



Source: TIRDO (1989)

Given its infancy and the small number of qualified and experienced technical staff only few projects have been undertaken. And with regard to facilities, many of the laboratories and workshops have not yet been completed mainly due to lack of adequate funds.

Apart from those basic problems, such as insufficient skilled R & D personnel, inadequate and incomplete laboratories and workshops, the other serious problems which TIRDO face include: lack of adequate funds; lack of a strong national technological policy to back up such institutions as TIRDO and others; lack of a strong umbrella organization to coordinate the technology development process and enforce policies to facilitate provision of inputs to technology promotion and transfer; lack of government follow up on local technological activities, lack of prioritization of sectors; and liquidity problems faced by TIRDO's clients which negatively affect TIRDO's earnings. For instance according to Table 8.11, for five years (1983-1988) TIRDO collected only Tshs. 1,229,450 (1976 Prices) from fees. The annual and total fees earned by TIRDO are shown in Table 8.11.

Table 8.11: TIRDO Departments Fees Earned, 1983-1988 (1976 Prices)

As at June	Instrumentation	Engineering & Energy Audits	Chemical & Food	Information	Total
1983	21,488	11,878*	-	-	33,366
1984	19,528	25,275*	-	37,773	82,576
1985	34,858	130,258	-	26,955	192,071
1986	74,839	10,856*	26,393	18,121	130,209
1987	46,707	370,542	80,022	3,948	501,219
1988	41,116	105,305	71,773	71,815	290,009
Total	238,536	654,114	178,188	158,612	1,229,450

Note: * Energy audit fees only.
Deflated by 1976 GDP deflators

Source: TIRDO (1989)

With the above background (to establishment and the capacity/role and operations of TIRDO), the future prospects will depend much on the Tanzanian government committment to its effective development. In this respect the Tanzania government will have to provide TIRDO with more funds to at least enable the completion of the required facilities as originally planned. To minimise problems of shortages of funds and to strengthen the skills and experiences of its manpower, TIRDO should be encouraged to identify, establish and utilize effectively cooperation arrangements with institutions of similar setting in both developed and developing countries.

In TIRDO (1989), it has been reported that since 1979, several TIRDO staff have visited several such institutions as the Pakistan Centre for Scientific and Industrial Research (PCSIR of Pakistan); the Federal

Institute for Industrial Research Oshodi (Nigeria); Caribbean Institute for Industrial research and Standards (CARIRI) and Tata Energy Research Institute (India); and that advances made by these institutions are not only appropriate in their levels but are also relevant to Tanzania. And that from such contacts, then, cooperative research programmes could be introduced. And that such programmes could be proposed under the Technical Cooperation between Developing countries programmes of the United Nations Industrial Development organization or under the World Association of Industrial and Technological Research Organization of which TIRDO has been a member since 1980.

8.3 Provision of Spare-Parts, Research and Consultancy Services

In Chapter 7 of this study it was observed that only few Tanzanian manufacturing firms have the capability in terms of qualified and experienced personnel and adequate facilities like workshops and laboratories to produce locally, at least few of the required spare-parts. However, such capabilities are found to be quite small and hence the surveyed firms have not been able to undertake technological activities and research fully. In view of all these limitations, there have developed some technological institutions to play that role, and one of such institutions is the Institute of Production Innovation (IPI) of the University of Dar es Salaam.

8.3 (i) Institute of Production Innovation

In 1976, a group of lecturers within the office for relations with industry (ORI) at the FoE together with leaders from industries realized the necessity of establishing a practical link between the FoE and Tanzanian industry. Although right from the beginning the FOE made some efforts to render consultancy and routine services to industry which were more academic oriented little room were left for direct services to industry. The group therefore, resolved to establish a strong link which could facilitate the tapping of concentrated know-how and laboratory facilities which were primarly agglomerated for teaching purposes, for direct services to industry also.

Operationally, IPI was launched and recognized as a developing institute since 29 May, 1979, and in legal terms it was established on 12 December 1983. However, officially, IPI was established according to University Act No. 12 of 1970 section 21(4) by Tanzanian Government notice No. 236 of 6 October 1989, with the following objectives: (i) product innovation up to prototype production and subsequent transfer to a suitable industry,

(ii) consultancy and services to industry and (iii) supplying curriculum advice to the FoE through its feedback from industry.

It should be noted that closer cooperation between the IPI and the FoE is presumed without excluding individual technical developments on either side. In the past decade of IPI operation, the technical developments has been more predominant. And to be able to realize the above stated objectives, IPI engaged in building its capacity in terms of availability of qualified and experienced personnel and facilities. When IPI started operating, in 1979, it had 3 expatriate staff (two engineers and one technician) and continued to recruit local staff members and by 1989/90 it had 61 permanent staff members; as Table 8.12 indicate.

Table 8.12: Institute of Production Innovation (IPI) Manpower Development

	1979/80	1980/81	1981/82	1982/83	1986/87	1987/88	1988/89	1989/90
Engineer**	-	1+2*	2+2*	2+2*	10+2*	10+3*	10+3*	11+2*
Tchnicians	-	-	-	-	3	3	4	8
Draftsmen	-	-	1	1	1	5	6	4
Artisans Administrators	-	- 1*	- 1	- 1*	1 1	5 1	6 2	4 4
Secretaries	-	·1*	1*	1*	4	4	5	6
Supplies Officers	-	-	-	-	3	3	3	3
Accountants	-	-	-	-	2	2	2	2
Drivers	-	1	1	1	2	2	2	5
Messengers/Cleaners	-	2	3	3	7	4	4	4
Total								61

Note: * : Expatriate.
** : Most engineers have B.Sc.and M.Sc Eng. degrees. And in the 1990/91 there were 3 engineers pursuing their Ph.D studies abroad.

Source Prospectus (1990/91)

IPI employs engineers with first degrees who then go for further training after working for 2 years. From 1984 to-date, 11 engineers have gone abroad for MSc. studies under GTZ/DAAD, NORAD, British and Canadian Commonwealth scholarships. And 3 engineers were pursuing their Ph.D studies abroad. And apart from overseas training, IPI staff members attend local training programmes from time to time, ranging from full Technician certificate courses, to Trade Tests among others. There is also on-the job training using the already existing trained and experienced staff, in a wide range of skills ranging from basic artisan-skills for metal working to computer applications relevant for improved work performance.

It should be noted that, with regards to the above first stated objective of IPI, "Product Innovation up to prototype production and subsequent transfer to suitable industry" very little have been achieved.[3] This is because the development of a new product up to commercial manufacturing involve scale passing through many steps which are complex and long. They thus require substantial inputs in terms of staff, equipment and finance. IPI is a very young institute with a very small technical staff and with inadequate funds and hence failure to achieve much with respect to its first objective.

And with respect to the second objective, that is the area of "consultancy and service to industry", there have been remarkable achievement with a wide range of products and services being provided by the IPI. With severe scarcity of foreign exchange especially in the period since the late 1970s to the mid 1980s, many manufacturing firms in Tanzania faced the problems of lack of spare parts and hence some of them opted in some cases, to IPI's services. Thus IPI has been utilising its facilities to fabricate the needed spare-parts from local materials and rehabilitating some parts to extend their useful life.

[3]There are different opinions as to what constitute product and process innovation. In the IPI context, product innovation include both original design of new products and processes from frist principles, and the adaptation of existing products and processes to facilitate local manufacture and use in Tanzania.

The client industries include both private and parastatals. The main beneficiaries of this service have been, Aluminium Africa Ltd (ALAF), National Urban Water Authority (NUWA) Tanzania Automobiles Manufacturing Company Ltd (TAMCO), Morogoro Canvas Mill, Benwell Engineers, Sabuni Industry in Tanga, Reliable Woodworks, Muhammadi Ltd., Southern Paper Mills (SPM) and Kibaha Education Centre.

It has been IPI's policy not to take just any spare-part manufacture for this purpose. Emphasis has always been put on those which require a lot of engineering input and cannot be made in other local workshops. The parts include gears, worms, shafts, blades and cutters for machines, axles, housings, couplings, ratchet wheels, mandrils, gear boxes, bearing caps, plugers, moulds, pulleys among others. In addition, IPI has fabricated and rehabilitated very huge spare-parts like the 6 meters tall and 1 meter diameter catalysis tower made for the Tanga Sabuni Industry; boiler chimney for Tanzania Distilleries Company; and trailer axles.

Also, IPI has been transfering its own technologies to some industries like NECO and Themi Farm Implements in Arusha for production of oil processing equipment; though without success.

The type of cooperation arrangements which have been successful are that of utilizing capacities in other industries for production of equipments or parts. This has been mainly for those services which cannot be provided internally by IPI. These include casting, rolling of thick steel structures, galvanizing, forging, heat treatment, materials testing, cutting of thick sheet and fabrication of huge structures. And institutes/firms which have been involved in this sort of cooperation with IPI are TATC (casting), NECO (fabrication of huge structures), FoE (Materials testing, heat treatment), ALAF (Galvanizing), UFI (forging), Guru Engineering (casting) and SIDO (casting and cutting of steel plates). In addition, another successful mode of cooperation is that of joint venture of projects, such as with SIDO in palm oil processing.

And with regards to its third objective, that of "curriculum development and training services to the FoE", the IPI has been participating as a member of the FoE curriculum development committee, as well as supervising and financing some FoE student projects. The IPI has also been offering practical industrial training exposure to some FoE students. In addition IPI facilities have also been extended to other local technical colleges, to National Institute of Transport and to Water Resource Institute. Some students from abroad, such as from Netherlands, Delf University of Technology have visited and used IPI's facilities.

As noted above, there has been only limited success in respect to IPI's original first and second objectives. This has been caused by a number of problems such as: shortages of qualified and experienced manpower, delays in recruitments and problem of technological dissemination. That is, it may happen that a product is developed by IPI but it becomes difficult to promote its use by firms due to: one, there being no patent law in Tanzania which guide in transferring the product either in part or wholly. Two, since a unit may be produced for a single consumer, the cost of it becomes very high and hence it becomes cheaper to import such an item, which in most cases then ends up being under priced. There is also a problem of lack of adequate market, especially due to cheaper imported alternatives made possible by the recent trade liberalisation policies.

However, IPI has been trying to solve some of the above noted problems by recruiting and training more personnel and engaging some personnel on contract basis. And to boost its income, IPI has been selling its mature marketable prototypes and also services and engineering consultancy to manufacturing firms. However, some of the problems are difficult to solve. The problem of the lack of market for instance may continue for a long time to come as long as the market itself remains small.

8.4 Coordination and Promotion of the Development of Specific Manufacturing Industrial Sector

From the literature review chapter of this study, it was noted that it is important to give priority to certain industrial sectors in as far as industrial development is concerned. Further, it was noted in Chapter 7, that in the Tanzanian manufacturing sector there is a gap of information between potential producers and users of various technological services and products such as spare-parts. Lack of market for NECO's products and services for instance, reveal partially that problem of lack of information. However, this may also be due to the problem of poor quality and too expensive products of NECO especially in the view of imported alternatives. Noting these problems then, the Metal Engineering Industries Development Association (MEIDA) was formed.

MEIDA was formally registered under the societies ordinance cap. 337 in August 1979. When it started in 1979 it had 40 members who increased to 160 in 1987 and to 180 in 1989. The 180 members included 137 private manufacturers, 26 public metal manufacturers, 3 public holding corporations and 6 other institutions. MEIDA members account for more than 90% of all production within the metal engineering sector in Tanzania.[4] And MEIDA is run by a small permanent secretariat, whose primary

[4]See MEIDA (1989).

objective is to assist and develop the Metal Engineering Industry in Tanzania. The importance of metal engineering sector in Tanzania is explained in chapter 2.

MEIDA was formed with the following four objectives, viz: One, to provide a forum for interchange of information and experience among industrialists on one hand and Tanzanian government on the other. Two, to represent the interest of the sector in a combined forum and to evolve and recommend steps for development of the metal industry in Tanzania. Three, to constantly identify problems facing the sector and evolve and recommend measures for solutions of these problems. And four, to take an active role in the development of the metal engineering industry by promoting and investing in shares in companies aimed at vertical and horizontal expansion and integration of the sector.

With those four objectives, then, the MEIDA secretariat operate under standing and ad hoc committees formed from within the MEIDA membership. By 1989 there were six activity oriented standing committees, viz: Metal cutting, welding and fabrication; metal forming; metal finishing; foundry activities; and air conditioning, refrigeration and electrical services. And the ad hoc committees include: The TAMCO ancillary Committee, Ginery spare parts manufacturers committee and MEIDA Habari Editorial Committee.

In assessing partially the role of MEIDA, we have in this chapter analysed mainly activities related to ginnery spare parts manufacturing, and briefly, activities related to TAMCO ancillary committee. In respect to ginnery spare-parts, MEIDA took upon itself to encourage, plan and organize a series of meetings and conferences with local manufacturers, users, financial institutions as well as coordinating bodies cum technical institutions. The first of such meetings involved Tanzanian Cotton Marketing Board (TCMB) as a user representing most of the ginnery units in Tanzania and some of the MEIDA members as manufacturers. The ginning capacity in Tanzania stood at 300,000 bales of cotton per one season of nine months and the cost of imported spares surged from USD 10 in 1986 to USD 20 in 1988 per bale, giving a seasonal cost of USD 6 million for spares only.[5]

TCMB presetned a list of about 280 items for possible local manufacturing; and six firms, NECO, Mang'ula Mechanical and Machine Tools, Pamba engineering workshop, dm Investments, Guru Engineering Works Ltd. and Nyanza engineering and foundry co. had the capacity and capability to manufacture. At least 50% of the items were manufactured by the six firms for the season 1989, and still better performance was achieved in 1990. By July 1990, orders worth USD 3.5 million had been received by

[5]See Meida (1989)

local manufacturers and deliveries valued at USD 1.7 million had been made to users.

To supplement the efforts already undertaken by MEIDA, the Dutch aid cotton project provided a mission of experts aimed at apporaising the present and future production capacity of local gin spares, determine requirements for improvement in quality and quantity of spares production, provide list of items suitable for import substitution, indicate company viability and propose possibilities for Dutch aid support and or joint venture. The mission was in Tanzania from 16th July to 10th August 1989 when it completed its task.

The Dutch mission came up with a report in which among other things it justified the need for support and proposed a small body to operate under MEIDA supervision mainly for manufacturers coordinating unit. It found that Tanzanian spares manufacturers were confronted by a number of problems such as (i) lack of experience of serial production of spare parts espcially for firms such as NECO which had started as repairers rather than as producers of spare parts; (ii) raw material shortages due to delays in importation and cash cover problems, to meet the Bank of Tanzania requirements of 100% cash cover. In view of liquidity problems faced by respective firms, this was difficult to implement. In addition, in some cases wrong materials or materials in wrong form were used. (iii) problems related to methods of production, mainly due to lack of experience in calculations and time estimates of productions; (iv) payments to manufacturers from, say, cooperative unions were not coming smoothly as the latter also had liquidity problems. And (v) the problem of lack of "drawings", that is the Tanzanian manufacturers were not using original "drawings" of spare-parts, but were using "samples" and thus lacked "standardisation".

The Dutch aid intended to solve the above noted problems with the exception of (ii) and (iv). In that respect, the Dutch promised to give "drawings" and get involved in training technicians in the methods of producing spare parts in a 2 year project. Unfortunately, according to the interviewed MEIDA officials, up to 1990 the outcome of these Dutch promises were being awaited.

In addition, in the 1990/91 period, the cooperatives required less spare-parts because they had anticipated a low cotton crop and had also retained a stock of the previously received spare-parts. As a result, the prepared list of spare-parts provided by the Dutch aid was not used and somehow they got discouraged and there was little progress thereafter.

Besides ginnery spares, MEIDA conducted a series of meetings on textile spares and the first MEIDA/TEXCO spare parts contact conference took place on May 23, 1989 involving users and manufacturers of textile spares.

Although a lot of "orders" were made there were no "firm orders" and so very little progress was made in this regard.

With respect to TAMCO ancillary committee activities, the emphasis has been on trying to localise some of Scania parts, such as the "radiator" which is now locally made by Afro-Cooling Company and "silencers". The other locally manufactured components that go into the assembly of the Scania trucks in Tanzania include paints and thinners, bumpers and inner cross members, various brackets and tyres and tubes. And the list of components in the process of being approved for local manufacturing include springs, various rubber parts, fuel tanks and driver seats.

However, there are problems encountered in the above noted "localisation of spares", these include: difficulty in meeting high Swedish standards since the parts have to be approved by Scania in Sweden. So in general lack of experience and expertise in the methods of production is the main problem. But on the other hand, the Scania - Sweden had agreed to give "drawings" and provide some funds as assistance in technological development in Tanzania. And once approved, the parts are no longer imported from Sweden. The problem is that because of low skill, it takes so long, with very high production costs and hence low profit to produce such parts in Tanzania.

Therefore the benefit here is more in terms of acquiring and building technological capability in Tanzania and in the short-run that may be at the expense of efficiency and profitability. In the long-run, however, that may not be a useless effort altogether.

Despite such noted problems, MEIDA which is still a young association has at least started confronting some of the noted problems in the technological development in Tanzania, that is, lack of "coordination" and lack of "market" by filling in the "information gap". With the help of foreign expertise and experience, if utilized well, MEIDA may thus promote the growth of the Tanzanian metal and engineering firms.

8.5 Provision of Preventive Maintenance Services

In chapter 7 of this study, "machinery breakdowns" was mentioned in many cases as one of the causes of capacity underutilisation. It is noted here that, in many manufacturing firms in Tanzania, equipment is run until it breaks down. Most such firms lack "preventive maintenance" programmes and this is related to the above noted problem of shortage of qualified and experienced managerial and technical personnel. Noting this lack of preventive maintenance in most Tanzanian manufacturing firms, then, MEIDA Maintenance Services (MMS) was established.

The MMS was established as an association in 1985 and started operation in 1987. MEIDA owns 51% of its (MMS) shares and the rest is owned by 30 different people. There is no foreign shareholder. MMS is, however, managed by a mixed Tanzanian-Swedish management. The cooperation between MMS and Lamtrac AB in Sweden has made it possible for Swedish engineers to train Tanzanian engineers and technicians especially in the fields of preventive maintenance and consultancy. It should be noted here that, the maintenance procedures at most Tanzanian firms, are to operate to failure and then repair. The results of such maintenance procedures are very high maintenance costs due to over consumption of spare parts and short lifetime of equipment. The MMS task then is to help local industries avoid such a problem and achieve the benefits of efficient high quality maintenance.

In order to provide Tanzanian industries with the preventive maintenance services, MMS is involved mainly in three areas. First, MMS offers training for engineers and technicians, in the whole concept of maintenance. The training is either tailor made covering specific needs of an industry or an open programme dealing with general topics of maintenance. The contents offered in the training programmes include maintenance overview, preventive maintenance, condition monitoring, corrective maintenance, practical/Hands on courses for technicians and maintenance improvement programme.

Secondly, MMS offers consultancy services mainly in areas of trouble shooting, maintenance organisation, maintenance routines and systems maintenance service contracts and boiler and pressure vessels technology. And thirdly, MMS has equipment and capability (a workshop) to assist firms with reconditioning and repair of worn out machines/parts, oil testing and oil cleaning as well as condition monitoring. Specifically in this respect MMS performs reconditioning and repair, metal spraying, metal plating, maintenance welding, metal stitching, machining/metal cutting, in-situ repair for worn out industrial parts, equipments and machineries. In this case, MMS helps in the rehabilitation process in the Tanzanian industrial firms.

In terms of employment, MMS is still young and small with a general manager who is an engineer with MSc. (Eng.) and 5 years working experience in the field; Finance and administrative manager with a CPA diploma and 10 years experience; a service and maintenance engineer with a number of years of experience in the field and a consultancy engineer who is a Swedish expartriate. There is also a production engineer and technician supervisor with 9 artisans. And there are 6 supportive staff.

A few problems has been encountered by MMS so far. These include shortages of electricity and water and of customers (Industrial firms). However, there are no serious problems with respect to input supplies both local and imported. Locally, copper wires are adequately supplied by Tanzania cables. And for imported inputs such as chemicals, spare parts, equipments and machines, all are imported from Sweden mainly under the assistance from SIDA which provide grants to MEIDA.

And the existing technical and managerial manpower though small, appear to be adequate, in view of current small number of the customers. There is also on - the job training conducted mainly by Swedish qualified and experienced consultants. In this case, MMS has so far managed to undertake reconditioning works as requested by customers, provide training and conferences and seminars to the production, quality control and maintenance engineers from various Tanzanian manufacturing firms. Particularly, MMS have been used by Tanzanian manufacturers of spare parts such as NECO, on the issues of design, drawing, material and measurements.

MMS has been cooperating with TBS on aspects of quality control of local spare parts manufacturing. Also MMS has been using TAZARA heavy machines in the general reconditioning and maintenance of large spare parts which

MMS has no capacity to "turn".[6] MMS has also been cooperating with Auto-Mech and Auto-Parts companies in Dar es Salam on the aspects of "drawing" and "designing".

In as far as foreign contact is concerned, MMS cooperate with some institutions in Sweden which provide technical consultancies, seminars, funds (import support funds provided by SIDA) and sometimes offer chances (abroad) for further studies. Detailed "drawings" and "designs" for different technologies are quite rare in developing countries, Tanzania included. In this case effective exploitation of foreign knowledge and experience in these fields is quite important and so MMS cooperation with Swedish institutions and any other foreign institutions/firms is a good start and should therefore be encouraged and strengthened.

8.6 The Role of Tanzania Commission for Science and Technology (COSTECH) and the Ministry of Science and Technology and Higher Education

It has been implicitly explained elsewhere in this study that if Tanzania is to feel the impetus of development in the industrial sector then there has to be progress in research and development in the science and technology. Only little progress has, however, been

[6] "Turn" is a technical term which means shaping an iron steel to the required measurement.

achieved so far despite the objectives stated in the Long-term Basic Industrial strategy (1975-1995) and the Lagos Plan of Action for the economic development of Africa (1980-2000). For instance it was generally stated in the Lagos plan of Action (1980) that the science and technology development should have been allocated 1% of GDP by 1980 and up to 3% by 1990. However, up to 1992 in Tanzania less than 0.5% of GDP is made available for science and technology development in the economy as a whole.

We have noted however in this chapter (8) that Tanzania has made some efforts in promoting science and technology within such meagre resources. Most important as discussed above has been the establishment of techological institutions in the early 1970s and the 1980s. Among the several institutions established was the Tanzania National Scientific Research Council (NSRC) in 1968. The NSRC gave way to the Tanzania Commission for Science and Technology (COSTECH) in 1986. That is, the NSRC and some seventeen other Research and Development institutes became affiliated to the commission (COSTECH) through the enabling Act No. 7 of 1986. It is important to note here that there are several other institutions/organizations involved in technology research in Tanzania which have no statutory affiliation to the commission.

The COSTECH is the principal advisory organ of the government on all matters relating to science and technology development in Tanzania. As such the functions of COSTECH are mainly to formulate, monitor and coordinate science and technology policy in Tanzania. COSTECH is expected to acquire, store and disseminate scientific and technological information and to advise the government on matters related to scientific research such as priorities, training and effective utilisation of manpower, funds and equipment. In the course of discharging these functions, COSTECH is guided by the national objective and expectation that science and technology will play a key role in bringing about rapid socio-economic development and subsequent realization of self reliance. In that case COSTECH has proposed in broad terms programmes which will form a basis for scientific and technological development in each of the major sectors of the Tanzanian economy. It has also set out the institutional arrangements required and proposed a target of about 3.5% of GDP to be used for Research and Development Activities by year 2000. As noted above then the current portion of less than 0.5% of GDP does not indicate success achievement in the direction and expectation of building a self-reliant Tanzanian economy.

Another important function of the COSTECH is the provision of the Tanzania Award for Scientific and

Technological Achievement (TASTA) as explained also in chapter 2. This too faces a number of problems such as lack of funds, facilities, the impoverished social amenities and the poor motivation of scientists. In general, so far, there have been very few operational activities by COSTECH. To a large extent the COSTECH, besides the noted problems, has been pre-occupied with the structural and organizational establishment. For instance, COSTECH got its director-general only in 1988.

In 1990, the Government of Tanzania, realizing a lack of effective science and technology policy decided to create, for the first time since independence in 1961, a ministry of "Science and Technology and Higher Education" so that it could help in the promotion and guidance of technological development in Tanzania, for all sectors, including the industrial manufacturing sector. Although the new ministry is still very young and therefore has not so far done much in its role, the move itself of establishing such a ministry is a step in the right direction. It is an indication of new commitment by the Tanzanian government towards scientific and technological development in the country. It only remains to be seen how and to what extent the new ministry will be promoted and strengthened so that it can play its role effectively.

8.7 Summary and Conclusions

The empirical analysis in this chapter 8 focused on the qualitative evaluation of the functions and services of some Tanzanian educational and technological institutions which have been set up to support direct technological development in the Tanzanian industrial manufacturing sector. In that respect, we have, analysed the establishment, capacity, role and utilization of such institutions. The objective of this analysis has been to reveal the levels of technological efforts and capabilities at national level in the Tanzanian manufacturing sector. Implicitly, this have been done through "static" and "dynamic" analysis.[7]

In section 8.0 above, it is mentioned that in 1967, Tanzania proclaimed in the Arusha Declaration, intention to promote a self-reliant development strategy. And that "technological self-reliance" is a crucial and key component in such a self-reliant development strategy. It was important therefore to evaluate to what extent Tanzania undertook the promotion of "technological self-reliance" so as to build a self-reliant economy. In general from chapter 8 it may be said that not much was

[7]See Chapter 5. "Static" analysis has been implied in the levels and capabilities of qualified and experienced manpower, and state of workshops and laboratories. And "dynamic" analysis has been implied in the quality and quantity of functions and services rendered by such institutions.

achieved in this regard and only recently some notable steps started to be taken and some results obtained.

Among the mentioned technological institutions in section 8.0, only Dar-Technical College was there before the Arusha Declaration and FoE started operating some 6 years later after the Arusha Declaration in 1967. The rest of the institutions started at least some 10 years or more after 1967, indicating that, initially there were no serious technological efforts to promote technological development as part and parcel of the long term national development strategy. The neglect of scientific and technological development was seen in the lack of any effective technological policy. It was after 23 years since the proclamation of the Arusha Declaration in 1967, that the Tanzanian government created the Ministry to deal with the scientific and technological development in the country. A good move but somehow a late one.

Tanzania's efforts in technological development started late due to the implementation of the Basic Industrial Strategy (BIS) which was adopted in 1974, together with the effects of policy and institutional factors such as inadequate planning process, mis-directed foreign aid flows and a distorted pricing policy as also discussed in chapter 7.[8]

According to BIS, industry was to be the principal

[8]Wangwe and Luvanga (1990) has more or less similar observations.

agent of structural transformation and self reliance for the Tanzanian economy. The strategy emphasized import substitution and the production of producer goods, which were expected to use a large share of domestic resources. Implementation of the BIS in the period of the mid 1970s to the mid 1980s, resulted in very large investments in industry, generally capital intensive, relatively large-sized and import intensive. All this increased substantially the demand for foreign exchange while export earnings dwindled. Priority was on industry rather than on agriculture which is the main export earnings earner in Tanzania.

Tanzania did not have the resources to implement BIS in terms of massive investment. Therefore, foreign sources of financing (Donor Aid) played a greater role. Donors had bias towards new investments. Moreover, the donor-induced bias in favour of new investments was reinforced at the planning stage by Tanzania's financing strategy. For instance investment projects with promised or committed foreign finance and with longer repayment periods were easily approved by the Treasury, DevPlan and BOT. And the approved investment projects were largely unappraised, uncoordinated and had few, if any, details of finance. The major criteria considered in the investment projects was commerical (or financial) profitability and as such issues such as long term financing ability of the investments and development of technological capability were not considered.

Later, however, the Government of Tanzania became aware that human and technological capability constraints were a significant bottlenecks to industry since trade, industrial and educational policies have not been conducive to the appropriate development of technological capability in Tanzania's industry. Therefore some steps (the noted late efforts) have been taken such as establishing and utilizing technological institutions and the recent creation of the Ministry of Science and Technology and Higher Education.

It was noted in the literature and theory chapters of this study, that in general, technological institutions require a period of about 15-20 years to mature and deliver expected goods and services. Most of the covered technological institutions in this chapter 8, are less than 15 years old and thus still very young. And also that, they are still very small in terms of the size of their qualified and experienced managerial and technical manpower. For instance, TISCO in 1990/91, had only 40 personnel engaged in R & D activities and TIRDO in 1989 had only 37 such personnel. These, can not adequately serve many Tanzanian manufacturing industries. The same situation face the rest of the institutions. Even the Dar-Technical College and FoE which comparatively are older, still have small capacities and hence small output, as was noted for example in section 8.1 that the university education (engineering and science) in Tanzania was small and even lagged behind many other African countries too.

Apart from the small numbers of qualified and experienced manpower, in some cases, even the workshops and laboratories have been small, inadequate and incomplete. For instance in section 8.2 (ii) it was noted that TIRDO has been operating with partially completed laboratories and workshops due mainly to lack of funds. This has been caused also by very small amount of funds given to such institutions by the Tanzanian government.[9]

In view of the smallness of the Tanzanian economy and the resource shortages (manpower, funds and equipment) facing the Tanzanian technological institutions it is clear that the large number of such institutions may never be strengthened and thus continue to offer little and poor services to the industrial sector both in terms of promoting technological development and in terms of achieving industrial efficiency. As such concentrating on few such institutions should be considered. Alternatively, the parastatals (technological institutions) should be scrapped off and the door be opened to foreighn investors.

---

[9]The small contribution of government funds is also a partial reflection of the small expenditures on R & D by developing countries particulary African countries. See also Appendix 8.2

Foreign assistance in terms of expatriates, know-how and equipments and funds have been noted and found to be particularly important especially in terms of technologies which require detailed engineering; "drawings" and "designs". It was argued elsewhere in this study that, "technological self-reliance" does not mean cutting off from the rest of the world. This is because effective utilisation of foreign expertise and experience is an important basis for acquiring technological capabilities. The reviewed experiences in the literature review chapter confirm this too. In this sense the noted contacts and interactions with foreign sources, have to be encouraged and strengthened if at all Tanzania is to succeed in building and acquiring technological capabilities. This is a major source of technological transfer.

It is also noted from this chapter that, there is a problem of lack of strong coordination of activities, functions, and findings amongst the technological institutions and with the industrial manufacturing firms in Tanzania. Duplication of certain activities, as noted in section 8.2 (i) is thus one possible outcome. In addition there is lack of information linking the would be local producers and consumers of the products and services of such technological institutions. However, with respect to this, some notable efforts have been carried by MEIDA, for example, as noted in section 8.4. The problem is that there is lack of stronger and broader promotion efforts for such products and services to be adequately used in Tanzania. In other words, even the small output and services by technological institutions do not find an adequate market in Tanzania. To correct this problem there is a need for a stronger and effective science and technology policy in Tanzania, which could help in the promotion, guidance and marketing of Tanzania's technological products and services. With the establishment of the COSTECH and the recent creation of the Ministry of Science and Technology and Higher Education, it is hoped that this problem of lack of effective science and technology policy have begun to be addressed in Tanzania. And further, as noted in chapter 2 consideration of the creation of "information centres" for coordination purposes may be quite important and crucial.

Despite all such problems, Tanzania's efforts in establishing and in utilisating technological institutions is but a good starting point in the promotion of technological development in Tanzania's industrial manufacturing sector. Most of these institutions are not yet strong. However, with time and more investments, with relaxation of the economic crisis and more importantly with the provision of incentives for efficiency through creation of conducive macroeconomic environments (policies) some of the technological institutions may be strengthened and thus play their expected roles effectively. Such roles include provision of indigenous, skilled, technically trained manpower; promotion and coordination of development of subsectors crucial to technological capability development, particularly metal working; provision of methods and techniques of preventive maintenance services and provision of industrial research, consultancies and R & D.

It has been noted that the technological institutions expected to play those roles are faced with a number of problems mainly inadequate trained manpower, facilities, funds and specific promotional policies. Therefore, their success depend partially on the commitment by the government of Tanzania to solve these problems. Also success depend on mobilisation of foreign sources for funds, expertise and facilities. And more importantly in view of the fact that most of the established technological institutions are too small (inadequate technical personnel funds and equipment) and too many with some duplication of activities amongst them, then it would be much more reasonable to consider some actions which would promote the concentration of such activities in few but efficient institutions, and thus avoid wastage of the meagre resources and thus promote both technological development and efficiency in the Tanzanian industry.

Chapter 9

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

9.1 Summary and Conclusions

This study has quantitatively established that generally for the period 1966-1988, the Hicks neutral technical change (efficient organization of inputs) did not contribute significantly to output variations in the Tanzanian manufacturing sector as a whole, as well as in the metals and engineering sub-sector and in other ISIC digit three industrial groups.

Using the average Cobb-Douglas production function the Hicks neutral technical change wa estimated by the time trend with its rate (m) representing a trend increase or decrease for productivity (or growth output) over a period.

For the period 1966-1980, the rate of time trend (m) was found to be quite small but positive and significant (t-test) in 4 of the covered cases. Only in one case it (m) was found to be small, negative and insignificant. Therefore, generally for the covered cases (except in one) a small part of the industrial growth was due to the Hicks neutral technical change. The massive investments in the late 1970s had in their technological packages a component of expatriates. It is presumed that these expatriates contributed to efficient organization of capital and labour in the 1970s. However, a larger part of output growth was due to increase in labour and capital inputs.

The small neutral technical change that occured in some cases in the period 1966-1980, declined when we extended the estimate to the whole period 1966-1988. The rate of time trend (m) in the 1966-1988 was negative, quite small and insignificant (test) in all cases except in one, where it was positive but very small and insignificant. In general, therefore, over the whole period 1966-1988, the Hicks neutral technical change did not contribute significantly to output variations in the covered Tanzanian industrial cases.

This study has also qualitatively analysed technological efforts and capabilities in the surveyed Tanzanian metals and engineering firms and in the technological and educational institutions. The surveyed firms experienced, in general, low and declining labour productivities and widespread capacity underutilization, especially in the period since the late 1970s to the 1980s. Very low levels of technological efforts and capabilities were found in these firms.

There are too many technological institutions (in some cases unnecessarily duplicating their activities) and these are also small due to the thin spread of the little available necessary resources (manpower, funds and facilities) from the government. The educational institutions, too, face severe resource constraints. These institutions are inefficient and have failed to effectively promote the desired technological development in the Tanzanian manufacturing industries. This is the result of weak planning and their harphazard establishment without proper coordination, particularly in the case of technological institutions.

Technological change, efforts and capabilties are very important factors of economic growth. Their absence affect economic growth negatively. In this sense, the poor industrial performance in Tanzania may be partly attributed to such absence of technological change, efforts and capabilities.

Overall we conclude that Tanzania erred by not seriously incorporating technological efforts and capabilties improvement in the various industrial development policies, and strategies viz; the import substitution industrialization policies of the 1960s and the 1970s, the nationalization and self-reliance policies of the Arusha Declaration (1967), the massive industrial investments of the 1970s, the BIS (1975-1995) and the adjustment and recovery programmes of the 1980s. Tanzania, thus lacked effective science and technology policy for too long. The late creation of COSTECH and the Ministry of Science and Technology and Higher Education to cater for such a policy partly indicates this ommission. These institutions are yet to provide substantial results.

The few technological efforts made so far in promoting technological development are inadequate, uncoordinated and wrongly or poorly undertaken in certain cases. Thus, despite the high achieved localisation levels in the Tanzanian manufacturing firms, the locals who replaced the expatriates have failed to efficiently organize inputs and to perform some managerial and technological functions effectively. This may indicate that the localisation was premature, and made worse by problems such as lack of funds, facilities and incentives to local skilled manpower. These problems together with the absence of effective science and technology policy and the small supply of local skilled manpower contributed to Tanzania's failure to utilize effectively the massive technology imports of the 1970s for technological development.

In view of the noted inhibiting factors to technological development in Tanzania, the lessons from the reviewed successful developing countries and the results of the empirical analysis of the data from the surveys we make some recommendations for improving the technological development and the efficient industrial perfomance in Tanzania.

9.2 Recommendations

The following recommendations are made:

(i) Implementation of the localisation policies should be effectively monitored so as to avoid pre-mature localisation.

(ii) Only few technological institutions should be strengthened. Institutions which unnecessarily duplicate their activities should be merged. Alternatively, the parastatal technological institutions should be scrapped off and the door be opened to foreign investors or joint ventures. However, Cost-Benefit analyses are required to ascertain all these.

(iii) The educational institutions should be strengthened so that they supply adequate local skilled manpower. This is a key factor to technological development.

(iv) A technological data bank should be created.

(v) The Tanzanian government should increase its funds' allocation to technological activities.

(vi) The government should concentrate on providing policies which are conducive to technological development. For instance, protection should be specific and limited in levels and time and thereafter if the firms or technological institutions are matured they should be exposed to competition which is an impulse for technological activities.

Appendix 6.1: Table 1

TEXTILE

Estimates of Capital Input, 1966-1988 (1976 Prices)

Year	Incremental RGVA 3 yrs Moving Averages	Net F. Capital Formation 3 yrs moving Average	ICORs	Estimated Capital Stock	Invest ment Producti vity	Capacity utiliza tion (%)	Utilised Capital stock.
1966	-	-	-	347615.7	-	100	347615.7
1967	-	56389.3	-	370990.9	-	100	370990.9
1968	14372.1	92179.0	3.9	482120.4	0.256	100	482120.4
1969	31983.1	95918.7	2.9	503995.4	0.345	100	503995.4
1970	34919.0	111943.7	2.8	656764.6	0.357	100	656764.6
1971	30058.9	74474.0	3.7	799405.4	0.270	100	799405.4
1972	19415.7	40811.0	3.8	891619.1	0.263	88	784624.8
1973	4173.7	39668.3	9.8	881835.1	0.102	90	793651.6
1974	4710.8	49249.0	8.4	900553.4	0.119	81.3	732149.9
1975	18237.6	65929.0	2.7	969273.7	0.370	87.04	843655.8
1976	22425.0	68683.7	2.9	989831.0	0.345	83.0	821559.7
1977	55072.4	68542.3	1.3	1042407.5	0.769	63.1	657759.1
1978	57358.5	126547.3	1.2	1116746.1	0.833	66.6	743818.9
1979	61624.0	128769.3	2.1	1137755.8	0.476	68.1	774811.7
1980	-18436.4	137316.0	-7.0	1405941.0	-0.143	45.6	641109.1
1981	-101962.6	116981.7	-1.4	1521350.0	-0.714	37.5	570506.3
1982	-76357.9	65327.7	-1.5	1625723.5	-0.667	33.1	538114.5
1983	-37100.8	89494.0	-1.8	1789414.3	-0.556	23.8	425880.6
1984	8176.8	67984.7	11.0	1726910.6	0.090	24.0	414458.5
1985	-33292.1	279186.3	-2.0	1879589.0	-0.500	21.3	400352.5
1986	-16735.5	768152.0	-16.7	2020572.6	-0.060	21.2	428361.4
1987	-22274.8	1332580.3	-34.5	2775993.0	-0.029	19.6	544094.6
1988	-	-	-	4526873.3	-	19.0	860105.9

Appendix 6.1: Table 2
FOOTWEAR

Estimates of Capital Input, 1966-1988 (1976 Prices)

Year	Incremental RGVA 3 yrs Moving Averages	Net F. Capital Formation 3 yrs moving Average	ICORs	Estimated Capital Stock	Investment Productivity	Capacity utilization	Utilised Capital stock.
1966	-	-	-	76410.1	-	100	76410.1
1967	-	-3544.6	-	79875.6	-	100	79875.6
1968	-984.6	8611.0	3.6	85824.8	0.278	100	85824.8
1969	2087.6	12440.3	4.1	100293.5	0.244	100	100293.5
1970	5730.0	15860.7	2.2	102309.9	0.455	100	102309.9
1971	7209.4	11769.7	2.7	119609.4	0.370	81.3	97242.4
1972	4433.8	8343.0	2.7	125417.9	0.370	81.3	101964.8
1973	914.8	21579.7	9.1	132082.0	0.110	70.1	92589.5
1974	12185.9	31330.0	1.8	136921.9	0.556	73.4	100500.7
1975	15816.8	53835.7	2.0	181893.8	0.500	69.4	126234.3
1976	13210.0	60676.7	4.1	214346.2	0.244	67.0	143612.0
1977	24801.6	66538.7	2.5	286894.8	0.400	68.4	196236.0
1978	1449.5	6143.3	45.9	381765.1	0.022	50.6	193173.1
1979	1970.9	72144.7	31.0	429103.9	0.032	51.7	221846.7
1980	-24939.3	89734.3	-2.9	478497.7	-0.345	36.3	173694.7
1981	-2279.1	131471.3	-39.4	588128.8	-0.025	29.0	170557.4
1982	-818.0	105186.3	-160.7	776240.4	-0.006	21.0	163010.5
1983	-1635.4	79936.7	-64.3	1034779.4	-0.016	19.0	196608.1
1984	-12771.2	24302.3	-6.3	1023491.4	-0.159	14.0	143288.8
1985	-17291.8	26558.3	-1.4	1019358.8	-0.714	14.7	149845.7
1986	-15252.2	26688.3	-1.7	1005103.9	-0.588	22.5	226148.4
1987	-8880.0	33679.7	-3.0	1023314.7	-0.333	8.8	90051.7
1988	-	-	-	1057543.0	-	10.6	112099.6

Appendix 6.1: Table 3

METALS

Estimates of Capital Input, 1966-1988 (1976 Prices)

Year	Incremental RGVA 3 yrs Moving Averages	Net F. Capital Formation 3 yrs moving Average	ICORs	Estimated Capital Stock	Investment Productivity	Capacity utilization (%)	Utilised Capital stock.
1966	-	-	-	72334.1	-	100	72334.1
1967	-	2746.9	-	74409.4	-	100	74409.4
1968	1194.3	5291.0	2.3	76174.9	0.435	100	76174.9
1969	4575.5	13645.0	1.2	79870.2	0.833	100	79870.2
1970	10273.3	19103.0	1.3	80281.7	0.769	100	80281.7
1971	11996.9	40938.7	1.6	114693.6	0.625	90.12	103361.9
1972	13075.2	43887.0	3.1	143520.9	0.323	89.71	128752.6
1973	8321.7	43180.0	5.3	246185.8	0.189	72.05	177376.9
1974	15980.7	58149.7	2.7	295290.5	0.370	64.54	190580.5
1975	23278.2	93263.3	2.5	323497.0	0.400	54.83	177373.4
1976	19220.8	154916.3	4.9	439333.1	0.204	48.0	210879.9
1977	37049.5	192563.7	4.2	778633.5	0.238	47.42	369228.0
1978	12089.5	158024.7	15.9	1260865.8	0.063	47.64	600676.5
1979	-1161.6	128993.0	-136.0	1539073.5	-0.008	45.47	699816.7
1980	-36224.8	88695.7	-3.6	1523244.8	-0.278	43.0	654995.3
1981	-30783.4	109794.0	-2.9	1594629.6	-0.345	40.0	637851.9
1982	-151.5	68742.0	-724.7	1648375.1	-0.002	33.0	543963.8
1983	5092.4	51513.3	13.5	1746732.4	0.074	32.0	558954.4
1984	14667.8	44309.0	3.5	1680969.7	0.286	33.0	554720.0
1985	1485.1	50090.3	29.8	1693548.3	0.034	26.0	440322.6
1986	-1961.6	57987.7	-25.5	1720845.8	-0.039	32.36	556865.7
1987	3130.7	42111.0	18.5	1669659.6	0.054	33.12	552991.3
1988	-	-	-	1679834.6	-	30.74	516381.2

Appendix 6.1: Table 4

MACHINERY

Estimates of Capital Input, 1966-1988 (1976 Prices)

Year	Incremental RGVA 3 yrs Moving Averages	Net F. Capital Formation 3 yrs moving Average	ICORs	Estimated Capital Stock	Invest ment Producti vity	Capacity utiliza tion	Utilised Capital stock.
1966	-	-	-	23187.2	-	100	23187.2
1967	-	3132.7	-	24076.8	-	100	24076.8
1968	1183.0	7316.7	2.7	25700.0	0.370	100	25700.0
1969	3205.0	10948.3	2.3	33024.0	0.435	100	33024.0
1970	3878.9	12380.8	2.8	46833.8	0.357	100	468833.8
1971	5895.6	11308.2	2.1	59322.1	0.476	100	59322.1
1972	8536.9	9788.7	1.5	72420.0	0.667	100	72420.0
1973	11793.3	10328.3	1.3	78149.0	0.769	97.6	76273.4
1974	5987.4	7319.0	1.7	84011.6	0.588	90.5	76030.5
1975	5940.9	7642.0	1.2	91186.0	0.833	81.8	74590.2
1976	7490.9	8683.0	1.0	105337.7	1.000	83.5	87957.0
1977	12279.9	10073.7	0.7	114843.8	1.429	70.3	80735.2
1978	8648.6	10281.7	1.5	128261.6	0.667	64.4	82600.5
1979	47.7	33478.0	215.5	134873.5	0.005	45.2	60962.8
1980	-14634.6	48952.0	-2.3	192032.8	-0.435	42.4	81422.0
1981	-12693.7	60199.0	-3.9	232037.2	0.256	30.4	70539.3
1982	-10628.8	54687.7	-5.7	285938.3	-0.176	22.9	65479.9
1983	2360.5	62901.3	23.2	361184.4	0.043	18.0	65013.2
1984	3440.4	37196.3	18.3	379980.2	0.055	17.0	64596.7
1985	10764.9	35598.3	3.5	397608.2	0.286	18.0	71567.0
1986	-271.6	30465.0	131.1	396084.8	-0.008	20.0	79217.0
1987	-4259.0	45302.0	-7.15	417360.6	-0.140	19.0	79298.5
1988	-	-	-	438209.6	-	16.3	71368.8

Appendix 6.1: Table 5

TRANSPORT

Estimates of Capital Input, 1966-1988 (1976 Prices)

Year	Incremental RGVA 3 yrs Moving Averages	Net F. Capital Formation 3 yrs moving Average	ICORs	Estimated Capital Stock	Invest ment Producti vity	Capacity utiliza tion	Utilised Capital stock.
1966	-	-	-	15688.4	-	100	15688.4
1967	-	6072.0	-	20775.0	-	100	20775.0
1968	3034.0	6698.7	2.0	26951.3	0.500	100	26951.3
1969	5144.8	7406.3	1.3	34010.7	0.769	100	34010.7
1970	4956.7	7044.3	1.5	40371.2	0.667	100	40371.2
1971	5609.5	7965.3	1.3	49116.6	0.769	100	49116.6
1972	5290.7	9610.7	1.5	53904.8	0.667	100	53904.8
1973	7669.2	12085.7	1.3	61336.5	0.769	97.88	60036.2
1974	7121.6	14019.0	1.7	72456.7	0.588	76.64	55530.8
1975	6794.7	20206.3	2.1	83999.9	0.476	62.88	52819.1
1976	4858.0	31831.0	4.2	96552.9	0.238	60.35	58269.7
1977	3331.2	38942.7	9.6	126643.3	0.104	58.60	74213.0
1978	9615.3	66936.7	4.1	172044.1	0.244	67.60	116301.8
1979	12191.5	56457.7	5.5	202516.9	0.182	52.78	106888.4
1980	6301.4	80276.0	9.0	320197.0	0.111	47.45	151933.5
1981	7742.3	91456.7	10.4	328354.2	0.096	28.99	95189.9
1982	-5160.6	120952.7	-17.7	425639.5	-0.057	28.38	120881.6
1983	-7038.0	92333.0	-17.2	561480.5	-0.058	21.92	123076.5
1984	-4097.0	89161.0	-22.5	646667.5	-0.044	17.0	109933.5
1985	-6400.4	60547.0	-13.9	639762.1	-0.072	14.66	94045.0
1986	7782.1	62471.7	7.8	756462.0	0.129	13.60	102878.8
1987	16656.6	26931.7	-3.8	749759.9	-0.263	25.91	194262.8
1988	-	-	-	745327.9	-	22.35	166580.8

Appendix 6.1: Table 6

METAL AND ENGINEERING SUB-SECTOR

Estimates of Capital Input, 1966-1988 (1976 Prices)

Year	Incremental RGVA 3 yrs Moving Averages	Net F. Capital Formation 3 yrs moving Average	ICORs	Estimated Capital Stock	Invest ment Producti vity	Capacity utiliza tion	Utilised Capital stock.
1966	-	-	-	119148.4	-	100	119148.4
1967	-	9705.1	-	126802.9	-	100	126802.9
1968	4411.4	19306.3	2.2	135990.8	0.455	100	153711.3
1969	12925.3	32000.0	1.5	153711.3	0.667	100	153711.3
1970	19108.8	34968.2	1.7	173952.7	0.588	100	173952.7
1971	23312.1	58046.9	1.5	229275.1	0.667	100	229275.1
1972	25237.8	61705.0	2.3	265681.3	0.435	100	265681.3
1973	22853.7	65594.0	2.7	388715.2	0.370	85.9	333906.4
1974	286612.7	79487.7	2.3	454650.5	0.435	77.3	351444.8
1975	36013.8	121111.7	2.2	501430.0	0.455	70.6	354099.6
1976	31569.8	195430.3	3.8	633833.58	0.263	63.5	402484.3
1977	52660.6	241579.7	3.7	1013099.8	0.270	59.7	604820.6
1978	28353.4	249243.0	8.5	1554501.8	0.118	56.8	882957.0
1979	11077.5	218928.7	22.5	1870127.7	0.044	49.8	931323.6
1980	-44557.9	217923.7	-4.9	2029455.3	-0.204	40.5	821929.4
1981	-45733.7	261450.0	-4.8	2149302.6	-0.208	33.3	715717.8
1982	-15909.3	244382.0	-16.4	2461985.6	-0.061	31.8	782911.4
1983	415.0	206747.7	588.9	2766328.3	0.002	24.6	680516.8
1984	14011.1	172333.0	14.8	2799701.9	0.068	24.0	671928.5
1985	5817.9	147902.3	29.6	2878398.8	0.034	21.5	618855.7
1986	5549.0	152591.0	26.7	3013498.9	0.038	22.3	672010.3
1987	-17785.0	114344.7	-8.6	1969880.9	-0.116	24.8	736530.5
1988	-	-	-	3027984.9	-	24.2	732772.4

Appendix 6.1: Table 7

TOTAL MANUFACTURING SECTOR

Estimates of Capital Input, 1966-1988 (1976 Prices)

Year	Incremental RGVA 3 yrs Moving Averages	Net F. Capital Formation 3 yrs moving Average	ICORs	Estimated Capital Stock	Investment Productivity	Capacity utilization	Utilised Capital stock.
1966	-	-	-	1239782.8	-	100	1239782.8
1967	-	290325.0	-	1526154.6	-	100	1526154.6
1968	96137.1	260486.3	3.0	1864154.9	0.333	100	1864154.9
1969	117628.7	313810.0	2.2	2239940.1	0.455	100	2239940.1
1970	124590.7	338643.3	2.5	2471512.1	0.400	100	2471512.1
1971	119654.6	358213.7	2.8	2988370.5	0.357	100	2988370.5
1972	113319.6	281901.3	3.2	3445301.0	0.313	100	3445301.0
1973	120836.9	273220.7	2.3	3692275.9	0.435	95.7	3533508.1
1974	81634.6	349796.0	3.4	3972919.1	0.294	90.5	3595491.8
1975	127728.6	638485.7	2.7	4406204.2	0.370	81.7	3599868.8
1976	123628.6	1065093.3	5.2	4856003.0	0.192	74.3	3608010.2
1977	170838.0	1271619.0	6.2	5956202.8	0.161	60.8	3621371.3
1978	126342.2	1253066.7	10.1	7574436.7	0.099	49.1	3719048.4
1979	12655.7	1000359.7	99.0	8498199.9	0.010	44.2	3756204.4
1980	-12655.7	929090.7	-7.7	9462488.9	-0.130	38.0	3595745.8
1981	-147409.3	1061297.7	-6.3	10261322.4	-0159	32.2	3304145.8
1982	-113855.5	933324.3	-9.3	10984154.3	-0.108	29.4	3229341.4
1983	-12412.4	927154.0	-75.2	12124441.6	-0.013	26.2	3176603.7
1984	-48876.2	925077.0	-19.0	12417119.5	-0.053	25.8	3203616.8
1985	-23462.0	964433.7	-39.4	13067666.5	-0.025	24.2	3162375.3
1986	-18658.2	1440933.0	-51.7	14249935.2	-0.019	22.0	3134985.8
1987	13173.4	1731789.3	109.4	14782277.4	0.009	20.5	3030366.9
1988	-	-	-	16797798.6	-	21.3	3577931.1

Appendix 6.2: Table 1

Estimates of the Production Function in the concerned Manufacturing Industrial Cases

1966-1980 (Unutilized Capital stock = Ke) included

Industrial Case	Const.	LKU	LL	LKe	Ad.R	DW	F	df
Textiles	-0.901 (-0.210)	0.914 (0.616)	0.913 (3.960)	0.007 (0.597)	0.908	1.746	32.866	9
Metals	-0.009 (-0.002)	0.224 (1.435)	0.849 (1.840)	0.002 (0.052)	0.924	1.833	40.282	9
Machinery	-3.866 (-1.580)	0.494 (3.106)	0.880 (3.960)	0.017 (0.952)	0.979	1.875	112.053	8
Metals & Engineering	5.653 (1.396)	0.027 (0.074)	0.579 (2.199)	0.004 (0.287)	0.969	1.682	103.296	9
Total Manufactur ing Sector	0.005 (0.005)	0.260 (2.824)	0.779 (6.347)	0.004 (0.906)	0.978	2.147	145.045	9

Note: Unutilized Capital stock (Ke) is obtained by subtracting utilized capital stock (KU) from Estimated Capital stock (K).

Appendix 7.1: Table 7.1

Name of Firm: UBUNGO FARM IMPLEMENTS LTD.
Year started Production: 1970
Ownership: Wholly (100%) public (Government)
Principal Activities/Products: Production of farm Implements.
Basic Data (1976 Prices)

Year	Actual Volume M. Tons	Planned Volume M.Tons	Gross Value Added 000'Tshs.	Employ-ment No.	Production Costs 000'Tshs
1972	N/A	N/A	6405.5	233	41668.7
1973	714	1130	5772.4	356	42359.9
1974	831.4	1130	7064.7	349	42033.4
1975	890.7	1130	9461.9	369	54368.4
1976	1688	1854	7542.0	407	54552.0
1977	1111	N/A	N/A	403	N/A
1978	1068	1748	12251	418	46510.0
1979	1084	1363	11367.4	454	57404.6
1980	N/A	N/A	N/A	599	N/A
1981	2463	4105	9115.9	646	60102.4
1982	1600	3720	8773.3	649	51508.2
1983	2791	3414	22842.0	640	58217.2
1984	3416	3710	29720.9	623	77140.7
1985	2420	3710	22815.4	627	39396.9
1986	3342	4515	N/A	666	N/A
1987	3386	2340*	N/A	728	N/A
1988	N/A	N/A	N/A	754	N/A
1989	980*	1217*	N/A	810	N/A
1990	1405*		N/A	835	N/A

Note: Gross Value Added, Production Costs and Sales each deflated by 1976 GDP deflators.

: Total Fixed Assets deflated by 1976 Implicit Fixed Capital deflators.

: * for hoes only.

Appendix 7.1: Table 7.2

Name of Firm: **STEEL ROLLING MILLS LTD.**
Year started Production: Commercial Production in 1971
Ownership: by 1989 = 95.6% NDC & 4.4 Daniel and Co. of Italy
Basic Data (1976 Prices)

Year	Actual Volume	Planned Volume	Installed Volume	Gross Value Added	Employment	Production Costs
	M.Tons	M.Tons	M.Tons	000'Tshs	No.	000'Tshs
1971	4300	8000	20000	N/A	118	N/A
1972	4849	8000	20000	N/A	120	N/A
1973	4630	8000	20000	N/A	117	N/A
1974	7368	10000	20000	N/A	212	N/A
1975	10480	10000	20000	14790.2	135	31267.7
1976	12235	10300	20000	13756	145	26708
1977	10104	10300	20000	5311.7	150	23680.7
1978	16677	16700	20000	N/A	N/A	N/A
1979	18600	19850	20000	11478.4	306	53521.6
1980	18867	18990	20000	11757.0	390	63023.2
1981	17061	18990	20000	8645.1	340	48978.9
1982	12764	15000	20000	3633.7	341	42487.3
1983	9469	15000	20000	10009.1	355	25811.6
1984	8192	15000	20000	99	358	27660.5
1985	11900	15000	20000	7171.3	365	35920.8
1986	11300	15000	20000	9639.1	368	43363.6
1987	9550	15000	20000	27946.5	370	15531.5
1988	10487	15000	20000	26839.4	377	17647.3
1989	10464	15000	20000	N/A	371	N/A
1990	9129	15000	20000	N/A	381	N/A

<u>Note</u>: Used same deflators as in Table 7.1.

Appendix 7.1: Table 7.3

Name of Firm: CMB PACKAGING (T) LTD.
Year Started production: 1948
Ownership: 50% Public/Private (CMB P. UK Ltd.)
Principal Activities/Products: Manufacturing of Metal Products such as Tin Cans, battery, Jackets & Crown Corks.

Basic Data (1976 Prices)

Year	Volume	Real Gross Value Added	Employment	Production Costs
	000'Tshs	000'Tshs	No.	000'Tshs
1975	20810	9997.7	314	28401.7
1976	76367	11572.0	323	32750.
1977	80268	7821.7	332	27451.1
1978	91621	N/A	339	N/A
1979	79968	9820.4	343	33376.7
1980	N/A	11993.4	345	35533.7
1981	27842	N/A	N/A	N/A
1982	19113	N/A	N/A	N/A
1983	16830	N/A	N/A	N/A
1984	16147	4889.7	403	15121.8
1985	9557	3937.4	366	14218.8
1986	9156	7806.3	458	14684.2
1987	8250	6937.5	N/A	24596.7
1988	6000	6308.6	N/A	22366.9
1989	8496	N/A	N/A	N/A
1990	5206	N/A	320	N/A

Note: Used similar deflators as in Table 7.1

Appendix 7.1: Table 7.4

Name of Firm: **NATIONAL ENGINEERING COMPANY**
Year Started Production: 1967
Ownership: Public/Private
Principal Activities/Products: Metal fabrication, Industrial, automotive & gunnery parts, Repairs and Allied Engineering services.

Basic Data (1976 Prices)

Year	Real Gross Value Added	Employment	Production Costs
	000'Tshs	No.	000'Tshs
1975	2826	302	3081.4
1976	3470.6	327	3784.2
1977	4576.5	356	4571.5
1978	7129.9	N/A	N/A
1979	6353.2	315	2443.4
1981	N/A	N/A	N/A
1982	N/A	N/A	N/A
1983	N/A	N/A	N/A
1984	8950.8	300	6497.1
1985	3391.1	292	9443.6
1986	4628.7	349	12209.3
1987	4414.1	348	4414.1
1988	N/A	N/A	N/A
1989	N/A	N/A	N/A
1990	N/A	N/A	N/A

Note: Used same deflators as in Table 7.1.

Appendix 7.1: Table 7.5

Name of Firm: **MANIK ENGINEERS**
Year Started Production: 1970
Ownership: Private (local) 100%
Principal Activities/Products: Manufacture of Maize Grinding Mills and Basement frames.

Basic Data (1976 Prices)

Year	Actual volume	Installed Capacity	Real Gross Value Added	Employment	Production Costs
	(Units)	(Units)	000'Tshs	No.	000'Tshs
1971	130	360	N/A	12	N/A
1972	217	360	N/A	16	N/A
1973	319	360	N/A	N/A	N/A
1974	274	360	N/A	16	N/A
1975	162	360	135.7	14	343.1
1976	90	360	69	13	251
1977	84	360	51.6	11	315.5
1978	286	360	N/A	11	N/A
1979	309	360	251.7	19	2298.5
1980	320	360	128.2	24	2035.9
1981	444	600	255.3	25	695.8
1982	156	600	126.7	27	359.1
1983	288	600	305.2	23	838.4
1984	144	600	95.4	19	434.4
1985	64	600	347.9	15	625.4
1986	41	600	250.9	15	262.0
1987	71	600	296.8	16	442.4
1988	71	600	N/A	16	N/A
1989	Nil	600	Nil	13	Nil
1990	30	600	N/A	14	N/A

Note: Used same deflators as in Table 7.1.
: Nothing was produced in 1989 due to unsold stocks

Appendix 8.1

A list of Local and International Organisations which FoE has some relations

Local Organizations

- Ministry of Water and Labour

- Parastatal organizations such as National Construction Council (NCC), Tanzania Bureau of STandards, TANESCO, Tanzania Posts and Telecommunication Cooperation, Tanzania Distillers Ltd., Tanzania Breweries Ltd., and Tazara.

- Professional bodies such as the Institution of Engineers Tanzania (IET), the association of consulting engineers (ACET), the engineers registration Board (ERB), and the National Board of Architects, Quantity Surveyors and Building Contractors (NBA QSBC).

International Organizations

- Norwegian Institute of Technology
- University of Leeds (UK)
- Technical University of Eindhoven
- IUPHY (Belgium)
- Technical University (Denmark)
- Chalmers University (Sweden)
- Tampere University of Technology (Finland)
- Federal Institute of Technology (Swirtzerland)

and is in process of establishing relations with

- Imperial College (UK)
- Technical University of Braunschweig (Germany)

These cooperations are funded by:

- Irish government
- NORAD
- British Council/oda
- Nuffic
- Belgium government
- Danida
- Finida
- Unicef
- IDRC.

Appendix 8.2
Industrialized and Developing Countries
Expenditure on R & D (1980)
(% of GNP)

A. Industrialized Countries

Country	Expenditure	Country	Expenditure
France	2.25	Netherlands	1.97
Federal Rep. of Germany	2.54	UK	2.3
Japan	2.65	USA	2.69

B. Developing Countries

ASIA	Expenditure	Latin America & Carribean	Expenditure	Africa	Expenditure
Bangladesh	0.2	Argentina	0.5	Algeria	0.3
India	0.9	Brazil	0.6	Egypt	0.2
Indonesia	0.3	Chile	0.4	Nigeria	0.3
Iran	0.5*	Cuba	0.7		
Iraq	0.1*	Mexico	0.6		
Pakistan	0.17	Peru	0.2		
Philippines	0.2	Venezuela	0.4		
Singapore	0.5				
Sri Lanka	0.2				

Source: UNESCO Statistical

* 1975 figures

REFERENCES

Abramovitz, M. (1956), "Resource and Output Trends in US since 1870" American Economic Review, 5-23, May.

Adei, S. (1987), "Technology Transfer and Nationalization in Ghana; African Studies in Technology Policy;" International Development Research Centre, 55e, Ottawa.

Allen, R. G. D. (1973), ed. Macroeconomic Theory, The Macmillan Press Ltd. , London.

Alänge, S. (1987), "Acquisition of capabilities through International Technology Transfer: The case of Small Scale Industrialization in Tanzania.", Department of Industrial Management, Chalmers University of Technology, Göteborg.

Amsden, A. and Kim, L. (1982), "Korea's Technology Exports and Acquisition of Technological Capability", Washington DC; World Bank, Development Research Department (mimeo).

Arrow, K. (1962), "The Economic Implication of Learning by Doing", Review of Economic Studies XXIX, pp. 154-174, June.

Arrow, K.J., Chenery, B.H., Minhas, B.S. and Solow, R.M. (1961) "Capital Labour Substitution and Economic Efficiency", Review of Economics and Statistics, pp. 225-250.

Atkinson, A.B. and Stiglitz, J.E., (1969), "A New View of Technological Change" Economic Journal, 79, pp. 533-579.

Bagachwa, M.S.D., (1992), "Choice of Technology in Small and Large Firms : Grain Milling in Tanzania," World Development, Vol.20, No.1, January.

Balassa, B., (1982), ed. Development Strategies in Semi-Industrial Countries, The Johns Hopkins Press, Baltimore.

Baltagi, B.H., and Griffin, J.M. (1988), "A General Index of Technical Change" Journal of political Economy, vol.96 no.1, February.

Barker, C.E.; Bhagavan, M.R.; Mitschke-Collande, P.V.; and Wield, D.V. (1986), ed. African Industrialization, Gower Publishing Company Ltd., England.

Bell, R.M. (1982), "Technical Change in infant Industries: A Review of Empirical Evidence", Washington DC, : World Bank, Development Research Department, July.

Bell, R.M.; Scott-Kemis, D. and Satyarakwit, W. (1982), "Limited Learning in Infant Industry: A Case Study", in Stewart,F. and James, J., ed., The Economics of New Technology in Developing Countries., Pinter, pp. 138-156, London.

Bell, M., Ross-Larson, B. and Westphal, L.E. (1984), "Assessing the Performance of Infant Industries.", Journal of Development Economics, Vol.16, No1/2, pp.101-128, September-October.

Binswanger, H.P. (1974), "The Measurement of Technical Biases with many Factors of Production", American Economic Review, 64 (6), pp. 964-976, December.

Blaug, M. (1963) "A Survey of the Theory of Process-Innovations", Economica, pp. 13-33, February.

Blomström, M. and Meller,P. (1991) "Diverging Paths: Comparing a Century of Scandinavian and Latin American Economic Development", Inter-American Development Bank, Washington DC.

Brown, M. (1966), ed. On the Theory and Measurement of Technology Change, Cambridge.

Brown, M. (1967), ed., The Theory and Empirical Analysis of Production; National Bureau of Economic Research, New-York, Colombia University Press.

Bukuku, E. (1988), Income Distribution and Economic Growth in Tanzania, Ph.D. Dissertation, University of Dar-es-Salaam.

Chenery, H.B. (1949), "Engineering Production Functions", Quarterly Journal of Economics.

Chenery, H.B. (1960), "Patterns of Industrial Growth", American Economic Review, pp. 624-654, September.

Cooper, C. and Sercovich, F. (1971), "The Channels and Mechanisms for Transfer of Technology from Developed to Developing Countries", Report No. TD/B/A C.M./5, UNCTAD, Geneva.

Dahlman, C.J. (1982), "Foreign Technology and Indigenous Technological Capability", Paper presented at the University of Edinburg Workshop on Facilitating Indigenous Technological Capability, Edinburg.

Dahlman, C.J. and Fonseca, F.V. (1978), From Technological Dependence to Technological Development, The Case of the Usiminas Steel Plant in Brazil, Research Program Working Paper No. 21 (Economic Commission for Latin America, Buenos Aires).

Dahlman, C.J.; Ross-Larson,B. and Westphal, L.E. (1987), " Managing Technological Development: Lessons from the Newly Industrializing Countries", World Development, Vol. 15, NO.6 pp. 759-775.

Dahlman, C.J. and Sercovich, F. (1984), "Exports of Technology from Semi-Industrialized Economies and Local Technological Development", Journal of Development Economics, Vol.16, No.1/2, pp. 63-99, September-October.

Dahlman, C.J. and Westphal, L.E. (1984), "Technological Efforts in Industrial Development: An Interpretating Survey of Recent Research", in James and Stewart (1982) ed. The Economics of New Technology in Developing Countries, Frances Printer Publishers and Westview Press, London and Colorado.

Dahlman, C.J. and westphal, L.E. (1983), "The Transfer of Technology: Issues in the Acquisition of Technological Capability by Developing Countries", Finance and Development, Vol.20, No.4, December.

Diewert, E.W. (1976), "Exact and Superlative Index Numbers" Journal of Econometrics, 4, pp. 115-145, May.

Diewert, E.W. (1981), "The Theory of Total Factor Productivity Measurement" in Regulated Industries, edited by Thomas G. Cowing and Rodney E. Stevenson, New York: Academic Press.

Dosi, G. (1982), "Technological Pardigms and Technological Trajectories", Research Policy, No. 11, pp. 147-162.

Enos, J. (1962), "Invention and Innovation in the petroleum Refining industry", in: National Bureau of Economic Research. The Rate and Direction of Inventive activity : Economic and Social Factors., Princeton University Press, Princeton, N.J.

Farrell, T.M.A. (1979), A Tale of Two Issues: Nationalization, the Transfer of Technology and the petroleum multinationals in Trinidad-Tobago. Social and Economic Studies, 28 (1).

Fransman, M. (1982), "Learning and the Capital Goods Sector Under Free Trade: The Case of Hong Kong", World Development, 10,11.

Fransman, M. (1983), "Promoting Technological Capability in the Capital Goods Sector: The Case of Singapore", Research Policy, Vol. 13, pp. 33-54.

Fransman, M. (1985), "Conceptualising Technical Change in the Third World in the 1980s : An Interpretative Survey", The Journal of Development Studies, Vol. 21, No.4, pp. 572-652, July.

Fransman, M. and King, K. (1984), eds., Technological Capability in the Third World, Macmillan, London.

Freeman, C. (1982), 2nd.ed., The Economics of Industrial Innovation, pp. 211-214, Francis Pinter, London.

Freeman, C.; Clark, J. and Soete, L. (1982), ed., Unemployment and Technological Innovation : A study of Long Waves and Economic Development, Francis Pinter, London.

Furubotn, E.G. (1965), "Engineering Data and the Production Function", American Economic Review.

Forsund, F.R. and Hjalmarsson, L. (1987), ed., Analyses of Industrial Structure : A Putty-Clay Approach, The Industrial Institute for Economic and Social Research, Stockholm.

Gilfillan, S.C. (1953), "The Prediction of Technical Change", Review of Economics and Statistics, pp. 368-385, November.

Girvan, N. (1981), Notes on Technological Capacity. Carribean Technology Policy Studies, Phase II, Port of Spain, Trinidad.

Gold, B. (1977), "Research, Technology Change and Economic Analysis: A Critical Evaluation of Prevailing Approaches", Quarterly Review of Economics and Bussiness, pp. 7-29, Spring.

Goldsmith, M. (1970), ed., Technological Innovation and the Economy, Wiley Interscience, London.

Harrod, R.F. (1939), "An Essay in Dynamic Theory", Economic Journal, 49.

Hicks, J.R. (1963), 2nd.ed. The Theory of Wages, Macmillan, London.

Hicks, J.R. (1981), "The Mainspring of Economic Growth", American Economic Review, Vol.71, No.6, pp. 23-29.

Hirschman, A.D. (1958), The Strategy of Economic Development, Yale University Press, New Haven, ct, USA.

Hjälmarsson, L. (1973), "Optimal Structural Change and Related Concepts", The Swedish Journal of Economics, Vol.75, No.2, pp.176-192, June.

Hollander, S. (1965), The Sources of increased Efficiency: A Study of Du Pont Rayon Plants, Mit Press, Cambridge MA.

Intrilligator, M.D. (1965), "Embodied Technical Change and Productivity in the USA, 1929-1958", Review of Economics and Statistics, pp. 65-70.

Intrilligator, M.D. (1982), new ed., Econometric Models, Techniques and Applications, Prentice Hall, Inc.

Kaldor, N. (1957), "A Model of Economic Growth", Economic Journal, 67.

Kaldor, N. and Mirlees, J. (1962), "A New Model of Economic Growth", Review of Economic Studies, 29, pp. 174-192.

Kaplinsky, R. (1984), "Indigenous Technical Change: What We Can Learn from Sugar Processing", World Development, Vol. 12, No. 215, pp.419-432.

Katz, J. et. al (1978), "Productivity, Technology and Domestic Efforts in Research and Development (the growth path of a rayon plant), Research Programme Working Paper, No.14, Economic Commission for Latin America, Buenos Aires (mimeo).

Katz, J. and Ablin, E. (1979), "From Infant Industry to Technology Export : The Argentine Experience in the International Sale of Industrial plants and Engineering works, IDB/ECLA, Buenos Aires, (mimeo).

Katz, J. (1984), "Domestic Technological Innovations and Dynamic Comparative Advantage : Further Reflections on a comparative Case Study programme.", Journal of Development Economics, 16, pp. 13-37.

Keller, R. (1991) Technological Capability and Development: A Study of India and Korea. Memorandum No. 156, Göteborgs Universtitet.

Kendrick, J. (1961), Productivity Trends in the United States, Pinceton University Press, Pinceton, N.J.

Kendrick, J. (1973), "Post war Productivity Trends in the USA, 1948-1969, Pinceton University Press for the NBER.

Kenney, M. (1986), "Schumpeterian Innovation and Entrepreneurs in Capitalism: A Case Study of the US Biotechnology Industry", Research Policy, Vol. 15, No. 1, February.

Koutsyiannis, A. (1977), Theory of Econometrics, 2nd.ed., London: Macmillan Press.

Kuuya, P.M. (1977), "Transfer of Technology: An Overview of the Tanzanian Case", Economic Research Bureau, No. 77.3, March, Dar-es-Salaam.

Kuznets,S. (1954), Economic Change, Heinemann, London.

Lall, S. (1979), Third World Technology Transfer and Third World Transnational Companies, in UNIDO (1979) : International Flows of Technology, Industry 2000, UNIDO/1OD.326.

Lall, S. (1982), Technological Learning in the Third World : Some Implications of Technology Exports, in Stewart, F. and James, J., The Economics of New Technology in Developing Countries. Frances Pinter, London.

Lall, S. (1982a),"Developing Countries as Exporters of Technology, A First Look at the Indian Experience", London: Macmillan. (Also Published in Research Policy (1980) Vol. 9, pp. 24-52.

Lall, S. (1982b), "The Emergence of Third World Multinationals: Indian Joint Ventures Overseas", World Development, Vol. 10, No.2, pp. 127-146.

Lall, S. (1984a), "Exports of Technology by Newly Industrializing Countries: An Overview", ms.; published with revisions in World Development, Vol. 12, No.5/6, pp. 471-480.

Lall, S. (1984b), "India's Technological Capacity: Effects of Trade, Industrial Science and Technology Policies", in Fransman and King (1984).

Lall, S. (1992), "Technological Capabilities and Industrialization", World Development, vol.20, No.2, February.

Lall, S. and Mohammed, S. (1983), "Technological Effort and Disembodied Technology Exports: An Econometric Analysis of Inter-Industry Variations in India", World Development, Vol.11, No.6, pp. 527-535.

Leonard, W.N. (1971), "Research and Development in Industrial Growth", Journal of Political Economy, 79 (2), pp.232-256, March-April.

Levihari, D. (forthcoming), "Extensions of Arrow's Learning by Doing", Review of Economic Studies.

Levin, R.; Klevonick, A.K.; Nelson, R.R. and Winter, S.G. (1984), Survey Research on R & D Appropriability and Technological Opportunity, Part 1, Yale University, New Haven, CT. July.

Little, A. (1961) :Tanganyika Industrial Development, Inc. Dar-es-Salaam.

Little, I.M.D. (1979), "The Experience and Causes of Rapid Labour-Intensive Development in Korea, Taiwan, Hong Kong and Singapore and the possibility of Emulation", Bangkok: ILO- ARTEP.

Lydall, H.F. (1968), "Technical Progress in Australian Manufacturing", Economic Journal, pp. 821-822, December.

Mansfield, E. (1961), "Technical Change and the Rate of Immitation", Econometrica, pp. 741-766, October.

Mansfield, E. (1968), The Economics of Technological Change, W.W. Norton and Company, Inc., New York.

Mansfield, E. (1969), Industrial Research and Technological Innovation : An Econometric Analysis, Longmans, Green and Company Limited, London.

Mansfield, E. (1970), Micro Economics : Theory and Applications, W.W. Norton and Company, Inc. New York.

Mansfield, E. (1980), "Basic Research and Productivity Increase in Manufacturing", American Economic Review, pp. 863-873, December.

Maxwell, P. (1977), "Learning and Technical Change in the Steel Plant of Acinder S. A. in Rosario, Argentina", Buenos Aires: IDB/ECLA, Research Programme in Science and Technology.

Maxwell, P. (1982), "Steel Plant, Technological Development in Latin America : A Comparative Study of the Selection and Upgrading of Technology in Plants in Argentina, Brazil, Columbia, Mexico and Peru", Buenos Aires : IBD/ECLA Research Programme on Scientific and Technological Development in Latin America, Working Paper 55.

Mbelle, A. (1988), Foreign Exchange and Industrial Development: A Study of Tanzania. Published Ph.D. Thesis, Gothenburg School of Economics and Commercial Law, University of Gothenburg.

Mclean, L.W. and Round, D.K. (1978), "Research and Product Innovation in Australian Manufacturing Industries", Journal of Economics, Vol.XXVII, No.1, September.

Merrett, S. (1971), "Snares in the Labour Productivity Measure of Efficiency: Some Examples from Indian Nitrogen Fertilizers Manufacture", The Journal of Industrial Economics, Vol. XX, Nov.1, pp. 71-84.

Mlawa, H.M. (1983), "The Acquisition of Technology, Technological Capability and Technical Change: A Study of the Textile Industry in Tanzania, Unpublished Ph.D. Dissertation, University of Sussex, Brighton.

Nelson, R.R. (1981), "Research on Productivity Growth and Productivity Differences: Dead Ends and New Departures", Journal of Economic Literature, Vol.XIX, pp. 1029-1064.

Nelson, R.R. and Winter, S.G. (1974), "Neo-Classical vs Evolutionary Theories of Economic Growth", Economic Journal, 89, pp.886-905.

Nelson, R.R. and Winter, S.G. (1977b), "Simulation of Schumpeterian Competition", American Economic Review, Vol.67, pp.271-276.

Nelson, R.R. and Winter, S.G. (1977c), "In Search of Useful Theory of Innovation", Research Policy, 6, pp.36-76. Nelson, R.R. and Winter, S.G. (1982), An Evolutionary Theory of Economic Change, Belknap-Havard University Press, Cambridge, MA.

Ndulu, B.J. (1986), "Investment, Output Growth and Capacity Utilization in African Economy: The Case of Manufacturing Sector in Tanzania", Eastern Africa Economic Review, Vol. 2, No. 1, pp. 14-30, June.

Pack, W. and Westphal, L.E. (1986), "Industrial Strategy and Technological Change: Theory versus Reality", Journal of Development Economics, Vol. 22, No. 1, June.

Pavitt, K. (1982), " R and D Patenting and Innovative Activities: A Statistical Exploration", Research Policy, 11, pp.33-51.

Pavitt, K. (1984), "Sectoral Patterns of Technological Change: Towards a Taxonomy and a Theory", Research Policy, 13, pp.343-374.

Perkins, F.C. (1983), "Technological Choice, Industrialization and Development Experience in Tanzania", Journal of Development Economics, 19 (2), p 213-243, January.

Rosenberg, N. (1976), Perspective on Technology, Cambridge University Press, Cambridge.

Rosenberg, N. (1982), Inside the Black Box: Technology and Economics, Cambridge University Press, Cambridge.

Rweyemamu, J. (1973), Underdevelopment and Industrialization in Tanzania: A Study of Perverse Capitalist Industrial Development, Oxford University Press, Nairobi.

Sahal, D. (1981), "Alternative Conceptions of Technology", Research Policy, 10, pp.2-24.

Sahal, D. (1985), "Technological Guide Posts and Innovations Avenues", Research Policy, Vol.14, pp. 61-82, February.

Salter, W. (1966), Productivity and Technical Change, 2nd.ed., Cambridge University Press.

Sato, R. (1970), "The Estimation of Biased Technical Progress and the Production Function", International Economic Review, XI, pp. 179-207.

Schmookler, J. (1966), Invention and Economic Growth, Havard University Press, Cambridge MA.

Schumpeter, J.A. (1934), The Theory of Economic Development, Havard Economic Studies, Vol.XLVI, Havard University Press, Cambridge MA.

Shaaeldin, E. (1989), "Sources of Industrial Growth in Kenya, Zambia and Zimbabwe: Some Estimates, African Development Review.

Shaw, J.A. and Leet, D.R. (1973), "Research and Development and Productivity Change in the USA 1948- 1968", Journal of Industrial Economics, No.2, pp.153- 215, December.

Skarstein, R. and Wangwe, S.M. (1986), Industrial Development in Tanzania: Critical Issues. SIAS and TPH.

Smith, A. (1776), An Inquiry into the Nature and Causes of the Wealth of Nations, Oxford.

Solow, R.M. (1957), "Technical Change and the Aggregate Production Function", Review of Economics and Statistics, Vol.39, pp.312-320, August.

Solow, R.M. (1959), "Investment and Technical Progress", in Mathematical Methods in Social Sciences, ed. by Arrow, J.K.; Karlin, S. and Suppes, P. (1960), Stanford University Press, Stanford, California.

Stewart, F. (1978), 2nd.ed., Technology and Underdevelopment, The Macmillan Press Limited, London.

Stewart, F. and James, J. (1982), eds., The Economics of New Technology in Developing Countries, Pinter, London.

Stewart, F.; Lall, S. and Wangwe, S.M. (1992), Alternative Development Strategies in Sub-Saharan Africa, The Macmillan Press Ltd., Hong Kong.

Sutcliffe, R.B. (1971), Industry and Underdevelopment, Addison Wesly, London.

Tanzania, United Republic of : (1967), "The Arusha Declaration and TANU Policy on Socialism and Self-Reliance", TANU, Dar-es-Salaam.

Tanzania, United Republic of: (Various Issues), Bank of Tanzania: Economic and Operation Reports, Dar-es-Salaam.

Tanzania, United Republic of : (1982), Bank of Tanzania : Twenty Years of Independence 1961-1981, A Review of Political and Economic Performance, Dar-es-Salaam.

Tanzania, United Republic of : (1978), Census for Industrial Production, Dar-es-Salaam.

Tanzania, United Republic of : (1986, 1989), Economic Recovery Programmes, Government Printer, Dar-es-Salaam.

Tanzania, United Republic of : (Various Issues), Economic Survey, Government Printer, Dar-es-Salaam.

Tanzania, United Republic of: (1989), Metal Engineering Industries Development Association (MEIDA), Dar-es-Salaam.

Tanzania, United Republic of : (Various Issues), National Accounts, Government Printer, Dar-es-Salaam.

Tanzania, United Republic of : National Development Corporation (NDC): Annual and Accounting Reports, Dar-es-Salaam.

Tanzania, United Republic of : (1982, 1982), National Economic Survival Programme, Government Printer, Dar-e Salaam.

Tanzania, United Republic of : (1987), Selected Statistical Series 1951-1985, Bureau of Statistics, Dar-es-Salaam.

Tanzania, United Republic of : (1982), Structural Adjustment Programme, Government Printer, Dar-es-Salaam.

Tanzania, United Republic of : (Various Issues), Survey of Employment and Earnings, Government Printer, Dar-es-Salaam.

Tanzania, United Republic of : (Various Issues), Survey of Industrial Production, Government Printer, Dar- es-Salaam.

Tanzania, United Republic of : (1989), Tanzania Industrial Research and Development Organization (TIRDO): 10 Years (1979-1989), Dar-es-Salaam.

Tanzania, United Republic of : (1990), Tanzania Industrial Studies and Consulting Organization (TISCO): Annual Reports and Accounts, Dar-es-Salaam.

Tayler, S. (1981), The Brazilian Industrial Economy, Laxington, MA: Laxington Books.

Teitel, S. (1981), "Towards an Understanding of Technical Change in Semi-Industrial Countries", Research Policy, Vol. 10, No.2.

Teitel, S. (1984), "Technological Creation in Semi-Industrial Economies", Journal of Developing Economics, Vol. 6, No.1/2, pp.39-61, September-October.

Teitel, S. (1987), "Science and Technology Indicators, Country Size and Economic Development: An International Comparison", World Development, Vol.15, No.9, pp.1225-1235.

Teitel, S. and Sercovich, F.C. (1984), Latin America, in special issue: Exports of Technology by Newly Industrializing Countries, World Development, 12.

Teubal, M. (1984), "The Role of Technological Learning in the Exports of Manufactured Goods: The Case of Selected Capital Goods in Brazil", World Development, Vol.12, No.8, pp.849-865.

United Nations Industrial Development Organization (1982), "Technological Self-Reliance of Developing Countries: Towards Operational Strategies", Development and Transfer of Technolgy Series, No.15, ID/262, Vienna, November.

UN, Yearbook of International Trade Statistics, (1977, 1982 and 1985 Issues).

Usher, A. (1954), 2nd.ed. A History of Mechanical Inventions, Havard University Press, Boston MA.

Venkataswami, T.S. (1974), "Production Functions and Technical Change in Indian Manufacturing Industries", Indian Journal of Economics, Vol. 55.

Wangwe, S.M. (1976), "Excess Capacity in Manufacturing Study of Selected Firms", *Economic Research Bureau* No.76.2, University of Dar-es-Salaam.

Wangwe, S.M. (1979), "Capacity Utilization and Capacity Creation in Manufacturing in Tanzania with Special Reference to the Engineering Sector", Unpublished Ph.D Thesis, University of Dar-es-Salaam.

Wangwe, S.M. (1983), "Industrialization and Resource Allocation in a Developing Country : The Case of Recent Experience in Tanzania", *World Development*, 11 (66).

Wangwe, S.M. and Luvanga, N.E. (1990), "Technological Transformation in the Third World : The Case of Tanzania, *Tanzania Journal of Economics*, Vol.2, No.1, January.

Westphal, L.E. (1982), "Fostering Technological Mastery by Means of Selective Infant Industry Protection, in: Syrquin, M. and Teitel, S., eds., Trade, Stability, Technology and Equity in Latin America, Academic Press, Chapter 12, pp. 255-279, New York.

Westphal, L.E. (1984), The Origins of Technological Capability in South Korea, in Fransman and King (1984).

Westphal, L.E. and Rhee, Y.W. (1982), " Korea's Revealed Comparative Advantage in Exports of Technology : An Initial Assessment", Washington, DC: World Bank (mimeo).

Westphal, L.E.; Rhee, Y.W. and Pursell, G. (1984), "Sources of Technological Capability in South Korea" in Fransman and King (1984).

World Bank (1961), Economic Development of Tanganyika, Baltimore, John Hopkins Press.

Zuscovitch, E. (1986), "The Economic Dynamics of Technologies Development", *Research Policy*, 15, pp.175-186.