TECHNICAL PROGRESS IN THE ETHIOPIAN MANUFACTURING SECTOR: EXTENT AND IMPLICATION FOR INDUSTRIALIZATION

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Technical Progress in the Ethiopian Manufacturing Sector: Extent and Implication for Industrialization

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ABSTRACT

Cognizant of the importance of technical progress in the process of industrialization, examining its nature and extent in the Ethiopian manufacturing sector is essential. To this end, different statistical and econometric models are employed. Four main findings emerged in the effort.

Firstly, the Ethiopian manufacturing sector as a whole registered a negative technical progress. Secondly, the production technique, in general, was capital-consuming and labour-saving, contrary to the theory of initial factor endowments. Thirdly, there was real sub-sectoral differences; those sectors which are light and with long production experience recorded a positive technical progress while others did not. Finally, the private sector, in general, appeared to be more effective in resource use than the public ones.

These results have implications for industrialization in Ethiopia. Firms should build the necessary technological and managerial capabilities to adapt, assimilate and modify to local conditions. In parallel, the government should create the conducive environment by installing the appropriate capabilities, incentives and institutions, paying due attention to their complementarity.

1. INTRODUCTION

1.1. BACKGROUND

Industrial growth could be achieved through either extensive use of resources (growth based on more accumulation of physical and human capital) or intensive use of resources (through improving productivity and efficiency of resource use) or both. A tendency of improvement in resource use reveals some form of technical progress.

In Ethiopia, resources available for industrial growth are scarce and the prevailing conditions (saving rate, purchasing power, debt service ratio, investment confidence) do not suggest that accumulation of resources will take place at a massive scale. At the same time, the extent to which accumulated resources are efficiently utilized depends on the extent of technical progress. As a result, if there should be industrial growth, it will be more effective through intensive use of resources (through increasing productivity) together with capital accumulation. However, efficiency in resource use would be attained only if efforts are put to attain some sort of technical progress which includes acquisition of technological capability and technical change (which come through accumulation of experience and learning by doing).

If a good level of technical progress is recorded in any economy, it implies then that there is development in acquisition of technological capability; and, in turn, if development of technological capability is observed, then there is an element of industrial development in that economy.

In this regard, technical progress is a decisive factor to industrial growth (Solow, 1957; Massell, 1960) as witnessed by the American economy. Solow (1957; 316) had come up with the conclusion that about one-eighth of the total increase (in output per man hour) is traceable to increased capital per man hour, and the remaining seven-eighth to the technical change. Massell (1960: 186) says that roughly 90 percent of the increase in output per man-hour was attributable to technical advance. Other estimates by Brown, Intriligator, Kendrick and Kennedy for the US economy and Aukrust for Norway (see Intriligator, 1978) show how technical progress significantly contributes to improvements in resource utilization.

On the Ethiopian economy, such empirical works are scant. Most works in this sector are descriptive. Recently, however, an attempt was made to measure the efficiency of the Ethiopian public manufacturing industries by The World Bank (1985, 1989). The methodology used by the World Bank is domestic resource cost (DRC). Based on a sample of 19 industrial public enterprises in 1983, the World Bank (1995: iv) concluded that the available evidence on the sector's efficiency suggests that i) there might have been a slight improvement in the efficiency of the sector between 1972 and 1983, partly as a result of increased capacity utilization; and (ii) the overall level of efficiency continues to be low.

A later survey made by the World Bank in 1989 on a sample of 36 firms had arrived at a DRC of 0.82 which, according to Eshetu, was more sanguine about the economic efficiency of Ethiopian public manufacturing enterprises (Eshetu, 1992:2).

Alemu (1992) measured efficiency by using financial rate of return and DRC (the DRC is based on the work of the World Bank in 1983 and 1989). He then concluded that firstly, public manufacturing industries are in general profitable, secondly, more than half are allocatively efficient.

These results might give some insight as to how important was learning in the manufacturing sector. But measuring the extent of allocative efficiency will not be a substitute for that of technical progress, as the latter focuses more on the extent of learning and technological capability acquisition in order to catch up with the world frontier.

An attempt to estimate technical progress was made by Admit (1994) on the Ethiopian private industries for the period 1976-1989. The study found out that the rate of technical progress was significant - around 5 percent per annum. But the study did not incorporate the public sector, the nature of technical progress, sectoral/ownership differences and alternative econometric techniques. This research paper attempts to build on this previous work.

1.2. OBJECTIVE OF THE PAPER

The objectives of this research paper are the following:

1. As Pack and Westphal (1986: 106) said, industrial development is a process of acquiring technological capability in the course of continual technological change. Differences in the degree of industrialization among countries is ascribed to differences in the 'independent technology learning and creating capacity' which has an impact on technical progress, which, in turn, has an impact on total factor (or input) productivity. In this regard, technical progress and industrialization are closely linked. An assessment of the theoretical link between technical progress and industrial development and substantiating it with country evidence for these linkage is, then, one of the objectives of the paper.

2. From the work of Solow, Massell and others, technical progress is believed to play a significant role for output growth in industrialized countries. Herbert-Copley (1990: 1458) stated that significant technical progress can and does occur in developing manufacturing enterprises, as well. It is the purpose of this paper to assess the extent of technical progress in the manufacturing sector of Ethiopia.

3. Technical progress could be labour-saving, capital-saving, resource-saving or neutral. Identifying the nature of technical progress in the Ethiopian manufacturing industries is another objective of the paper.

4. The extent and intensity of building up technological capability and adaptation power is supposed to vary across firms as factors affecting these processes are not identical across firms or between ownership. The argument for privatization is based on the assumption that the private sector is more responsive in this regard than public enterprises. Testing whether there is sectoral/ownership differences in rate of technical progress and identifying the causes is the other objective of the study.

5. Lastly, the study will try to highlight the implications of technical progress on the extent of protection and selective intervention.

2. INDUSTRIALIZATION AND TECHNICAL PROGRESS: THEORETICAL RELATIONS AND EMPIRICAL EVIDENCE

2.1. INDUSTRIALIZATION AS A LEARNT PROCESS

Industrialization is largely an evolutionary process which is identified with structural transformations that signify the transition from a primitive, low productivity, low income economy to one that is dynamic, sustained and diversified (Chenery et al, 1986)[1]. These structural shifts of an economy are a cumulative results of each piece-meal effort of using ideas which transcend to producing ideas. In this regard, Dore (1984:67) argued,

> independent technology learning capacity (ITLC) is overwhelmingly more important than independent technology creating capacity (ITCC). Japan ... put nearly all its effort... into ITLC. ITCC was reserved for marginal adaptation. But now they have got to the frontiers, and ITCC has become central.

The implication of this is that it is through the cumulative learning process that the capability of creating technology and producing ideas becomes possible.

Industrialization as a learnt process can be visualized both historically and technologically. Historically, as late as 1750's, only one country was on the way to a successful industrial revolution - England. Since then, however, industrial revolution has spread across the world first in Northern and Western Europe and Northern America, subsequently in Japan, Southern and Eastern Europe, and parts of Latin America and Occania (Easterlin, 1981). UNIDO (1987:3) also stated that

> The Industrial Revolution did not long remain the monopoly of a single country not even a single region... Countries of the south have now entered such phase of adjustment. From palm-oil to steel, from footwear to software, developing countries have proved in the last decade and a half that they are capable not just of producing an increasing range of industrial products, but of producing them at internationally competitive prices...

If countries in the South entered into the phase of industrial revolution at an increasing number with different paces and patterns, then industrialization is a learnt process in which the latecomer accumulates knowledge on the successes and failures of the predecessors.

Industrialization as a learnt process can rather be reflected from its strong relationship with technological capability. Evidences have been growing that the process of acquiring technological capability is the process of industrial development and the costs of achieving international competitiveness are the costs of acquiring technological capability (Pack and Westphal; 1986). The capacity to operate, assimilate, adapt and modify processes determines industrial development. Similarly Stewart (1984: 833) argued that any successful industrial expansion is associated with some local technological activity since adaptation to local conditions is part of the process of successful industrial activity.

If technological capability acquisition is an evolutionary process of learning and if industrialization is the process of acquiring technological capability, then it directly implies that industrialization is a learnt process.

2.2. TECHNICAL PROGRESS: CONCEPT.

There does not seem to be a consensus among scholars on the concept of technical progress. That is why Kennedy and Thirlwall (1972: 12) said that "over the years the term technical progress has been given a range of meanings and interpretations".

However, there is a convergence of thought in one respect. At least, all understand that it is an addition/advance in technological knowledge which has a bearing on production. Technical progress includes all forces which raise the combined productivity of all factors of production; it is a shift in the production possibility frontier over time that enables to produce greater output with the same volume of inputs; and/or it is a move towards the best practiced production possibility frontier through learning. Using Roemer's terminology, technical progress encompasses the ability of `using ideas and producing ideas'.

Technical Progress has two potential sources: technical change and technological progress. Technical change refers to a change and/or an alteration of the choice of techniques out of the existing art.

It is the acquisition of knowledge through experience in production (the process of learning-by-doing). Jackson (1982: 339) describes this as follows:

> ... as the work force becomes accustomed to, and experienced in, the production process, the workers steadily learn how to do tasks more efficiently and quickly. At the beginning, nothing is routine, everything is unfamiliar, and it takes time to learn how to cope with snags. After time, everything is routine and familiar, and the quickest and best way of dealing with snags and awkward parts is well-known.

Technological progress implies an expansion in the shelf of international technology; an addition to the stock of technological knowledge. Technological advance can be summarized by the following matrix.

	Method of Production		
products/services	Existing Method	Improved Method	New Method
Existing Products/Services	1	4	7
Improved Products/Services	2	5	8
New Products/Services	3	6	9

Source: Jackson: 1982:316.

Position 1 in the matrix is the present state of production technology; and any shift/movement from 1 to any one of the eight positions purport technological change.

Here, it shall be noted that introduction of unused but known technique or its diffusion is not a technological change. In practice, however, " it is extremely difficult to distinguish improvements in efficiency due to movements towards known production boundaries from the expansion of the boundaries themselves due to increases in knowledge" (Kennedy & Thirlwall, 1972: 12).

But communication gap or level of capability would keep a good part of the world technology shelf in the dark. Then, the diffusion of hitherto unused but known (or existing) techniques somewhere could be considered as technical progress in countries like Ethiopia.

Technical progress is also different from increasing returns to scale as the former does not necessarily require addition of scale.

2.3. INDUSTRIAL STRATEGIES AND TECHNOLOGICAL CAPABILITIES: RELATIONSHIPS

Many countries of the South have entered into a phase of industrialization through the initiation and implementation of deliberate industrial strategies - a set of policy interventions aimed specifically at guiding and promoting industrial development.

The types of intervention, however, were diverse and changing to different styles: import substitution industrialization (ISI) strategy, export promotion industrialization (EPI) strategy and trade liberalization[2].

ISI strategy is adhered to on the belief that the strategy makes considerable economic sense in terms of efforts to create an economy that is sufficiently flexible, diversified and responsive to opportunities for growth (Helleiner, 1986; World Bank, 1992; Stewart, 1984).

The premise for ISI strategy stems from the prevalence of market failure. Markets often fail; they do not function properly; either they are imperfect, missing, fragmented, or malfunctioning. The market results, due to externalities, are incorrect; price signals may not reflect the true value or could totally be irrelevant. The market might yield undesirable results; it does not necessarily ensure optimum rates of savings and investment; the pattern of resource allocation might not be the most appropriate one; it might not produce as high a rate of growth as is desirable.

Some of the pertinent arguments in favour of ISI strategy are infant industry argument, foreign exchange argument, linkage and externalities argument, saving argument, and self-sufficiency argument[3] (Schmtiz, 1984; Sutcliffe, 1971; Krugman, 1993).

Export promotion, on the other hand, is pursued on the assumption that

- ♣ Export allows the home country to concentrate investment in sectors where it enjoys a competitive advantage. The resulting specialization augments overall productivity.

- ♣ The larger international market permits economies of scale to be realized in the export sector.

- ♣ World wide competitive pressures are likely to reduce inefficiencies in the export area and result in the adoption of more efficient techniques in the overall traded goods sector.

- ♣ A large export sector would make available more of the resources necessary to import both physical and human capital, including advanced technologies used in production and management, and for training higher quality labour.

The theoretical base for EPI strategy is that market rations supplies of consumer goods among consumers; allocates the different factors of production among various uses; distributes income among individuals. Thus, it solves all the economic problems of allocation of scarce resources among alternative ends. Even if there are some market imperfections, these might not require corrective actions as they are features of market economies which do not detract from their efficient functioning. The task of the government is just to create an enabling environment.

In fact, the wave has been towards free trade regime since the early 1970's. UNIDO (1979: 7) identifies that "in the past 10 years more developing countries have shifted the emphasis of their trade policies away from import substitution towards export promotion". The move was mainly due to the disenchantment with the results of ISI strategy[4]. But it was a gross move and un unsubstantiated one (Pack & Westphal; 1986).

Not only do many countries use protectionist policy but also most outward oriented countries passed through import-substitution phases with high and variable protection of domestic import substitutes (Fransman, 1981; World Bank, 1994). This implies that it is import substitution that put some initial threshold for them to be internationally competitive. That is why it is said that "import substitution has been the natural first stage of industrialization" (Helliener, 1986:887). Liberalization will move an economy nowhere unless there are expanding sectors which absorb the displaced resources in the declining sectors. The existence of these sectors depend, to a large extent, on the intensity of building domestic production capability and on the degree of import substitution strategy practiced.

A firm which starts out, with a few resources, in a fragile economic environment has no chance of success unless it has some protection, at least during the early years (Noir, 1994:57). Without protection, there would be no chance for a developing country to move from footwear production to that of soft-ware production.

The goal of protection is to create an economy with a capacity to move in various directions depending on opportunities. When such capacity exists, the economy can specialize because with such capacity it can move from a declining sector into one that is recognized to be expanding (Helleiner, 1986:888). Liberal trade regime might have an export impact in developing countries but only on agricultural commodities. This export sector, however, may not produce a technological spill-over of a magnitude that can be reckoned. It is the manufacturing export that might have these spill-over technological effects. Manufacturing export cannot be achieved the day the plant is installed in a developing country. It requires sometime to learn and gain experience; and, it requires efforts to develop the necessary technological capabilities. This could happen only if it is protected.

Thus, acquisition of technological capability is associated with biased trade regime. Unlike the neoclassical framework, technology is implicit; the seller always possesses more information about its use than could be embodied in the blue prints and training sold to the buyer. Lall (1995: 32) argued that

> technological knowledge is not shared equally among firms, nor is easily imitated by or transferred across firms. Transfer necessarily requires learning because technologies are tacit, and their underlying principles are not always clearly understood. Thus, simply to gain mastery of a new technology requires skills, effort and investment by the receiving firm, and the extent of mastery achieved ... necessarily varies...

The development of these inputs depends largely on the extent of experience the firm has undertaken which in turn depends on the extent of infant-industry protection. ISI strategy therefore plays a vital role to the acquisition of technological capability of a developing economy.

In general, acquisition of technological capability implies building up the capacity to search for and select technologies for use in particular environments; operate, assimilate, adapt and modify processes and products in the light of prevailing conditions and producing minor or more substantial innovations that involve a degree of `newness' (See Fransman, 1981:992). It is all these traits and activities of acquiring technological capability that are referred to as technical progress. The intensity of building up technical progress influences the degree at which industrialization is taking place.

And all these require some form of biased trade policies. In this regard, ISI strategies (or inward looking trade policies) have strong link with the effort to produce technical progress.

2.4. LINKAGES: EMPIRICAL EVIDENCE

Regarding the importance of technical progress to industrialization, Ansal contends that

> In industrialized countries...the contribution of `technical progress' is of far greater significance than is the growth of resources per capita... The importance of technical change for developing countries may be even greater... Developing countries have to ensure that generation of technical change is built into their industrialization (Ansal, 1990:1513).

Empirical evidences that justify the strong link between industrialization and technical progress can be seen from two sources. The first source of evidence is the prevalence of high rate of total factor productivity growth (the measure of technical progress) in industrialized economies.

From the work of Chenery, it has been found that, on average, rate of total factor productivity growth (TFPG) in industrialized countries is much higher than that of developing countries: It was found to be 2.7% in the former and 2% in the latter (Chenery et al, 1986: 20-22). Table 1 indicates the extent to which rate of TFPG varies across countries, specifically how patternistic was the difference between developed and developing economies. The table reveals the fact that rate of TFP is higher in industrialized than developing economies.

In addition, not only the growth rate but the contribution of TFP to the aggregate economic growth is higher for industrialized economies than for developing economies. The same study reveals that:

> The developed economies are characterized by little growth of labour inputs (1.1%), moderate growth of capital (5.2%) and output (5.4%), and a relatively large contribution of TFP to aggregate growth (50%). The developing economies, in contrast, have high growth of labour inputs (3.3%), a higher total factor growth (4.3%) and a relatively small contribution of TFP to aggregate growth (30%).

These facts reflect the case that producing higher rate of technical progress leads an economy to the higher stage of industrialization.

TABLE 1
TFPG IN DIFFERENT COUNTRIES IN PERCENT

INDUSTRIALIZED COUNTRIES		DEVELOPING COUNTRIES	
Canada (1947-60) ...	3.5	Argentina (1950-60) ...	1.05
France (1950-60) ...	2.9	Chile (1950-60)	0.85
Germany (1950-60) ...	3.6	Columbia (1950-60)	0.95
Italy (1952-60)	3.8	Ecuador (1950-62)	2.18
Japan (1950-73)	4.5	Greece (1951-65)	2.39
Holland (1951-60) ...	2.3	India (1950-60)	-0.18
Norway (1953-65) ...	2.9	Peru (1950-60)	-0.70
Sweden (1949-59) ...	2.5	Mexico (1950-60)	1.60

Source: Chenery et al. Industrialization and growth: A comparative study, 1986: 20-22

The second evidence for the linkage is the rise of rate of TFPG, on average, in developing economies as time passes which put their industrialization at a higher level. Cases in point are Chile, Columbia, Korea, Mexico and Peru, as observed in Table 2. For instance, Rate of TFPG in Korea for 1950-60 was 2.10% but it turned out to be 4.10% for the period 1960-1974 where the Korean economy was considered as one of the newly industrializing economies.

TABLE 2
TFPG AND SHARE OF TFP IN DEVELOPING COUNTRIES IN PERCENT

COUNTRY		TFPG	SHARE TO GROWTH
Chile	(1950-60)	0.85	24.3
	(1960-74)	1.20	27.3
Columbia	(1950-60)	0.95	20.7
	(1960-74)	2.10	37.5
Korea	(1955-60)	2.00	47.4
	(1960-73)	4.10	42.3
Mexico	(1950-60)	1.60	28.3
	(1960-74)	2.10	37.5
Peru	(1950-60)	-0.70	-15.6
	(1960-70)	1.50	28.3

Source: Chenery et al. Industrialization and growth: A comparative study, 1986: 20-22

These evidence shed light on how strong is the link between industrialization and technical progress. The rate of technical progress attained (as measured by TFPG) would give a clue about the level of industrialization in which a economy is in.

3. RATE OF TECHNICAL PROGRESS

3.1. MEASUREMENT

There does not exist an easy direct measure of technical progress. Kennedy and Thirlwill stated that " advance in knowledge per se defy direct meaningful quantification. The best that can be done is to measure technical change by its effects, such as its impact on the growth of total productivity..." (Kennedy & Thirlwall; 1972:13).

Measuring technical progress via its impact on output can be outlined as follows. Assume a general production function for two consecutive periods of the form:

$$Q_t = A_t \; F(L_t, K_t) \ldots\ldots\ldots\ldots\ldots (3.1)$$

and

$$Q_{t+1} = A_{t+1} \; F(L_{t+1}, k_{t+1}) \ldots\ldots\ldots\ldots (3.2)$$

and assume Y as output at time t+1 solely due to L_{t+1} and K_{t+1} inputs, i.e.,

$$Y = A_t \; F(L_{t+1}, K_{t+1}) \ldots\ldots\ldots (3.3)$$

A_t measures the efficiency level at time t. The change from Q_t to Y is due to the change in L and K, and the change from Y to Q_{t+1} is due to `technical progress'. Rate of technical progress will, therefore, be

$$\frac{Q_{t+1} - Y}{Y} = \frac{A_{t+1}}{A_t} - 1 \ldots\ldots (3.4)$$

Technical progress can, as well, be estimated using a general production function of the form:

$$Q = F[L(t), K(t), t] \ldots\ldots\ldots\ldots (3.5)$$

where t is time. The change in output overtime is given by

$$\frac{dQ}{dt} = \frac{\partial F}{\partial L}\frac{dL}{dt} + \frac{\partial F}{\partial K}\frac{dK}{dt} + \frac{\partial F}{\partial t} \ldots\ldots\ldots (3.6)$$

The change in output is decomposed into two: Change in output due to a movement along the production function and the change in output due to a shift in the production function or due to disembodied technical progress (see Intriligator, 1978:289). Dividing equation (3.6) by Q and converting to proportionate change, yields

$$\frac{1}{Q}\frac{dQ}{dt} = \frac{L}{Q}\frac{\partial F}{\partial L}\frac{1}{L}\frac{dL}{dt} + \frac{K}{Q}\frac{\partial F}{\partial K}\frac{1}{K}\frac{dk}{dt} + \frac{1}{Q}\frac{\partial F}{\partial t} \ldots\ldots (3.7)$$

The first two terms on the right are the proportionate rate of change of the two inputs, each weighted by their respective elasticity of output. The third term is the proportionate rate of disembodied technical progress. Assuming the elasticities remain fairly constant overtime and the proportionate rate of disembodied technical progress is constant at a rate m, equation (3.7) can be converted into the following:

$$\frac{1}{Q}\frac{dQ}{dt} = a\frac{1}{L}\frac{dL}{dt} + b\frac{1}{K}\frac{dk}{dt} + m \ldots\ldots\ldots\ldots (3.8)$$

where a and b are the labour and capital elasticities of output respectively. Solving for m and assuming dt=1, equation (3.8) turns out to be

$$m = \frac{dQ}{Q} - a\frac{dL}{L} - b\frac{dk}{K} \ldots\ldots\ldots (3.9)$$

Rate of technical progress is thus the difference of output change from the combined input change; inputs are combined weighted by their respective elasticity of output.

The above result is implied by a Cobb-Douglas production function of the following:

$$Q = A_o e^{mt} L^{a} K^{b} \ldots\ldots\ldots (3.10)$$

where Q= output, L= labour input, K= capital input, m= proportionate change of Hick's neutral disembodied technical progress, A_0=initial efficiency parameter, t= time and a and b are partial elasticities of output with respect to L and K respectively (a and b are non-negative)[5].

If Cobb-Douglas technology does not characterize the production process, other functional forms such as Constant Elasticity Substitution (CES) technology or translog technology could be utilized and one would get the same result. It requires only to transform the efficiency parameter as an increasing function of time. In this case, technical progress can be introduced in the CES technology as follows:

$$Q = \gamma_0 e^{mt}[\delta K^{-\rho} + (1-\delta)L^{-\rho}]^{-\frac{\nu}{\rho}} \ldots\ldots (3.11)$$

and in the translog technology, it will take the form

$$LnQ_t = Ln\gamma_0 + mt + \alpha_1 LnL + \beta_1 LnK + \alpha_2 (LnL)^2 + \beta_2 (LnK)^2 + \gamma_1 \, LnL \, LnK \ldots\ldots (3.12)$$

m here represents Hicks neutral disembodied technical progress.

In this paper, similar statistical and econometric models are applied to calculate the rate of technical progress consistent with other salient works. However, no model is selected a priori. This is so in order to benefit from the different alternatives and hence to choose the one that characterizes the production process of the Ethiopian manufacturing sector.

These alternatives are the following:

1. The simple approach to identify the rate of technical progress is to compute total factor productivity (TFP) and then calculate its rate using the expression:

$$A = \frac{Q}{aL + bK} \ldots\ldots\ldots\ldots (3.13)$$

where Q = output, L = labour input, K= capital input, A = TFP and a and b are labour and capital elasticities of output respectively. This was how Kendrick (1961) estimated technical progress in the US manufacturing industries for the period 1899-1953 which gave him a 2% rate of technical progress.

This expression is calculated for Ethiopian manufacturing sector by assuming different values for factor elasticities of output. With some stringent assumption, factor elasticities of output are considered to be identical with factor shares. Four alternatives are considered to attach a value for factor share: average shares (arithmetic and geometric), initial shares and current shares[6].

Growth rate of TFP are computed using different types of growth rate formula (some use all information and others use only two-end values)[7].

2. Another statistical method used is Solow's Geometric Index or the expression

$$\frac{\Delta A}{A} = \frac{\Delta Q}{Q} - a\frac{\Delta L}{L} - b\frac{\Delta K}{K} \dots\dots\dots (3.14)$$

An index of technical progress for each year can be derived from the identity

$$A(t+1) = A(t)\ [1+ \frac{\Delta A(t)}{A(t)}] \dots\dots (3.15)$$

and setting $A(t_o) = 1$, a series of A(t) can be constructed. From the expression $A(t) = A_o\,(1+m)^t$, the proportionate rate of technical progress (m) can be arrived at. The path-breaking work of Solow on nonagricultural sector of America (1957), Massell's work on the manufacturing sector of America (1960), Mabro & Radwan's attempt in the manufacturing sector of Egypt (1976), Krueger and Tuncer (1980) in the Turkish manufacturing sector and Katz (1969) in the Argentine manufacturing sector follow this approach. As well, Kendrick's arithmetic measure (Mabro et al, 1976:177) which takes the form

$$\frac{A_2}{A_1} = \frac{Q_2/Q_1}{a\frac{L_2}{L_1} + b\frac{K_2}{K_1}} \dots (3.16)$$

and the expression utilized by Kazashi et al (1983:4)

$$GA = a(GQ-GL) + b(GQ-GK) \ldots (3.17)$$

are employed.

The problem in these approaches are that they employ restrictive assumptions about the structure of technology - they assume constant returns to scale, perfect competition in both output and factor markets and neutral technical progress (Suers, 1995:277; Baltagi & Griffin, 1988:23).

3. Econometric approach has become a dominant and preferable alternative. As Suers (1995: 277) argued, econometric estimation of the production technology does not have to impose restrictive assumptions on returns to scale, thus, it enriches our information on the productivity performance of an industry. It also enables us to determine the extent to which technical progress alters the optimal level and mix of inputs.

3.a. The most common technique, in this regard, is to estimate a model:

$$LnQ = LnA_o + mt + aLnL + bLnK + u \ldots\ldots (3.18)$$

which is the linear transformation of a Cobb-Douglas production function. Katz (1969: 34) on the Argentine manufacturing sector for the period 1946-1961 put an effort to estimate technical progress using this approach and arrived at 1.6% rate of technical progress. Assuming a linearly homogenous Cobb-Douglas production function, equation 3.18 can be written as

$$Log\left(\frac{Q}{L}\right) = Ln\ A_o + mt + b\ \log\frac{K}{L} \ldots\ldots\ldots (3.19)$$

m measures the proportionate rate of technical progress and the constant term measures the initial efficiency parameter. Equation (3.19) has the advantage of increasing the accuracy of the estimate since multicollinearity between L and K can be minimized, though the assumption of constant returns to scale is the shortcoming. But, by adding (Log L) to the right side of equation (3.19), the nature of returns to scale can be captured since the coefficient for L indicates returns to scale[8].

3.b. In case, Cobb-Douglas specification does not fit the production system, the CES production function of equation 3.11 is employed. Arrow et al (1961) used this approach on the US economy and arrived at slightly higher (but not significantly different) rates of 1.8% than Solow. Since direct estimation with OLS is impossible, a linear transformation of Kementa's type is adopted in this paper:

$$LnQ = LnA_o + mt + aLnL + bLnK + c[LnK-LnL]^2 + u \ldots\ldots (3.20)$$

where

$$1)\quad \gamma = antilogA_o,\quad 2)\quad \delta = \frac{b}{a+b},\quad 3)\quad \rho = \frac{-2c(a+b)}{ab},\quad 4)\quad \nu = a+b$$

3.c. A translog production function type (equation 3.12) is as well estimated to relax the CES assumptions if CES does not characterize the production process.

All these models assume technical progress to be Hick's neutral disembodied type. The estimation technique is OLS unless cases are encountered which violate the basic assumption of OLS.

3.2. DATA: SOURCES AND MEASUREMENT

Measuring technical progress has not only conceptual but also measurement problems especially on measuring output and factor inputs. Which output (gross or net), labour (man-year or man-hour), and capital (net or gross) reasonably reflect the productive content of inputs?.

Net or gross output? Due to its heterogeneous nature and difficulty of aggregation, measuring output physically is hardly possible even at an enterprise level. Furthermore, physical output as a measure of `production' does not take account of difference between the quality of the two products; nor does it take into account the work done to achieve the improvement in quality (Silver, 1984:38).

Thus, it becomes customary to focus on value measures; the issue again is which value to use - gross or net[9].

To measure technical progress properly, output should avoid double counting if figures are to be aggregated and should include additional works done on intermediate inputs while excluding works done by others[10]. Output which excludes brought-in materials, double counting and includes additional works is then net output (value-added).

In this paper, output will therefore be measured by value-added in national account concept at factor cost. The source of data is CSO/CSA. It contains disaggregated data up to four-digit industries for 20 years.

Man-Year or Man-Hour? Which concept of labour input measure the productive content of labour is an issue. Is it the stock available for use in production (Man-year)? Is it the time in which stocks are available for production (man-hour)? Is it the compensation to the flow of services (wages)? There appears to be no conclusive prescription.

Labour input can be measured in man-year. But, man-year may not be a satisfactory measure of the number of persons working over the whole year. Such data only records the number of persons employed on the census day or during a short reference period of one or two weeks which might ignore inter-seasonal variations. It is a weak approximation if employment is highly seasonal or irregular or when uneven changes have taken place during the year (Mabro & Radwan, 1976:137-138). Silver proposed a monthly or quarterly count of workers; "the more frequent the count, the more appropriate is the resulting average for purpose of calculating productivity" (Silver, 1984:90).

However, due to incidence of absenteeism and sickness, changes in the number of overtime workers, changes in proportions of full time and part-time workers, employment in man-year is not a good measure of labour inputs in production, as the number of hours worked may differ among firms and vary from period to period (Mabro and Radwan, 1976:138). They therefore propose to utilize man-hour.

Even then, would the productive content of an hour of labour be identical so that labour will be a simple additive? The answer does not seem affirmative. Differences among labour in sex, age, ability, education, training, experience, devotion, etc., would be inevitable. Thus, the productive content of an hour of labour will not be identical. In this case, a simple additive of man-hour disguises the heterogenous nature of labour force.

To make labour homogeneous, different approaches have been forwarded, like treating skills as a stock of intangible assets (Mabro and Radwan, 1976) or weighing man-hour of different categories of labour force by their average earnings (Silver, Mabro and Radwan)[11].

In this paper, wage is used as a measure of labour input because it is the simplest mechanism available to make labour homogenous. Data source is CSO/CSA.

Which capital? A converging idea on measuring capital in production had ever been reached. Solow, stressing on the measurement problem, said "the capital time series is the one that will really drive a purist mad" (Solow: 1957:314). Capital input in production is measured through estimate aided by some proxies. The proxy measures are still debatable.

One area of controversy is its coverage. There is no agreement on it. The coverage extends as wide as `all human and man-made assets' and as narrow as only `machineries'[12].

Another controversy is on the valuation of capital stock. Walters stated that

> ...the most intractable difficulties are involved in measuring capital. In a mythical world where all machines are the same overtime, the ideal measure would appear to be the number of homogeneous machines.... The main difficulties... arise from the fact that the stock consists of various kinds of machines, buildings and land at different stages of their life cycles. Combining these into a monetary measure involves not only all these social index number problems but also difficulties which are peculiar to capital (Walters: 1963:23).

Indeed, to aggregate a heterogeneous stock of capital requires the knowledge of the price of each item: "... the unit of measurement varies with rate of profit; the relative prices of equipment are determined by future profit expectations" (Walters, 1963:23).

In most empirical studies, as Mabro and Radwan pointed out, first cost provide the basis of valuations[13]. The normal procedure is to measure capital value through perpetual inventory system and then deflate it by price index. Another alternative is valuation at current prices which include:

> ... First, collecting the valuation for fire insurance, second, multiplying valuations for estate or inheritance duties by the reciprocal of suitable specific normality rates, and third, multiplying the property income stream by reciprocal of the estimated rate of return...(Walters, 1963:24)

Which one to utilize then depends on the weights given to quality and cost changes and also on data availability.

The other debate[14] is on the question of whether changes in capital inputs are proportional to changes in the gross or to changes in the net capital stock.

There are some (Walters, Mabro and Radwan, Samuelson) who prefer gross. The main argument of those who propose for gross concept is that a machine or a building does not decline over time in the way implied by the usual depreciation methods. They also stated that net stock suffers from the arbitrariness involved in the concept of depreciation (Mabro and Radwan, 1976:152)[15].

On the other side, there are others who argue for net rather than gross; their main argument is that capital input is proportional not to that of gross but to that of net. For instance, Silver (1984: 127) stated that the value of capital stock in any period is given by the value in an initial period plus additions to and subtractions from the stock in each respective period. Kendrick argues for net capital as follows:

> Real stocks net of accumulated depreciation allowances are taken as a better measure of a basic capacity to contribute to production than gross stocks... Studies have shown that the gross output capacity of various types of machinery tends to fall with age, and the repair and maintenance charges rise so that the contribution to net revenue product of groups of items over time is roughly

approximated by the gradual decline in the depreciated real value of stock shown by the usual depreciation accounting procedures reflected in the national accounts (Kendrick, 1961:35)

The choice between gross or net capital varies according to weights given to each factor[16]. In this paper, net fixed asset is employed due to lack of data.

Issues on inflation: The main source of data is "the Results of Surveys of Manufacturing and Electricity Industries" published by Central Statistical Authority for various years (1976-1995). These years are chosen because it is in these years that data relevant to this study are available.

But data in these documents are at current prices. When value-added, wages and fixed assets are employed in this paper, it is on the understanding that they reflect quantity concept. Value reflects quantity if the effect of price is removed. This can be done by converting nominal values into real ones by using deflator. In this paper, however, inflation is not taken into account because of strong conviction that proxy deflating mechanisms distort results worse than price movements in the context of Ethiopian manufacturing sector.

Deflating using consumer price index would not be appropriate when output is value-added at factor cost. Prices in the manufacturing sector (which are dominantly public) were regulated and even if there were some price adjustments, it was mainly to counterbalance increments in intermediate costs and indirect taxes. Thus, when taxes and intermediate inputs are excluded, the fear of price fluctuation would be minimized.

Value-added increment that arises from average wage increment would not necessarily be ascribed to inflation; average wage shall increase overtime to capture the ever-increasing quality of labour. Profit was deliberately undermined since prices were fixed for a long time (at least pre 1991) while intermediate inputs (mostly imported) were subject to price effect.

3.3. RESULTS AND INFERENCES

Expression (3.13) is calculated for Ethiopian manufacturing sector for the period 1976-1995 by assuming different values for factor shares. Four cases are considered to attach a value to factor shares (see end notes). Growth rate of total factor productivity (TFPG) are computed using different types of growth rate formulae (see end notes). The results are reported in Table 3 and

Table 3
Growth Rates of Total Factor Productivity in %

Factor Shares	Growth Rate Formula					
	1	2	3	4	5	6
Arithmetic	2.39	-0.18	-0.84	-0.18	-4.11	-4.02
Geometric	2.39	-0.19	-0.85	-0.19	-4.15	-4.07
Initial	0.55	-0.44	-1.04	-0.46	-3.10	-3.05
Current	2.36	-0.19	-0.85	-0.19	-4.14	-4.06

Table 4
TFPG (Using Arithmetic Average) in %

Factor Shares	Periods			
	1976-80	1976-84	1976-87	1976-95
Arithmetic	15.83	6.18	3.25	2.38
Geometric	15.93	6.24	3.28	2.39
Initial	15.99	6.27	3.29	2.39
Current	14.35	5.92	2.81	0.55

Expression (3.14), (3.16) and (3.17) are computed using the same assumption for factor shares as that of the above. The results are provided in Table 5.

Table 5
Growth rate of total factor productivity in %

Factor shares	Techniques		
	Equation 3.14	Equation 3.16	Equation 3.17
Arithmetic	3.251	4.855	3.253
Geometric	3.227	4.870	3.224
Initial	3.209	4.880	3.212
Current	3.212	5.451	*

Using equation (3.15) and setting A_{1976}=1, a series of technology index (A_t) is constructed. The index of technology which indicates the extent to which the production function shifted since 1976 and the rate of technical progress (m) from the expression A_t=A_o $(1+m)^t$ is reported in Table 6.

Table 6
Technology index and rate of technical progress

Periods	Factor shares			
	Arithmetic	Geometric	Initial	Current
1980 - A_{80}	1.3632	1.5692	1.5725	1.5822
- m	11.82%	11.92%	11.98%	12.15%
1984 - A_{84}	1.4061	1.4128	1.4165	1.4287
- m	4.35%	4.41%	4.45%	4.56%
1987 - A_{87}	1.2089	1.2099	1.2104	1.2094
- m	1.74%	1.75%	1.75%	1.74%
1991 - A_{91}	0.578	0.5752	0.5737	0.6045
- m	-3.59%	-3.62%	-3.64%	-3.3%
1995- A_{95}	1.6181	1.613	1.6103	1.7089
- m	2.57%	2.55%	2.54%	2.86%

The econometric estimates are run using OLS for models 3.18, 3.19, 3.20 and 3.12. The results are summarized in Table 7.

Table 7
Econometric Estimates of Different Models

Models	Coefficients	T-ratio	F-ratio	R^2	D.W
Model 3.18					
- Constant	-24.6249	-5.4288	49.75	88.5	1.2167
- T	-0.17191	-6.0677			
- L	2.588	9.0625			
- K	0.58334	2.4508			
Model 3.19					
Case 1					
- Constant	1.4149	5.5144	3.125	18.28	0.889
- T	-0.0139	-1.207			
- k/L	-0.277	-0.951			
Case 2					
- Constant	-24.62	-5.429	17.001	71.64	1.2167
- T	-0.1713	-6.067			
- k/L	0.5833	2.561			
- L	2.1713	5.744			
Model 3.20					
- Constant	-21.46	-5.439	55.616	91.99	1.772
- T	-0.169	-7.145			
- K	-2.791	-2.309			
- L	5.845	4.968			
- $(k-L)^2$	1.555	2.827			
Model 3.12					
- Constant	63.93	1.5848	52.34	94.19	2.361
- T	-0.1419	-5.99			
- L	4.4314	0.6128			
- K	-14.0286	-2.797			
- L^2	-0.685	-0.6128			
- K^2	-0.0011	-0.0015			
- K*L	1.1378	0.6015			

The inferences made from the results of the estimate can be summarized as follows:

1) Total factor productivity calculated using equation (3.13) and different assumptions about factor shares basically reveals non-increasing trend for the whole period (see table 3). And it is true regardless of types of factor shares considered. The rate, of course, varies depending on the formula used.

Despite the general stagnation exhibited for the period under study, there were periods in which TFP revealed an increasing trend (for example, 1976-1980). This fluctuation of TFPG went with the economic and political conditions of the time.

The base year of the period under study - 1976 - was a time of political upheaval; endogenizing management and ownership through nationalization was initiated. Ethiopians took over the managerial and other key positions previously held by foreigners and these put the manufacturing sector, and hence TFP, in crisis.

It took time for the Ethiopians to gain the lost skills due to the withdrawal of the foreigners (at least up to 1980). Gaining the lost skill back combined with the "production campaign" put TFP at its climax in 1980. This indicates some sort of learning (acquiring production capability) in a sense that Ethiopians managed to run the nationalized industries.

1985 was a year of drought which affected heavily the agricultural sector and hence the manufacturing sector (by limiting raw material, foreign exchange and market). Its impact is then reflected on TFP. There after, foreign exchange shortage, lack of managerial autonomy (in investment, pricing, labour management) and agricultural stagnation exerted their impact on the performance of the manufacturing sector, revealed by the decline in TFP.

1992 was the case where the majority of economic units were nearly ceased operation. Intense shortages of foreign exchange and hence shortage of raw material were encountered. This resulted in the decline in TFP further, the lowest that had ever reached in the period under study.

2) Technology index, assuming $A_{1976}=1$ and using different assumptions for factor share, reached about 1.6. Growth rate of total factor productivity (TFPG), as measured by equation (3.14), (3.16) and (3.17), exhibited Positive growth rate (see table 6).

This, however, does not imply that technical progress in the whole period has a positive trend. When growth rate is computed using other methods (other than arithmetic average), the result becomes different. TFPG, using equation (3.14) and a geometric average factor share, is re-worked for the whole period using the other growth rate formula. The results are reported in Table 8. The table reports that, except the arithmetic average, the other formulae reveal either no or a negative growth rate.

Table 8
TFPG in % using different formula

Formula	Growth rate
Formula 1	3.23
Formula 2	-0.48
Formula 3	0.08
Formula 4	0.21
Formula 5	-3.62
Formula 6	-4.86

Moreover, both technology index and rate of technical progress assumed a different trend when the 1991-1993 was omitted. For instance, if 1991-1992 is excluded, technology index on 1995 would be 1.0651 and if 1991-1993 is excluded, technology index becomes 0.6919. This indicates no or a negative rate of technical progress.

But, there were periods in which no less than 10% growth rates were registered. For instance, technical progress was increasing by 11.92 percent for the period 1976-1980.

3) Econometric estimates do produce quite puzzling results; either coefficients are theoretically meaningless or estimates are statistically insignificant. Cobb-Douglas model gives the initial efficiency parameter a number almost identical to zero which makes equation (3.10) almost zero whatever are the values of L and K. The increasing returns to scale (3.16 fold) obtained for the

Ethiopian manufacturing sector is unexpected given the declining TFP or negative rate of technical progress. Model (3.19a) gives a negative coefficient for b implying that labour productivity is negatively affected by capital intensity which is theoretically meaningless. CES Model, as well, gives a negative capital share which is unjustifiable. Thus, econometric estimates obtained from the above production functions[17] do not satisfy a priori expectations. Heterogeneity of aggregate data and small sample size (only 20) might be the cause for such inconsistent outcomes. Despite all these, coefficients for T are statistically significant and the overall fitness is satisfactory. This gives an impression that the rate of technical change is negative.

Due to the negative consequences of aggregate data and small sample size, the above models are re-estimated using panel data. The data is dis-aggregated by sub-sectors (each of the 19 sub-sectors have observations for 20 years) to enlarge the sample size. Enlarging the sample size has one clear advantage: it increases the degrees of freedom and reduces the impact of collinearity (Hsiao, 1986:2). The results are summarized in Table 9.

Table 9
Econometric Estimates of different models

Models	Coefficients	T-ratio	F-ratio	R^2	D.W
Model 3.18					
- Constant	1.3775	4.2085	215.35	62.92	1.1168
- T	-0.00713	-0.9199			
- L	0.82819	14.0278			
- K	0.11537	2.5145			
Model 3.19					
- Constant	0.9249	9.8371	4.546	1.83	1.1185
- T	-0.01098	1.5056			
- k/L	0.11812	2.5726			
Model 3.20					
- Constant	1.438	4.369	162.67	63.05	1.1368
- T	-0.00359	-0.444			
- K	0.23385	2.5932			
- L	0.6977	6.7114			
- $(k\text{-}L)^2$	-0.05739	-1.5251			
Model 3.12					
- Constant	-2.0824	-1.0758	112.34	63.81	1.1227
- T	-0.0035	-0.423			
- L	-0.0327	-0.074			
- K	1.6104	3.6126			
- L^2	0.0423	0.753			
- K^2	-0.0836	-2.176			
- K*L	0.014	0.171			

Panel data set changes all the natures of the parameters. Coefficients are theoretically meaningful and statistically significant. Unlike the previous result, the coefficient for T is not different from zero; and the situation does not change even if adjustment for heteroscedasticity (using White) is made. This implyies that there has not been technical progress in the Ethiopian manufacturing sector.

4. From the results arrived, especially regarding growth rates, one can observe that methodologies employed affect the conclusions to arrive at, as Table 8 demonstrates.

In a nutshell, two pictures are coming into front from the movements of technical progress of the manufacturing sector of Ethiopia for the period 1976-1995: Stagnation and periodical variation. TFPG and rate of technical progress are negative or zero, unless simple arithmetic annual average growth rate is assumed.

The implication, however, should be seen critically, at least, with respect to learning. There were periods where TFP growth rate was substantial. Withstanding the tremendous disruption caused by the Revolution and withdrawal of skills, not only running but also producing a 10% rate of TFPG for the period 1976-1980 reflected acquisition of knowledge. But it was mainly to attain capacity which did not continue.

4. NATURE OF TECHNICAL PROGRESS

Technical progress has various prefixes: Exogenous, endogenous, disembodied, embodied, neutral, labour saving, or capital saving depending on its impact on factor productivity and its sources and carriers. Embodiment is an issue of vintage as a carrier of technological progress, giving different weights to different vintage of technology.

Neutrality is an issue of whether technical progress causes an equi-proportionate rise of factor inputs' efficiency. There are Hicks neutrality, Harrod neutrality or Solow neutrality; their difference is on whether technological progress leaves factor ratios unchanged (Hicks), capital-output ratio unchanged (Harrod), labour-output ratio unchanged (Solow) for given factor prices (Heathfield & Wibe, 1987:121).

4.1. NON-NEUTRAL TECHNICAL PROGRESS

There is a method for identifying whether technical progress is neutral or not. One simple method is to measure factor inputs in their efficiency units (Da Costa, 1984:185; Heathfield & Wibe, 1987:123). As time passes, each man-hour gets experience and becomes more efficient. As well, capital input especially through replacement investment embodies new technology which is more efficient. Factor inputs in production should, as a result, be measured in their efficiency in order to identify whether technical progress is capital or labour saving. This requires a general Cobb-Douglas production function of the form

$$Q = A\,[L(t)]^{a}\,[K(t)]^{b} \quad .... (4.1)$$

where K(t) and L(t) represent capital and labour inputs in their efficiency units. The basic assumption here is that as time passes, their efficiency increases. To make it specific, let

$$K(t) = e^{nt}K_e \quad ....(4.2)$$

and

$$L(t) = e^{vt}L_e \quad .....(4.3)$$

where K_e = actual capital input, K= capital input in efficiency unit, L_e = actual labour input, L = labour input in efficiency units, n and v are rates of growth of efficiency per unit of time. Through substitution, equation 4.1 turns out to be

$$Q_t = Ae^{avt} e^{bnt} L_e^a K_e^b \ldots (4.4)$$

or

$$Q_t = Ae^{(av+bn)t} L_e^a K_e^b \ldots (4.5)$$

If n=v, technical progress is Hicks neutral; it raises efficiency of factor inputs at the same proportion. If n = 0, it is Harrod neutral and technical progress is labour saving; and if v = 0, it is Solow neutral implying that technical progress is capital saving. If there is a need to use CES or translog technology, the mechanism will be the same - use factor inputs in their efficiency unit. This method of estimation is not employed in this paper for lack of easy estimation techniques.

Another method is that of Katz. Katz (1969: 97-99) used CES technology of the following form:

$$Y = [(E_L L)^{-\rho} + (E_K K)^{-\rho}]^{-\frac{1}{\rho}} \ldots . (4.6)$$

where $E_L K$, and $E_K K$ constitute, respectively, the inputs of labour and capital in "efficiency units"; L and K being conventional measures of such inputs. It assumes constant returns to scale. Changes in E_L and E_K through time are considered as "labour-augmenting" and "capital-augmenting", respectively. Least cost efficient input use in production requires the condition (assuming perfect factor and product market):

$$\frac{w}{r} = \frac{E_L^{-\rho} (Y/L)^{(1+\rho)}}{E_K^{-\rho} (Y/K)^{(1+\rho)}} \ldots . (4.7)$$

Solving for K/L, (equation 4.7) will take the form

$$\frac{K}{L} = \left(\frac{w}{r}\right)^{\sigma} \left(\frac{E_L}{E_K}\right)^{(1-\sigma)} \ldots (4.8)$$

Multiplying both side by $(L/k)^{\sigma}$ yields:

$$\frac{K}{L}\left(\frac{L}{K}\right)^{\sigma}=\left(\frac{w}{r}\frac{L}{K}\right)^{\sigma}\left(\frac{E_L}{E_K}\right)^{(1-\sigma)} \quad ...(4.9)$$

Labelling as π_L and π_K the shares of labour and capital respectively and solving for K/L, equation (4.9) can be written as follows:

$$\frac{K}{L}=\left(\frac{wL}{rK}\right)^{\left(\frac{\sigma}{1+\sigma}\right)}\left(\frac{E_L}{E_K}\right)=\left(\frac{\Pi_L}{\Pi_K}\right)^{\left(\frac{\sigma}{1+\sigma}\right)}\left(\frac{E_L}{E_K}\right)..(4.10)$$

Assuming that changes in E_L/E_K, the relative efficiency of labour, take place at a constant geometric rate (ϵ_L-ϵ_K), where ϵ_L and ϵ_K are the respective constant geometric rate of growth of the efficiency of labour and capital, then:

$$\frac{E_L}{E_K}=A_o \exp(\epsilon_L-\epsilon_K)t...(4.11)$$

where A_0= $E_L(0)/E_K(0)$ which represents the relative efficiency of labour at the base period. Substituting equation (4.11) into equation (4.10) yields a regression model in logarithmic form which can be written as follows:

$$Log\frac{K}{L}=A_o+\frac{\sigma}{(1+\sigma)}Log\ \Pi+(\epsilon_L-\epsilon_K)t...(4.12)$$

Equation (4.12) can be fitted by OLS to aggregate data on capital, labour and relative factor shares for the manufacturing sector to identify whether technical progress is non-neutral and whether it is biased to labour or to capital. Katz (1968:108) employed this method on the Argentine manufacturing sector and found out that it was labour saving: the efficiency of labour grew at a rate which was 1.6 to 1.7% higher than the rate at which the efficiency of capital grew though time.

Another method which does not limit the extent of substitution or returns to scale is the augmented translog production function. Treating time as the variable that captures technical progress, translog technology of the following form can be used.

$$lnY=lnA_o+a_1t+a_2t^2+\sum b_iLnX_i+0.5\sum\sum b_{ij}LnX_iLnY_j+c_itlnX_i+u..(4.13)$$

where Y= output, t= time, x= inputs (labour and capital) and $b_{ij}=b_{ji}$. This specification allows the calculation of the rate of technical progress,

$$\frac{\partial lnY}{\partial t}=a_1+2a_2t+\sum c_ilnX_i...(4.14)$$

which incorporates both the effect of disembodied technical progress (a_1 and a_2) and the effect of any bias in technical change on the use of each of the factor inputs (c_i). The c_i coefficient indicates the extent to which technical change is biased towards the particular factor input. That is, technical progress is factor i-using, i-neutral or i-saving if the estimate of c_i is positive, zero or negative, respectively.

Both the latter two approaches are utilized in this paper using aggregate and longitudinal data.

4.2. EMBODIED TECHNICAL PROGRESS

Embodiment is an issue of whether the recent capital and labour inputs acquire the latest technology and better quality. In this regard, Hildebrand and Liu (1965:49-52) tried to devise some proxy or dummy variables that would reflect changing technology to a significant extent. They assumed that important change in the level of technology could not take place without being reflected in the following:

- ♥ a change in the ratio of the value of equipment to the value of plant;
- ♥ a change in the average age of the capital assets as expressed in the ratio of the net value of assets to the gross value; and
- ♥ a change in the ratio of technical and professional personnel to production workers.

They proposed a Cobb-douglas production function which enables to incorporate technology explicitly as a variable of the following type:

$$Q=AL^{(a \log r)}K^{(b \log R)} \quad \ldots (4.15)$$

where r = the ratio of technical personnel to production workers and R= the ratio of equipment to plant or the ratio of net value to gross value of capital assets. In this setting, factor-output elasticity or factor ratios will not remain constant overtime since the exponents are (a log r) and (b log R).

For a given level of technology, r and R are constant, and therefore the exponents are also constant. In this case, changes in quantities of labour and capital inputs would result in changes in output along a given production surface (Hildebrand & liu, 1965:50). Shifts in production would take place as the exponents themselves change when the technological level (or the level of mastering and adapting technology and learning-by-doing) itself undergoes changes, modifying the original surface. The exponents will change only if r and R changes; and they would only change, in normal cases, if there is a change in the level of technology itself or in the use of technology.

Embodied technical progress using vintage model had been estimated by Solow and Intriligator (Intriligator, 1978:291). A production function incorporating both embodied and disembodied technical progress was estimated by Intriligator for aggregate US manufacturing output for the period 1929-1958. According to this estimate, disembodied technical progress was 1.67 percent per annum and technical progress embodied in capital amounts to on average 4 percent annually (Intriligator, 1978:292). Hildebrand and Liu (1965:58-62), using equation (4.15), tried to incorporate technological change in the production function and attempted to identify the capital-output elasticity and technology-output elasticity for the three digit industries of USA; and their result had come out that technical progress was, by and large, capital embodied.

To identify whether or not technical progress is embodied in labour or capital, equation (4.15) is employed in this paper. r and R are used as a proxy measure to capture technological change.

r is taken to be the ratio of labour cost of non-production workers to production workers in percent. Payment to non-production workers is assumed to represent payment to technical and professional personnels which have more relation with the extent of technology utilization than production (or manual) workers. The problem here is that payment to non-production workers might not be a good representation of technical and professional personnels. It would have an upward bias as the former includes other payments. Furthermore, payment to production workers heavily correlates with the extent of capacity utilization. If capacity utilization falls for whatever reason, there will be a tendency to reduce, at least, temporary manual workers.

R is the ratio of the value of equipment (machineries, tools, etc.,) and the value of the plant (structures, buildings, etc.,) which indicates the extent of "technological intensity". The problem here is the way the plant and equipment are assumed to depreciate. The rate at which equipments are assumed to depreciate is quicker than that of the plant which leads R to vary without any implication on technology. Had it not been for lack of data on gross fixed asset, the "average age" of the capital assets would be preferable.

4.3. RESULTS

Equation (4.12) is run using OLS. Relative factor share (π) is the ratio of labour and capital share (π_L/π_K). Capital-labour ratio is net fixed asset per unit of labour cost. The estimation is made using both aggregate data (which assumes homogeneity among sub-sectors) and using longitudinal data. The result which corrects the problem of serial correlation using Cochrane-Orcutt iterative method is reported in Table 10. From the table, it is clearly seen that the significance of the coefficients especially that of π and T do not remain consistent when one uses aggregate and panel data set. While the coefficient for π is significant in the case of panel data, it is not significant in the case of aggregate data; and, the reverse is true for T.

Table 10
Econometric Estimates of Equation (4.12)

Regressors	Coefficients	T-ratio	F-ratio	R^2	D.W
Panel					
- Con	0.7925	4.8556	122.48	56.31	1.9988
- T	-0.0114	-1.466			
- Ln(π)	-0.1295	-3.359			
Aggregate					
- Con	0.4631	1.8368	18.92	74.92	2.14
- T	0.4730	2.8261			
- Ln(π)	-0.0163	-0.278			

Model (4.13) is run by OLS using both aggregate and panel data. The result corrected for serial correlation (in the case of panel data using Cochrane-Orcutt Method) is reported in Table 11.

Table 11
Econometric Estimates of Equation (4.13)

Regressors	Coefficients	T-ratio	F-ratio	R^2	D.W
Aggregate					
- Con	-1052.6	-1.975	52.75	96.08	1.976
- T	-15.598	-2.553			
- T^2	-0.0568	-2.838			
- LnW	129.91	1.8422			
- LnK	50.30	1.1367			
- LnW^2	-4.69	-1.647			
- LnK^2	-1.304	-1.049			
- LnW*LnK	-1.625	-0.715			
- T*LNW	0.8634	2.2124			
- T*LNK	0.4538	1.546			
Panel					
- Con	-6.301	-2.321	93.91	74.78	1.96
- T	-0.143	-1.683			
- T^2	0.0031	1.4823			
- LnW	0.0608	0.1191			
- LnK	2.5873	5.098			
- LnW^2	0.1997	3.5871			
- LnK^2	-.0436	-0.975			
- LnW*LnK	-0.245	-2.702			
- T*LNW	-0.022	-1.923			
- T*LNK	0.0305	3.2661			

Estimate of coefficients on aggregate data and panel data are dis-similar both in size and sign in most cases. For example, while the coefficient of LnW is 129.9 in the case of aggregate data, it is only 0.0608 in the case of panel. The same is true with respect to sign. While the sign is positive in the case of aggregate (the coefficient for T*LNW), it is negative in the case of panel and is the vice versa for the coefficient of T^2.

With regard to embodiment, equation (4.15) is run using both aggregate and panel data. As well, different alternatives are assumed regarding the carriers of technical progress; technical progress is embodied in labour, capital or in both but at different rate. The results of the estimate using aggregate data become theoretically meaningless or statistically insignificant and they are not reported here. The result on panel data and corrected for autocorrelation is reported in Table 12.

Table 12
Econometric Estimates of Equation (4.15)

Regressors	Coefficients	T-ratio	F-ratio	R^2	D.W
- Log r log W - log R log K - con	0.0240 0.0123 8.2745	7.2416 3.4263 29.168	135.81	64.19	1.9715
- log W - log R log K - con	0.85348 0.00581 1.92120	14.5496 1.7664 3.931	198.96	72.47	1.9834
- Log r log W - log K - con	0.02146 0.36057 5.51350	5.8804 6.5576 10.917	170.61	64.28	2.1195

From Table 12, all coefficients are statistically significant and theoretically meaningful. In fact, there seems no significant reason to choose one from the other. Then, it is justifiable to claim that the carriers of technical progress are both labour and capital. As a result, factor elasticity of output is supposed to vary overtime. If factor elasticity of output and hence factor substitution (implied by Cobb-Douglas model) increases through time, it indicates occurrence of technical progress. To see the situation in this regard, index of factor-elasticity of output is constructed. This is done by calculating the annual factor-elasticity of output and then by indexing it making 1979 a base year. 1979 is selected simply because it is the beginning of data set that allows the estimation.

Table 13
Index of Factor-Elasticity of Output (Base 1979)

Years	labour	Capital
1980	100.34%	97.42%
1981	102.98%	97.78%
1982	102.47%	99.61%
1983	99.99%	98.39%
1984	101.87%	103.30%
1985	102.64%	95.34%
1986	102.68%	97.46%
1987	103.75%	97.57%
1988	105.07%	98.71%
1989	106.99%	96.67%
1990	111.73%	102.55%
1991	109.09%	103.14%
1992	110.64%	98.12%
1993	109.07%	95.54%
1994	108.43%	99.69%
1995	110.48%	97.91%

From Table 13, one can see that labour elasticity of output, on average, is tending to increase overtime while that of capital is constant. This implies technical progress (or regress) was non-neutral and labour saving.

In summary, the nature of technical progress using the above approaches becomes unclear. It tends to vary on the methodology and the data set utilized, as one can see from Table 14. Table 14 is constructed by seeing the significance of the coefficient which contains information about nature of technical progress (or regress) regardless of the significance of others. The significance of the model as a whole measured by F-ratio is, however, a pre-condition.

Table 14
Nature of Technical Progress

Models	Data set	
	Aggregate	Panel
Equation 4.12	L-saving	Neutral
Equation 4.13	L- and K-using	L-saving/K-using
Equation 4.15	Unfit	L-saving

The coefficient for T in equation 4.12 is positive (0.473) and significant at 5% level using aggregate data implying that labour efficiency is 47.3% higher than capital which indicates labour-saving nature of technical progress. But it is negative in the case of panel data and not significantly different from zero indicating the absence of differences in factor efficiency which in turn reveals neutral nature of technical progress (or regress). In the case of equation 4.13, the coefficients for T*LnW and T*lnK using aggregate data are positive (indicating labour consuming nature of technical progress) but insignificant for the latter one (indicating its neutrality). For panel data, however, the coefficient for both become significant though the sign for the former change to negative. This indicates that technical progress is labour-saving and capital-using. Regarding equation 4.15, it is already stated that technical progress have labour-saving character.

The problem here is choosing the one that reveals the nature of technical progress in the Ethiopian manufacturing sector. From the advantage of panel data and the non-restrictive nature of translog production function, estimation results from panel data and translog production function seem appropriate to reveal the nature of technical change. Therefore, it is safe to conclude that technical progress (or regress) in the Ethiopian manufacturing sector used to have a labour-saving and capital using nature.

5. SECTORAL AND/OR OWNERSHIP DIFFERENCES IN THE RATE OF TECHNICAL PROGRESS

"... learning does not occur in all firms... Technical effort need not proceed in the same direction, even in firms within the same market " (Hebret-Copley; 1990:1457-1460). This chapter attempts to examine the validity of this statement.

It seems certain that firms are not similar in the nature of technology they use, size composition, market structure, incentive framework, man-power composition and in their respective strategy. The task here is then identifying the situation in Ethiopia. Is there a variation in performance among sectors or between ownership in the Ethiopian manufacturing sector? If there is, is it significant?

5.1. SECTORAL DIFFERENCES

To reflect the complete picture of sectoral differences equation (3.13) and (3.18) are re-employed. TFP using equation (3.13) is estimated for each sub-sector using a geometric average factor shares (which is mild in volatility when encountered with extreme values). But because geometric average does not accept negative values, such incidence (in case of negative value-added or operating loss) are excluded when calculating average factor shares. The results for selected years are provided in Table 15[18].

Table 15

Total Factor Productivity by Sub-Sector at Different Periods

Sub sectors	years				
	1976	1980	1983	1992	1995
Food	0.7698	1.9334	0.9116	0.6616	2.0094
Beverages	1.4724	1.4221	1.1417	0.6744	1.5171
Tobacco	1.8515	3.8991	7.8517	1.4328	13.0447
Textiles	1.7383	2.5819	0.8942	0.2846	0.6061
Wearing app	1.4095	1.2982	1.7791	0.7600	1.2107
Tanneries	3.1516	1.077	2.0339	0.3153	2.7497
Footwear	1.9720	4.1626	1.1214	1.2642	1.3434
Wood	1.4740	1.5783	1.8875	0.9841	3.8295
Furniture	1.3081	1.8856	1.9519	1.7675	1.2871
Paper	0.1065	.8908	2.6405	0.5050	1.7023
Printing	1.8587	2.4880	3.2098	2.8782	1.8768
Chemicals	1.0229	1.1910	1.0788	1.1796	2.3590
Other chem.	2.7188	2.1766	3.6767	1.2541	1.9833
Rubber	0.5321	1.4279	2.0194	0.1572	0.2055
Plastic	0.5489	1.0421	2.9894	2.7049	2.0327
Glass	0.5565	0.8096	0.0964	0.2024	0.9100
Nonmetal	0.4899	1.3228	0.1809	0.2871	0.7851
Iron & steel	1.7162	3.0203	3.3219	0.7946	8.1940
Fabricated m.	0.5989	1.7424	2.2198	0.037	0.3354
Total	1.038	1.9916	1.4044	0.4645	1.0628

The Table clearly demonstrates a huge difference in the productive content of inputs among sub-sectors; a 25-fold difference was observed in 1976 between other chemicals sub-sector and paper sub-sector. The same was true in 1995 between tobacco and rubber sub-sectors; TFP in tobacco was 63-fold greater than that of rubber. Of course, the structure did not remain constant; while other chemicals and leather were the highest in 1968, it was footwear in 1980, tobacco in 1985, printing in 1992 and again tobacco in 1995 that registered the highest TFP. All these facts reveal the prevalence of differences in total productivity across sectors.

More important is the rate of technical progress registered between the period 1976-1995 which reveals the extent of learning or unlearning. Rate of TFPG approximately measures the rate of technical progress.

TFPG is calculated using equation 3 and equation 4 (see endnote). The arithmetic average growth rate is left out since it is extremely volatile and unrevealing due to extreme values that are common in this data set. Equation 3 uses only two end values and hence is sensitive to the years chosen while ignoring all information in between. A trend function, equation 4, is fitted using time as a regressor, and it has an advantage, at least, in utilizing all information. Because some of the causes for excessive fluctuations in TFP were political which impeded full capacity utilization, equation 4 is estimated using time dummy variables for 1991, 1992 and 1993 to capture these political factors. The results are depicted in Table 16.

TFPG over the period under study is different across sectors. The implication of the size of the rate, however, is puzzling. TFPG estimates are indicative of the rate of increase of output per unit of inputs, but they do not give indication about the efficiency level. Firms with low rate of TFPG are those that are already efficient is a plausible hypothesis. It is also equally plausible to claim that firms with high rates of TFPG are now efficient (Krueger & Tuncer, 1980:33). Whatever its implication may be on static efficiency, it is clear that the size of the rate of technical progress indicates the size of learning or unlearning.

Table 16
TFPG by Sub-Sector for 1968-1987 in %

Sub sectors	Formula		
	Equation 3	Equation 4 with out dummy	Equation 4 with dummy
Food	4.80	No trend	no trend
Beverages	0.32	-3.76	-3.09
Tobacco	9.76	8.20	8.77
Textiles	-5.27	-9.09	-7.51
Wearing app	-0.76	no trend	no trend
Tanneries	-0.68	5.06	7.41
Footwear	-1.92	-5.43	-5.42
Wood	4.77	no trend	no trend
Furniture	-0.08	-1.19	-1.4
Paper	13.86	7.37	11.34
Printing	0.05	no trend	no trend
Chemicals	4.18	no trend	no trend
Other chem.	-1.58	no trend	no trend
Rubber	-4.76	-10.1	-8.73
Plastic	-6.55	5.09	5.26
Glass	2.46	no trend	no trend
Nonmetal	2.42	no trend	no trend
Iron & steel	7.82	no trend	no trend
Fabricated m.	-2.90	-11.8	-7.77
	0.12	-4.15	-2.68

"No trend" indicates that the coefficient of T is either statistically insignificant or the overall model is unfit.

In this regard, the learning process in the Ethiopian manufacturing varies extremely across sub-sectors. While paper registered a 11.35% rate of technical progress, textiles and fabricated metal sub-sectors produced a 7.7% rate of technical regress. Cases of unlearning are equally persistent as cases of learning. In fact, (using the measure with time dummies) 6 sub-sectors are exhibiting a decline, 9 sub-sectors showed "no trend" and only 4 sub-sectors (tobacco, paper, plastic and leather) reveal learning.

To add to the evidence on the issue, econometric estimates of Cobb-Douglas model (equation 3.18) was run using OLS in order to directly observe the rate of technical progress (or regress) for each sub-sector. But none of the coefficients are significantly different from zero or theoretically justifiable.

To prove the growing impression that sub-sectoral variation is prevalent, the preferable approach, and most probably the reliable one, is to use pooled data. By doing so, testing the validity of the growing impression econometrically becomes orderly.

In a panel data set, equation 3.18 asserts that rate of technical progress (m) is identical across sub-sectors over the period under study, i.e., $m_1 = m_2 = m_i = m$ where m_i represents rate of technical progress of the i's sub-sector. Time here assumes an identical pattern for each sub-sector and serves only as a variable whose coefficient is interpreted as a measure of autonomous growth.

In actual fact, m_i differs across sub-sectors since their respective internal and external environments (or strengths and potentials) differ. Technical progress not only exhibits variation overtime but also differs among sub-sectors, and hence their rate of technical progress (or regress). Testing the null hypothesis that $m_i = m$ in all i's against the alternative hypothesis that m_i is not equal to m will prove the case.

To do so, one shall insist on time to assume two purposes - first, as a sector specific dummy and second, as a variable whose coefficient measures autonomous growth. This can be done by attaching sector specific dummies that accommodate steady changes in that particular sector. In this case, the value of the dummies should change steadily. This will give us 19 sector specific dummies whose values range from 1 for 1976 to 20 for 1995 and 0 otherwise. This, in turn, gives us the following equation:

$$LnY = LnA_0 + \sum m_i T_i + a \ln L + B \ln K + u \ldots (5.1)$$

where m_i represents sector specific rate of technical progress (Hicks neutral type) and T_i represents sector specific dummy variable whose value ranges from 1 to 20 to that particular sector and 0 otherwise.

Fitting equation 5.1 and checking the significance of the coefficient for the variable T_i as well as the general fitness of the model might be one way of varifying the existence of technical progress variation across sub-sectors. This is done using time specific dummies for 1983, 1984 and 1985 and without; and the result, adjusted for heteroscedasticity (using White), is reported in Table 17. The regression with time specific dummies did not prove itself better than without and hence not reported here.

Table 17
Econometric Estimates of Equation 5.1

Regressor	coefficients	T-ratio	F-ratio	R^2	D.W
LnW	0.8949	13.07	57.61	75.82	1.5673
LnK	0.1762	2.94			
con	0.3369	0.61			
T1	-0.02	-1.27			
T2	-0.203	-1.40			
T3	0.097	8.87			
T4	-0.0766	-4.13			
T5	-0.0325	-4.27			
T6	-0.0169	-1.11			
T7	-0.0351	-5.10			
T8	-0.0377	-3.03			
T9	-0.0259	-5.03			
T10	-0.0113	-0.82			
T11	-0.0067	-1.03			
T12	-0.002	-0.22			
T13	0.0176	1.77			
T14	-0.0363	-3.05			
T15	0.0117	1.75			
T16	-0.0849	-1.96			
T17	-0.053	-3.04			
T18	-0.0069	-0.38			
T19	-0.0493	-3.14			

According to Table 17, the econometric estimate of equation 5.1 is generally fit implying that variation in the dependent variable is well explained by the regressors. Besides, the majority of the coefficients for T_i, along side with that of labour and capital, become statistically significant, at least, at 10% significance level. But their size as well as their sign did not appear identical. This indicates that the rate of technical progress is significantly different across sub-sectors.

Formally, F-test can be used to test the hypothesis. In this instance, equation 5.1 is unrestricted while the equation without dummy is the restricted one since it implies that $m_1 = m_2 = m_i = m$.

The calculated F-ratio[19] in this particular case becomes 9.44 which is by far higher than the theoretical F-ratio at 1% level (at 18 and 356 degrees of freedom). Hence, this result proves that m_i's are not identical across sectors. Then differences in rate of technical progress across sub-sectors is strong. There are some that registered positive rate of technical progress and others which registered technical regress over the period under study.

5.2. OWNERSHIP DIFFERENCES

"The private sector is on the whole better equipped to respond to radically changing demands ..." (Schloss, 1992: 6). "While it may be true in theory that a properly managed public enterprise can be as productive and efficient as a private one, the reality is that politics, usually of a virulent nature, intrudes" (Summers, 1992:8). Specially, "centralized decision making, lack of profit motive, and absence of competition, which typifies government operations, make government production always less efficient than private sector production" (Diamond, 1990: 34). To what extent are these statements valid in the Ethiopian context?

Though the implication of the size of the rate of TFPG seems puzzling, it conveys the idea that firms with high rates of TFPG are now efficient. To test the existence of ownership differences in rate of technical progress in the Ethiopian manufacturing sector, the above methodology is applied. TFP and its growth rate is calculated the way it was done above. And the ratio of TFP of public sector to that of private for selected years is reported in Table 18.

Table 18
Ratio of Public TFP to private TFP by sector

Sub-sectors	1968	1972	1979	1984	1987	average
Food	84.3%	134.0%	77.4%	76.6%	193.4%	89.9%
Beverages	66.9%	52.4%	76.3%	33.5%	1519.5%	85.1%
Textile	73.8%	202.9%	63.1%	28.9%	62.1%	87.6%
Wearing app.	118.6%	118.8%	137.2%	553.3%	491.7%	212.2%
Tanneries	871.2%	77.4%	256.4%	370.1%	252.2%	183.2%
Footwear	116.6%	230.2%	67.1%	111.6%	291.9%	135.2%
Wood	68.3%	79.2%	118.7%	114.6%	348.3%	124.6%
Furniture	115.8%	212.3%	145.5%	98.5%	289.6%	164.8%
Paper	52.2%	59.5%	92.7%	47.9%	669.1%	141.0%
Printing	216.6%	240.9%	231.0%	330.6%	231.8%	231.5%
Other-chem	178.8%	147.9%	150.7%	141.9%	258.2%	186.5%
Rubber	13.4%	36.8%	68.3%	8.2%	25.3%	29.9%
Plastic	129.9%	154.7%	217.6%	196.8%	1126.0%	334.9%
Nonmetal	60.8%	131.6%	12.4%	16.5%	53.1%	33.5%
Fabric. metal	59.2%	229.2%	201.2%	0.0%	28.6%	92.7%
total	89.7%	142.1%	87.9%	43.4%	96.0%	88.0%

Generally, the ratio did not reveal a consistent pattern overtime. On the average, however, TFP in the private sector is higher than that of the public sector (since the geometric average of the ratio of TFP in the public sector to that of the private for the period 1976-1995 was 0.88). This implies then that the combined inputs in the private sector are more productive than that of the public. Of course, there used to be sub-sectoral and temporal variations. While in the late 1970's the public sector was more productive than the private, it appeared different for the late 70's and 80's. In fact, the public sector was highly affected during 1991 and 1992. As well, ownership was observed to affect the productive content of inputs. Wearing apparel, tanneries and footwear, wood and furniture and the plastic sector had become more productive in the public sector than that of the private.

Recently, especially in 1995, the situation apparently changed; it is only for 4 sub-sectors (textile, rubber, non-metallic mineral products and fabricated metal) that the private sector TFP is better than that of public but not for others. This happened despite the set up of enabling environments favouring the private sector.

Regarding the rate of technical progress, measured by the geometric annual average rate of TFPG (semi-log time trend), the difference between private and public (as can be seen in Table 19) becomes clear. While the public sector registered a technical regress of 4.35% per annum, the private sector assumes no progress or regress; its coefficient (-0.31%) becomes significantly not different from zero. These ownership differences are observed across sub-sectors, in most cases, the private sector registering a good record. But the difference did not produce a systematic pattern, in a sense that the private sector did not produce consistently a better result in all sub-sectors. For instance, while technical progress is positive in the public tanneries and leather finishing sector, the private sector produces rather no trend.

Table 19
Rate of Technical Progress by Ownership and by Sub-Sectors

Sub-sectors	Public	Private
Food	0.0070583*	0.0010894*
Beverages	-0.040628	-0.079167
Textile	-0.094499	-0.040168
Wearing app.	0.03542*	-0.08749
Tanneries	0.057048	0.019797*
Footwear	-0.039488	-0.065817
Wood	0.023646*	-0.0060548*
Furniture	-0.000507*	0.008423*
Paper	.080495*	0.016012*
Printing	.0065772*	-0.0073772*
Other-chem	0.0020798*	-0.015624*
Rubber	-0.10088	-0.10069
Plastic	0.058404	0.0015587*
Nonmetal	-0.051458	0.040705
Fabricated metal	-0.11655	0.019102*
total	-0.043509	-0.0031156*

* Statistically insignificant even at 10% significance level.

An econometric estimate of a Cobb-Douglas function for each group (public and private) supports the above result - a good record of the private sector with respect to rate of technical progress though some coefficients are unjustifiable. Rate of technical regress in the public sector (17.94%) is by far higher than technical regress registered by the private sector (1.6%).

To assure ownership differences in the rate of technical progress, both panel data set and F-test is applied in the way applied above. Equation 5.1 is estimated by attaching ownership specific dummy variables that handle both ownership effects and autonomous growth. The result, adjusted for autocorrelation, is provided in Table 20.

The coefficient of T_1 represents the rate of technical progress of the public sector while that of T_2 is the private sector. The result again implies that technical regress is not identical in both groups (higher in the public sector - 6% per annum). The coefficient for T_2 is not statistically significant even at 10% level while that of T_1 is significant. F-ratio (the test for the hypothesis that rate of technical progress is identical to both groups) becomes 28.9 which rejects the hypothesis. This confirms difference in the rate of technical progress due to ownership.

Table 20
Estimates of Cobb-Douglas function and equation 5.1

Regressor	coefficients	T-ratio	F-ratio	R^2	D.W
PUBLIC					
LnW	2.5893	8.6342	44.59	87.3	
LnK	0.59312	2.2127			
con	-24.5111	-4.8616			
T	-0.17944	-5.4348			
PRIVATE					
LnW	1.2317	6.8405	78.12	92.4	1.5339
LnK	0.35822	6.3677			
con	-5.2004	-3.433			
T	-0.015983	-2.4637			
EQUAT. 5.1					
LnW	1.0742	11.086	690.12	99.26	1.9642
LnK	0.2624	3.3284			
con	-2.759	-5.7713			
T_1	-0.06	-7.0066			
T_2	-0.008	-1.5709			

5.3. CAUSES FOR DIFFERENCES

Difference in the rate of technical progress across sub-sectors has been demonstrated. Rate of technical progress appeared to vary among sub-sectors, between ownership and across time in the Ethiopian manufacturing sector. Whether this difference has real causes has yet to be examined.

Intuitively, sub-sectors are not supposed to have identical strategies, strengths and weaknesses or opportunities and treats. This is so because the technology, the market, the extent of import intensity, the rate of protection, the industrial structure (extent of concentration), the incentive structure and the accumulated experience are different. As a result, the productive content of inputs will differ across time, among sub-sectors and between ownership. How much do these variables explain the outcomes of the Ethiopian manufacturing sector is a pertinent question.

Important variables that determine differences in the rate of technical progress across sub-sectors are identified to be technique of production, import intensity, effective rate of protection, market structure, size structure, incentives and experiences. To shed some light on factors that causes differences, a model is formulated that specifies TFP as a function of these variables as follows:

$$A_{it}=a_0+a_1q_{it}+a_2L_{it}+a_3K_{it}+a_4S_{it}+a_5M_{it}+a_6W_{it}+a_7I_{it}+a_8D+u_{it}\ldots(5.3)$$

where A =TFP, q= capital-labour ratio, L= the ratio of payment to production workers to non-production workers, K = the ratio of machinery and equipment to building and infrastructure, S= the ratio of number of enterprises with less than 50 employee to the total in that particular sector, M = the ratio of imported raw materials to total raw material consumed, W= average wage per annum, I = average incentive payments per annum and D= dummy variable for light and heavy industries.

Capital-labour ratio is included as a variable to represent production techniques which has a strong correlation with level of technology. A modern production technique generally appears to be more productive with high quality products; and, at the same time, will be capital intensive. Hence, high K/L is associated with high value-added and high TFP. Then, differences in technological level would lead to differences in TFP positively. A negative relation, however, could not necessarily be wrong. High K/L could imply high value of fixed assets and high share of capital from value-added which could cause the cost to outweigh its impact on value-added.

The composition of non-production to production workers as well as the composition of equipment and machinery to building and other infrastructures is considered as a variable to reflect the "intensity of technology" as mentioned in the previous chapter. The higher these ratios, the higher will be the "intensity of technology" and hence the higher factor productivity (including TFP). But their cost implication (which is a certain outcome) might outweigh the benefits thereby its effect on TFP might be neutral or negative.

Size structure could be an important variable to influence TFP. The premise here is that large scale firms enjoy economies of scale whereas small scale firms do not. Hence, a sub-sector with high composition of higher large scale enterprises will record a higher TFP. In this paper, size is classified according to the number of permanent workers counted at the end of each fiscal year.

In countries like Ethiopia where foreign exchange constraints is severe, import intensity may be an influential variable to determine the size and rate of TFPG. A firm with high import intensity, because it cannot procure as much as it needs, might frequently run below capacity which as a result undermines value-added and thereby TFP. Import intensity, in this paper, is calculated using a simple ratio of imported raw materials to total raw material consumed. Here, it shall be noted that it is not a good measure of import intensity (clearly, in the case of cement), but it is the easy way available to capture the idea.

A favourable incentive framework influences the productive content of labour given its production technique; it exerts pressure on each labour input to put all its effort, thereby push the production frontier up. In this paper, average annual wage and average annual commission, bonuses, allowances, food and lodging are considered as variables to capture the incentive mechanisms; high averages are supposed to lead to high TFP, even outweighing their cost implication. Payment system, on-job-training and industrial peace, while important to influence productivity, are not considered here due to lack of information.

Experience in production and its spill-over effects on new similar activities appears to be important to influence TFP. Learning will be higher in these activities which started earlier and whose technology is not complex. In this regard, Ethiopian industries are frequently claimed to be predominantly import-substitute, consumer type and light industries. And most of them were established in 1950's and 60's. Thus, these sectors, because of the learning and spill-over effect, might register high TFP. Then, a dummy variable is included to differentiate these sectors; only chemicals, non-mineral product and metal sectors are considered as heavy industries.

Of course, there are other variables like the effective rate of protection, the extent of oldage (the difference between value of gross and net fixed asset), sex composition of employee, educational structure, extent of on-job-training, extent of competition (concentration ratio), government policies which would cause differences, but they are not included for lack of data.

The model is estimated using a pooled data set from 19 sub-sectors each having 17-year observation. All the above variables are included as explanatory variables to identify the influential variables that cause sub-sectoral differences in the productive content of combined factor inputs[20].

The data set suffered problems of serious serial correlation (fifth order) and it is corrected using Cochrane-orcutt iterative method. The result is summarized in Table 21.

Table 21
Econometric Estimates of Equation 5.3

Regressor	coefficients	T-ratio	F-ratio	R^2	D.W
ALL					
q	-0.1153	-5.1687	28.7005	53.18	1.9762
L	-0.00273	-1.1386			
K	-0.0209	-0.665			
S	-1.2174	-2.3782			
M	2.0630	4.1959			
W	-0.00729	-0.1599			
I	0.7675	3.0918			
D	-0.60638	-2.7411			
con	1.3174	2.941			
SELECTED					
q	-0.11477	-5.1627	37.29	53.38	1.9743
S	-1.2182	-2.3869			
M	2.0679	4.2267			
I	0.69358	3.6751			
D	-0.59376	-2.6927			
con	1.2102	2.9469			

According to the result, the coefficients for "intensity of technology" and average annual wage did not appear significantly different from zero. This implies, then, that these variables are not the cause for sub-sectoral differences and hence are excluded in the estimation. The result without these variables becomes not only statistically significant (at 5% level) but also increases the over-all fitness of the model (according to the F-ratio). Five variables are identified for TFP differences and hence rate of technical progress across sub-sectors; namely, capital intensity, size structure, import intensity, incentives and the nature of industries. Because these variables differ across sub-sectors, they cause differences in TFP.

An important point to notice is the signs of their coefficients since they indicate the direction of influences. Two outcomes are surprising, then. The first is the negative relationship between TFP and K/L. Sectors with high K/L appeared to be low in TFP. The second is the positive relationship between import intensity and TFP; the more a sector is dependent on imports, the higher is its TFP. The latter one is more surprising in countries like Ethiopia where foreign exchange used to be a severe constraint causing enterprises to run below capacity. The former can simply be understood to mean that technical progress is not capital embodied whereby its cost outweighs its benefits.

The other variables appeared to assume a justifiable sign. The larger the share of small scale in the size structure, the lesser will be TFP in that sector since small scales are claimed to be less efficient than the larger ones. The same is true for incentives and experiences.

6. IMPLICATION TO PROTECTION AND SELECTIVE INTERVENTION

"Neither static Hecksher-Ohlin theory nor product cycle theories are sufficient to explain the evolution of comparative advantage. LDC producers are neither prisoners of initial factor endowments, nor mere imitator of earlier industrializers... (Herbert-Copley, 1990: 1464). The rate, pace and direction of technical progress achieved in any particular country alters factor endowments and hence the dynamic comparative advantage of that country. The implication of the results of this paper, thus, could help formulating policy environments to fine-tune the direction and movement of the dynamic comparative advantage of the country.

The implication to be drawn, however, needs some caveats, at least, in two areas: that it is based on neoclassical models and that its data base assumes some level of aggregation. Neoclassical models usually use strict and stringent assumptions: Production function, profit maximization, perfect competition, free and immediate access to information and zero transaction costs. All these assumptions are nearly untenable in the Ethiopian context. The methodology employed assumes learning as a simple function of time, whereas case studies proved that a process of technical progress does not proceed at a constant rhythm (Herbert-Copley, 1990: 1460). Furthermore, the way TFPG, an indicator of technical progress, computed does not entertain quality improvement, productivity increase in intermediate input and fluctuations in capacity utilization for factors beyond the control of the firm. Besides, technical change is measured by its impacts on productivity not by its absence or presence on the hard-ware side of production. Technical progress might occur without significant impact on productivity .

Secondly, the results arrived at and the implications rest on aggregate data (data is collected at three digit industry level). But the process of technical progress across firms will not be uni-directional which the results of this paper assumes. Heterogeneity is certain and generalization without due consideration to firm-specific characters might be misleading. Despite all these, however, the results arrived at may shed some light on the issue and tentative implications can be made.

From the results arrived at, four points are clearly observed. First, the Ethiopian manufacturing industry, regardless of its status on allocative efficiency, registered technical regress for the period 1976-1995, though the picture is quite different for sub-period 1976-1980 which by itself was caused by capacity increases, not by capacity stretching. This result indicates that there was no any technical progress produced in the Ethiopian manufacturing sector. In turn, this implies that the sector proved itself to be unlearning at least for the period under study and its efficiency in resource use did not reveal improvements; rather, it was deteriorating. Second, the nature of production technique was capital consuming and labour saving contrary to the theory of initial factor endowments. Third, sectoral difference in total productivity achievement was observed implying that learning did not occur at an equal rate across sectors. Those sectors which are light, not technologically complex and with long production experience, though not all, produced a positive technical progress. The fourth point is the importance of ownership in determining the extent of technical progress. The private sector, in general, appeared to be more effective than the public ones, though it was not across all sub-sectors and throughout the period covered by study. This puts some doubt on the motives of privatization.

These results are implying that protection alone and production experiences, (i.e., passive "doing-based" learning) is not sufficient to produce technical progress to alter the comparative advantage of the country. In turn, this implies, for Ethiopia to industrialize, a lot remains to be done by firms and the government has to make conditions fertile. This, of course, rests on the answer to the question "need Ethiopia Industrialize? Is industrialization a must?"

This question is raised because deindustrialization moves has started in Africa and the reason could be the disappointing outcomes of modern industry. In fact, if the industrial sector is becoming a net drain on the economy's resources, and if shifting resources from industry to other activities enhances growth, then the move may make some sense.

As a matter of fact, Ethiopia should industrialize. Industrial development alleviates poverty, increases welfare, attains economic diversity and stability. Industrialization becomes evident when one considers the fluctuating and persistently deteriorating prices of primary products vis-a-vis industrial products on world markets and the fixed nature of land and its low productivity with population pressure. Lall argued that "in nearly all economies, manufacturing industry has been the critical agent of the structural transformation that marks the transition from a primitive low productivity, low income state to one that is dynamic, sustained and diversified (Lall, 1992:105). Cornia et al, as well, said, "the history and experience of developed and developing countries alike show clearly that the process of change from a low income, low-productivity economy based on traditional agriculture and some manufacturing to one utilizing highly productive modern technologies nearly always requires a sustained period of industrial expansion" (Cornia et al, 1992: 210). The work of Chenery et al (1986) convincingly demonstrates that, too.

The issue shall only be then what sorts of industries it should set up, at what pace and what other actions it should take. The action should revolve around acquisition of technological[21] capability by firms and it should include the capacity to enhance technical progress in every firm.

Unlike the neoclassical view of technology as set of "blueprints" readily available to be used by technology importers, empirical evidence started to reveal different characteristics of technology that it is tacit, that its imitation is not trivial in the sense that it demands considerable effort on the part of imitating firm, and that production experience is crucial (Herbert-copley, 1990: 1459). This has implications. First, accumulation of technological capabilities is not automatic outcome of production experience though it is important. Second, learning does not occur in all firms. Third, the process of technical change is irregular both in its rhythm and direction.

These correspond to the results arrived at in Ethiopia, too. Learning is not automatic, and hence no technical progress was registered in the manufacturing sector; technical progress does not occur in all firms, and that is why tobacco, leather and printing sub-sectors recorded a technical progress while others did not; technical progress does not have a constant rhythm and that is why high TFPG was registered in 1976-80 in contrast to other periods.

Given these stylized facts, the outcomes in the Ethiopian manufacturing sector shall not be frustrating since it happened almost everywhere; and it only tells us that the right policy measures were not in place, which in turn alerts both firms and government to further put an effort to attain a reasonable rate of technical progress. The firm should insist on building the necessary technological capabilities and the government should create a conducive environment by installing the appropriate public goods, incentives and institutions.

6.1. FIRM LEVEL EFFORTS

The premise here is that "technological knowledge is not shared equally among firms, nor is it easily imitated by or transformed across firms... Transfer necessarily requires learning" (Lall, 1992:160). As a result, acquiring technological knowledge required firstly experience in production and secondly investment on learning and those firms with these elements produce the required capability. Raut reported, " ... while knowledge from private R & D capital spills over to create public domain knowledge, a firm must invest in private R & D to acquire the technical capability needed to make use of the public domain knowledge to enhance productivity" (Raut, 1995: 2). Utilizing public domain knowledge fruitfully has costs, but the cost will be minimal for those firms which have accumulated the stock of technological knowledge through considerable investment in R & D in the past (Raut, 1995).

This process is the deliberate effort of the firm to adapt technology to new conditions, to improve it slightly or very significantly, and this process might pass through three stages of capability: Production, investment and innovation (Lall, 1992; Dahlman et al, 1987). Production capability includes production management - ability to oversee and improve operations; production engineering - ability to obtain information (about systems of raw material control, production scheduling, quality control) and act to optimize Operations; trouble-shooting to overcome problems and adapting process and products to increase productivity; repair and maintenance of physical capital. These capabilities can be gained from gathering and interpreting information from the production system, from attempting adaptations and modifications, from understanding why some work and others do not, and from keeping records to preserve such information. And it entails a continuous systematic efforts and resources; it shall not just happen when shocked by changes in inputs or production markets. The process may take up to 20 years to acquire its full range (Dahlman et al, 1987: 764-765; Lall, 1992: 168-169).

Investment capabilities include the skills needed to identify, prepare, obtain technology for design, construct, equip, staff and commission an expansion which determines the capital cost, the appropriateness of the scale, product mix, technology and equipment selected which in turn affects the efficiency with which it will operate (Lall, 1992:168). Innovation capability consists of major and minor innovations including improvements in existing technology; and, acquiring the former two capabilities is the main impetus to develop some capabilities in innovation. These capabilities are important for diversification and change and every firm has to give due respect for efforts to attain these capabilities. A firm that fails to achieve these capabilities will fail to survive. Lall argued

> if a firm is unable by itself to decide on its investment plans or selection of equipment, process, or to reach minimum levels of operating efficiency, quality control, equipment maintenance or cost improvement, or to adapt its product designs to changing market condition, or to establish effective linkages with reliable supplies, it is **UNLIKELY** to be able to compete effectively in open markets (Lall, 1992: 168)

The pace of acquiring these capabilities by firms, however, depends on the level of development in which the economy is in, physical and human capital development, national technological efforts, incentives, institutions, government policies, etc, which are not the domain of individual firms, but the environment which it is supposed to live with.

6.2. GOVERNMENT EFFORTS

Firm level technical capabilities can be acquired only if there are sufficient entrepreneurial capabilities, deep industrial experiences, proper incentives and adequate institutions. And the government has to provide all these in sufficient magnitude.

6.2.1. DEVELOPING CAPABILITIES

These capabilities include the launching of physical investment, the provision of human capital and the undertaking of technological efforts . Lall reported that "these three are strongly interlinked in ways that make it difficult to identify their separate contributions to national performance, but they do not always go together" (Lall, 1992:170). One without the other will not exert a sufficient impact, or the existence of one does not necessarily bring into existence of the other. Of course, physical investment is a pre-requisite: for industry to exist, plants and equipment are necessary. The undertaking of physical investment in Ethiopia was hindered by lack of the domestic investment capabilities which in turn is caused by lack of entrepreneurial capability. The extent to which the private sector participates and the experience on industrial activities would have been important to enforce the development of entrepreneurial capabilities.

The size of the informal sector might give an impression that there is no shortage of entrepreneurial drive. But the drive to profit from opportunity might not *per se* be the same as the entrepreneurial capability required to organize, set up and run modern industry, which requires larger scales, longer time perspectives, more advanced technologies and more complex organizations than traditional crafts or informal sector activities (Lall, 1992: 116). They rather favour rent seeking and trade activities which produces quick returns. The other point is that the private sector was stifled by wrong economic policy for about two decades that impedes to produce its impact on physical investment.

Three facts are revealed in the study. First, rate of TFPG on average is better in private than public; second, rate of TFPG has been declining in the period under study where the private sector was deliberately stifled; third, TFP tends to vary positively to scales since TFP is low in sectors where the composition of small scale enterprises (less than 50 employees) is high. If such is the case, entrepreneurial development would have then improved the rate of TFPG and hence industrialization, first by increasing physical investment, second by increasing efficiency of physical capital and third, by raising the scale of activities to those which favours high rate of TFPG.

Now, the move is already on progress in Ethiopia but efforts should continue to be made further by the government to increase the participation of the private sector (not necessarily through privatization) and the process of learning entrepreneurial capabilities. This entails commitment beyond installing a favourable environment especially in identifying basic barriers to industrial entrepreneurial capability and initiating selective intervention on industrial activities.

The other important element that government should focus is upon education and training. Its primary importance is its impact on entrepreneurial capability; a person with high level formal education is better placed to adapt, understand, learn, use and create ideas. Entering into more demanding activities calls for increasing level and technical specialization in education. Quality of education and its technical orientation (vocational training) is quite important which currently Ethiopia lacks. Firm level training is crucial and efforts made at the firm level to create skills and train workers could make a difference on TFP but firms usually are reluctant to invest on training. Regarding the importance of in-firm training and the role of government in providing it, Lall said

> Since there is a serious risk of private underinvestment in training at the firm level when labour is mobile, (which is important to the diffusion of knowledge), human capital development requires measures to induce more investment to support employee training, by firms individually or collectively, or by governments where private agents consistently underinvests. These measures may be functional, applied to all activities, or they may be selective, targeting emerging sectors (Lall, 1992:181).

As to what measures to be taken, when and to what extent, it shall depend on individual cases.

Even if labour is trained and physical investment is made, these will only be productive when combined with technological efforts made by the government to guide firm level efforts and fill the gap, if there are gaps.

6.2.2. INCENTIVES

Incentives determine the efficiency with which capabilities are used. It affects the pace of accumulation of capital and skills; the type of capital purchased and the kinds of skills learned: and the extent to which existing endowments are exploited in production (Lall, 1992: 171).

Competition is the mechanism. Competition (domestic and import) would make price to reflect the relative scarcity of inputs used as well as the demand and cost of supplying the goods and services to be produced provided that there are no both product and factor market failures. But failures are likely in labour, human capital, capital, finance and product markets (World Bank, 1992:26-27). As a result, government has to intervene either to overcome market failure or to give promotional supports.

Where market fails and enterprises underinvest, government should intervene so that enterprises internalize markets (for example, provide self-financing or subsidize training of workers) and to overcome the failures directly by providing finance (loans venture financing, R & D subsidies, etc) to enterprises. This intervention could be functional as well as selective, but in countries like Ethiopia where resources are limited, selective intervention will be dominant in order to selectively promote activities which have greater linkages and externalities and that generate positive spill over effects, thereby produce the required capabilities sooner given the limited resources.

It is not only market failures but also, in countries like Ethiopia, structural problems need the attention of the government; the production structure might give not only a wrong or irrelevant signal to price but also might not be totally responsive to prices at all. In this setting, "getting-price-right" would lead a country with severe structural bottlenecks nowhere on the ladder of technological capabilities. The government has thus to intervene especially to protect or promote until some level of structural transformation is assumed.

But, as Lall said, high level of intervention can frustrate or dissipate the development of healthy capabilities and prop up unviable enterprises that should die out (Lall. 1992:171); an optimum level has to be searched out.

Moreover, though acquisition of technological capabilities require inward-looking trade policies, the dichotomy between inward and outward orientedness is irrelevant. In the first place, they are not mutually exclusive, they rather are complementary. Secondly, two of them can be used in phases, inward-oriented as a pre-requisite until the domestic economy becomes price-responsive. Or they can be used jointly, outward-looking for established industries and inward-looking for infant industries. There is already an empirical evidence for that. All newly industrializing countries went through import-substitution phase before turning to export-orientedness (Hellinier, 1986; Pack & Westphal, 1986; Fransman, 1984).

What is relevant is not the dichotomy between being inward- and outward-looking, as both are important to bring about technological capability and technical progress sooner. A period of protected import substitution is useful - perhaps even necessary - to build a base for launching successful export drive with associated positive rate of TFPG; opening up to international competition, as well, is essential to spur increases in domestic efficiency; export promotion is good and so is import liberalization to produce technical progress (Nishimizu & Robinson, 1986: 283). What matter most is combining them together fruitfully.

More relevant is identifying the appropriate duration of protection or promotion policies, deciding whether the duration should be uniform across industries or whether it should differ from industry to industry. And if there should be a differences, which sectors should get priority.

Industrial activities differ in their technological, organizational and linkage characteristics and so may have different learning periods and costs (The World Bank, 1992:29). Hence, the duration of protection and promotion should be different accordingly.

To define the duration and to select a priority sector, though there is no rule, the rate of TFPG (the extent of learning) can be a guideline: "Input per unit of output must fall more rapidly in more protected industries if there is to be any rationale for infant industry protection" (Nishimizu & Robinson, 1986:307).

One always should note that technological capabilities may be enhanced under conditions of protection, nevertheless, it does not necessarily follow that protection is always needed for the development of technological capability or that the granting of protection will be followed by improved technological capability (Fransman, 1984:21). Thus, there is a need always to contain the cost of protection or subsidy by introducing limits and safeguards through selectivity and flexibility. In this regard, it is said that "the best combination may be the selective and temporary protection of domestic markets, together with strong incentives for export activity and domestic competition" (Lall, 1992: 172).

It is this direction that the Ethiopian industrial strategy should follow. Industrialization is a must neither to regret nor to ignore. But the industrialization process should generate the domestic benefits or the exchange earning capacity soon to sustain its growth.

In line with this, the government of Ethiopia has taken trade policy reforms. The reform has reduced the extent of protection in most firms; and interfirm variations of protection rate has decreased (Abraham, 1995). Most enterprises are exposed to competition both from domestic (by encouraging private investment which was stifled deliberately) and imports (by liberalizing trade). The move is in the right direction but gross and indiscriminately. Quoting Lall (1992: 125) here is appropriate.

> Given the inherent costs and duration involved in building up capabilities in new, complex industrial activities, and given the differences between technologies, there is no reason to argue that all industries should be protected equally... More difficult technologies call for higher protection, and activities which have high linkages with others call for broader protection to embrace related industries which are also undergoing learning. Similarly, activities that generate higher externalities need more support because investors cannot appropriate all the benefits.

Competition is necessary but it is a double-edged weapon. Too much competition can wipe out firms that cannot finance the costs of capability acquisition. Thus, the adjustment in Ethiopia must be selective and armed with considerable information. Sectors must be identified and these sectors (the selected one) must have a good record on allocative efficiency and rate of TFPG. For instance, four sectors (tobacco, tanneries, plastic and paper) in Ethiopia produced a positive and high rate of TFPG in the period under study. After analyzing their respective allocative efficiency, it seems reasonable to make a move in these sectors to exploit the comparative advantage by initiating export promotion schemes. Otherwise, the reform might not be a rewarding effort.

6.2.3. INSTITUTIONS

Both incentives and capabilities operate within an institutional framework and these institutions - those entities established to facilitate the working of markets - sets rules. Institutional deficiencies are the main causes of inefficiency and underinvestment. Thus, the development of institutions that facilitates technological capabilities and industrialization requires due consideration in industrial policy formulation and implementation.

Institutions are important in the provision of finance, information, services, standards, expert assistance, etc. Successful industrialization entails building systematically institutions to support or supplant market forces.

There must be industrial institutions to promote interfirm linkages in production, technology or training, to provide support to smaller enterprises, to help firms to restructure and update. There must be technological institutions to remedy market failures especially in the area of information on sources of technology since technological information does not exist everywhere; nor are the international markets competitive.

Ethiopia, as well, lacks supportive institutions; even if there are some, they are either poorly staffed and managed or engulfed with conflicting objectives or starved of funds or stranded by bureaucracy and policies.

In Ethiopia, no institutions are set up to supply information about technology or markets while selecting appropriate technology - technology that is easy to adapt, assimilate and change to local conditions - rests upon information and the ability to use that information effectively. Because information, by its character, is a public good and characterized by large economies of scale in collecting and organizing information, the private actor underinvest on it since they cannot appropriate all the benefits of their activity. This justifies the need for the government to subsidize the collection and dissemination of technological information or set up such institutions and provide to those in need of at affordable charges.

In Ethiopia, interlinkages between large and small firms are absent, and still are not facilitated by appropriate institutional assistance to potential small suppliers or subcontractors. And there are strong arguments for sub-contracting both for efficiency of large ones and expansion of small scale activities (Schmitz, 1982; Anderson, 1982; Kashyap, 1988).

Supportive institutions are not adequate in Ethiopia, as well, for physical investment to grow faster and capabilities to expand. While "directed credit" is necessary to make sectoral preferences (through subsidized interest rate and easy access to credit) to shift the structure of the economy towards the productive sector which is more liable to generate spillover effects, no such schemes is practiced. Due to lack of collateral, but mainly due to failures on financial markets, good investments might not receive finance while some bad ones do. Creating specialized institutions, like Small Business Administration of USA, could finance industrial entrepreneurs stranded by these problems. Having such institutions not only help to increase capability but also improve incentives by encouraging domestic competition.

Setting up industrial estates and export processing zones in Ethiopia in which capabilities and industrialization is at a stage of infancy could be an institutional mechanism to selectively intervene in order to overcome infrastructural, information and service deficiencies. Export processing zone helps to meet the requirements of legal and regulatory environment favourable to entrepreneurs and exports. Industrial estates not only reduces the entrepreneurs' investment costs but also provides basic infrastructures and industrial services which the market cannot supply and which are real bottlenecks to entrepreneurs to invest. Installing these institutions invite capability development.

Of course, installing institutions is not sufficient, incentives and capabilities, and most imperatively, good governance is necessary for its effectiveness.

7. CONCLUSION

Resources available for industrial growth in Ethiopia are limited and the prevailing conditions (saving, investment, purchasing power, debt, stability, etc.) are not conducive for resources to be accumulated at extensive scale. Industrial growth therefore depends more on improved productivity and efficiency in resource use. This itself would be possible only if efforts are exerted to produce technical progress.

Acquisition of the technical progress calls for building up the capacity to search for and select technologies for use in particular environments; operate, assimilate, adapt and modify processes and products in the light of the prevailing conditions and producing minor or more substantial innovations. In turn, the extent and intensity of building up these activities in any economy influences the magnitude and pace of industrialization. In a nutshell, the process of acquiring technical progress is at the same time the process of industrial development.

Three stylized facts have already emerged on the link between technical progress and industrialization. The first is high contribution of technical progress to output growth. Secondly, the rate of technical progress is higher in industrialized economies than that of developing countries. Thirdly, rate of technical progress increases as a developing economy enters into a further stage of industrialization. Thus, developing economies have to ensure that the capacity to generate technical progress has taken place in their industrialization process.

Given its importance in the process of industrialization, a close scrutiny whether technical progress is built in the Ethiopian manufacturing sector becomes imperative. For this purpose, different statistical and econometric models are employed. Four points are clearly observed in this effort:

Firstly, the Ethiopian manufacturing sector, regardless of its state of allocative efficiency, registered a negative technical progress for the period 1976-1995, though there was a positive technical progress for the sub-period 1976-1980 which by itself was caused by capacity increases. This result indicates that there was no any technical progress generated in the sector.

This, in turn, implies that the sector proved itself to be unlearning and the efficiency in resource use did not reveal improvements; rather it was deteriorating.

Secondly, the production technique, in general, was capital consuming and labour saving contrary to the theory of initial factor endowments.

Thirdly, sub-sectoral differences in the rate of technical progress was real. Those sectors which are light, not technologically complex and with long production experience, though not all, produced a positive technical progress while others do not.

Finally, the importance of ownership in determining the extent of technical progress was clearly observed. The private sector, in general, appeared to be more effective in resource use than the public ones, though it was not across all sub-sectors and through all the years under study.

These results imply, for Ethiopia to industrialize, serious actions have to be taken by firms and the government has to make conditions fertile. These actions should revolve around the capacity to generate technical progress in every firm.

Firms should insist building the necessary technological and managerial capabilities by putting every effort to adapt and assimilate technology to new conditions and to improve it. This requires investment since technological knowledge can not be easily imitated, transferred or modified.

Parallel with this, the government should create the conducive environment by installing the appropriate public goods, incentives and institutions. The government should give due attentions to those activities that are usually underinvested by the private sector. These activities include launching physical investment, developing human capital and undertaking technological efforts.

Since incentives determine the efficiency with which capabilities are used, affect the pace of accumulation of resources, influence the type of capital purchased and the kinds of learning, and determine the extent to which existing endowments are exploited in production, it should be given due consideration by government. More importantly, as long as acquisition of technological capabilities requires inward-oriented trade policies, the government has to intervene by initiating these policies.

But high level of intervention might frustrate or dissipate the development of healthy capabilities and prop up unviable enterprises that should die out. Thus, there is a need to contain the costs of protection or subsidy by introducing limits and safeguards through selectivity and flexibility. Sectors must be selected, the appropriate duration of infant industry protection or promotion has to be specified and the gauge to evaluate performance should be defined.

Installing the right incentives are necessary, nevertheless without institutions, the ability to respond to incentives is bound to be very limited. Thus, building institutions which facilitate the working of the markets are necessary. There must be industrial institutions to promote interfirm linkages in production, technology or training, to provide support to smaller enterprises, help firms to restructure themselves and overcome infrastructural, information and service deficiencies.

Nevetheless, installing institutions alone is not sufficient, incentives and capabilities should also be built in; one without the other will not produce the required effect.

ENDNOTES

1. According to Chenery and Syquin, common features of industrialization are shifts in domestic demand (fall in the share of food consumption, rise in investment, rise in nonfood and government consumption), the growing intermediate use of industrial products, and the transformation of comparative advantage as factor proportions change (Chenery et al, 1986:54). For Sutcliffe, industrialization is a process to structural transformation in which industry contributes 25 percent of GDP, of which at least 60 percent emanates from manufacturing, and employs 10 percent of total population (Sutcliffe, 1971: 18).

2. Sometimes the latter two are used interchangeably though they convey different meanings: trade liberalization is an episode of trade policy with no trade bias while EPI strategy tends to be export biased (Helliener, 1986).

3. Some of the arguments for ISI are:
Infant Industry Argument: Developing countries would not have comparative advantage if they have no experience of producing the goods. As a result, they do not compete in the world market. Importing will be easier than domestic production. If no protection is provided by the government, the firm would fail. Hence, till it becomes competitive fully and efficiently in the world market, protecting the infant industries through various protection measures would be crucial.

The infant industry argument connects efficiency to both scale and time. With respect to the former, it is after attaining a critical minimum size which requires time and experience that a firm begins to operate more efficiently than is otherwise possible. The time consideration is the one that is usually given more attention, the argument being that as a result of learning by doing, domestic industries will, in due time, overcome their initial cost disadvantage and reach a stage where they can produce competitively. (Eshetu, 1968; Sutcliffe, 1971; Schmitz, 1984).

Foreign Exchange Argument: By keeping out a substantial portion of hitherto imported commodities, a country saves foreign exchange which can be used for the importation of capital goods. Foreign exchange previously spent on imports will be available for other uses, since the goods are produced domestically now.

Linkage and Externalities Argument: A policy of protection generates linkage effects. The establishment of a firm locally stimulate the production of inputs and provide a stimulus to the creation of activities that use the output of newly established industry as inputs. Besides, there will be an income linkage effect - i.e., new incomes will be created which may enlarge the market for a number of additional final demand goods to the point where their domestic production becomes, in turn, feasible. As well, domestic production make possible such benefits as the training of an indigenous labour force and technological improvements - benefits which would not be accrued without domestic production of the goods in question. New industries may also result in external economies that involve lower unit costs for already existing industries.

Saving Argument: Protection generates saving and makes possible a higher rate of investment. The argument goes as follows. Behind import controls the domestic manufacturer can obtain high prices for goods even of inferior quality, thereby earning high profits that can be saved and reinvested. This turns the terms of trade against agriculture to create the savings for industrial growth. Eventually, agriculture too will benefit as industrial progress reduces costs and prices and offers higher productivity employment to rural labour.

Strategic Argument: This is rather a weak argument, since it does not apply for developing countries. The argument rests up on the potential "strategic" role of government action in shifting the terms of competition to the benefit of domestic firms. A case in point is export subsidies. A pre-announced export subsidy, by inducing foreign firms to produce less, can raise the profits of domestic firms by much more than the amount of the subsidy (Krugman, 1993).

4. More specifically, Schmitz (1984: 3) put the disenchantment with protection as follows:

Intrinsic Problems of Government Interference: Excessive administrative regulations gave rise to bureaucratization, corruption, uncertainty and delays and thus discourages productive private initiatives.

Bias Against Exports: The existence of import restrictions led to a higher exchange rate than would have prevailed under a free trade regime, reducing the relative gains obtained from exporting.

Bias Against Agriculture: The protection of local industry raised the prices of manufacturing goods relative to agricultural products in the home market and the over valued exchange rate reduced the domestic currency receipts from agricultural exports.

Under-Utilization of Installed Capacity: Since import controls did not equally apply to capital goods and since credit for installing machinery was relatively cheap, factories were over-equipped. Moreover, protection in product markets made it possible to earn good profits even at low capacity utilization.

Import-Intensity: While the importation of consumer goods can be reduced substantially, this is achieved at the expense of increased imports of equipment and materials, resulting - contrary to expectations - in an even more rigid dependence on foreign supplies and renewed foreign exchange crises.

Under-Utilization of Labour: Capital goods can be obtained relatively cheaply due to the combined effect of over-valued exchange rates, low import restrictions for such goods and subsidized financing conditions, resulting in a bias against employment of labour.

Slowing Down: Although initially industry can grow faster than domestic demand for manufactures, developing countries soon run out of import substitution possibilities. After that growth rates can only be maintained by a growth in domestic demand or in exports; but by then the structure and inefficiency of industry stand on the way of conquering export markets.

5. Moreover, from (3.5), assuming a neutral technical progress, time can be factored out in order to write it as:

$$Q = A(t)\ F[K, L] \ldots\ldots\ (3.14)$$

A(t) measures the cumulative effect of shifts over time (see Solow, 1957, P.312). And it is easy to arrive at

$$\frac{dQ}{Q} = \frac{dA}{A} + a\frac{dL}{L} + b\frac{dK}{K} \ldots\ldots\ldots\ (3.15)$$

where a and b are the relative shares of capital and labour . If one takes the total differential of equation 3.14 with respect to time, it will be

$$\frac{dQ}{dt} = \frac{dA}{dt}F(k, L) + A\frac{\partial F}{\partial L}\frac{dL}{dt} + A\frac{\partial F}{\partial K}\frac{dK}{dt} \ldots\ (3.16)$$

If the whole expression is divided by Q, it turns out to be

$$\frac{1}{Q}\frac{dQ}{dt} = \frac{1}{Q}\frac{dA}{dt}F(k, L) + \frac{A}{Q}\frac{\partial F}{\partial L}\frac{dL}{dt} + \frac{A}{Q}\frac{\partial F}{\partial K}\frac{dK}{dt} \ldots\ (3.17)$$

After simplifying the first term of the right side expression, it will take the form

$$\frac{1}{Q}\frac{dQ}{dt} = \frac{dA}{Adt} + \frac{A}{Q}\frac{\partial F}{\partial L}\frac{dL}{dt} + \frac{A}{Q}\frac{\partial F}{\partial K}\frac{dK}{dt} \ldots\ (3.18)$$

Since

$$A\frac{\partial F}{\partial L} = \frac{\partial Q}{\partial L} \ldots\ (3.19)$$

and

$$A\frac{\partial F}{\partial K}=\frac{\partial Q}{\partial K}\ldots(3.20)$$

and assuming dt = 1, the above expression will be

$$\frac{dQ}{Q}=\frac{dA}{A}+\frac{\partial Q}{\partial L}\frac{dL}{Q}+\frac{\partial Q}{\partial K}\frac{dK}{Q}\ldots(3.21)$$

Multiplying the last two terms by L/L and K/K respectively, the expression will take the form

$$\frac{dQ}{Q}=\frac{dA}{A}+\frac{\partial Q}{\partial L}\frac{L}{Q}\frac{dL}{L}+\frac{\partial Q}{\partial K}\frac{k}{Q}\frac{dK}{K}\ldots(3.22)$$

Defining a and b to be labour and capital elasticity of output respectively, i.e.,

$$a=\frac{\partial Q}{\partial L}\frac{L}{Q}\ldots(3.23)$$

and

$$b=\frac{\partial Q}{\partial K}\frac{K}{Q}\ldots(3.24)$$

and through substitution one can arrive at equation 3.15.

6. Arithmetic average (the arithmetic mean of factor shares within the period) assumes a constant factor elasticity of output, a Hick's neutral technical progress and a non-variable elasticity of substitution among factors. The approach gives room for factor shares to vary overtime unsystematically (it implicitly assumes a zero mean and constant variance of the variation) so that the average become a representative. Its drawback is that it could easily be influenced by outlier (specially by influential extreme values). This could mostly be the case in the Ethiopian manufacturing industries in which the correlation between in capacity utilization and labour employed is insignificant due to lack of power to fire-and-hire. Geometric average (the geometric mean of factor shares) during the period has the same characteristic as that of the average with a special advantage on reducing the influence of the extreme values.
The initial share, i.e. labour and capital shares to value-added at the initial period assumes a deterministic nature of factor shares which does not vary overtime whatever is the environment (the case of stationary process with a mean of its initial value). Year-by-year factor shares is quite the opposite of the others; elasticities are variable and technical progress is non-neutral and could be embodied, as well.

7. These formula are:-

a) Simple arithmetic growth rate:

$$i)\ r=\frac{1}{n-1}\sum\left(\frac{yt+1}{yt}-1\right)x\ 100\ldots\ldots(1)$$

This formula uses all information. But it is highly affected by extreme values.

$$ii)\ r=\frac{1}{n}\left(\frac{Y_t}{Y_o}-1\right)\times 100\ldots\ldots\ldots(2)$$

This formula considers only two end values. It is not affected whatever happened in between. As a result, it heavily depends on the values on the two end values.

b) Compound growth rate:

$$i) \quad r = \frac{1}{n} Ln \frac{Y_n}{Y_o} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

It only considers two end values and it basically assumes a continuous process:

$$ii) r = antilog[\frac{1}{n} \log (\frac{Y_n}{Y_o})] - 1 \times 100 \ldots\ldots\ldots (4)$$

It considers only two end values, but it is a discrete case.

c) Econometric estimates: This is regressing a trend function taking time as an explanatory variable and then computing the growth rate.

$$i) LnY = LnA_o + rt \ldots\ldots\ldots\ldots (5)$$

It is for continuous cases and it uses all information.

$$ii) \log Y = Log A_o + [\log(1+r)]t \ldots\ldots (6)$$

It is for discrete cases.

8. Given

$$Q = A_o e^{mt} L^a K^b$$

Divide it by L. It will be

$$\frac{Q}{L} = A_o e^{mt} \frac{L^a K^b}{L^b L^{(1-b)}}$$

or

$$\frac{Q}{L} = A_o e^{mt} (\frac{K}{L})^b L^{(a+b-1)}$$

Transforming to logarithms, it will take the form
Log Q/L=Log A_o + mt + b Log (K/L)+(a+b-1)L. If a+b-1<0, it implies decreasing returns to scale. Otherwise, it is increasing returns to scale if a+b-1>0 or constant returns to scale if a+b-1=0.

9. Net output is value-added - the value which is added to the materials which are brought-in. It is the difference between gross value of production and the value of brought-in materials.

10. `Output should avoid double counting' shall be understood in the way described below. Take two firms, A and B, both belong to the same industrial classification and one being the supplier of inputs such as flour mills and bakeries. Let the value of goods produced in A (the input supplier) and B (the input receiver) be 30 and 50 respectively. There would be then double counting if the values of goods produced by each firm is added to give the figure of the industrial group. If new values added by each firm is summed up to give the aggregate figure, the problem of double counting will be avoided; i.e., 30 (contribution of firm A) plus 20 (contribution of firm B) would equal to 50 (the value of goods produced). M. S. Silver said "the output of establishments, say car lights, when brought-in by another establishment, a care manufacture, is not double counting when net output is utilized" (Silver,1984: 5).

11. But questions like:

- Is it possible to identify the relevant expenditures made for skill formation?
- Even if it is identified, is that skill differential the only cause for an hour productive content differential of labour? What about differences in sex, age, natural ability, environment, etc.,
- To what extent is the contribution of formal education to skill? Is there concrete evidence?
- To what extent is the analogy between physical capital and skill so as to group them in the same category?
- How are institutional factors (labour union, minimum wage legislation and market imperfections) handled if relative earning are to be utilized as weights?
- Would relative earnings really match with relative marginal productivities? Would it imply that different professions, say a medical doctor and an engineer, because they earn similar salaries are substitutable?

Despite all its theoretical and practical constraints, weighted man-hour seems a more reasonable measure of labour input in production, for the reasons that:

- firstly, it properly accounts the productive services provided by each worker;
- secondly, it is the flow of services rendered during a period specified; and,
- thirdly, differences could be handled, at least for some factors, through weighing system to minimize heterogeneity of labour.

12. Mabro and Radwan limit capital only to equipments, machineries, plants and structures (Mabro & Radwan,1976:151). For Massell (1960: 183) capital consists of structures, equipments, and machineries. For Arrow and et al, capital was measured by net fixed assets (including land) plus cash and working capital but excludes financial investments(Arrow and et al,1961: 231). For Hilderbrand and Liu (1965: 133) data on capital inputs are book values of historical records of purchased of assets at original prices. And, for Tidrick, capital inputs was intended to include working capital had it not been for lack of data.

13. But, does first cost accommodate distortions due to market imperfections, difference in transport costs, concessions grants, repair and maintenance, etc., so that Q/K ratio change reflect the change of average product of real capital stock? The answer is not affirmative. Moreover, valuation at first cost could be at historic price (purchase year price) or constant price (base year price) or current price (valuation year price). If it is historic price, though it handles quality changes, it doesn't adjust to cost change; and the vice versa is true if it is constant price. To value first cost at a base year price requires information on individual prices and physical inventory of capital items which, by itself, is a problem.

14. Though the debates on coverage of capital inputs are unsettled, most frequently used data for capital inputs are what accountants call fixed asset. The estimate of fixed asset stock could be normally derived from book values which itself is derived through perpetual inventory system. But should capital stock be with or with out deprecation is debatable.

15. Moreover, the statement "probably a more direct relationship exists between changes in the technology and gross investment, for innovations are embodied in capital goods which represent not additions to the capital stock, but replacements of existing equipment" (Massell, 1960:187) would strengthen capital stock to be that of gross than net. Furthermore, because maintenance and repair, in most cases, considered as annual capital expenditure, its effects on the productive content and age of capital stocks would be neglected if capital stock is that of net. Barna noted that "... in most industries which are capital-intensive the efficiency of plant tends to increase rather than decrease with life" (Barna, 1961:91); thus, net capital stock disguises the real picture.

16. Another area of controversy is on the question of capacity utilization. Capital inputs in production should be proportional not to capital stock in existence but to capital stock in use. Adjustment for capital utilization should be made so as to take proper accounting of the services capital stock provided: machine-hours must be properly handled. But, as Massell pointed out, while we can get a reasonably good approximation to actual man-hours worked for years in which there is considerable unemployment as well as in full employment years, corresponding figures for the capital stock are not easily available (Massell; p.183). Adjustment for capital utilization is necessary; "... if variations in the number/length of shifts take place or where production is not evenly distributed over the reference period, say the seasonal demand for the product with a low or expensive storage life" (Silver, 1984:128).

Several ways of adjustment have been propounded. For instance, solow used variations in the unemployment rates of labour as a proxy. Solow, when proposing a means in favor of capital in use, stated the following:

> ... lack any reliable year-to-year measure of the utilization of capital I have simply reduced the figure on capital by the fraction of the labour and capital always suffer unemployment to the percentage. This is undoubtedly wrong, but probably gets closer to the truth than making no correction at all (Solow, 1957: 314).

Another method is to utilize fluctuations in the power of fuel usage as an indicator of capital capacity utilization. Still another method is to treat capital in terms of physical measures such as horse powers. Even then, there are problems. Is it possible to identify the rate of sectoral unemployment? Would data on power consumption and others be available accurately? Does labour laws permit the enterprises to dismiss or accept workers? The answer is negative.

17. Estimating this type of production function is not without a problem, however. In the first place, perfect competitive market, divisibility and homogeneity of output and inputs are assumptions widespreadly in use in theoretical formulation of production functions while non of these assumptions are realistic. Given this assumptions, the data are assumed to represent points on the production function, i.e., the actual figures are the optimal ones while a huge discrepancy exists between them in time-series data like this due to variation in capacity utilization at different times in point. Aggregation problem is as well prevalent. As a result, estimates tend to be biased and inconsistent.

18. The years selected are those which are the initial or terminal values or those years which represent unique characteristics in the history of the manufacturing industries - the climax year of production campaign, the beginning of the second phase of the ten year perspective plan and the end of the socialist era respectively).

19. F-ratio can be computed using the following expression.

$$F = \frac{(\sum e_R^2 - \sum e_{UR}^2)/c}{\sum e_{UR}^2/(N-K)} \quad \ldots (5.2)$$

where $\sum e_R^2$ = restricted residual sum of squares, $\sum e_{UR}^2$ = unrestricted residual sum of squares, N= number of observations, K= number of parameters estimated; and, c= number of restrictions.

20. The sources of ownership differences or the extent of these variables to influence the productive content of inputs across sub-sectors in public and private sector is not assessed. The premise for not to entertain is that, once this done, it transcends to the others.

21. Technology here should be understood as defined by Fransman (1984:9-10) that encompass every thing pertaining to the transformation of inputs into outputs which include social organization of the production and labour process, knowledge and competition. Any change of these will bring technological change since they have a bearing on the transformation of inputs into outputs.

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DECLARATION

I, **Admit Zerihun**, hereby declare that this thesis is the product of my original research work. All materials are duly acknowledged, and that it has not been submitted to any other university for an award of any academic degree.

Signature: __________________

Date: June 19, 1997.