Source of Economic Growth, Structural Dynamics, and Uncertainty: the case of Ethiopia

Kilder til Økonomisk Vekst, Strukturelle Dynamikk, og Usikkerhet: exsempelet Ethiopia

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Thesis as a partial fulfillment of Masters of Economics

by

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Abstract

The performance of the Ethiopian economy has been poor for a long time before the recent high growth since 2004. This therefore triggers a question what the reasons could be behind the poor economic performance, and what have been the changes that have taken place. This study covered three periods, covering 1960-2010, over which time there have been different economic systems namely: a mixed economy from 1960-1972; a socialist economy from 1973 to 1991; and a transition economy from 1992This study develops a model to explain the effect of factor inputs determining economic growth, evaluate the overall technological progress, and assess the contribution of structural dynamics and rainfall. A translog production function was applied to develop the mode. The results indicated that physical capital contributed positively *(P=0.012)* to economic growth whereas labor was not statistically significant *(P>0.1)*. It was also found out that the change in production structure of the economy has been contributing positively to growth *(P= 0.041)*. The results of two rainfall variables have the expected signs, and the effect of the "main rain" season was negative. The findings of this study also revealed that the growth of total factor productivity (TFP), in its broad sense, and the rate of technical change were not boosting growth. The implication is that an emphasis should be given to physical capital accumulation, promoting structural transformation of the economy, while reengineering technical and technological factors so that performance of the economy is driven by productivity growth, and the need to address the negative effect of the "main rain" season.

Key words: Economic growth, Factor accumulation, TFP, Structural change, Rainfall

Table of contents

Contents

Acknowledgement i
Abstract iii
Table of contents iv
Abbreviations vi
List of figures vii
List of tables viii
1. Introduction 1
2. Background 4
  2.1. Policy environments 4
  2.2. Economic structure and some macroeconomic indicators 5
3. Theory and Literature 15
  3.1. Theories of economic growth 15
    3.1.1. Harrod-Domar growth theory 16
    3.1.2. Neoclassical growth theory 18
    3.1.3. Endogenous (New) growth theory 24
  3.2. Structural Dynamics 29
  3.3. Uncertainty 30
  3.4. Related literature 31
4. Methodology and Data 35
  4.1. Methodology 35
  4.1.1 Model Specification 35
  4.1.2 Regression analysis 40
  4.2. Data and Measurement 41
  4.2.1 Data Sources 42
  4.2.2 Data Construction 42
  4.2.2.1 Output 42
  4.2.2.2 Capital 43
  4.2.2.3 Labor 44

4.2.2.4 Rainfall 44
5. Results and Discussion 45
6. Conclusion and future perspectives 54
6.1 Conclusion 54
6.2 Limitations of the study 55
6.3 Future research 55
Reference 56
Appendix 59

Abbreviations

CRT: Constant Returns to Scale

CSA: Central Statistical Agency

EEA: Ethiopian Economic Association

EPRDF: Ethiopian Peoples Revolutionary Democratic Front

FDRG: Federal Democratic Republic Government

GDS: Gross Domestic Saving

GDP: Gross Domestic Product

GFCF: Gross Fixed Capital Formation

IFPRI: International Food Policy Institute

IMF: International Monetary Fund

MoFED: Ministry of Finance and Economic Development

MoPED: Ministry of Planning and Economic Development

NBE: National Bank of Ethiopia

NMAE: National Meteorological Agency of Ethiopia

NMSA: National Meteorological Services Agency

PPP: Purchasing Power Parity

R&D: Research and Development

TFP: Total Factor Productivity

TFPG: Total Factor Productivity Growth

WB: World Bank

WEO: World Economic Outlook

WWII: World War II

List of figures

Figure-1: Share of Sectors …. …………………………………………………………… 6

Figure-2: Share of Agriculture Vs nonagriculture ………………………………………..... 6

Figure-3: Gross Domestic Saving ………………………………………………………... 9

Figure-4: Growth of Capital Stock, Labor and GDP ………………………………………. 10

Figure-5: GDP, K, GFCF and L ………………………………………………………… 11

Figure-6: Growth of population and GDP per capita ……………………………………… 12

Figure-7: GDP per capital stock and per unit labor ……………………………………… 13

Figure-8: Fixed Factors Combination …………………………………………………… 16

Figure-9: Path of equilibrium …………………………………………………………… 21

Figure-10: Effect of Technological Progress ……………………………………………… 23

Figure-11: Constant Returns to Scale …………………………………………………… 25

Figure-12: Increasing Returns to Scale ………………………………………………….. 25

Figure-13: Growth of total factor productivity ………………………………………………50

List of tables

Table-1: Selected macroeconomic indicators ……………………………………………………….6

Table-2: Estimation Results ………………………………………………………………… .52

1. Introduction

Historical records of economic growth show that different countries experience an economic growth pattern that is specific to their resource endowment. However, there are similarities based on those resources. The source of growth of a country might have a greater importance on capital accumulation through the ability to achieve a high proportion of savings, as a percentage of GDP. Conversely, some countries strategically orient economic activity to absorb the ample supply of cheap labor, including promoting the use of labor-intensive production techniques.

Various structural changes take place in the process of economic growth. A deliberate intervention to change the production structure and the application of appropriate economic incentives can generate economic growth through the reallocation of resources and accompanying efficiency improvement. The effect of such intervention is enormous in developing economies where agriculture and other primary sectors are dominant, consistent with the natural and human resource endowment.

Uncertainty, on the other hand, hampers economic activity. Where there is uncertainty, the choice made by economic agents can differ from conditions in the absence of uncertainty and thus uncertainty usually creates a challenge for efficient resource allocation. An uncertainty that can arise, for example, from rainfall variability can affect the economic growth of an agriculturally-based economy unless capital investments have been made in irrigation systems or the adoption of production practices that can cope up with moisture stress. Rainfall, however, plays a significant role in countries whose economy is dependent on rain-fed agriculture. Therefore, an uncertainty arising from erratic rainfall affects the agriculture sector, and, consequently, the overall economic activity, and the country's economic growth.

The Ethiopian economy is characterized as agriculturally based structured by small holding subsistence farming. Agriculture, on average, contributed to 55.2% of the total GDP, while industry and service sector contributed 12.6% and 32.2%, respectively, in 1960-2010. The effect of factors affecting Ethiopian agricultural sector is significant on GDP due to the large share the sector contributes to national income and the indirect effect that agriculture has on the other sectors.

Before the recent rapid and consistent economic growth rates since 2004, the performance of the Ethiopian economy was poor. The per capita income level based on purchasing power parity terms, (PPP) of the country is $ 1014, which ranks it 169th out of 182 countries (IMF, 2010). This requires an understanding of the role that factor inputs and technological progress plays in Ethiopian economy. Since the dynamics of the production structure of the economy is associated with resource reallocation, factor input and technology are expected to have an effect on economic growth. The contribution of agriculture to the Ethiopian economy is considerable because of its direct and indirect link with the other sectors. Any uncertainty arising from rainfall therefore has a significant effect on the overall economy for the agricultural activity in Ethiopia is highly dependent on rainfall. Therefore, this study tries to address the following questions:

- What is the contribution of factor accumulation (capital and labor) for economic growth?;
- How does the technical change and growth of total factor productivity change over the study period?;
- Did the change in the structure of the economy contribute to the economic growth; and
- Does rainfall (three seasons) of the year affect the country's GDP?

The study covers 1960 to 2010 over which time there have been three types of economic systems, namely: a mixed economic system from 1960 to 1972 (during the Imperial period); a socialist economic system from 1973 to 1991 (during the Derg period); and a transitional economy from 1973 to 2010 (during Ethiopian Peoples Revolutionary Democratic Front (EPRDF) period). Therefore, the study tried to compare and contrast the three periods due to the difference in their economic system.

A model is developed to present the underlying complex economic system in a simplified but systematic way, that serves to analyze how the economy works and thus to draw policy implications. A translog production function is used to develop three models. The objective of this research is therefore to develop a model to explain the effect of factor inputs determining economic growth, evaluate the overall technological progress, and to assess the contribution of structural dynamics and rainfall. The study attempts to test the following hypotheses.

Hypothesis 1: Ethiopian economy is in transition and therefore, factor accumulation will have considerable contribution for economic growth.

Hypothesis 2: Structural dynamics, i.e., a shift from agriculture to non-agriculture sector, increase economic growth in Ethiopian economy due to accompanying efficiency improvement.

Hypothesis 3: The performance of Ethiopian economy is subject to the performance of agricultural production, which is predominantly rain-fed production system, and hence the sufficiency of rainfall size influences economic growth.

The thesis is organized as follows: section two provides background information on policy regimes, production structure and some macroeconomic performance. Section three details theory and reviews related literatures. Section four discuss the production technology used in the methodology, and develops the econometric analysis. It also details data construction. Section five presents empirical results. Section six provides concluding comment.

2. Background

The economic performance of a country is a reflection of its institutions, resource utilization, and the decisions agents make in economic activity. Therefore, this section presents economic policies, selected macroeconomic indicators, and related review of the study period under consideration.

2.1. Policy environments

The form of economic system adopted governs the national economic objectives and strategies, and characterizes the institutional environment in which the economy is working. There have been three different types of economic systems in Ethiopian economy over the study period.

During the Imperial regime, the Ethiopian economy had a mixed type of economy, characterized in such a manner where the private and public sectors were given equal importance. The economic strategy contained elements of both export-oriented growth and import-substitution industrialization. The emphasis was export promotion and diversification in the post Second-World War. After 1960, however, the emphasis shifted to import substitution and protecting infant industries from external competitors from developed countries. The focus of the development policy in the beginning was on infrastructure development and then the emphasis shifted to productive activities and later the priority shifted to optimization of activities (Kuris, 2003).

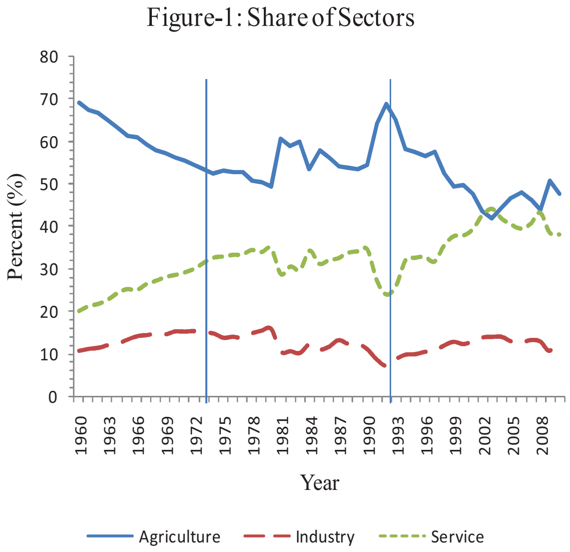
During the Derg period, from 1973-1991, the economic system moved from a mixed market-oriented economy to a type of command economy, the aim of which was establishing a socialist economy. The Derg regime appeared with new institutions that were opposite to the previous regime. One of them was the nationalization of land in the rural and urban areas. The administration also nationalized extra houses, major enterprises in manufacturing industries, banks and insurance companies. The agricultural policy was directed to state and cooperative farms with peasants made to move in to settlement under village settlement programs. The government's role in the economic activity was increased while the private sector's role was diminished (Kuris, 2003).

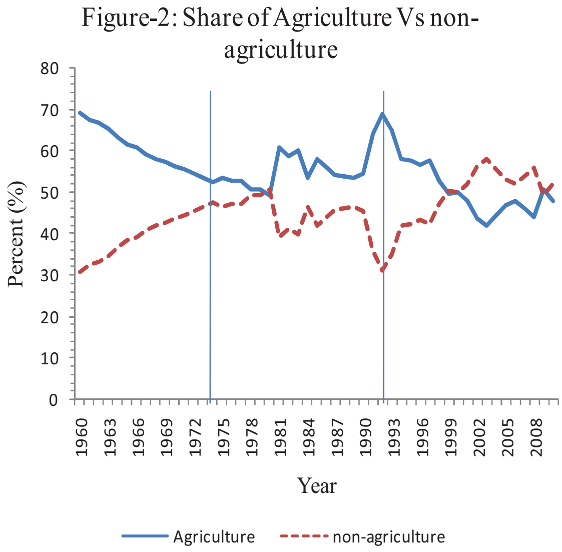
The policies had discouraging effects on private investment and capital inflows, and created less willingness of big international institutions to lend money. The private sector and individuals had no incentive to save or to invest, due to the capital ceiling imposed by the government. Thus, the economic policies were not favorable to attract foreign direct investment (FDI) either.

The global spectrum of the political economy changed with the dissolution of Soviet Union, and any new government that came into power by then had to adapt a "free market system" even though it was not a proponent of such system. The EPRDF government that assumed power after the fall of the socialist Derg administration had to reform the command economic system into market oriented one and to ease the over-extended state control of the economy. The government introduced a labor intensive, export-oriented and agricultural-led industrial development strategy (MoPED, 1993). It made an effort to stimulate private sector development and privatized public enterprises. The economic reforms made by the EPRDF government have helped to attract FDI and get acceptance from international donor community.

2.2. Economic structure and some macroeconomic indicators

The Ethiopian economy is agricultural-based, characterized by small holding subsistence farming. Agriculture, on average, contributed to 55.2% of the total GDP, while industry and service sector contributed 12.6% and 32.2%, respectively, over the study period. The agricultural sector provided living for 82.4% of the total population in 2010 (WB, 2010) and contributed to about 90% of the export earnings in 2008/09 (NBE, 2008/09).





Source: Data source MoFED and WB

The recent trend of the production structure of the economy shows that agricultural value added to GDP is declining and for the first time the service sector has taken up the lead in 2003 (figure 1 and 2). This is a natural dynamics in the history of economic development, in the process of structural transformation sectoral lead shifts from agriculture to other sectors.

Table-1: Selected macroeconomic indicators

Variable	1960-72	1973-91	1992-2010
Gross domestic expenditure: % of GDP	102.09	106.97	113.11
Consumption Expenditure: % of GDP	91.51	92.33	92.67
Private	78.95	77.49	81.61
Government	12.56	14.84	11.06
Gross capital formation: % of GDP	10.58	14.64	20.44
Gross fixed investment	10.58	14.64	20.44
Change in stocks			
External balance: % of GDP	-2.09	-6.97	-13.11
Exports of goods and services: % of GDP	11.85	8.70	11.10
Imports of goods and services: % of GDP	13.94	15.67	24.21
Deposit interest rate (%)	NA	4.0	6.12
Inflation, consumer prices: annual %	0.80	9.81	8.25
Official exchange rate: LCU per US$, period average	2.48	2.07	8.01

Source: author's calculation based on MoFED and WB data.

In Table 1 selected macroeconomic indicators are reported for the three periods of interest. The expenditure side of the national income shows that aggregate consumption expenditure increased in 1967 and onwards which was above 92% of GDP. Government consumption expenditure was more than 13% of GDP during the Imperial period. Private consumption expenditure was below or at 80% except in 1985 (84%) and 1991 (83%). The aggregate consumption expenditure, was above 90% except in 1981, 1984, and 1986-88, and was at a maximum, in 1974 at 96.3% during the Derg period. Aggregate consumption was above 90% almost throughout the EPRDF period except for the years 1995, 1997, and 1998. It showed a marked rise since 2005, and was above 99% in 2008 and 2010. Government consumption expenditure increased and was above 10% during 1999 to 2007 while private consumption was stable or increased slightly in the same period.

GFCF (gross fixed capital formation) as percentage of GDP had a declining trend over the Imperial period from about 14% in 1969 to below 10% at the end of the period (1972). Its trend improved upward and was in the range of 12% - 18% except in 1973 (10.6%), 1988 (23.4%) and 1991 (11.1) over the Derg period. It showed a marked rise during the EPRDF period, which was above 20% for 63% of this period.

Except in 1965 and 1966, the trade balance was negative in the Imperial period. The percentage of import of goods and services to GDP increased since 1967 to 15.3% and reached 20.5% in 1972, where the trade deficit increased to 6.3% in that year.

During the Derg period, the export of goods and services as a percentage of GDP was below 8% since 1981 and onwards. The trade deficit was 8-10% of the GDP from 1974 to 1981 and import of goods and services was above 20% of GDP in the same period. The deficit was less than 6% since then.

The trade balance was worst during the EPRDF period than any of the other periods. The trade deficit as a percentage of GDP was above 11%, which was the case for all the years since 1999 onwards, for 63% of the EPRDF period. An import of goods and services as a percentage of GDP was above 14% for the whole EPRDF period except 1992. It was above 30% since 2004 and onwards except in 2009, which was 28.8%. Export, on the other hand, has been below 13% for 79% of this period, and appears to be having a declining trend since 2005.

The deposit rate for the Derg period was 4%. Inflation, at consumer price index, was at double digits for almost a third of the time during the Derg period (1976-79, 1985, and 1991), and was at its worst rate at 35.7% in 1991. By contrast, 1983, 1986, and 1987 were deflationary years. The EPRDF administration increased the deposit rate to 11.5% in 1993 just after it assumed power. The rate stayed above 10% until 1995, and declined to 6-7% from 1987 to 2001, and further declined below 4% from 2002 to 2006, and it was between 4-5% from 2007 to 2010. Inflation, on the other hand, was below the deposit rate from1973 to 2003 except in 1993 and 1999. However, it was above the deposit rate since 2003 and onwards at considerable margin, for example, the deposit rate was 4.7% in 2008 while inflation skyrocketed at 44.4%. Years 1996 and 2001 were deflationary years during this period.

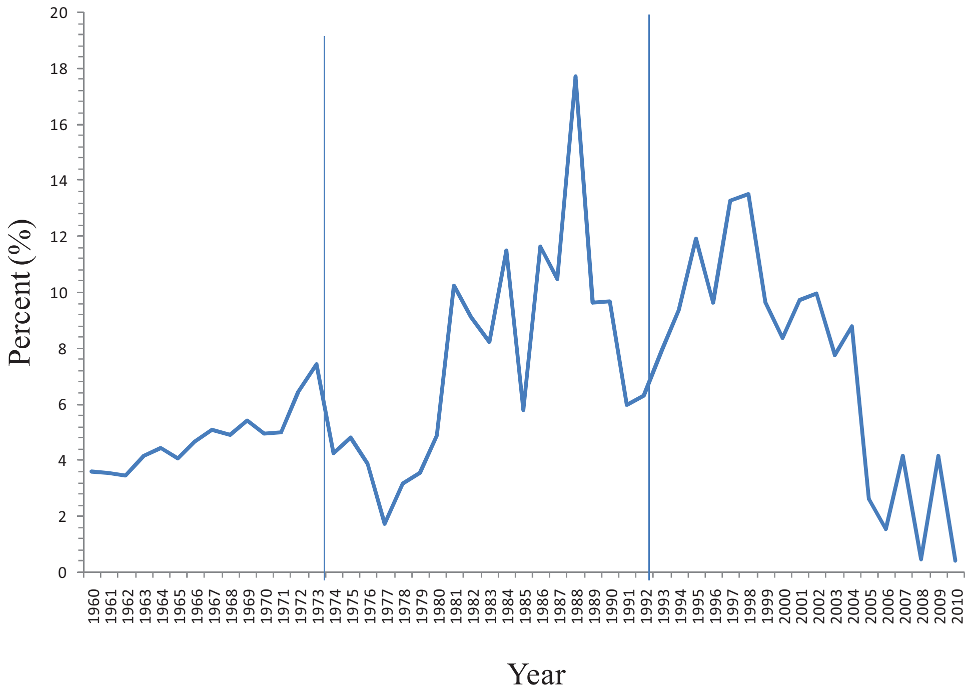
The official exchange rate of the local currency, Birr, against the dollar was in the range of 2.3-2.5 during the Imperial period. The Derg regime used a fixed exchange rate fixed at Birr 2.07 = $ 1.00. The EFRDF administration devaluated the Birr at Birr 5.00 = $ 1.00 in 1993 and introduced a free floating exchange rate. The exchange rate was in the range of 7.94-8.97 during 1999 to 2007. It then reached Birr 14.4096 to the dollar in 2010. The administration have devalued the Birr multiple times between1992-2010.

Gross domestic saving (GDS) is one of the major factors that determine growth of a country, because it is the available saving that can be mobilized into investment. The more proportion of GDP is saved the more potential to mobilize the resource to investment particularly in capital scarce economy. In figure 3 one can observe the pattern of GDS over the study period. The average GDS as percentage of GDP was higher during the Derg period, 7.55%, compared with 7.33% and 4.59% during EPRDF and imperial periods, respectively. It has declined since 1998.

The Imperial period was a phase of monetizing the economy compared to the other two regimes. Expanding branch of banks and savings mobilization explains the rise in GDS. The abrupt change of regime, abolition of private sectors, and the 1973-74 drought caused the decline of

GDP the period following the government change, and increased tax levied on luxuries contributed for later rise in GDS. An attempt made to develop the private sector, and an increase in the deposit rate (EEA, 2000) improved GDS but the decline of GDS since 1998 was due to rise in consumption, a low rate of demand deposit, and skyrocketing inflation.

Figure-3: Gross domestic saving (% of GDP)

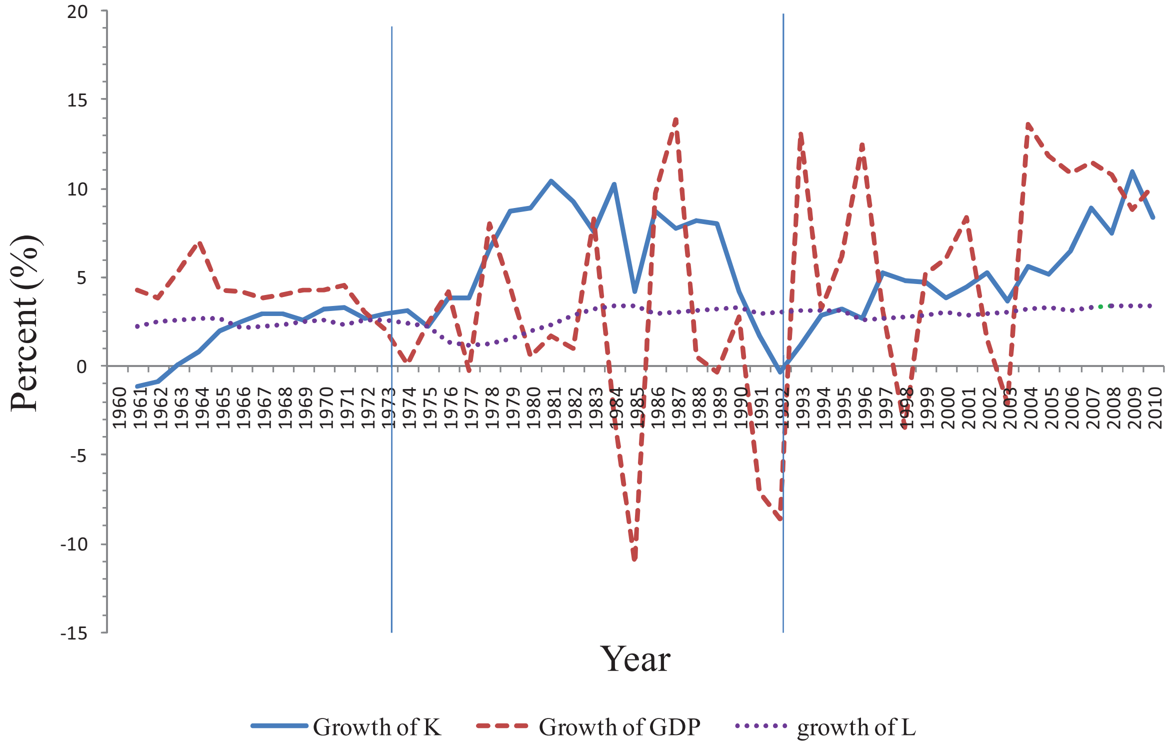


Source: Data source MoFED and WB

The labor force grew significantly over the study period. The labor force at the end of 2010 was 176% and 282% of the end of Derg and Imperial periods, respectively. The average growth rates of labor force were 2.42%, 2.51% and 3.05% for Imperial, Derg, and EPRDF periods, respectively. The average population growth was slightly higher during EPRDF, 2.71%, compared to the Imperial, 2.59%, and Derg, 2.63%, periods.

The growth of investment is critical for economic growth. In this respect, we do not observe clear pattern in the growth of GFCF except some during the Imperia period. Figure 4 shows that many fluctuations and even negative growth records (six during EPRDF, five during Derg, and two during Imperial period). Negative investment growth is undesirable because it results in depletion of capital stock. The lowest average growth of GFCF was during Derg period, 7.43%, and the highest during EPRDF, 9.2%, whereas it was 7.52% for Imperial period. The average growth of net investment per GDP was 8.9% and 9.3% during the Derg and EPRDF periods, respectively, whereas very low during the Imperial time (1.7%).

Figure-4: Growth of Capital stock, labor and GDP

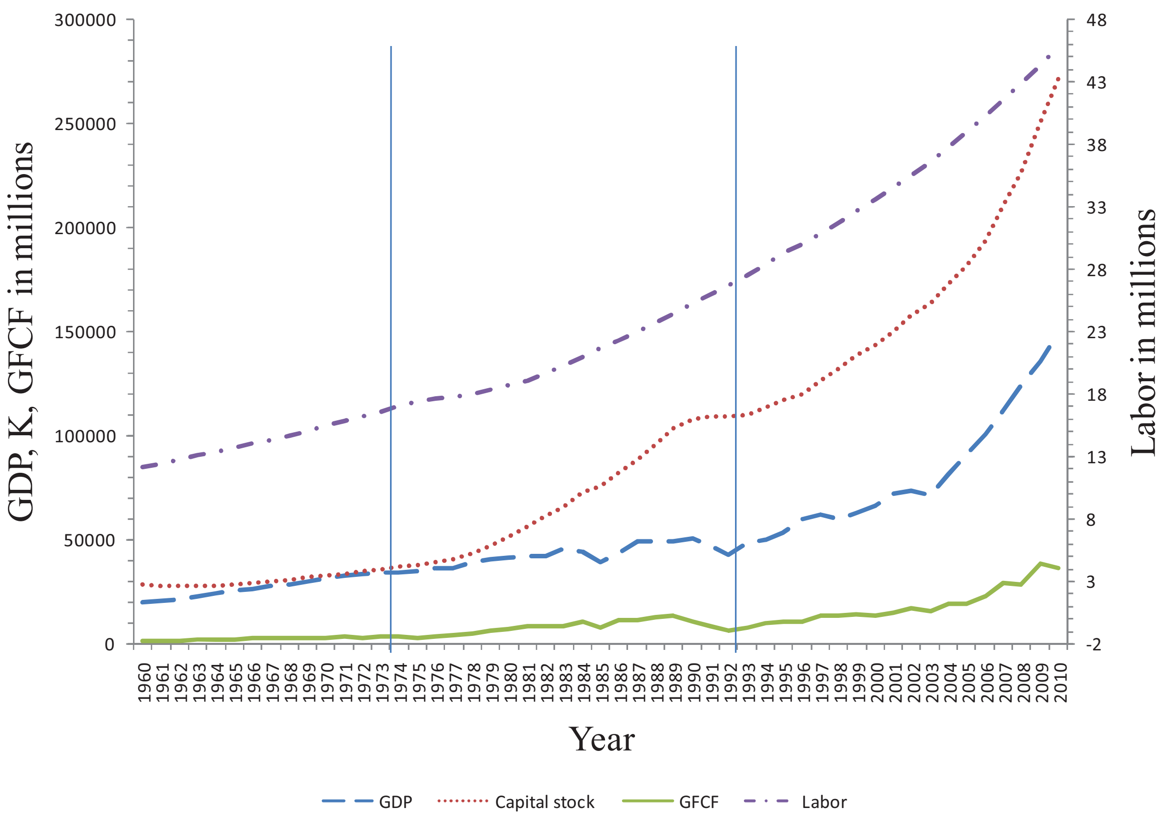


Source: Data source MoFED and WB

The growth of GFCF affects the capital stock because capita stock is an accumulation of investment. The growth of capital was high during the Derg period compared to the other two periods. Negative growths were also recorded twice, 1961-62, during Imperial period and once, 1992, during EPRDF period. The average growth of capital stock was 6.29% during the Derg period, followed by 4.94% during the EPRDF period and 1.74% during the Imperial period. The lower growth during the EPRDF period was because of, partly, the negative average growth of net investment, -6.34%, though the net investment per GDP was higher during this same period, 9.34%, compared to 8.9% during the Derg and 1.75% during the Imperial periods.

The average GDP growth was higher, 6.43%, in the EPRDF period compared to the Imperial, 4.38%, and Derg, 1.96%, periods (figure 5). There were four, during Derg period, and three, during the EPRDF period, negative growth records. The high GDP growth of the EPRDF period was mainly the result of big oversea development aid (ODA) and foreign direct investment (FDI). According to the World Bank (2010), ODA as percentage of GDP of the Derge period was 5.5% (an average of 1981-1991) whereas during the EPRDF period ODA as percentage of GDP averaged 12.5%, a 272% rise. Likewise the country was able to attract a FDI, on average, 1.94% of its GDP yearly from 1992-2010, though it was small when compared with the Sub-Sahara African (excluding South Africa) countries' yearly average of 3.18% for the same period. Nevertheless, there were years when it recorded above the Sub-Sahara Africa average. For example, the FDI level was 4.28%, 5.45%, and 4.43% of GDP in 2001, 2003, and 2004, respectively.

Figure-5: GDP, K, GFCF and L

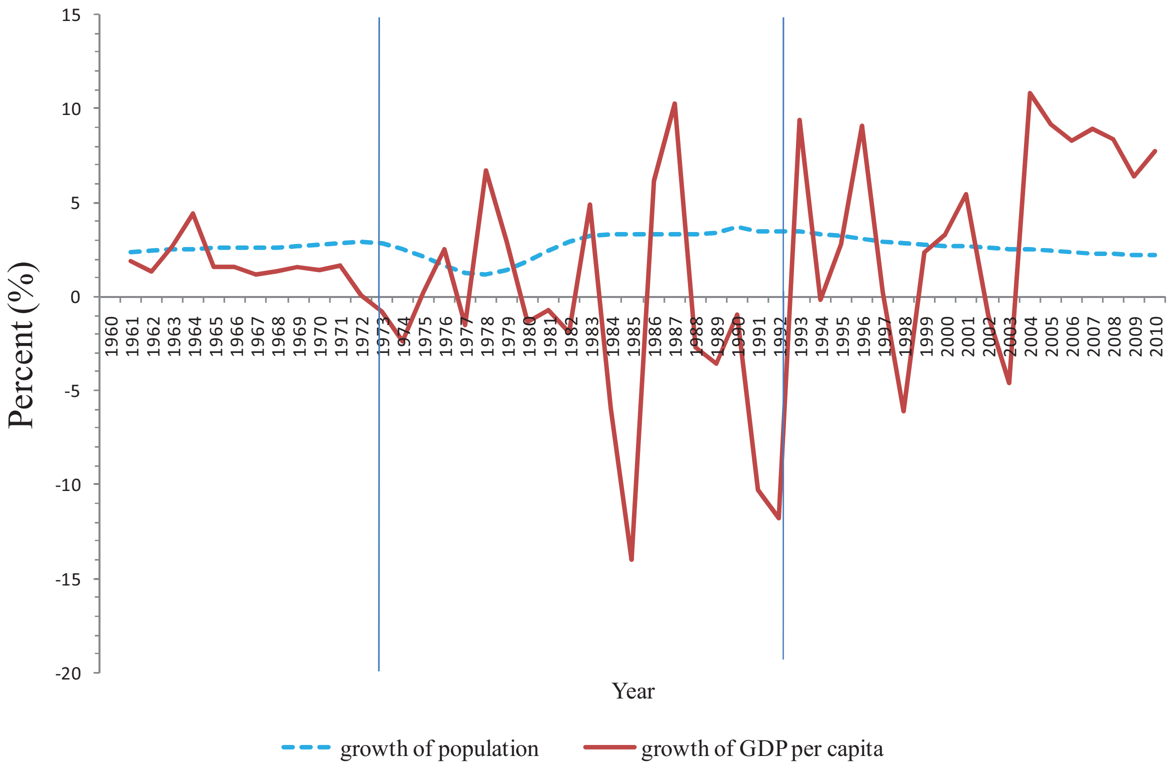


Source: Data source MoFED and WB

The observed capital stock rise during the Derg period was because of increased public investment in heavy industries, but later stagnated in 1989-92 associated with high military expenditure. Later the capital stock increased during the EPRDF period due to big infrastructure development and increased FDI.

The growth in per capita terms had same pattern, it was even negative during the Derg period, (-0.63%), whereas it was 1.75% and 3.6% during the Imperial and EPRDF periods, respectively (figure 6). The average GDP growth rates were above the population growth rates except for the Derg period. That is why the growth of GDP per capita was below 1% (i.e, -0.63%) only in this period.

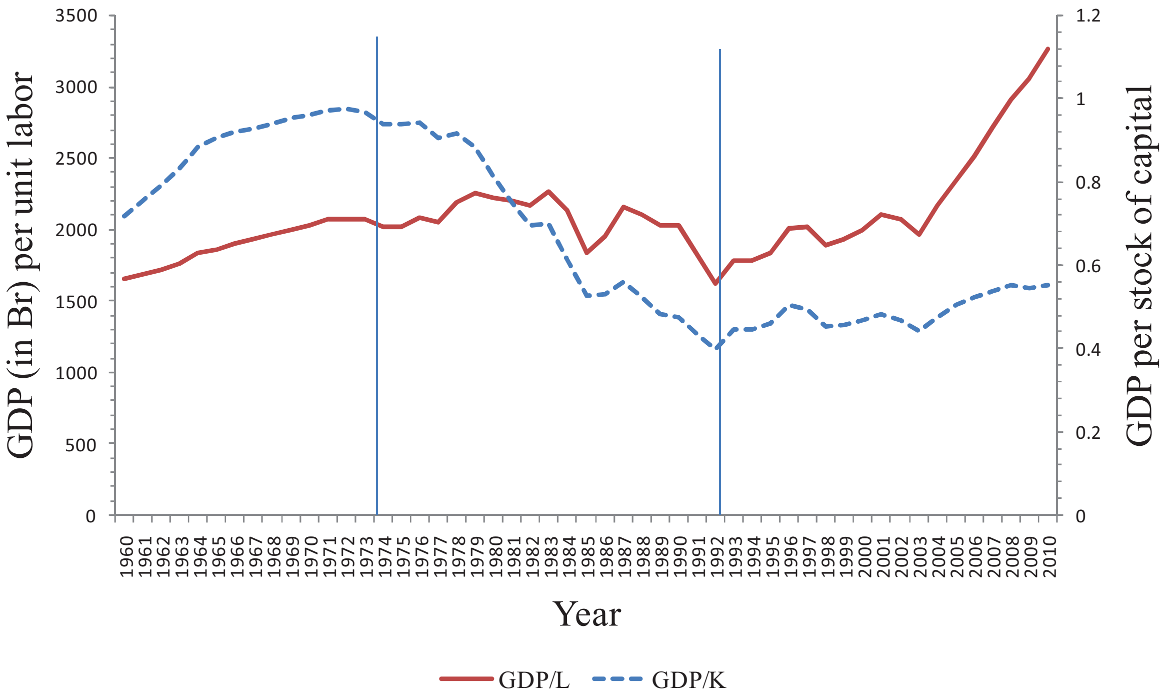
Figure-6: Growth of population and GDP per capita



Source: Data source MoFED and WB

As can be seen in figure 7 the partial productivity of capital and labor had different pattern one another. The average GDP/L had an increasing trend, 1877 Br/L during the Imperial period whereas 2080 Br/L and 2204 Br/L during the Derg and the EPRDF periods, respectively. The average GDP/K had, in contrast declining, trend in the three periods, it was 0.88 (i.e 0.88 Br per a Br of K) during the Imperial period whereas 0.71, and 0.48 during the Derg and the EPRDF periods, respectively.

Figure-7: GDP per capital stock (GDP/K) and per unit labor (GDP/L)



Source: Data source MoFED and WB

The average growth were negative during the Derg period for both partial productivity of capital and labor that were -4.05%, and -0.52% respectively. The highest average growth of GDP/K was during the Imperial period, 2.62%, and it was 1.42% during the EPRDF period. On the contrary, the highest average growth of GDP/L was during the EPRDF period, 3.28%; in contrast to 1.91% during the Imperial period.

Agricultural options of a particular area are a reflection of a composition of many local conditions. Countries develop their own agroecological zonations depending on the most important local conditions. Eighteen (18) major agroecological zones were defined in Ethiopia to characterize the country based on both temperature and moisture regimes, and some crops grown either only or dominantly in a particular zone (IFPRI and CSA, 2006). The year is also classified into three seasons, based on the rainfall and its distribution, namely, "Kirement" the "main rain" season which covers the period from June to September, "Belg" the "short rain" season which covers the period from February to May, and "Bega" the "dry" season which covers the period from October to January (NMSA, 1996a).

The amount of seasonal rainfall is highest in the "main rain", "Kiremt", and lowest in the dry, "Bega", season. Agricultural activity, in general, and crop production, in particular, is carried out mainly during "Kiremt" and "Belg" seasons. The areas are also categorized into major "kiremt" season producing and "Belg" season producing areas. The types of crops grown also differ depending on the seasons. For example, the "Belg" rain is important for long duration crops such as maize and sorghum (NMSA, 1996b).

The rainfall condition is highly variable in time and space during the "Belg" season, so the season is more susceptible to droughts. Nevertheless, it tends to be more consistent with fewer and milder droughts during the "Kiremt" season. Therefore, uncertainty is higher in the "Belg" season (NMSA, 1996b).

3. Theory and Literature

The question of economic growth goes back as far as the theory of "division of labor" or specialization, to Adam Smith's work commonly known as the *Wealth of Nations*. Smith placed a primary role in the process of accumulation of wealth to division of labor assuming increased specialization increase returns to labor. Economic growth theories that came to appear after the publication of Keynes' general theory are commonly known as modern economic growth theory and are inspired by the general theory (Shapiro, 1999).

3.1. Theories of economic growth

Economic activity and growth processes are multidimensional and complex. They involve different economic agents and their decisions over the use of factor inputs and the various combinations of them employed in economic activity, and the institutional environment in which the economy functions. Thus, the institutions and the dynamics of the economic system influence the response of economic agents.

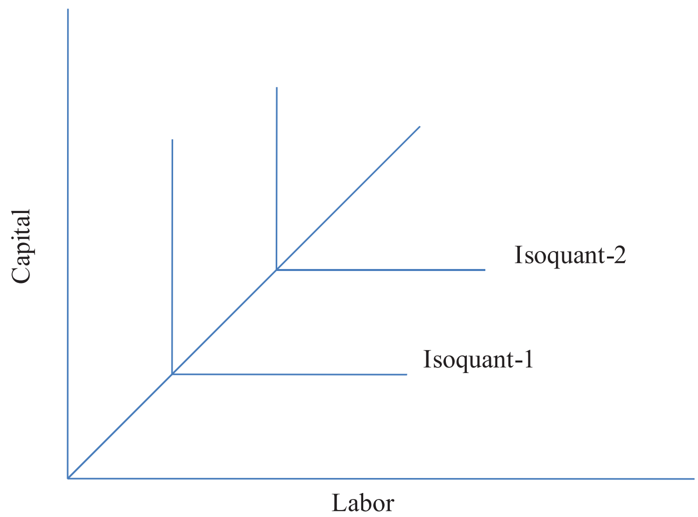
In growth processes various variables plays their role independently or in interaction with each other; hence, the question of which variables are relevant and which ones are the determinant ones in economic growth is basic in growth study. Economic growth can come from either factor accumulation or technological progress or a combination of both. Since the creativity of human being has no limit, technological progress generates permanent growth whereas factor accumulation produce temporary growth that the economy later tends to settle at some equilibrium state where the growth of all factors remain constant. Besides, the development of complementarities in production structures is crucial to realize the benefits from externalities. The most widely known branches of modern growth theories are: (i) the Harrod-Domar growth theory, (ii) Neoclassical growth theory, and (iii) Endogenous (new) growth theory.

3.1.1. Harrod-Domar growth theory

Net investment has a dual effect because it has a demand effect for goods, and supply effect by generating capacity of production. For example, if one expands its cement factory it demands building materials, tools, and machinery, and after finishing planting the factory it increases the productive capacity of the economy. Harrod-Domar paid primary emphasis on the dual effect of net investment and all subsequent growth theories included net investment in their growth models (Shapiro, 1999).

The Harrod-Domar theory assumes a fixed capital-output ratio, and the techniques of production as given. It is also only the capital stock that is explicitly taken into account as a factor of production (Shapiro 1999). The combination of factors is assumed to be fixed, meaning the ratio of say capital and labor is always fixed in the production process. As can be seen from figure 8, a change in the amount of one input alone, given the other factor constant, does not change the level of output. Both inputs should increase (decrease) proportionally to increase (decrease) the level of production because one factor would not substitute the other given fixed proportion.

Figure-8: Fixed Factors Combination



If one assumes the national income (Y) consists of consumption goods (C) and investment goods (I), then:

$$Y = C + I \tag{1}$$

A change in a capital stock (Δ) is used to represent investment in the Harrod-Domar model as follows:

$$\mathrm{Y} = \mathrm{C} + \Delta\mathrm{K}\,. \tag{2}$$

Under the assumption discussed above, the Harod-Domar model implies that:

$$\frac{\mathrm{K}}{\mathrm{Y}} = \theta \;=>\; Y = \frac{1}{\theta}\mathrm{K}\,. \tag{3}$$

This, in turn, implies that $\Delta\mathrm{Y} = \frac{1}{\theta}\Delta\mathrm{K}$ because the capital-output ratio, θ, is assumed to be constant.

If people save a portion of their income at a rate of s, then ΔK = I = S = sY assuming investment is equal to saving, such that:

$$\Delta\mathrm{Y} = \frac{1}{\theta}\,\mathrm{sY} = \frac{\mathrm{s}}{\theta}\mathrm{Y} \qquad \text{and} \tag{4}$$

$$\frac{\Delta\mathrm{Y}}{\mathrm{Y}} = \frac{\mathrm{s}}{\theta} = \mathrm{g}. \tag{5}$$

According to the original Harrod-Domar theory, growth is directly related to the saving rate and inversely related to the capital-output ratio. For example, if one doubles saving then output doubles. An increase in capital-output ratio decreases the growth rate because a lesser amount of output is generated from a unit of capital.

The above growth rate does not show the change in per capita terms, so the Harrod-Domar model needs some amendment to change it into per capita form and to include the effect of depreciation (Ray, 1998). When we convert it into per capita form, we get the following expression (It is detailed in Appendix-2)

$$g^* \cong \frac{s}{\theta} - n - \delta \qquad (6)$$

where g* represents per capita growth of GDP.

The policy implication of the augmented HD model is that as long as people increase their saving, i.e., deferring their current consumption for future consumption, the growth rate of output per labor increases. In other words, an increase in investment always increases output per labor, all other things remaining constant. Population growth, on the other hand, decreases growth. Any exogenous improvement in how much capital is demanded to produce a given output level would improve the growth rate because technology (θ) is given.

When we summarize the Harod-Domar growth theory it states that output growth rate is determined by the saving rate and the inverse of the technical capital-output ratio, which is constant. However Easterly (1998) argued that this did not make sense as a growth model and cited the comment made by Domar that the purpose was not to derive "an empirically meaningful rate of growth," and the assumption of constant capital-output ratio was unrealistic. The model was widely used early by development economists to calculate the investment financing gap, given a planned rate of GDP.

3.1.2. Neoclassical growth theory

The most widely known growth theory that came after the Harod-Domar is the Solow growth theory. The Solow growth theory answered the fundamental weakness of Harrod-Domar assumption of constant capital-output ratio. Solow assumes factor inputs to be continuously substituted for each other and variably combined. In other words, unlike the Harrod-Domar model's fixed factors combination, the Solow model permits continuous substitution between factors of production. The marginal product of each factor varies depending on the amount of the other factor it is combined with. It also assumes diminishing returns to each factor of production, and technology as exogenously determined. Thus, it implies that if the economy is far below an equilibrium state, factor accumulation would result in output growth at a high rate initially and then at a diminishing rate until it reaches a steady state.

Solow used a production function of two factors to display his theoretical analysis.

$$Y = F(K, L). \tag{7}$$

Then, cY = F(cK, cL) = cF(K,L) by the assumption of a homogenous production function of degree one (implying constant returns to scale).

Letting c= 1/L provides:

$$\frac{Y}{L} = F\left(\frac{K}{L}, \frac{L}{L}\right) = \mathrm{F}\left(\frac{\mathrm{K}}{\mathrm{L}}, 1\right) \tag{8}$$

where $y = \frac{Y}{L}$ and $k = \frac{K}{L}$. If we assume I = S we get the following expression:

$$y = f(k) \tag{9}$$

where i=I/L, investment per labor.

The size of the capital stock depends on investment and depreciation, and, thus, the change of capital stock is dependent on the size of investment relative to the size of depreciation.

$$\Delta \mathrm{k} = \mathrm{i} - \delta \mathrm{k} = \mathrm{sf(k)} - \delta \mathrm{k} \tag{10}$$

where s is rate of saving.

The Solow growth model assumes a constant depreciation and saving rate and the production function, f(k), and saving function, sf(k), that experiences diminishing returns to any single input, i.e, both functions increase at decreasing rate.

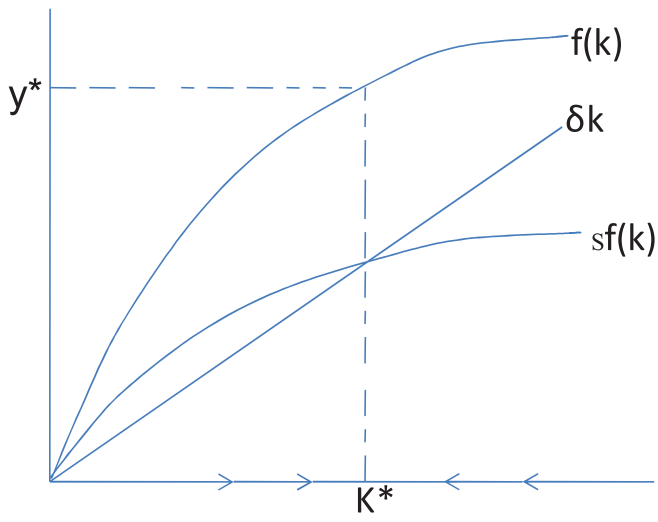
In the basic Solow model (without technological progress and population growth), if depreciation exceeds investment, capital stock decreases. On the other hand, if investment is greater than depreciation, capital stock increases. The relative size of investment to depreciation and the effect of diminishing returns determine the path of the capital stock function, thereby the production function. Conditional on the relative size of investment to depreciation and the effect of diminishing returns, output per labor tend to move towards a stable equilibrium state, i.e., steady state. In steady state the growth rate of output per labor and stock of capital per labor are zero (Solow, 1956), such that

$$g = \frac{\Delta k}{k} = \frac{sf(k) - \delta k}{k} = \frac{sf(k)}{k} - \delta \quad (11)$$

at steady-state $g = 0$, and $\frac{sf(k)}{k} - \delta = 0$ implying $\frac{sf(k)}{k} = \delta$.

Equation 11 shows that the growth of capital stock is zero at steady state due to diminishing returns to capital; therefore, the amount of investment would not create additional capital but merely replace depreciating capital stock. In figure 9, one observes that the growth rate of capital stock would be negative if it exceeds the steady-state level and would be positive if it is below. The amount of investment needed to replace depreciating capital increases in proportion to the size of capital stock, it is however impossible to convert all the national income into saving.

Figure -9: Path of equilibrium



The size of the saving rate, all other things remain the same, determines the steady state level of output per labor. An increase in the saving rate increases the level of output per labor, and the higher the saving rate, the higher the steady state output per labor. A steady state, however, is not essentially an indication of, and does not necessarily imply an optimal level of the economy where it is a preferred state for human welfare. It does not necessarily mean that citizens would be better off in consumption at higher steady state (Van Der Berg, 2001).

Solow was responding for Harod-Domar shortcomings, that continuous growth of saving and investment would bring about everlasting growth. Because of diminishing return, however, continuous growth of investment would ultimately result in a decline in marginal output and finally zero growth of output. In this sense investment does not bring permanent growth because once the economy has reached the steady-state growth, then per labor output is zero (Van Der Berg, 2001).

The Solow model so far discussed implies that increasing the capital stock will not generate a long-term permanent economic growth due to the possibility of diminishing marginal returns. This shortcoming of the model invites a question of assessing the effect of other factors such as population growth and technological progress to explain the continuous growth that so many countries experienced over the past decades.

When population is added into the Solow basic model the amount of investment needed to keep the capital stock per labor growing is not only that required to cover the part of capital depreciating, but also required to equip new entrants to the labor force. Therefore, the change in the capital stock per labor becomes a function of per labor investment less depreciation and required capital proportional to the growth of labor force (Van Der Berg, 2001), or

$$\Delta k = i - \delta k - nk = sf(k) - (\delta + n)k. \tag{12}$$

Therefore, the higher the population growth rate, all other things remaining the same, the lower the steady-state output per labor and income. The phenomenon of diminishing returns does not happen if investment grows in the exact proportion of population growth rate. Output per labor growth continues at steady state as long as there is positive labor force growth. At steady state, the growth of the capital stock and output per labor is zero, but the capital stock and output grow at the rate of labor force (Acemoglu, 2009). In other words, $g_y = g_k = 0$ but $g_Y = g_K = g_n$.

The other factor taken into account in the Solow growth theory is technological progress, z. When technological progress is included in Solow model the investment needed is not only to replace depreciating capital and that required to equip new entrants into the labor force, but also to make available the amount of capital needed to utilize the change in labor's ability to produce associated with technological progress. Therefore, if the stock of capital per labor is to grow it must exceed the sum of these three demands (Acemoglu, 2009): e.g.,

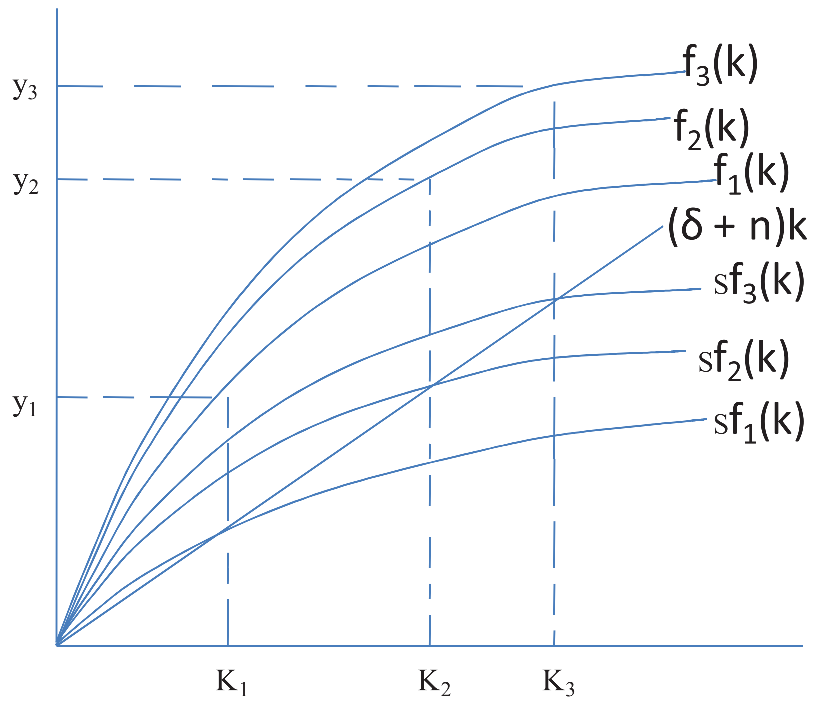
$$\Delta\hat{k} = \hat{\imath} - \delta\hat{k} - n\hat{k} - z\hat{k} = sf(\hat{k}) - (\delta + n + z)\hat{k} \tag{13}$$

where $\hat{k} = \frac{K}{(L*E)}$, and $\hat{\imath} = \frac{I}{(L*E)}$ assuming that technological progress improves labor efficiency. Therefore, E represents labor efficiency, and the production function is specified as Y = F[K, (L*E)].

As long as the labor force accompanying increasing stock of capital keep growing, n, output (Y) and capital stock (K) grow at a rate of n+z without experiencing diminishing returns. In other words, a decline in marginal product of capital does not arise if the labor force grows proportional to the growth of capital stock. The per capita level, per labor output and stock of capital per labor, grows at the exogenous rate of technological progress (Mulder, De Groot and Hofkes, 2001).

The development of the Solow growth theory shows that, without population and technological progress, the growth of output, Y, and capital stock, K, as well their per labor terms, respectively, is zero at steady state. When the population is included in the basic model, Y and K grows at a rate of n while their per labor term growth is zero. Finally, when the basic model takes into account both population and technological advancement, capital stock (K) and output (Y) grow at a rate of n+z while stock of capital per labor and output per labor grows continuously at a rate of technological progress, z.

Figure-10: Effect of technological progress



Van Der Berg (2001) discusses the Solow's growth theory with the functions depicted in Figure 10. If one assumes all other things remain the same, a change in technological advancement shifts the production function $f_1(k)$ upward to $f_2(k)$. This shift results in upward shift of the saving function from $sf_1(k)$ to $sf_2(k)$, because, with constant saving rate, an increase in per labor output increases saving and thus the capital stock, consequently the economy transition into a higher level of steady-state. If there is further technological advancement, it shifts the production function upward to $f_3(k)$, the same for saving, $sf_3(k)$, and capital stock and the economy moves towards a higher level of steady-state, y_3 and k_3. If technological progress continues advancing, the steady-state level of per labor capital and output continue to move further to a higher level. Therefore, a transition towards a new steady-state at a higher level of output per labor, all other things remaining the same, depends on three exogenous parameters: an increase in saving rate or a decrease in population growth rate, or a continuous increase in the rate of labor-augmenting technological progress. The model, however does not explain how the magnitude of the parameters (n, s, z) are determined but simply assumes they are determined outside the model. Unlike the possibility of no limitation on human thinking, innovation, or creativity, an increase in the saving rate or a decrease in population growth or depreciation rates has a limit. Hence, changes in s, n, and δ will result temporary transition to a higher output per labor, and then, the possibility of permanent growth depends on technological progress because it enables to produce effective labor continuously.

3.1.3. Endogenous (New) growth theory

Endogenous growth theory, on the other hand, assumes that the accumulation of knowledge as the leading driving force of long-run growth, and new knowledge is assumed to be the product of research technology. The interests of economic agents determine technological progress, meaning technological progress is not something that is determined outside the model. Mankiw, Romer and Weil (1992) discussed that technological progress is an endogenous outcome of investment in human capital. The other assumption of this theory is the spillover effect. Firms benefit from the creation of new knowledge by other firms through positive externalities.

Endogenous growth theory drops the assumption of diminishing marginal returns of neoclassical theory and assumes constant returns to scale (CRT) at firm levels in line with the assumption of perfect markets. It further assumes positive externalities determine the rate of return of capital.

Public and private investment generate external economies that affect the aggregate economic activity and offset diminishing marginal returns, and produce economy-wide increasing returns to scale (Todaro and Smith, 2011). However, there should be proper complementary investments to realize the spillover effect from private gains.

Suppose we are using labor and capital to produce a given output Y. Doubling both labor and capital would result in doubling output Y as shown in figure11, meaning that the technology exhibits constant returns to scale. However, an increase in factor inputs does not necessarily produce a proportional increase in output. An increase in factor inputs, for example doubling both labor and capital, can generate a more than or less than proportionate increase in output. As can be seen from figure 12, doubling the factor inputs, labor and capital, shifts the isoquant upward but the proportionate rise in output exceeds the proportion of rise in factor inputs, i.e., a technology that exhibits increasing returns to scale. For example, at firm level there are increasing returns to scale when use of factor inputs doubles, allowing the use of a more efficient method of production. The endogenous growth theory claim about increasing returns to scale arises from positive externalities in aggregate economic activity.

Figure-11: Constant Returns to Scale

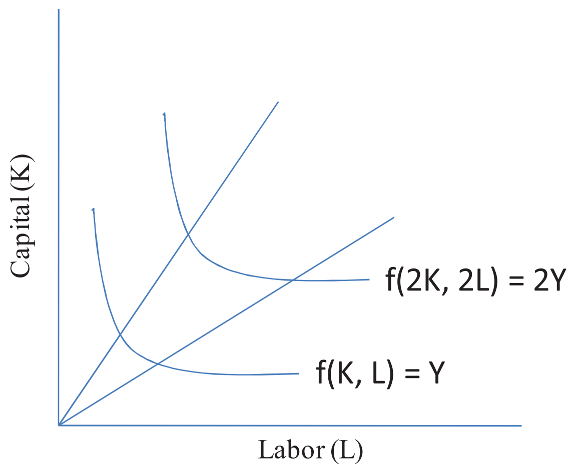
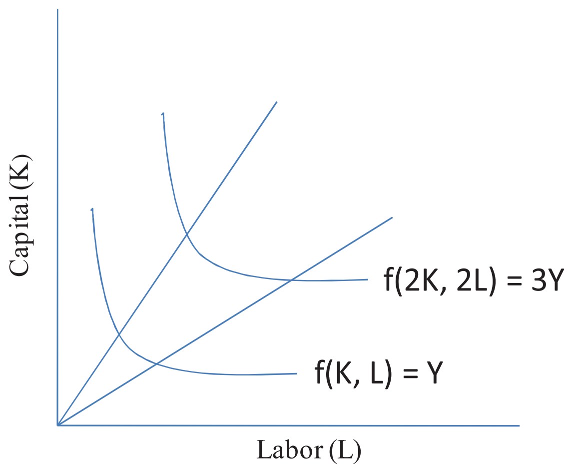


Figure-12: Incresing Returns to Scale



Newly generated private knowledge cannot be fully kept secret and patented. So a firm’s or industry’s innovations or inventions leads to productivity increases in other firms or industries because of the positive externality (Romer, 1986). The action of one agent can positively affect the action of other agent. For example, consider a country that opens a new port because of an increase in import and export volumes. With the opening of a new port, the existing roads are upgraded, new routes of roads and train lines are also built. This new development creates increased economic activity such as opening of new hotels, or supply of new goods and services, and establishment of new firms in the formerly rural villages and small towns. Neighborhood areas would also benefit from the amount of travelers. Their local production will get demand and additional return, which initiate them to start producing new products that have higher returns than the previous products. Not all these new benefits can be fully captured through pricing mechanisms by port firm, and there are also external benefits gained by other agents.

According to Romer's model, suppose a firm's production is a function of state of knowledge, k, and a vector of other factors of production, **X**. He assumes CRT at firm level in the sense that F is homogeneous of degree one and output as a function of ki and $\mathbf{X}_i$ when K is held constant. The state of knowledge, for simplicity, is assumed as a stock of disembodied knowledge but it is possible to work out the analysis based on embodied knowledge assumption because it does not affect the result of the analysis (Romer, 1986). Consider a cotton-processing machine. The machine has a processing capacity of 10 tons of cotton per hour. In the case of disembodied knowledge, we can think of the machine as one cotton-processing machine and 10 ton/hr cotton processing knowledge like two separate things. In the case of embodied knowledge, we can think of as 10 ton/hr cotton-processing machine one single item. Now suppose we take one given machine and have an engineer refit the same parts of the machine and upgrade the processing capacity of the machine to 15 ton/hr. In embodied knowledge we define it as a 15 ton/hr cotton-processing machine; whereas in the disembodied knowledge we define it like one cotton-processing machine and a 15 ton/hr cotton processing knowledge; i.e technological progress increased by 50%. The same holds for labor. Suppose one man has a capacity of assembling two computers per hour. In embodied knowledge presentation two computers per hour assembling man. In disembodied knowledge presentation one man and 2 computer/hr assembling knowledge. If we assume a technological progress of 50%, that is an increase of production from 2 computer/hr to 3 computer/hr due to labor-augmenting technology, all other things remaining the same such as the type food and amount the worker eats, and same working environment. In embodied knowledge we express this as a 3 computer/hr assembling man, whereas in disembodied knowledge expression one man and 3 computer/hr assembling knowledge.

When the source of technological change is not precisely known, in practice it is often termed as disembodied knowledge, and when the source that brought a change in productivity is known or is attributable to particular factor input it is termed as embodied knowledge (Ellis, 1993). Therefore, Romer's assumption of disembodied knowledge does not affect a result of the analysis.

According to Romer (1986), the production function of firm i depends on firm-specific inputs k_i and X_i, and on the aggregate level of knowledge in the economy. By the assumption of homogeneity of degree one (CRT) in k_i and X_i, and increasing returns in the aggregate stock of knowledge, K, the aggregate production function exhibits increasing returns to scale. In other words, if we have two factors of production, capital and labor, each individual production function is assumed to be constant returns to scale in capital and labor (Ray, 1998).

For any $\psi>1$, where ψ is constant.

$$\underbrace{F(\psi k_i, \psi K, \psi X_i)}_{\substack{\text{Aggregate production function} \\ \text{Assuming increasing returns to scale}}} > \underbrace{F(\psi k_i, K, \psi X_i)}_{\substack{\text{Aggregate production function} \\ \text{assuming constant returns to scale}}} = \psi F(k_i, K, X_i)$$

Suppose there are several firms, Romer assumes that growth process originates from firm level, in the economy, and each firm has a production function that exhibit CRT. It follows that:

$$Y = E\, K_t^{\alpha} L_t^{1-\alpha} \tag{14}$$

where E is a macroeconomic parameter and represents a measure of overall productivity. It is a positive externality, available to all firms in the economy, that arise from a joint capital accumulation of all firms in the economy, and neither exogenously specified, as in the Solow model, nor output of intentional R&D. The parameter E captures the positive externality comes with the process of capital accumulation of firms in the economy (Ray, 1998).

Let K_t^* denotes the average capital stock in the economy and is related to the average capital stock as follow (Ray, 1998):

$$E_t = a\, K_t^{*\beta} \tag{15}$$

where a and β are positive constants, and

$$Y_t = a\, K_t^{*\beta}\, K_t^{\alpha}\, L_t^{\alpha\text{-}1}. \tag{16}$$

Equation (16) represents a production function at firm level. If one assumes symmetry across firms, i.e. all firms are identical; then we have the aggregate function,

$$Y_t = a\, K_t^{\alpha+\beta}\, L_t^{1\text{-}\alpha}. \tag{17}$$

Because (α+β) + (1-α) > 1, equation (17) implies that the effect of positive externality generates increasing returns to scale for the overall economy.

The endogenous growth theory also shares some shortcomings that are common with the previous growth theories. An economy is a composition of different sectors, and these sectors of a given economy are not identical, they differ with one another including the intensity of capital verses labor use, but the new growth theory assumes that all sectors are symmetrical. The economies functioning in traditional market undergoes transition to commercialized markets in the process of economic development, so it is common to observe allocation inefficiency during the transition period. The new growth theory however does not capture the effects of allocation inefficiencies. It is also important to note that the importance of developed infrastructures, the level of capital and goods market, and conduciveness of institutional structures because these factors determine how efficient is the economy. An economic system that has efficient institution minimizes barrier of economic growth, but the new growth theory does not take into account the effect of institution (Todaro and Smith, 2011).

3.2. Structural Dynamics

The correlation of growth verses structural change is a research focus in the study of economic growth. Szirmai (2005, p.260) defined structural transformation “in which factors of production are transformed from the sector with the lowest productivity, agriculture, to the industrial sector where productivity is much higher and the pace of technological change and productivity is more rapid”.

Economic growth changes the structure of an economy in the sense that the economies’ sectoral composition of output tends to change with economic growth. It appears that structural change come as a result of increase in per capita income according to the “balloons” view of economic growth (Ocampo, 2004).

According to neoclassical theory, economic growth brings about structural change in at least two ways: (i) People spend a major part of their income for basic necessities if their income is low and not surplus enough above required for subsistence consumption. When per capita income however grows people include consumer durables and entertainment in their mix of consumption basket, and change their consumption pattern; and (ii) Economic growth creates a capacity to convert cumulated knowledge into physical capital because of surplus resources available for R&D. Economic growth also enables to import capital goods to process raw materials that were exported in primary form. Firms also benefit from the scale of the economy from the demand-driven expansion of production, and new firms enter into the market with new products accompanying the change of consumption pattern. Besides, firms improve technical efficiency, because learning-by-doing is partly a function of volume of output. Therefore, the process results in change in production pattern.

Ocampo (2004), however, argues that the interaction between innovations and development of complementarities in production structures are the driving force of economic growth. Efficiency difference among firms makes ease the release of resource from less efficient one, so efficient firms benefit from productive resources available in a market. Similarly, the spillover effect, as a result of efficiency, between and within sectors determines economic growth. In this respect the sectoral composition of production, linkages between and within sectors, and market structures have more contribution for economic growth for developing economies.

> " . . . economic growth in developing countries is intrinsically tied to the dynamics of production structures and to the specific policies and institutions created to support it, especially those that facilitate the diffusion of innovations . . ., and the creation of linkages among domestic firms and sectors. Avoiding macroeconomic instability is also essential,. . . However, macroeconomic stability is not a sufficient condition for growth. The broader institutional context and the adequate provision of education and infrastructure are essential "framework conditions", but generally do not play a direct role in bringing about changes in the momentum of economic growth," (Ocampo, 2004, p.2).

Therefore it is logical to argue that the dynamics of production structure and the stronger the linkage between and within sectors promote economic growth. However, the market structure and working factor markets in place influence complementarities of firms and sectors in the economy (Ocampo, 2004).

3.3. Uncertainty

In economic activity, there is uncertainty where it is not possible to have full knowledge over space of time, but it is still possible to attach a probable expectation. The sources of economic uncertainty are various such as changes in policy, or where there is a lack of clear perspective about future growth, such as a natural disaster, drought, flood, or war (IMF, 2012).

Uncertainty influences both microeconomic and macroeconomic level decisions. At the micro level a firm's production, sales volume and productivity is subject to uncertainty and at macro level uncertainty influences the overall factors reallocation and, thus, productivity.

A firms' interest to invest is negatively affected if they feel uncertainty and delay their decision to invest because the loss from investment can be unrecoverable (Bernanke, 1983). Similarly, households reduce their consumption of, particularly, durable goods and leisure services in the presence of growing uncertainty. Financial institutions also limit lending or increase interest rates if they feel high uncertainty. This hinders firms from investing, because of financial constraint, and, consequently, makes difficult to have an efficient reallocation of resources and results in a decline in total factor productivity that cause a decline in economic activity (Gilchrist, Sim, and Zakrasek, 2010).

Smallholding subsistence farmers, which accounts more than 96% of agricultural production in Ethiopia (CSA, 2009), often grow two or more types of crops on same or different plots, as a risk- coping strategy. If one fails due to unexpected drought they survive with the others, knowing that they would harvest more if they had grown one or two high-yielding crops. Lending institutions are also less willing to lend money to subsistence farmers because of the uncertainty of yields associated with moisture stress, so subsistence farmers are resource constrained.

3.4. Related literature

The research works explored tell what has been done so far in the related issues and the methodologies employed to adre3ss them. In addition, they also shoe the gaps that need to be covered in future.

The study of developing Asian economies by Lee and Hong (2012), using growth accounting framework, indicated that these economies had robust growth rate of capital accumulation and grew rapidly over the last three decades. Their study found that capital accumulation was the major source of rapid economic growth of these countries while the role of labor, education, and total factor productivity was limited. According to them developing Asia includes China; Hong Kong, China; India; Indonesia; the Republic of Korea; Malaysia; Pakistan; the Philippines; Singapore; Taipei,China; Thailand; and Viet Nam.

Weeks et al. (2004), in their study about Ethiopian economy, used an error correction model (ECM) based on Cobb-Douglas production function and estimated three models (two short term versions: version-1 compact ECM and version-2 scattered ECM) using 36 years data from 1960.

They found that labor is statistically insignificant in version-1 of short-term model whereas capital is significant in both versions of short-term and insignificant in the long-term specification. The study however does not detail how they arrived at capital stock and discussion of the methodology is not well detailed. The methodology also suffers from the inflexible properties of Cobb-Douglas function. Such works were taken as a lesson to better design the model specification.

One of studies of the performance of Ethiopian economy is that conducted by Nega and Nuru (2004). The study covers the period from 1960/61 to 2000/01. They studied the performance of Ethiopian economy examining capital stock, human capital, labor, foreign exchange earnings, and rainfall. They calculated capital stock as the accumulation of net fixed investment based on 1960/61 capital stock as benchmark, but the paper does not explain how they calculated the benchmark capital stock. It would have been important that they discuss their approach how they arrive at the benchmark capital stock because the assumptions and incorporated parameters and parameters size helps to evaluate the estimate. For example, how did they calculate their benchmark capital-output ratio? They developed an index of human capital stock using Jones' framework and used the index to assess the effect of human capital. The other factor they included in their model is yearly rainfall calculated from nine meteorological stations. In this respect, Ethiopia has very diversified many agro-ecological zones that are different to each other. One can find distinctly different weather conditions in a space of short distance. It is hardly possible observations from nine meteorological stations out of hundreds available to represent the whole agro-ecological zones, 18 agro-ecological zones, of the country and various seasonal farming activities. For example, major farm activities of some part of the country are dependent on the "short rain" season and others are on the other hand, on the "main rain" season; and there is a dry season where there is no major farm activity and expected to have no effect on the overall economic activity. Therefore, the annual rainfall data demands to be disaggregated into the three seasons. This necessitated a search for a different production function for developing the model; to disaggregate the rainfall variable into seasons and expand the representative rainfall data collected from the different agro-ecological zones.

They used the Johansen co-integration estimation technique to develop their model. The approach does not require a prior categorization of variables as exogenous and endogenous. They found that physical capital is statistically insignificant.

One of the efforts in economic growth studies is the search for other variables that are unique to and relevant for specific economic environments and adding those on the "traditional factors" to evaluate the effect of these variables, and look at the effect on the size of the residual if the added variables found statistically significant. Sala-i-Martin (1997) found 22 variables statistically significant out of 59 variables he has tested and emphasized the need to look at other relevant variables beyond the traditional ones to be able to understand the comprehensive policy implications.

Where there is uncertainty, even with best available information, the choices made by economic agents will differ from conditions in the absence of uncertainty and thus uncertainty usually creates a challenge in resource allocation. It could result in both technical and allocation inefficiency. The magnitude of its effect is far more when it comes to agricultural production because the system of agricultural production demands long duration, and it is less flexible for instant corrective measure.

The effect of factors affecting Ethiopian agricultural sector is significant on GDP due to the large share contribution of the sector and the indirect effect of agriculture on the other sectors. The agricultural production system is dominantly small holding rain-fed subsistence farming and highly vulnerable for moisture stress. The negative effect of a single year moisture stress extends to the following years for the reason that farmers not only loss farm income but also sell their farm asset for survival. Block (1999) estimated, using four sector simulation model, that the effect of a single shock to agricultural incomes decays over 5-6 years and drought cost 7% of the total GDP during the drought year alone.

A country's economic potential has a considerable role in maintaining its growth. On the other hand, if one assumes growth by factor accumulation, then other things remaining the same, a small-size economy reaches steady-state earlier than a large economy because of diminishing return of capital. If we relax the assumption of growth only by factor accumulation to include technology, and assume countries have similar economic characteristics (e.g., capital per capita) except size difference, the momentum of growth is stronger in large economies due to the contribution of economic size for the extent of multiplier and spillover effect and associated potential efficiency gain. According to Briguglio (1998) study on the effect of size of economies, he found that an increase in proportion of factor employment causes a higher proportional change in output since large economies benefit from economies of scale.

The above argument has implication for Ethiopian case. If we consider IMF ranking of countries, the rank of Ethiopia based on per capita income is very low but the total GDP figure changes the rank a lot. It indicates the relative economic capacity that the country has. For instance, according to the IMF data China, India, and Brazil were the 2^{nd}, 4^{th} and 7^{th} largest economy (in PPP) out of 182 countries (IMF, 2010). The ranking was based on how much their economy has produced in a year. That shows the capacity of their economy be able to produce at least at their current state of art. In terms of per capita income, however, their rank goes far down, China 93^{th}, India 127^{th} and Brazil 71^{th}, whereas Ethiopia's rank was 72^{th} by total GDP (in PPP) and 169^{th} on a per capita basis, so the reason behind for their economy have attracted a lot attention is the volume the economy have generated, partly, and the potential.

The various theories investigated in this section helped to sort out critical variables that have influence on growth. The review of the previous studies gives some insight about the gaps. The theories reviewed and practical experiences help to develop methodologies and thereby answer the research questions.

4. Methodology and Data

The methodology developed or chosen to study a give economy affects the policy implications derived from the study. Similarly, the quality of data and related measurement used influence the confidence we will have on the study results.

4.1. Methodology

The estimation of the model depends on the behavior of the function used in the study, so the methodology employed in study is so important. If the functional behavior and form applied is inappropriate, it is likely having incorrect estimation and consequently irrelevant policy implications derived from incorrect conclusions. Therefore, it is necessary to examine appropriateness of the functional specifications before using it to an analysis.

A translog production function is used and three models are estimated. First, a translog function includes a time variable for the purpose of technical change, and, thus, calculated the first derivatives of the function with respect to capital, labor, and time to get elasticity of capital, labor, and rate of technical change, respectively. The total factor productivity growth (TFPG) was derived as a residual between the growth of output and the contribution of growth of factor inputs. Second, the first model was augmented by including sector shift variable to look at the effect of structural dynamics on GDP. Third, the second model further augmented by including rainfall variables to examine their effect on GDP.

4.1.1 Model Specification

The Cobb-Douglas production function is widely used in growth models despite its restrictive assumptions. It assumes constant returns to scale, perfect market, and constancy of input substitution. It does not allow variable scale of return appropriate for a developing economy, or account for these economies being characterized by dynamic structural transformation, moreover the extent of externalities is considerable. In addition, factor reallocation is very dynamic in the process of structural economic transformation due to the differences in the marginal returns of factor inputs between firms and across industries. On the other hand, firms in developed economies are basically working more likely on the optimum production frontier because of cumulated knowledge and the established efficient institutions. These conditions are only in the process to come into existence in developing economies. Hence, variable returns related to the dynamics, as well variable factors rate of substitutions are the behavior of these economies. Therefore, a flexible or less restrictive production function would explain these economies. In this respect translog production function is more appropriate to characterize them.

The translog production function is a flexible form, imposes no a priori restrictions such as homotheticity, constancy of the elasticity of substitution, or additivity on the structure of technology (Christensen, Jorgenson and Lau, 1973) and allows one to derive returns to scale of the economy from the estimates of the production function.

Except the difference on the output levels associated with the isoquants, isoquants of a homothetic technology just looks isoquants of a homogenous technology since homothetic function is a monotonic transformation of a function that is homogenous of degree one. Suppose there is a production technology producing a single output (Y) using two inputs, capital (K) and labor (L). If one doubles the input levels, 2K and 2L, it gets two times as much as the original output in case of homogenous function of degree one. A homothetic technology, on the other hand, has almost the same property, and the isoquants shifts upward and behaves just like a homogenous function, the output level, however, will not be necessarily two times as much as the original level (f(2K, 2L) ≠ 2Y) (Varian, 1992). However, a translog function does not impose such a homotheticity restriction.

The translog production function, which takes into account a number of n inputs (production factors) and technical change, can be expressed as (e g Kim, Park and Park, 2010):

$$lnY_t = \alpha_0 + \sum_{i=1}^{I} \alpha_i \, lnX_i + \frac{1}{2}\sum_{i=1}^{I}\sum_{j=1}^{J} \beta_{ij} \ln X_i \ln X_j + \gamma_1 t + \frac{1}{2}\gamma_2 t^2 + \sum_{i=1}^{I} \delta_i \, t \ln X_i \qquad (18)$$

where $\beta_{ij} = \beta_{ji}$ for all i, j (Young's theorem-the order of differentiation does not matter)

The estimated model thus is:

$$lnY = \alpha_0 + \alpha_L lnL + \alpha_k lnK + \beta_{Lk} lnLlnK + \frac{1}{2}\beta_{LL} lnLlnL + \frac{1}{2}\beta_{kk} lnKlnK + \gamma_1 t + \frac{1}{2}\gamma_2 t^2 + \delta_L tlnL + \delta_k tlnK \tag{19}$$

where the variables Y, L, K and t are GDP, Labor, Capital, and time, respectively. The time variable, t, is a time-trend that serves as a proxy for technical change; and α, β, γ and δ are the parameters to be estimated.

The interaction parameter, β_{kL}, reflects the local level effect of two inputs where act together (Kox, Leeuwen and Wiel, 2007). In the presence of input complementarity, that is if the output elasticity of one input depends on the level of other input, the more significant will be the interaction parameter. The parameters β_k and β_L represent the linear effects of inputs whereas β_{kk} and β_{LL} are the non-linear effects, where γ_1 and γ_2 represent disembodied technical change, and δ_L and δ_K represent embodied technical change that show to what extent a technical change on the use of inputs is biased towards labor or capital, respectively.

The output elasticity of input i is defined by:

$$\varepsilon_i = \frac{\partial lnf(X,t)}{\partial lnX_i} = \alpha_i + \sum_{j=1}^{J} \beta_{ij} lnX_j + \delta_i t . \tag{20}$$

The elasticity of labor and capital thus derived from equation (20) are:

$$\varepsilon_L = \frac{\partial lnY}{\partial lnL} = \alpha_L + \beta_{Lk} lnK + \beta_{LL} lnL + \delta_L t \ \ and \tag{21}$$

$$\varepsilon_k = \frac{\partial lnY}{\partial lnK} = \alpha_k + \beta_{Lk} lnL + \beta_{kk} lnK + \delta_k t . \tag{22}$$

We can, therefore, infer that the marginal elasticity of output is dependent on both the input levels and technology index from the right-hand-side of equation (20) (Tzouvelekas, 2000).

The estimates of returns to scale (RTS) can be obtained as the sum of the marginal elasticity of output with respect to each input.

$$\text{RTS} = \sum_{i=1}^{I} \varepsilon i = \sum_{i=1}^{I} (\alpha_{\mathrm{i}} + \sum_{j=1}^{J} \beta_{\mathrm{ij}} \, lnX_{\mathrm{j}} + \delta_{\mathrm{i}} \, \mathrm{t}) \tag{23}$$

The derived function for two input case thus is:

$$RTS = \sum \varepsilon i = \alpha_{\mathrm{L}} + \beta_{\mathrm{Lk}} \, lnK + \beta_{\mathrm{LL}} \, lnL + \delta_{\mathrm{L}} \, t + \alpha_{\mathrm{k}} + \beta_{\mathrm{Lk}} \, lnL + \beta_{\mathrm{kk}} \, lnK + \delta_{\mathrm{k}} \, t \tag{24}$$

If RTS < 1, then are decreasing returns; if RTS = 1, then there are constant returns; and if RTS > 1, there are increasing returns.

This study examines the rate of technical change aggregated over the study period and disaggregating the period into the three regimes. Technical change is a change in the ability to produce a given amount of output using less amount of input than before or more unit of output using given amount of inputs (Ellis, 1993). For example, we have been producing a unit of output using four units of labor and three units of capital, then because of a change in techniques of production we have able to produce the same amount of output using less units of labor and capital, say three units of labor and two units of capital. If there is a biased technical change, in Hicksian case, the factor ratios change in favor of one of the factors than another, whereas a neutral technical change cause an equi-proportionate rise of factor inputs efficiency (Heathfield and Wibe, 1987). In the example given above the factor ratio, L/K, is changed from 4/3 (1.333) to 3/2 (1.5) meaning more labor is combined with a unit of capital as compared to the initial technology, an increase in the proportion of labor to capital. The increase in the factor ratio, L/K, implies, in this case, that the technical change moved in favor of using more labor than capital, i.e, labor biased technical change. Suppose the technology is changed from four units of labor and three units of capital factor combination to 3.333 units of labor and 2.5 units of capital for a given unit of output. The later change implies Hicks neutral technical change, named after the economist, for the factor ratio 4/3, (L/K = 4/3 = 1.33), remains same 3.333/2.5, (L/K = 3.333/2.5 = 1.33), constant factor ratio.

The rate of technical change (TC) is the elasticity of output with respect to time (Heshmati, 1996):

$$TC = \frac{\partial \ln f(X,t)}{\partial t} = \gamma_1 + \gamma_2 t + \sum_{i=1}^{I} \delta_i \, lnX_i \tag{25}$$

The derived function for two input case thus is:

$$TC = \frac{\partial lnY}{\partial t} = \gamma_1 + \gamma_2 \, t + \delta_L \, lnL + \delta_k \, lnK \tag{26}$$

Equation (26) implies that the measure of technical change varies with time and input use, and we can infer from the function whether the technical change is neutral or biased towards particular input. Technical change is capital (labor) using, neutral or saving if δ_K (δ_L) >, =, or < 0, respectively.

The TFP thus calculated capturing all the effects of variables not included in the model. The measure of growth of TFP for a production function as specified in equation (19) then becomes

$$TFPG = \Delta \ln Y_t - \beta_k \, \Delta lnK_t - \beta_L \, \Delta lnL_t - \frac{1}{2}\beta_{kk} \, (\Delta lnK_t)^2 - \frac{1}{2}\beta_{LL} \, (\Delta lnL_t)^2 - \beta_{kL} \, \Delta lnK_t \, \Delta lnL_t. \tag{27}$$

Then two models are developed by augmenting equation (19) to assess the effect of structural transformation and rainfall on growth. The assumption is that a change in contribution between agriculture and non-agriculture sectors for GDP represents the contribution of structural dynamics for GDP growth. Therefore, the difference between a percentage share of non-agriculture sector, (in %), minus a percentage share of agriculture sector, (in %), is used as a proxy variable for structural dynamics, ss.

The estimated function is thus:

$$lnY = \alpha_0 + \alpha_L lnL + \alpha_k lnK + \beta_{Lk} lnLlnK + \frac{1}{2}\beta_{LL} lnLlnL + \frac{1}{2}\beta_{kk} lnKlnK + \gamma_1 t + \frac{1}{2}\gamma_2 t^2 + \delta_L tlnL + \delta_k tlnK + ss. \quad (28)$$

Then the translog function is further augmented to include rainfall variables to see the effect of rainfall on GDP, becoming:

$$lnY = \alpha_0 + \alpha_L lnL + \alpha_k lnK + \beta_{Lk} lnLlnK + \frac{1}{2}\beta_{LL} lnLlnL + \frac{1}{2}\beta_{kk} lnKlnK + \gamma_1 t + \frac{1}{2}\gamma_2 t^2 + \delta_L tlnL + \delta_k tlnK + ss + lnRK + lnRB + lnRD \quad (29)$$

where RK is annual rainfall of "main rain" season ("Kiremt"); RB is annual rainfall of "short rain" season ("Belg"); RD is annual rainfall of Dry season ("Bega").

4.1.2 Regression analysis

This study used a time series data (1960 to-2010), a collection of random variables ordered in time, that is, a stochastic process, in the analysis. The purpose of regression analysis using time series data is to understand the relationship between two or more variables, implicitly assuming that the probability distribution of the time series process is stable over time, so the primary step in time-series regression is to test whether the variables are stationary or not. We cannot expect to figure out much about how one variable affects the other variable where there is no systematic change, i.e., if it is arbitrary, in each time period in a relationship between two variables (Wooldridge, 2009), so we need to look into stability of a variable under question before using them in regression analysis.

A stochastic process is said to be stationary if its mean and variance are constant over time. A nonstationary time series on the other hand will have a time variant mean or variance or both

(Gujarati and Porter, 2009). In the presence of nonstationary variable the t statistics does not have an asymptotic standard normal distribution even in large sample size since the assumption on the property of the error term (zero mean, constant variance) are no longer valid and, therefore, the t statistics cannot be used for testing hypothesis in the usual way (Wooldridge, 2009). If the time series is found nonstationary, AR(d), we can transform it into stationary by applying appropriate differencing or by including in the model a time variable measured chronologically for detrending. In this study, the data is transformed into difference form to avoid nonstationary problem because the stationary test showed that the data was not stationary; and there was no need to be concerned for detrending because the model have a time variable as proxy variable for technical change, thereby used for detrending.

The other problem that needs attention in time series variable is serial correlation in the error terms, because of temporal ordering of time series variable the successive observations are likely to exhibit intercorrelations (Gujarati and Porter 2009). In this connection differencing removes serial correlation as well any linear time trend nonstationarity. Hence, correction is made for serial correlation using Newey-West standard errors (HAC) for the Breusch-Godfrey test (AR(p)) carried out after the variables changed into first difference form showed autocorrelation in the error terms. Besides, the procedure simultaneously corrects for serial correlation and for Heterosckedasticity, so it has additional advantage though Heterosckedasticity is not common in time series data as in case of cross-sectional.

4.2. Data and Measurement

The sample size and quality of data highly influence the quality of regression estimation. The major constraint in growth models regression is the sample size. Therefore, in the study of Ethiopian economy consideration have been given on this aspect. Data since the 1950s was collected, when it was first recorded in the national accounts.

4.2.1 Data Sources

The data used in this thesis are collected from four sources: Ministry of Finance and Economic Development of Ethiopia (MoFED), World Bank (WB), United Nations Population Division, and National Meteorological Agency of Ethiopia (NMAE).

The GDP data for 1960-1980, in 1981 base year, were obtained from MoFED and the same data for 1981-2010, in 2000 base year, obtained from World Development Indicators of the WB. Similarly, the GFCF data for 1960-80 in current market price were obtained from MoFED and for 1981-2010, in constant 2000 price, obtained from World Development Indicators of the WB. The two GDP data series with different base years were spliced using the growth rate to convert the data with a 1981-base year into the 2000-base year. The time series data for rainfall were collected from NMAE, for the periods 1960-2006.

4.2.2 Data Construction

It was necessary to have some data construction work because: (i) some of the macroeconomic data had different base years and needed to convert them into common base year; (ii) it is hard to find data for capital stock for the early periods for most developing countries so it needs to build time series data for capital stock using available investment data, GFCF, and appropriate assumptions.

4.2.2.1 Output

Output is measured in real GDP in constant 2000 prices. The real GDP obtained from MoFED was at constant factor cost, i.e, less net indirect taxes, and the available net indirect taxes were at current market prices. So the net indirect taxes converted into constant prices by GDP deflator and added to GDP at factor cost to derive GDP at constant basic prices.

It was also necessary to convert the two time series data of 1981 and 2000 base years into one base year, to the latest 2000. I spliced them, or back adjusted them from 1980 to 1960, using growth rate in the following way, on the assumption that the two data sets have same growth rate.

$$g_{81}^{1981} = \frac{GDP_{81}^{2000} - GDP_{80}^{2000}}{GDP_{80}^{2000}} \tag{30}$$

$$GDP_{80}^{2000} = \frac{GDP_{81}^{2000}}{1+g_{81}^{1981}} \tag{31}$$

$$GDP_{t-1}^{2000} = \frac{GDP_{t}^{2000}}{1+g_{t}^{1981}} \tag{32}$$

where g is growth rate; GDP Real Gross Domestic Product; t years, and the subscripts 1981 and 2000 indicate base years.

4.2.2.2 Capital

I estimated the real capital stock for the aggregate economy using a perpetual inventory approach in the sense that the stock of capital is the accumulation of the stream of past investments.

$$K_t = (1-\delta)K_{t-1} + I_t \tag{33}$$

$$I_{net} = I_t - \delta K_{t-1} \tag{34}$$

where K is capital; I investment and δ fixed capital depreciation rate.

The investment series is used to construct a time series of physical stock is GFCF at constant price. However, the data for 1960-1980 obtained from MoFED was in current price and therefore converted into 1980 constant prices using the GDP deflator, and the same splicing method that applied for GDP was also used for GFCF data of two base years, 1980 and 2000, as shown below. The initial capital-output ratio in 1960 was estimated 1.4 for Sub-Saharan Africa (Nehru and Dhareshwar, 1993), and a fixed capital depreciation rate of 6% was used to calculate the capital stock series.

$$GFCF_{t-1}{}^{2000} = \frac{GFCF_t{}^{2000}}{1+g_t{}^{1981}} \qquad (35)$$

where GFCF is Gross Fixed Capital Formation; g growth rate; t years; the subscripts 1981 and 2000 indicate base years.

4.2.2.3 Labor

The working age population of aged 15-64 was used to measure the level of labor services. The main limitations of this labor measure however is that the effect of under-utilization, or unemployment can result underestimation of measured productivity level. The quality of labor service is not adjusted for skill, which is a function of formal education, on-job training and learning-by-doing, and therefore the effect of human capital would be captured in TFP.

4.2.2.4 Rainfall

The rainfall data were collected from 146 meteorological stations for various agro-ecological zones for 1960-2006. The monthly average rainfall in mm was calculated from those stations that had available data, then the sum of the months of June to September for the "main rain" season ("Kiremet"), February to May for the "short rain" season, ("Belg"), and October to January for "dry" season, ("Bega"), were calculated and used for estimation.

5. Results and Discussion

In this study, three models were developed and relevant tests were conducted. In table-2, the results of the econometric analysis performed on the three models are reported. The ADF test was conducted to assess the stationary of the time series data and a correction was made using first differencing. A time variable was already included in the function for technical change and therefore it was not necessary to add a detrending variable. Newey-West standard errors (HAC) were used after the Breusch-Godfrey test for autocorrelation as this simultaneously corrects both autocorrelation and heterosckedasticity problems.

After making the corrections, it is necessary to examine the appropriateness of structure of the function before discussing the results of the analysis. Therefore, the test for the joint significance of the second order and interaction variables of the translog production function showed that the joint distribution of the variables is statistically different from zero (P = 0.0000). This implies that translog production function for the Ethiopian economy is appropriate compared with a Cobb-Douglas functional form.

Model-1 was estimated as specified on equation 19, and elasticity of labor and capital were calculated as shown on equation 21 and 22, respectively. The explanatory variables included in model-1 are capital, both in linear and nonlinear form, labor similarly in both linear and nonlinear form, and the capital-labor interaction variable. Besides, the model included the proxy variable for technical change (t), as well both in linear and nonlinear form, and the interaction variables of time-capital and time-labor. The signs for both linear and nonlinear variables of capital and labor were as expected whereas their interaction variable was not, which was negative. The sign for technical change variable was not as expected because a shrink in the production function over time is not normally expected. The signs for the interaction variables of time-capital and time-labor were positive and could have either signs. Four of them out of the nine variables were found statistically significant at 10% significance level. The result for the correlation coefficient were 28% (R^2 = 28%).

With respect to individual inputs, capital was statistically significant in this study. This is in contrast to Nega and Nuru (2004) and the long-term specification of Weeks et al. (2004). Economic growth theories and the success of East Asian countries confirm that physical capital plays vital role for economic growth in developing economies. Growth theories explain that the marginal return of capital is high at an initial stage, which is the case in capital scarce developing economies. According to the World Bank (2010), the GDS was very small, the average of the study period as percentage of GDP was 6.7%, and the GFCF was 15.8%, which was below the average of Sub-Saharan African countries (20%). The capital output ratio was 1.4 in 1960 and 1.82 in 2010. Hence, the marginal return of capital, and its contribution for economic growth in this type of economy, is considerable. According to Lee and Hong (2012) capital accumulation was the driving force for developing Asian countries' rapid economic growth. Therefore, the finding of this study is consistent with the theory and historical experience.

Labor, on the other hand, was found to be statistically insignificant, which can be expected in conditions where there is high unemployment. The average unemployment rate for the period 1999-2009 was 14.8% (WB, 2011). In the presence of high unemployment, or underemployment the labor force is not producing and its contribution for growth would not be determinant. It rather competes for a resource that otherwise would have been converted into productive capacity. The marginal return of labor also will be low if the economic activity cannot accommodate it. This however does not mean that labor does not have contribution for growth. A firm's demand for labor and/or capital increases if the firm is creative enough to generate demand by developing a new product or producing at the least-cost, which would make them competitive and would give them market power. A deliberate effort to create such demand could be through infrastructure development by prioritizing potential development areas and selective incentives for economic activity that generates a positive externality. This can create further demand, which arise from increased income associated with newly employed labor, which in turn encourages firms to expand supply, and demand for more labor.

The result for the labor-capital interaction term, lnKlnL, showed that, the existing economic activity does not exhibit strong complementarities between capital and labor. It suggests that a factor is accompanying the other loosely, or that an increase in the use of one factor is loosely complementing the other. In this study, labor and the capital-labor interaction were statistically insignificant ($P > 10\%$) while capital stock was significant. From this, one can conclude that, capital is more of a determinant in explaining the economic activities of the country. The existence of surplus labor suggests, at least in an intermediate stage, labor using techniques, and policy instruments that helps labor shift from labor abundant to other sectors to increase the marginal return of labor. Therefore, the contribution of labor in a labor-surplus economy depends on the choice of technique of production and related policy instruments.

The value of the elasticity of capital suggests that there was a 0.98% increase in GDP for a 1% increase in capital during the Imperial period, the highest rates. The lowest was 0.21% during the Derg period, based on the comparison of averages of each period. In The EPRDF period, average elasticity of capital was 0.68%. This period had the highest record for elasticity of capital over the study period, which was 1.7% in 1992. However, the highest was 1.56% in 1961, during the Imperial period, when we compare the value for individual years instead of averages of each regime.

The elasticity of labor was negative throughout the study period. This can happen for at least two reasons. First, a high population growth in an economy where agriculture is a dominant sector would lead to a high pressure on arable land and consequently less and less land holding per household because of land reallocation. This will result in a decline per unit of land output of agricultural activity due to diseconomies of scale. The size of land after a certain minimum level limits farmers from using high yielding inputs such as fertilizer. Thus, it limits the type of crops grown because farmers would be forced to focus on production of crops for household consumption, even if it is a type of crop that yields less per unit of land. It also forces the farmer to use more hand tools for cultivation of land instead of oxen power which are not best suited for the activity. Second, in the presence of high unemployment, the potential labor becomes simply consumer than productive factor. This leads to resource competition and results in output decline in the long-term because of limited capital formation. Belay and Maning (2004) found that the small size of land holding was one of the most important barriers for agricultural production in the Ethiopia.

One of the advantages of the translog function is that, it enables to assess the effect of technical change on input use. If, for example, the estimate for interaction variable, i.e., technical change-capital variable (tlnK), is positive it implies that the change is capital using, if it is negative implies that capital saving and if it is zero it indicates that a neutral change. The test for Hicks neutrality showed that the joint distribution of the estimates for tlnK and tlnL is not statistically different from zero (P = 0.4139) meaning that technical change is Hicks neutral. This implies that the applied technical change produced a parallel shift of the production function, not biased to either capital or labor. In other words, the change in the technique of production generated an equi-proportionate increase or decrease in the use of capital and labor.

A technical change should be a reflection of factors' relative price. Technical change would be biased towards the cheaper factor input to reduce cost of product, given output level. The relative price of factor input, in turn, is a reflection of abundance. Abundantly available resource is cheaper than the scarce one. Hence a Hicks neutral technical change is not expected in an economy where one factor, labor, is available abundantly and other factor, capital, is very scarce. In this sense the technical change should be labor using or capital saving.

The aggregate technical change over the study period was found to be negative. It implies that, the production function in aggregate shifted inwards over the study period. In other words, the output was declining or the production technique has not been yielding more output from a given amount of input. It is therefore difficult from this path to expect considerable growth due to the poor performance of chosen technique of production. The general pattern of the technical change had a lot of fluctuation. It had a mix of outward and inward shifts in the production function, in all the three regimes. It was negative, on average -0.0045, throughout the latter decade of the Imperial period. This means that, there was an inward shift in the production function in each years of the period. The technical change estimate for about 63% of the Derg period was negative. The average estimate for technical change for the period was -0.0008. From this, one can conclude that same level of output have been produced from given inputs. In other words, there was almost no change, on aggregate, in the technique of production during this period. It implies there was no change in the production state of art. Technical change, however, has showed improvement in the EPRDF period, which was 0.003 on average and positive all over the years, which means, there was an outward shift in the production function. This makes it different from the others periods and implies that there was an increase in output from given output.

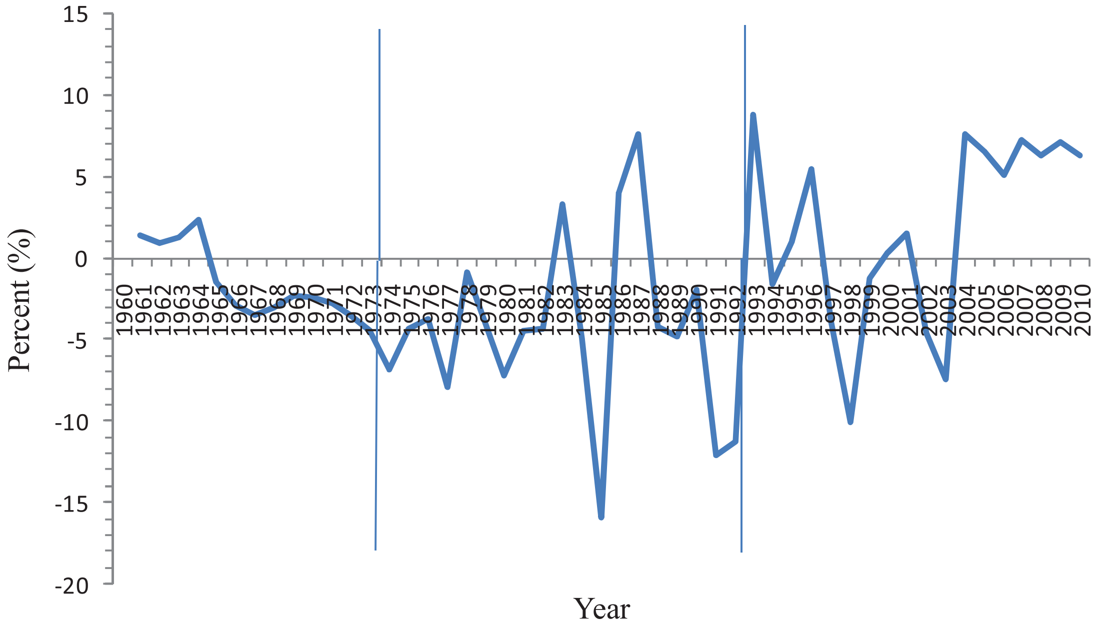
The growth of TFP was negative for 66.7% of the Imperial period, on average by -1.34%. There was further decline in TFPG during Derg period, which was on average -4.09%, and negative for 84.2% of this period. The average TFPG was positive only during EPRDF period where the average growth during this period was 1.19%, and about 36.8% of the growth rate of TFP was negative. The highest decline, over the study period, was -12.11% in 1991, -11.28% in 1992 and -10.12% in 1998. The years 1991 and 1992 were when the civil war was at its climax and finally the Derg administration ended.

Figure 13 shows a continuous decline of TFPG throughout the Imperial period. The major factors for the overall decline of productivity were structural bottlenecks related to landownership, armed conflict between 1967-69 in the northwest areas opposing tax reform on agricultural produce (mongabay, 2010), growing civil war in the northern part, the 1963 drought (NMSA, 1996b) and the 1960 attempted coup.

The decline of productivity further worsened during the Derg period with a few years of exception. The Derg period was characterized by inflexible product and factor markets due to fixed price on agricultural produce and other major consumption goods, continuous civil war throughout the period, three major droughts (1973, 1978, 1984-85) (NMSA, 1996b) and the 1977-78 war with neighbor country Somalia. Policy shocks were also the characteristics of the Derg period. For most of this period, the regime followed a socialist economic system and later, in 1991, had declared a mixed economy.

The EPRDF regime, on the other hand, adopted a market liberalization policy where price plays a resource allocation role. However, TFPG have not been improved immediately due to transition phase and the new government administrators did not have previous administrative experience. Besides, there were two major droughts in 1993 and 2003 (NMSA, 1996b; EEA, 2004), and the 1998-2000 Ethio-Eritrean war have contributed for poor TFPG.

Figure-13: Growth of total factor productivity (TFPG)



The augmented translog function including sector shift variable, model-2, showed that the transition from agriculture to nonagricultural sector contributed positively. A 1% shift from agriculture to the non-agricultural sector results in 17% rise in GDP. This is because the shift is composed of a shift in resources, such as transfer of labor from labor surplus or the less efficient sector to more efficient one. The reallocation of labor by itself contributes positively for growth because of the existing system of agricultural production, which is a less productive subsistence form of production. It is using oxen plow and, sometimes hand cultivation. The introduction of the shift variable made the capital-labor interaction estimate statistically significant. It implies that the capital-labor complementarity is becoming stronger with the shift from agriculture to non-agriculture. The non-agricultural sector is more capital using, relative to subsistence farming; and the intermediate structural transformation exhibits a more capital-labor complementarity, since the intermediate stage is not much automated. In fact, the more the production system is automated, the less complementarity there is between capital and labor. This however is the practice of developed production techniques and is different from the intermediate one. The explanatory power of the model is also increased to 32% (R^2 = 0.3189), but still small and needs further study including other variables relevant to explaining the working of the economy.

The model was further developed to include rainfall variables, model-3, where RK represents "kiremt"-the "main rain" season, RB refers to "Belg"- the "short rain" season, and RD the dry season. Unsurprisingly, the dry season does not have any influence on agricultural production. There is no major agricultural production activity during this season, except field animal grazing. Except for the pastoralist animal herding system, the other livestock production systems are supplemented from leftover and the aftermath in the field after harvest, prepared feed and stored, and some grazing available because of rainfall during the "main rain" season.

The result showed that, the rainfall during the dry season had no influence, as was expected (P = 0.881). It is the "Belg" rain that has high variability than "Kiremt" rain and more susceptible for droughts. Therefore, the positive sign of the coefficient for "Belg" season was as expected. The "main rain" season rainfall has effect on GDP (P = 0.058). However, the sign of the coefficient for this season was found negative which was not expected. In other words, an increase in rainfall in this season adversely affects the overall economic output. Rainfall can affect crop production positively or negatively, meaning it has adverse effect if its level is above or below an optimum range. The negative effect can be because of the level effect or time deviation from the usual farming period. According to NMSA study (1996b), more years of high rainfall than deficient years was observed in "kiremt" season and in aggregated annual rainfall.

Table-2: Estimation Results

Coefficients	Model-1		Model-2		Model-3[a]	
	estimates	P value	estimates	P value	estimates	P value
lnK	1.5336 (0.5818)	0.012	1.6372 (0.4683)	0.001	0.5416 (1.2393)	0.665
lnL	5.1811 (3.9692)	0.199	7.2602 (5.0401)	0.158	6.0483 (6.5624)	0.364
lnKlnK	-22.0309 (5.3668)	0.000	-16.3478 (5.3107)	0.004	-11.7638 (9.8284)	0.241
lnLlnL	-289.6036 (298.8743)	0.338	-446.6757 (341.1395)	0.198	-332.8691 (420.2485)	0.435
lnKlnL	-11.6813 (24.0455)	0.630	-38.1481 (20.2916)	0.068	-23.6319 (28.6649)	0.416
tlnK	0.0132 (0.0169)	0.439	0.0249 (0.0184)	0.185	0.0462 (0.0216)	0.041
tlnL	0.0403 (0.2007)	0.842	0.1651 (0.2049)	0.425	0.0529 (0.1945)	0.787
t	-0.0072 (0.004)	0.076	-0.0085 (0.004)	0.039	-0.0065 (0.0035)	0.073
t^2	0.0002 (0.0001)	0.000	0.0001 (0.0001)	0.082	0.0002 (0.0001)	0.196
ss			0.1742 (0.0825)	0.041	0.2083 (0.0893)	0.027
lnRK					-0.0384 (0.0195)	0.058
lnRB					0.0327 (0.0276)	0.246
lnRD					-0.0012 (0.0079)	0.881
lnRKlnRK					-0.3397 (0.3247)	0.304
lnRBlnRB					-0.0042 (0.1224)	0.973
lnRDlnRD					-0.0171 (0.0108)	0.124
cons	0.0218 (0.0591)	0.714	0.0087 (0.0723)	0.904	0.0319 (0.0929)	0.734
R^2	28%		32%		33%	

NB: a- from 1960-2006

The “main rain” season demands some mechanisms to avoid the negative effect. These include the examination of the timing of rainfall: the beginning and the ending periods if there is change in the regular patter due to climate change. There is no major change observed in farm schedules in small holding subsistence farming households, which are the dominant agent in the sector. If, for example, the current trend changes to early raining, a change from the usual pattern occurs, it needs farm activities such as land preparation and sowing to begin early in accordance with the new pattern. The same should apply otherwise, if the new pattern looks late coming. Similarly, a change in the period of farm activity is necessary in such a way that unseasonal rainfall does not damage crops before they are harvested. Second, if the problem is caused by excessive rainfall, then it is necessary to introduce and promote appropriate water drainage techniques.

It is also reasonable to examine the effect of rainfall by changing the measurement approach instead of the absolute form. In this respect, using deviation of the rainfall from its long-term average, instead of the direct measure can help drive sound implications. It is because the deviation from the optimum level that can more indicate the impact of rainfall on production.

In the third model sector shift, technical change, “main rain”, and capital-time interaction variables were statistically significant ($P < 10$). The capital-time interaction variable became significant, which have not been in early estimates. It may raise a question that the rainfall variables are irrelevant, because including irrelevant variable, can results in too large variance in estimates and makes them insignificant, which can make other variables insignificant too. However, this is not the case because the rainfall factor is relevant for this economy and two of the rainfall fall variables have showed expected signs. So it needs to change the measure of the variable in deviation form from their respective long-term average, assuming that their average is their optimum level for production, and to estimate the function.

The explanatory variables in model-1 explains only 28% of the change in GDP ($R^2 = 0.2801$). This is because, the country has been in civil wars for three decades, have experienced frequent droughts, change of government in coup and rebel fighting. These all magnify the influence of other factors such as institution, which are not included in the model, while reducing the explanatory power of traditional factor input, capital and labor.

6. Conclusion and future perspectives

This section provides concluding remarks, limitation and future perspectives

6.1 Conclusion

This study has attempted to evaluate the influence and contribution of major variables (labor, capital, sector-shift, rainfall, and technical change) to the Ethiopian economy. The study indicated that factor accumulation had two implications. Physical capital is contributing positively to economic growth. In a capital scarce economy, the contribution of physical capital, however, needs wise use of the resource. It needs to direct an investment into activities that has high marginal returns of capital and in such a way the multiplier effect of the investment amplified through backward and forward linkages, and generate positive externalities. However, the decline in GDS per GDP since 1998 can hamper the capital formation and its contribution. Hence, it needs to revise the deposit rate, to discourage consumption of selected goods and services, and identify sources of inflation and tackle them accordingly. The contribution of labor, on the other hand demands a better mechanism as to how to channel the surplus or underemployed agricultural labor to other sectors that can utilize labor productively. In this respect, promoting labor-intensive economic activities and labor biased techniques of production, in short and medium term, helps to utilize available labor effectively.

The way factor inputs were combined in the production process, in particular, and the overall technology in its broader meaning that includes institution were not encouraging. There has been inefficiency in the way the entire economy has converted productive inputs into output throughout the Imperial and Derg periods. Therefore, the productivity factor has to get substantial consideration to improve and make sustained growth.

A “New” variable, “sector shift” was included to assess how the change in the production structure affects economic growth. The result for structural change of the economy indicated important policy input. The result showed that the structural shift is contributing positively to growth. Therefore promoting this shift with selective economic incentives and development of complementary investments will help for efficient resource reallocation and speeding up the structural dynamics.

The inclusion of rainfall variable is also different from traditional approach that focuses mainly on capital and labor. The signs for the two estimates of rainfall variables were as expected. All the three variables were expected to be statistically significant; however, only two of them were. The existing volume and pattern of rainfall of the “dry” season, ”Bega”, did not show any influence on the overall economy. Therefore, any intended major agricultural activity during this season can only be realized by using irrigation or water conservation techniques. The “main rain” season, “kiremt”, on the other hand, needs an assessment of the timing of its pattern, and make some changes in the schedule of farm activity, or use of water drainage mechanisms to alleviate the negative effects.

6.2 Limitations of the study

However, it would have been more indicative if the rainfall variables were measured in deviation form from their mean level since it is the deviation from a given optimal level that affects agricultural production. Therefore, it is recommended that future study should consider this approach to study the effect of rainfall on GDP.

6.3 Future research

Civil war, frequent drought and coup had enormous influence in Ethiopian economy. The explanatory power of the models could have been improved if their effects were controlled by including the dummy variable representing them. Therefore, future works should incorporate this dummy variable to reflect their effect.

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Appendix

Appendix-1: Summary of some macroeconomic indicators

Variables	1960-72	1973-91	1992-2010
GDP average	26,573,495,150	42,204,618,780	79,950,333,318
Capital (K) average	29,874,733,736	65,527,736,360	162,376,346,835
Labor average	14,068,529	20,356,945	35,149,875
GFCF average	2,221,349,731	7,628,812,741	17,756,680,947
GDP end of period	33,530,017,919	47,167,924,281	149,298,562,835
GFCF end of period	35,761,592,465	8,251,588,215	35,761,592,465
Capital (K) end of period	34,468,755,855	109,198,354,403	271,185,484,833
Labor end of period	16,181,062	25,890,555	45,786,875
GDP/K average	0.8845	0.7137	0.4821
GDP/L average (Br)	1,876.61	2,080.18	2,204.39
Growth of GFCF average (%)	7.52	7.43	9.2
Growth of K average	1.74	6.3	4.94
Growth of GDP average	4.38	1.96	6.43
Growth of L average	2.42	2.51	3.05
Growth of GDP/K average	2.62	-4.05	1.42
Growth of GDP/L	1.91	-0.52	3.28
Growth of population average	2.59	2.63	2.71
Growth of GDP per capita average	1.75	-0.63	3.63
Growth of net investment average	73.07	12.66	-6.33
Net investment as %age of GDP average	1.75	8.92	9.34
Gross domestic saving as %age of GDP	4.59	7.55	7.33
Agricultural population average	24,468,769	36,818,421	54,588,833
Non-agricultural population average	2,277,462	5,062,105	12,325,833
Rural population average	24,228,868	34,529,239	57,158,065
Rural population (% of total population)	92.25	89.1	84.76
Agricultural population end of period	30,355,000	45,406,000	64,505,000
Non-agricultural population end of period	3,186,000	7,728,000	18,320,000
Rural population end of period	27,885,831	43,531,282	68,350,422
Rural population (% of total population) end of period	91.04	87.14	82.4

Source: Authors calculation based on MoFED and WB

Appendix-2: Per capita form of Harod-Domar model

$$K_{t+1} = (1-\delta)K_t + I_t$$

$$K_{t+1} = (1-\delta)K_t + S_t$$

where δ represents rate of depreciation

$$S_t = sY_t$$

$$K_t = \theta Y_t$$

$$\theta Y_{t+1} = (1-\delta)\theta Y_t + sY_t$$

$$Multiplying\ both\ sides\ by\ \frac{1}{L_t}\ ,the\ equetion\ (10) becomes$$

$$\theta \frac{Y_{t+1}}{L_t} = (1-\delta)\theta \frac{Y_t}{L_t} + \ s\frac{Y_t}{L_t}$$

$$\theta \frac{Y_{t+1}}{L_{t+1}} \left(\frac{L_{t+1}}{L_t}\right) = (1-\delta)\theta y_t + \ sy_t$$

$$where\ the\ small\ letter\ represent\ per\ capita\ term,\ y = \frac{Y}{L}$$

$$\theta y_{t+1} \left(\frac{L_{t+1}}{L_t}\right) = (1-\delta)\theta y_t + \ sy_t$$

$$Dividinge\ both\ sides\ by\ \theta y_t\ yields:$$

$$(\frac{y_{t+1}}{y_t}) \left(\frac{L_{t+1}}{L_t}\right) = (1-\delta) + \frac{s}{\theta}$$

$$\left[1 + \left(\frac{yt+1-yt}{y_t}\right)\right] [\ 1 + \left(\frac{L_{t+1} - L_t}{L_t}\right)\ ] = (1-\delta) + \frac{s}{\theta}$$

$$(1 + g^*)(1 + n) = (1 - \delta) + \frac{s}{\theta}$$

where g represents the growth of output and n the growth of labor

$$1 + n + g^* + g^*n = (1 - \delta) + \frac{s}{\theta}$$

And rearranging them produce the following expressions:

$$\frac{s}{\theta} = n + g^* + g^*n + \delta$$

Let $g^*n \cong 0$ because it is small number because the product of small fraction numbers is a very small number.

$$g^* \cong \frac{s}{\theta} - n - \delta$$