MODELING INFLATION DYNAMICS IN ETHIOPIA

A COINTEGRATION AND ERROR CORRECTION APPROACH

A THESIS PRESENTED TO THE

SCHOOL OF GRADUATE STUDIES

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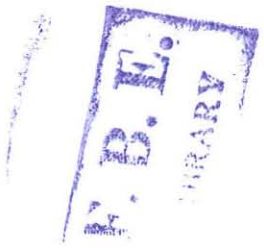

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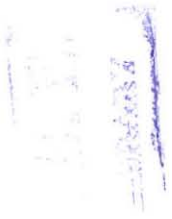

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"Modeling Inflation Dynamics in Ethiopia."

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ABSTRACT

This study examines the dynamics of the inflation in the long and short term using econometric techniques of cointegration tests and error correction modeling for the period 1992:4 to 2007:2. The empirical results show that the price index, real gross domestic product, broad money, official exchange rate and world price are cointegrated. They also indicate that in the long term the world price index and real gross domestic product are the strongest in affecting inflation in Ethiopia. On the other hand, the money supply is the strongest in pushing inflation up in the short term. The long term effect of official exchange rate is insignificant while it has the next strong effect in the short term. The important implication of the study is, hence; first, controlling the money supply and exchange rate to control inflation in the short term and, second, increasing production and keeping the economy from possible world price shocks are good instruments in the long term attempt of controlling inflation.

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Acronyms

ADF	Augmented Dickey Fuller
CP1	Consumer Price Index
GDP	Gross Domestic Product
IMF	International Monetary Fund
LDC	Less Developed Countries
M2	Broad Money
MoFED	Ministry of Finance and Economic Development
NBE	National Bank of Ethiopia
OER	Official Exchange Rate
PECM	Parsimonious Error Correction Model
PER	Parallel Market Exchange Rate
VECM	Vector of Error Correction Model
WB	World Bank
WP	World Price Index

CHAPTER ONE
INTRODUCTION

1.1 An Overview of Inflation in Ethiopia

Inflation has become one of the serious problems to the Ethiopian economy. Longer ago, a relatively stable price level has contributed to the economy that was at the verge of disaster for being too poor. But recently with improvement in the economy, continuous overall increase in price of goods and services is an experience for the Ethiopian economy.

Inflation is headache for every economy. This is why almost all governments try to include stabilizing the price level as one of their major policy. An unstable price brings about higher inequality and social instability. This hinders the economy from developing faster. It erodes households' savings; disturbs the aggregate demand and supply; reduces investment and impoverishes the economy. In a very poor country, where basic need is not satisfied the implication goes further than this. The effect of inflation is not only on the time it happens but also on the consecutive years after its happening. That is it has a hung-over effect on the future years as is explained by theories of inflation expectation.

During the Derg regime the overall average annual inflation rate was 6 percent. The highest rate was recorded by 1985/6 because of draught and by 1990/1 because of the change to new political system and instability. Different reasons are suggested for the lower inflation by the Derg regime. One of this is the price control by the government of the time. Some people also suggest that the true inflation rate was higher than what was reported by the government. But the real explanation to reveal the situation is open to research.

After the Derg regime, the first few years did not experience as such very high inflation. But, especially after 2003/4 there was consecutive record of higher inflation. And, by 2007/8, the inflation rate was 17.8 percent. By January, 2008, the rate was 22.6 percent. This is new experience for the Ethiopian economy, calling for special attention.

There were many reasons suggested as causes for recent inflation. And the suggested reasons seem to be so diverse and some times lie in opposite extremes requiring scientific investigation. On one hand the government suggests that the inflation followed the growth in economy. The growth in the gross domestic product (GDP) resulted in increased aggregate demand. The government reports an average growth of 11.8 percent in the past 4 years. This increased the publics demand more than the aggregate supply. As a result the inflation was supposed to affect only the fixed and very low income earners i.e. not majority of the population. Actually, the majority of the population, the farmer households, were said to benefit from the price increase. In relation with this it is suggested that farmers' access to price information and improved rural credit has played some role.

Some scholars, on the other hand, do not accept this explanation for the dynamics. They argue that if there were the growth recorded, then income of individual household must have increased. But when the income or the aggregate demand increases, this motivates producers to produce more. This increase in supply creates its own demand further. So even if there is inflation, it will be corrected by subsequent increase in aggregate supply. Hence, the inflation would only be short term. This is the neo classical flexible price system and the supply creates own demand notion. But on the other end is the counter argument of the notion that it takes time for the aggregate supply to respond to increased aggregate demand and income i.e the supply is inelastic. This seems to be the new Keynesian perspective. If right, it might be working as they suggest for agrarian economy where it takes at least a year for products-specially food-to come about.

The other suggested explanation for the inflation is the increase in world oil prices. The argument against this is that the high percentage of CPI is covered by agricultural products and they are the ones facing the higher changes and hence oil price seems to be difficult to be accepted as the cause. By September 2007, the increase was 22.6 percent for agricultural products. Of this, food prices as part of agricultural products increased by 29.2 %.

In addition to the above lines of argument, the boom in construction projects (high prices of cement and iron)-world price of commodities in general, supplies of broad money were also pointed out.

In general, no matter what the perspective is, there is a common point of agreement. There is a need for policy that stabilizes the prices and the overall economy. In relation with this, as short term solutions, fixed income and low income earners subsidy was suggested and practiced. For long term, policies that improve aggregate supply, other sources of energy like bio fuel, correcting the money supply and improving external trade were also suggested.

1.2 Statement of the Problem

Different groups have already had different perspectives and stands with respect to the causes and dynamics of inflation in Ethiopia. Therefore, it appears that there should be a neutrally scientific investigation that resolves the different perspectives. This study does not stand on any one of the perspectives but tries to resolve the problem of the diverse stands. It may be the case that all the perspectives are right with different levels of significances. This paper hence tries to see the degree of the strength of the suggested different causes for the inflation being experienced.

The inflation in Ethiopia has increased in the way that holds one's attention. The increase is so fast that it has not been like this since the time the consumer price index started to be measured and recorded. If this increase continues it results in unstable economy that faces serious problem of growth. The inflation will beat the poorer ones harder, it increase the income inequality and erodes the savings of the household. The income inequality further contributes to instability. The erosion of the saving, especially in currency form, will bring about the disincentive to save in financial institutions resulting in lower credit supply and investment. This jeopardizes the development and growth we always dream about. It also results in speculative behavior of households such as saving in other asset forms which may not be value adding. It can also bring depletion of foreign reserves as some will make their saving in foreign currency. This concerns and motivates me to lend hand in the researching the problem and search for solution.

Recently, it was reported that non-food inflation has reached so high and food prices have also increased significantly in spite of good harvests. In the past, whenever there was a shortfall in agricultural production (because of insufficient rain), prices tended to increase, and declined following good harvests. Therefore, policy makers and the public at large were puzzled on the cause of the recent inflationary pressure in Ethiopia. This paper, partly, gives a solution to the

puzzle of the public by taking a longer data and making a structural model that shows the structural relationship of the variables. It also studies short run dynamics.

This study is also made by the time the country is facing dynamic changes in different aspects. Consecutive growth record, higher levels of investments and other improvements seem to be picking up. The desire to make further information available and make scientific analysis also motivated the study. Analyses of the effects of the changes in exchange rates, the effect of the price dynamics to the stability of the economy, changes in money supply, and changes in world price indices needed to be studied.

1.3 Objectives of the Study

The main objective of this study is to produce a structural model that identifies the relevant macroeconomic variable that influenced inflation and make analyses to see the problems associated with inflation in Ethiopia.

The specific objectives are:

- To identify the relevant macroeconomic variables influencing inflation in Ethiopia based on macro economic theories framework and macro econometric set up of modeling
- Explore which explanatory variable is significant for policy implication in the short run and long run
- To explore (test) the stability of the inflation function (Both in the short run and long run)
- Inform policy options to keep inflation under control in Ethiopian economy.

1.4 Scope and Significance

The study uses a quarterly data from 1992/3:1 to 2007/8:2. There is no available data for Gross Domestic Product on quarterly basis. Hence, the annual GDP is interpolated to quarters. But the limitation is that these interpolated values are estimates, not actual values

The analysis uses the official exchange rate. Though there is no significant gap between the parallel and official exchange rates, the parallel market would be a better tool to better explain the market. This study is crucial for any one to make further analysis and make more elaboration.

The data used is attached to appendix (3). Other method of modeling the inflation is also be done to compare the results.

Establishing a stable economy is vital for a developing country like Ethiopia. This includes stabilizing the inflation rate. Hence, this study lends hand in modeling the inflation and sees how the variables of concern are related to the case in hand. This study, therefore, informs how the price in Ethiopia has been moving in the specified time of study. Many of the studies done until now were depending on yearly data. This one is showing how the price moves quarterly. This knowledge of how the inflation pattern would react to both internal and external shocks would enable to exploit the favorable shocks by taking counter active measures against the possible consequences of negative shocks.

1.5 Methodology and Data Source

The variable consumer price index (CPI) is the dependent variable to make the model. The logarithm of the variable is used in levels to model the long run structural equation. Inflation, rate (the first difference of the CPI) is used in the short run model of the error correction. The data for the CPI is collected from the National Bank of Ethiopia (NBE) while inflation is calculated by first differencing of the logarithm of CPI.

The explanatory variables used are Gross domestic product (GDP), broad money (M2), world price index (WP), and Official exchange rate (OER). The GDP was obtained from ministry of finance and economic development (MoFED) while M2 and OER are collected from the NBE. The world price index is available on international financial statistics and IMF publications. The one used here is calculated based on different country's price levels and their intensity (percentage share) of trade with Ethiopia.

The methodology of cointegration and error correction modeling is employed. The cointegration model will provide the long run relationship of the variables. The cointegration results of both Johansson procedure and Engle-Granger are shown. Unit root tests of all the variables were done as the first step to make the cointegration analysis. The augmented Dickey Fuller tests were used to test the unit root. Many other tests were made on the models and data.

CHAPTER TWO
LITERATURE REVIEW

This chapter deals with the theoretical and empirical works that have been done in order to explore and solve the problems related with inflation. The first part of this chapter is mainly concerned with theories of inflation. After explaining general causes of inflation it continues with the oldest quantity theory of money (Fisherian) and moves through all the developments in the theory up to Friedman's. The quantity theory is followed by the Keynesian theories followed by demand pull, cost push, and the structural theories. Here it should be noted that the theories are not exclusive of one another. They rather support each other. And the second part mainly emphasizes the empirical works done, mainly in Sub-Saharan Africa and Ethiopia. By the end of the theoretical literature the factors that determine the inflation of a country need to be understood both from the theories and empirical studies.

2.1 Theoretical Literature

In general, sources of inflation fall largely in three groups:-

- Those which focus on a purely monetary approach and point to the relationship between money and prices
- Those which employ a public finance approach and indicate that monetary expansion and inflation occurs in response to fiscal imbalances
- Those which analyze structural and cost-push factors. These highlight the importance of oligopolistic pricing and cost pressures because of wage increases and devaluation. They also recognize that for the structural and cost-push factors to operate monetary policy is accommodative.

a. The Monetary Approach

The monetary approach assumes a stable demand for real money balances determined by real income and returns on alternative assets. Given aggregate supply constraints in the short run, i.e. smaller production that cannot be increased immediately, an expansionary monetary policy will

result in higher prices. In this approach, in the long run, whole sale price inflation is exclusively determined by money supply.

b. The Public Finance Approach

The public finance approach emphasized that, given the limits on domestic and foreign borrowing dictated by financial market condition and solvency requirements, monetization is the residue form of deficit financing. This means that government has to sometimes borrow from outside (world) or domestic market (sale of securities). If government cannot easily get borrowing, from these two sources, then it turns it face to printing money to finance its deficits.

The World Bank (1991) has formulated the analysis of inflation in a framework that can be used to derive inflation for a given deficit and money demand; however, multiple equilibrium inflation rates can result because the inflation rate is also a determinant of money demand.

It is also argued that fiscal deficits are affected by the political cycle and that public price policy used in this connection, by keeping public prices unchanged before elections and raising them after elections. Thus inflation is lower just before an election and increases afterward, both because of the direct effect of public sector prices in the total price index and because of the indirect effect of public prices on private sector prices. Usually, the response of private sector prices to electrical energy prices, prices of refinery products and mining sector prices is significant and happens quickly.

This theory takes into account various possible sources of inflation, including cost push factors and concludes that fiscal variable dominate the inflationary process in some countries. In addition, it does not find significant effects of disequilibria in labour and goods markets, while the imbalances in the money market have an effect, but only in the short run.

c. Structural and Cost-Push Explanations of Inflation

A number of studies explore the role that structural and cost-push factors play in the inflation process. These factors include:

- The link between the exchange rate and prices.
- The markup on final product prices due to oligopolistic industrial structure; and

- Wage pressures stemming from indexation rules and entrenched inflationary expectations.

Rising inflation and continued devaluation give rise to the hypothesis of a devaluation inflation spiral. This process is facilitated by the degree of dependence of the economy on imports of capital and intermediate goods, and the predominance oligopolistic industrial structure that allows a markup over costs by manufacturing firms. Under these circumstances, increases in the price of foreign currency or the dollar price of imported imputes are translated in to higher prices of domestic products. However, the empirical evidence on the validity of this argument is mixed.

There is evidence of a two-way causal link between exchange rates and prices. Others provide counter evidence. Although no consensus has been reached on the causality between exchange rates and inflation, it is worthwhile noting that a key assumption of devaluation inflation argument was not always fulfilled. I.e. monetary policy was not uniformly accommodative.

With regard to markup pricing of oligopolistic manufacturing firms, they cannot stand alone to explain the causes of persistent inflation. Some times firms markup, expressed as a function of changes in excess demand, statistically determines private manufacturing wholesale price inflation, but with relatively small impact. Instead, inflationary expectations are found to be the more relevant factor, accounting for about 75% percent of the magnitude of the price changes. In turn, these expectation are shown to be determined by

- Inflation inertia - higher current inflation leads to higher expected inflation
- Public sector policy (e.g. energy prices); and
- Uncertainty

Estimation of the price equation indicates that the markup is positively associated to changes in excess demand; however, sector differences could not be identified in such a calculation.

It is also argued that the underlying sources of inertial inflation originate form the income inequality and conflicting social claims on national output. Wages are positively and

significantly associated with changes in excess demand and pass inflation, the latter suggesting backward looking indexation or expectations.

2.1.2The Problems Associated with Inflation and its benefits

There are a number of ways in which high rates of inflation impact on the lives of those people living and working in LDCs.

Rising prices causes worsening poverty as the essentials for survival become more expensive and thus less attainable to those with low incomes. In an economy where unemployment and underemployment is increasing, family incomes are less able to purchase the basic requirements such as staple foodstuffs.

Rising prices creates uncertainty. In a climate of uncertainty both domestic and foreign entrepreneurs will be reluctant to invest. This will slow down the potential for economic growth.

Low savings is a factor contributing to the cycle of poverty. During periods of inflation households that do have surplus funds are reluctant to save. Inflation erodes the real value of saving and hence there is less incentive to forego current consumption. Decreasing levels of savings and hence of investment will lead to a decline in economic growth and development.

Inflation will lead to increases in nominal interest rates. The real value of interest payments will be eroded with inflation and thus banks and financial institutions will have to raise their nominal interest rates in order to try to persuade people to keep their money deposited with banks. Increases in interest rates will make the cost of acquiring credit higher. This will cause firms to cut back on investment.

Inflation will make exports more expensive and less competitive in regional and world markets. This will worsen the balance of payments situation and increases the debt and dependency on donor countries.

Many of the problems connected with inflation depend upon the extent to which the inflation is anticipated correctly. Based on anticipating correctly or not, there may be certain distributional effects. This means that there may be some gainers and some losers. Often it is low paid fixed

income workers who lose out whilst those people whose incomes are dependent upon profits who gain. Workers in state owned enterprises often lose out if the government is being pressurized to cut back on government spending whilst those workers in private sector firms may see their wages increase as sales increase.

On the other hand, low levels of inflation will often result in firms experiencing increases in profitability. This will provide funds for more investment purposes.

Inflation will erode the real value of loans that have been taken out and therefore may make repayment of existing loans easier.

2.2 Developments in the Theories of Inflation

Attempts to explain "what causes changes in prices or the value of money?" dates back to Davanzatti and Jean Bodin in the 16th century, David Hume (1752) in the 18th century. This was followed in 19th century by Simon New comb (1886), Knut Wicksell (1898). And it was continued by Irving fisher (1911), Alfred Marshall (1923), A.C. Pigou (1917), Keynes (1930 and 1936), Patinkin (1948), and Friedman (1957) in the 20th century. These economists with different versions believed that quantity theory of money addresses the causes of the changes in the price level or the value of money. The value of money means the purchasing power of money over goods and services with in a country (Mc Vash p.243). The developments in the theories of inflation will be seen here under starting with the quantity theory of money

2.2.1 Quantity theory of Money

The quantity theory of money states that the quantity of money is the main determinant of the price level. *Any change in the quantity of money produces an exactly proportionate change in the price level.* We will view the different versions of quantity theory of money starting with Fisher's cash transactions approach fallowed by the Cambridge cash balance approach and Friedman's quantity theory.

Fisher points, "other things remaining unchanged, as the quantity of money in circulation increases, the price level also increases in direct proportion and the value of money decreases, and Vice versa." He explained his theory in terms of his equation of exchange

PT = MV + M'V' where p= is the price level and 1/p is the value of money, M is total quantity of legal tender money and V is the velocity of circulation of money. M' and V' are total quantity of credit money and its velocity of circulation respectively and T is total amount of goods and services exchanged for money. The left side of the equation represents the demand for money while the right side is its supply. Solving for p, the price level related directly to the quantity of money (M+M'), provided that the volume of trade (T) and velocity of circulation (V, V') remain unchanged.

This theory is based on the assumptions that P is passive and is affected by other factors; proportion of M' to M is constant; V, V', T are constant and independent of other factors; demand for money is proportional to the value of transactions while supply of money is exogenously determined constant; the theory is applicable in the long run and is based on the assumption of existence of full employment. The theory is criticized severely, though. Keynes points that it is a truism and "cannot be accepted that a certain percentage change of quantity of money leads to the same percentage change in the price level". As all variables are interdependent, V, V' and T are not constant. Further more, this theory can not explain variation in price level in the short run and the role of the interest rate is ignored. It is also criticized for failure to make use of the real balance effect.

Alternatively, Cambridge economists formulated the quantity theory of money in terms of cash balance approach. They regarded the determination of value of money in terms of supply and demand like any other thing. The four economists: Marshal, Pigou, Robertson and Keynes had different equations for the cash balance approach to quantity theory of money. Marshall's equation, formulated by Friedman later, was M=KPY where M is the exogenous money supply, K is the fraction of real money income (PY) which people wish to hold in cash and demand deposits, P is the price level and Y is the aggregate real income of the society. Hence $P = \frac{M}{KY}$ or the value of money is its reciprocal. Pigou's equation was $P=\frac{M}{KR}$. While P, K, and M are as in the Marshal's equation, R is total resources or real income expressed in terms of wheat. Robertson's equation was $P=\frac{M}{KT}$. I.e. replacing Pigou's R by T where T is the total volume of

goods and services purchased. Finally, Keynes' equation, in his *A tract on Monetary Reform*, is n=PK where K is the number of consumption units in the form of cash, n is the total currency in circulation, and P is the price for consumption unit. He extended this equation including r (cash to reserve ratio in banks) to the function. He considered his equation superior as the other equations could not point how to regulate P. K is outside the control of authorities so P is regulated by n and r. (Mc.Vash, P.257)

In addition to the unrealistic effect of quantity of money on general price level in proportion of one to one, the Cambridge school was criticized on different grounds. Few of these are neglect of rate of interest, failure to integrate the theory to commodity market, and the non-directness of the relationship between price and money. In addition, Cambridge cash balance approach discards the velocity of circulation totally.

Before Friedman's quantity theory of money, Keynes in his *The General Theory of employment, interest and money*, pointed out that it is wrong to take the price level as the only determinant of demand for money, and the changes in the price level as being mainly determined by changes in the supply of money. As a result the quantity theory of money was dismissed and "money does not matter" got great importance. Later on, it revived in 1950's by Milton Friedman and his students from Chicago. Here, the theoretical approach insisted that money matters as discussed below.

Friedman, agreeing with earlier quantity theory demand for money, holds that the quantity of money demanded will vary directly and proportionally with changes in the level of prices. That is, demand for money is unitary elastic with respect to price level. He also accepts that real income determines demand for money but rejects its unitary elasticity with respect to income and proposes that it is around 1.8. According to Friedman, in addition to the level of prices and income, money demand is determined by the cost of holding money. These costs are the rate of interest earned by lending and increase in price level eroding the purchasing power. Shortly, the demand for money depends on four factors: level of prices, level of real income, rate of interest, and rate of increase in the general price level. For him, the empirical validity of the theory is not open to question even in the short period of time. In his own words:

"there is perhaps no other empirical relation in economies that has been observed to recur so uniformly under so wide a variety of circumstances as the relation between substantial changes over short periods in the stock of money and in prices; the one is invariably linked with the other and is in the same direction; this uniformity is, in suspect of, the same order as many of the uniformity is. I suspect, of the same order as many of the uniformities that form the basis of the physical sciences.... Extraordinary empirical stability and regularity..."(Friedman, 1956, p.3)

According to Friedman, a quantity theorist believes the fallowing: demand for money is highly stable; important factors affecting the supply of money are independent of those factors which affect the demand for money; the realness of the rate of interest being determined by the forces of thrift and productivity.

Friedman holds that, like the theory of consumer choice, the demand for money (or any other particular asset) depends on: i) the total wealth to be held in different forms ii) the price of and the return on money or any other particular asset, and the alternative forms of holding wealth and (iii) tastes and preferences of wealth owners. Friedman believes that there is no 'transactions', 'precautionary' and an 'asset' motive of demand for money as Keynes does.

Given the tastes of the wealth owners, Friedman has given the following demand function for money

$$M = f(P, r_b - \frac{1}{r_b} d\frac{r_b}{dt}, re + \frac{1}{p}\frac{dp}{dt}, re + \frac{1}{p}\frac{dp}{dt} - \frac{1}{re}\frac{dr}{dt}, \frac{dp}{p}\frac{1}{dt}; W; \frac{Y}{r}, u)$$

Where M- demand for money, P-general price level which is affecting the real yield of every asset, r_b & r_e- market bond, equities interest rate, W is the ratio of non-human to human wealth, $\frac{Y}{r}$ is total wealth (money and owned physical capital, μ-variables affecting tastes and preferences of wealth owners.

Friedman, in his article *the demand for money: some theoretical and empirical results*, published in the Journal of political economy in 1959, tested the proposition that the demand for money varies directly and proportionately to changes in price level, and directly but more than

proportionately to changes in the level of income. He tested the equation $M_d = aPY^b$; where a is a positive the constant indicating that the demand for money changes in the same direction in which prices and income change, b is greater than one (around 1.8) showing income elasticity of demand for money.

The equation can actually be extended to $\frac{Md}{P} = ay^b$ and $P=\frac{Md}{ay^b}$. This teaches us that price is a function of money demand and real income. Supposing that the models for price determinants should hold md and y (real income) in their functions i.e. $p=f(md, y^b)$. In addition, Friedman has not found interest rate empirically significant as a determinant of the demand for money.

Generally, modern quantity theorists hold that "inflation is always and every where a monetary phenomenon". We also learn from quantity theory that income and money supply are the determinants of inflation.

2.2.2 Keynes' Theory of Inflation

The theory is drawn form chapter 21 of Keynes, *the general theory of employment and interest and money, page 292.*

The quantity theory of money which is the main of classical theory, states that any change in quantity of money produces a proportionate change in the same direction in general level of prices. In refute to this, he argues that the increase in supply of money increases output and prices, **not only prices**. Keynes criticism goes as:

> *"if we reflect on what we are being taught and try to rationalize, in the simpler discussions it seems that the elasticity of supply of output must have become zero (i.e. out put never responds to money supply) and demand proportional to quantity of money: whilst in the more sophisticated we are lost in haze where nothing is clear and every thing is possible. We have all of us become used to finding ourselves sometimes on the one side of the moon and sometimes on the other, without knowing what route of journey connects them related, apparently, after the fashion of our waking and our dream lives" (Keynes, 1936, p.292)*

This means that the classicals' quantity theory describes prices and money related without discussing the route which links them.

Keynes views classical school as faulty as there is dichotomy between the theory of relative prices and the theory of absolute price level. They regarded money as neutral and have no effect on economy's real equilibrium. So, in their perspectives, money supply does not affect **real** interest, out put and prices. But Keynes says general price level is aggregation of relative prices and money affects relative price levels. Rather than stationary equilibrium of classical, he considered shifting equilibrium in which money is vital in linking the equilibriums.

Keynes reformed quantity theory. He denied any direct causal relationship between increase on the quantity of money and the rise in the price level, as long as there is an unemployed resource in the economy. Change in quantity of money affects the price level through its effect on wage and employment. Assuming that: all unemployed resources are homogeneous; the resources are interchangeable in their efficiency to produce; and the marginal cost of factors of production equaling the wage rate (as there is surplus labor); there will be constant returns and a fixed wage rate. But, an increase in quantity of money will not raise prices so long as there is any unemployment. Rather, employment will increase in proportion to any increase in the aggregate effective demand brought about by the increase in quantity of money. But after full employment wage and prices increase in the same proportion in which the aggregate effective demar increase fallowing the increase in the quantity of money. In his words

> *"So long as there is unemployment, employment will change in the same proportion as the quantity of money; and when there is full employment, prices will change in the same proportion as the quantity of money."(Keynes, 1936, p.296)*

In addition, he considered that the effect of money supply on effective demand is by affecting interest rate. This further complicates the relation between money supply and price level. Generally speaking, the quantity of money supply affects the price level through a complicated chain and the relation is not direct. For the money elasticity of price level to be unity, as quantity theorists believe, or ($\frac{dp}{dm}.\frac{m}{p}$ =1) to hold, money elasticity of effective demand must be unity,

Keynesian theories that increase in government expenditure (related to public deficit) and export (working through exchange rate and other determinants) as factors influencing the price level. (Bent Hansen, chapter 7)

2.2.4 Cost Push Theory of Inflation

This one is an inflation that results from an initial increase in costs. The two main sources of increase in costs are in crease in nominal wage rates and increase in prices of raw materials. At a given price level, the higher the cost of production, the smaller is the amount that firms are willing to produce. So, if nominal wage rates rise or if the price of raw materials like oil rises, firms decrease their supply of goods and services.

More specifically, cost push inflation is the rise in money wages more rapidly than the productivity of labor. In countries where there are strong labor unions, they press employers to grant wage increase considerably in excess of increase in productivity of labor, thereby raising the cost production of commodities.

The cost push theory is also for other raw materials, for example, OPEC sharply increased the price of oil in 1979. This action meant a significant increase in cost of producing goods and services.

The cost push theory of inflation works in such a way that an increase in the cost of production decreases the aggregate supply in short run. Governments may observe this and may expand the economy to the full employment. But this still increases the price level and the inflation process is set in. In addition to what we already had we include the prices of raw materials and oil and wage rate as determinants of cost of production, and hence inflation rate. The initial increase in the prices of factors of production is captured by lagged inflation growth.

2.2.5 Structural theory of Inflation

In relation with structural theory of inflation it is good to start with the thesis of Shultz, 1959, in which he pointed the price increase in the united states in 1950's were caused neither by demand pull nor by cost push but by shifts in demand in different sectors.

$\frac{dD}{dM}.\frac{M}{D}=1$) and effective demand elasticity of price must be unity. i.e

$$\frac{dp}{dm}\bullet\frac{m}{p}=\left(\frac{dp}{dD}\bullet\frac{D}{p}\right)\left(\frac{dD}{dm}\bullet\frac{M}{D}\right)=1$$

Keynes' theory of prices stresses the need to finance deficit by creating more money to remove unemployment, when it prevails. This is only in depression and not after full employment. So his theory, being superior to classical quantity theory teaches us that the relation between money supply and general price level is indirect and complex, not direct and simple. (Dornbush R. and Fisher S., 1993)

We learn that in addition to money growth and real out put, public deficit financed through money creation affect the general price level.

2.2.3 Demand Pull Inflation

Demand pull or excess demand inflation is a situation often described as "too much money chasing too few goods." According to this theory, an excess aggregate demand over aggregate supply will generate inflationary rise in prices. Such inflation can arise from any factor that increases aggregate demand such as: increase in money supply, increase in government purchases or increase in exports.

The Keynesian theory on demand pull inflation is based on the argument that if the multiplier is stable, changes in income can be predicted from change in investment. So long as there are unemployed resources in the economy, an increase in investment expenditure will lead to increase in employment, income and out put. Once full employment is reached and bottlenecks appear, further increase in expenditure will lead excess demand and to increase in prices. This means that as inflation is created by excess demand, there is no serious price level distortion until full employment is reached. Demand pull inflation thus can only occur at full employment. At full employment, therefore, an increase in any of the mentioned above will keep the aggregate demand higher above the potential out put and hence the prices. This increase the price level requires the wage to rise and the short run aggregate supply to decrease. Finally, we get back to our original out put level with price level increased. Here, we add to quantity theories and

Shultz (1959), points out that prices and wages are flexible upward in response to excess demand but they are rigid in down ward direction. Even if over all aggregate demand is not excessive, excess demand in some sectors of the economy and deficient demand in other sectors will still lead to a rise in the general price level. This is because prices do not fall in demand deficient sectors, as prices are rigid in the downward direction. But the prices in excess demand sector rise. The net effect is an overall rise in the price level. Say, for example, the demand in construction sector increased significantly while not in manufacturing sector. This will increase the price in the construction while no change in the other. The net effect of this event will be increase in the price level in the nation.

In addition, increase in price in excess-demand industries (or sectors) can spread to the deficient ones through prices of materials and the wages of labor. The excess demand in some sectors leads to general rise in the prices of raw and intermediate materials. So the deficient sectors that use these materials as inputs face the price increase and hence raise their own product prices to protect their profit margin.

Further more, wages will increase in the excess demand industries and wages in demand deficient sectors must fallow the increase. If wages in the demand deficient sectors do not follow, this will lead to dissatisfaction among workers there by leading to inefficiency and fall in productivity. The wage bidding up, hence, spreads and takes up the general prices also

Another reason for demand shift inflation is an increase in the relative importance of overhead cost. This increase is due to two factors. First, there is an increase in over head staff at the expense of production workers. This includes growth of formal research and development in the sectors. If, for example, we have more agents to assist the growth of agriculture, the more the cost to products from agriculture would be.

The second reason, for the rise in overhead cost is that the ratio of relatively short lived equipment to long lived plant rising substantially. This works through the depreciation of the equipments.

The inflation explanation of structuralists is so wide ranged. The work of Fits Patrick and Nixon (1976) is one. He points that, institutional and structural factors are considered to be reasons for

inflation. In developing countries, though there are potential resources for development, utilization of the resources could not be realized due to little technical know how, poor infrastructure and etc. Hence, increasing money supply, to tap on production response through credit expansion, will not be successful because of the structural rigidities. But it comes out with inflation. Therefore, structuralists argue that the money supply effect on prices may be significant but it just indicates but can not become sole cause of inflation. It rather shows its effect because of the structures of the economies.

While money supply is an immediate cause, cost-push factors can put inflation to sustain directly or indirectly. By bringing about changes in the rate of monetization and the velocity of circulation of money (money supply), the latter process (cost-push factors) work through the impact of exchange rate, wage and in administered food and public service prices (a common feature in most developing countries), which affect the size of fiscal deficits which in turn gets monetized and leads to inflation.

Further more, structuralists criticize the monetarists in the ground of not taking into account and analyzing the sectoral differences in responses and the effect of relative price changes on the inflation rate. It seems this also works for the Keynesian theory. Though he stands against the proposition of the monetarist's one to one change in money and prices describing that the relation is complex, Keynes did not discuss the output response to money supply say in agriculture or industrial sector. Obviously, the agricultural sector, as production takes longer period, would be inelastic to money supply in the short run.

The degree of supply response varies from sector to sector. The output expansion (in industrial sector) requires an increase in employment and hence a rise in demand for food stuffs. The rise in demand for food stuffs leads to a higher demand for wages by workers and then high prices for industrial outputs.

Alternatively, importing food stuffs from abroad may not help. This is because it limits the foreign exchange necessary to import intermediate and capital goods for industrial output and, more importantly, it is too expensive in LDC's with poor infrastructure.

Here, decrease in money supply can reduce the output growth but not inflation. In LDC's as there are no alternative financial assets, a reduction in money supply makes credit more expensive. This creates shortage of working capital.

The other idea behind structural explanation (and also cost push factors), are (i) the link between exchange rate and prices; II) the mark up on final product prices due to the oligopolistic industrial structure; and (iii) wage pressures stemming from indexation rules and entrenched inflationary expectations.

Rising inflation and continued devaluation of a currency give rise to the hypothesis of a devaluation-inflation spiral. This is facilitated by the dependency of an economy on imports of capital and intermediate goods, and the predominance of oligopolistic industrial structure that allows a marking over costs by manufacturing firms.

Inflation expectations are also relevant factors. Expectations are determined by (i) inertia higher current inflation leads to higher expected inflation; (ii) public sector policy; and (iii) uncertainty.

The other aspect to see is an internationally generated inflation. It is usually argued by governments that inflation is not generated domestically but is rather an international phenomenon beyond their control. As many economies can be labeled as small economies they are vulnerable to international price pressures. Governments' claim is, usually; partly true as international inflation does exist, and partly, it tends to draw attention away from the domestic aspects of inflation. In 1974, as a result of sudden and perceptible rise in petroleum and petroleum products prices of many countries have experienced inflation. While it is true that international forces may contribute to inflationary pressures in any economy, particularly in an economy which is highly dependent on the outside world, at the same time it cannot be denied that inflationary pressures in the economy are chiefly fed by domestic factors.

Generally the theories that are ascribed as structural strengthen the determinants of inflation mentioned in the other theories discussed above. Specially, the effect of exchange rate devaluation, foreign prices, oil prices (in import dependent industries of LDC's), expectation of inflation, and public deficit are all important in structural theory of inflation.

In conclusion, the theories of inflation discussed up to now have taught us that the main players in the field of inflation are: income, money supply, public deficit, government expenditure, exchange rate, prices of raw materials and oil, wage rate, lagged inflation, foreign prices, oil price, and expectation of inflation.

2.3 Empirical literature

There are several empirical studies in sub-Saharan African countries. They used different techniques in examining the causes of inflation under both the frame works of monetarism and structuralism. Some of the studies used both. Chibber et al, (1989), for example developed a thorough econometric model for Zimbabwe using both monetarist and structural factors all together. The study showed that nominal monetary growth, foreign prices, exchange and interest rates, unit labor costs and real income are the determinants of inflation in Zimbabwe. Using similar model for Ghana, Chibber and Safic (1990) modeled causes of inflation for the country. The data used covered 1965-88, annual data. Money supply was found to be the main determinant of inflation in Ghanaian economy. Official nominal exchange rate and real wages were found insignificant. But using a parallel market exchange rate instead of nominal exchange rate, they found a highly significant coefficient. These studies implied that both structural and monetarist views worked for inflation in Ghana and Zimbabwe.

Similarly, Elbadawi (1990) researched on inflation in Uganda. He found that rapid monetary expansion and the depreciation of the parallel exchange rate were the main forces behind inflation during the 1988-89 periods. The evidence being similar, that the parallel exchange rate was significant while the official was not.

Tegene (1989), using Granger and Pierce causality test tried to investigate the role of domestic money supply on inflation in six African countries. The evidence showed a unidirectional causality from monetary growth to inflation in the sample countries. A similar analytical methodology was done by Canetti and Green (1991) on ten African countries during 1978-89, and the results are similar to that of Tegene (1989) that monetary growth had a significant causal influence on inflation.

London (1989), used the monetarist model in 23 African countries with the growth of money supply, exchange rates, expected inflation and real income as determining inflation and found that between 1974 and 1985 all the Variables were significant.

Appiah Kennedy and Boahere Bornard (2003), using ordinary least square for annual data from (1970-2002) have found that money supply and real GDP growth are the main determinants of inflation in Ghana explaining 36% of the inflation in the country both in the short run and long run. Based on the result they recommended the independence of the central bank of Ghana to check discretionary monetary practices such as financing of government debt via printing money. This policy recommendation was tried to be supported by success of inflation targeting practiced in United States and Sweden. Yet, the data used was annual data without including main factors like exchange rate and world prices that can seriously affect the inflation in small open economy like Ghana.

Emilio Sacerdoti and Yuan Xiao (2001) have attempted to model inflation dynamics in Madagascar. They tried to model the determinants of inflation in Madagascar giving special attention to short run dynamics and long run equilibrium. They used cointegration analysis and error correction modeling for the years, 1971-2000 using quarterly data. They found that Madagascar has experienced a stable money demand relationship and purchasing power parity relation of their variables in the long run. They have also concluded that money demand affects inflation and money growth while the purchasing power parity implied that the exchange rate does not affect inflation in the short run. They also found that inflation inertia is important in determining inflation. However, appropriate dummy variables for the shocks mentioned in their article were not included in their model. The shocks were change with respect to exchange rate, import restriction and price controls as well as external shocks like oil prices, coffee booms and political disruptions.

Dick Durevall and Njuguna S. Ndung'u have made a dynamic model of inflation for Kenya. Their paper developed an error correction model with the aim of analyzing the behavior of prices in Kenya during 1974 –1996. In estimating the model, they first tested for cointegration in the money and foreign exchange markets, using the Johansen procedure. The cointegrating vectors were then included in an autoregressive distributed-lag model, and a general-to-specific

procedure was applied to obtain a parsimonious, empirically constant, error correction model. They found that in the long run inflation emanates from movements in the exchange rate, foreign prices, and terms of trade. The error correction term for the monetary sector did not enter the model, but money supply and the interest rate influence inflation in the short run. Inflation inertia was found to be an important determinant of inflation up until 1993, when about 40% of the current inflation is carried over to the next quarter. After 1993, inertia dropped to about 10%. The dynamics of inflation were also influenced by food supply constraints, proxies by maize-price inflation. These findings indicated that the exchange rate is likely to be a more efficient tool than money supply in stabilizing price. And that inflation could be made more stable by policies that secure the supply of maize during droughts.

Moser (1995) derived and estimated an error correction model for Nigeria. The results confirm the monetarist view of inflation that monetary expansion explains a large degree of the inflationary process in Nigeria. Moser's (1995) clear-cut derivation of the inflation equation is immensely intuitive. His estimations, however, use Engle and Granger (1987) two-step procedure despite its well-know~ weaknesses.

Michael Dumba Ndaferankhande has tried to investigate the underlying determinants of inflation in Malawi using quarterly time series data from 1980.1 to 2002.4. His paper investigates the dynamics of inflation in Malawi. In particular, he derived and estimated an eclectic model of inflation using the Johansen procedure. The results show that outbreaks of inflation embody both the monetarist and structuralist claims of inflation. He also found that inflation has a long memory with inflation occurring four quarters away contributing 60 percent to the current inflation. High inflation inertia implies that the central bank can certainly contribute to stabilizing exchange rate expectations by firmly committing to an inflation target and by promoting transparency and accountability in their operations. Further, fighting high inflation should typically involve efforts to break the mechanism that gives inflation its own momentum. The key role played by food price shocks highlights the need to exclude these items from the index in order to avoid unnecessary frustrations of the fashionable inflation targeting as a newfound monetary policy framework for fighting inflation.

In a recent study, Rutasitara (2004) investigates the influence of exchange rates on inflation in Tanzania. Models estimations lend support to the structural view of inflation and show a high degree of persistence as the current rate reflects about 0.6 of its value four quarters back. The study contributes to the debate on the controversies about the relative role of exchange rates in discussion of structural adjustment programs and stabilization policies. Unfortunately, most key reforms occurred in the second half of 1990s, which are not captured by the study since the study period ends in 1995. It is also interesting to note that, almost all macro variables in the model, are stationary in levels.

2.3.1 Studies on Inflation In Ethiopia

Muche (2007) in his paper has argued that demand side problems are the main causes of the inflationary pressure especially after 2004/5. To explain this he used structural vector auto regression of the variables real GDP and consumer price index. He argued that expansionary monetary and fiscal policies have been followed since 2004/5. And the effect of these policies has largely affected the prices and smaller effect was seen on the out put relative to the prices. He stated that this is opposite to the effect that the expansionary policies had up to 2002/3. Up to 2002/3 the effect on output was more predominant than on prices.

Yohannes Ayalew and Muche Netsre, as stated in Muche(2007), on the other hand, have argued that prices in Ethiopia were more of a supply side phenomenon and the production function was below the potential level before 2004/5. Therefore, a little expansionary monetary and/or fiscal policy could stimulate growth at least in the beginning.

While Muche Netsre (2007) site Muche'(1997) position as

> *'A fiscal or monetary expansion that would bring about 4 percent real GDP growth would only increase the price level by about 2 percentage points. In other words, in the Ethiopian case we would give up about 4 percent real GDP growth in order to reduce inflation by less than 2 percentage points*"

Opposing this, he on the other hand argues

> *"... recent growth and inflation seem originated mainly from the expansionary policies of the government that are intended to achieve*

rapid economic growth. Banks injected Fresh loans of about 52 percent more in to the economy in 2004/5 as compared to previous year. Therefore, the main issue is to obtain the optimal level of expansion that would maximize long term economic growth while maintaining stable macroeconomic conditions."

However, Muche's paper considers only real output and CPI in his model and describes the variations. But a model incorporating the monetary and fiscal variables together with the supply factors might not suggest so. He describes the increase/decrease in the prices and real GDP based on other information not incorporated in the model.

Based on his analysis, Muche has concluded that, in 2004/5-2005/6, policy shocks increased aggregate demand more than the aggregate supply. Hence, inflation before the past two years was driven more by demand factors. He also suggested that the cost of price stabilization through tighter monetary policies and fiscal policies was very small compared to the past. Actually, there is a need to incorporate other variables such as the exchange rate, rainfall, world prices, oil prices and others. Therefore, it seems that the study concluded prematurely of the available information.

Josef Loening (2007) has tried to analyze the persistence and determinants of inflation in Ethiopia. He used monthly CPI of 1996: 1 to 2007: 9, broad money growth, and lagged inflation is his model. He used the error correction model of the variables mentioned. Based on his analysis, he found out that lagged inflation and broad money growth rate were the main determinants of inflation. He concluded that money growth significantly increases inflation in addition to driving inflationary expectations.

However, no external factors at all, though he acknowledged their importance, were included in his model. Even the other main factors like gross domestic product (which encompasses government expenditure and wage) have not been included. Rather than monthly inflation, though it increases statistical degrees of freedom, it seems that quarterly and annual inflation data are more important. This is because of the fact that the lions share of Ethiopia's production being held by agriculture depends on seasonal and annual rain.

Zewdu Belete (June, 1997), in his masters thesis, has tried to empirically explain the inflationary process in Ethiopia in addition to trying to find out the causes of the inflation. He limited himself to verifying which of the modeling strategy; the monetarist or the structural, better explains the inflation process in Ethiopia. He used annual data from 1967 to 1994. He found that inflation in Ethiopia is a supply rather than a demand side phenomenon and that the monetarists' one-to-one relationship between prices and broad money does not hold. He concluded that structural factors are more serious in affecting inflation in the country. In the long run, price level in Ethiopia is influenced by real income, import prices and government deficit. In the short run; broad money and rainfall were found to be important in influencing inflation.

However, in between the years 1967-1994 the country faced serious series of structural changes including political disruptions and droughts. While reducing the number of the years of study is almost impractical, he could have accounted for the structural changes. Acceptably, more frequency of the data was not available though. In addition, reliability of the annual variables is also questioned. Moreover, Zewdu's flexibility in choice of variables was limited as one of his objectives was to verify which of the monetarist or structuralist explains the process more. Finally, such a research is badly needed now after more than a decade to explain the inflation with better methodologies and tools developed in the later days.

Andinet (2008), on Report on Ethiopian Economy, published by Ethiopian Economic Association, has reviewed the food price inflation and the urban poor. He indicated that the source of welfare deterioration in urban areas in Ethiopia has been food price inflation. Continuous rise in food prices is a grave concern for poor house holds. The rapid rise in food prices in the world leads to violence and conflict.

Andinet (2008) has put the following tested hypothesis by different researchers as sources of inflation in Ethiopia

- Excess demand at the micro and macro level that determines nominal prices.
- Trade effect through export diversification, specifically a significant increase in non-traditional agricultural exports causing a shift in cultivated land to these products and hence relative decline in production of cereals in the face of increasing demand.

- monetization of food and
- Inflation inertia.

Though he mentions the global food price inflation, he focused only on domestic factors as sources of inflation. The report has also explained that the price elasticity of demand for major cereals like teff and wheat are below unity implying the necessity nature of the items. This further implies that the significant rise in price of cereals may lead to malnutrition and starvation. This could be due to the rigid nature of consumption of households, in the sense that rather than eating any food not usually eaten they would cut back the quantity of consumption.

Abdulaziz (2008) has investigated the long run and short run relationship among real output, the price level and money of different types in Ethiopia. He used yearly data covering the period 1964-2005. Using structural vector auto regression, he tested the elasticities of prices and outputs changes in monetary stock.

While testing the long run neutrality of money with respect to output and price, he found that unexpected shocks to nominal currency have a statistically significant positive effect on the price level. The longrun elasticity of the price level to a shock in nominal currency was 0.91(close to one) showing that the shocks have proportionate effect on the price level. The long run elasticity of price level to shocks in output was -2.64. For both nominal money and broad money, he found significant positive elasticity of the price level. And positive shocks to real output decrease the price level.

On the other hand, Abdulaziz (2008) short run analysis has shown that exogeneous positive nominal shocks to money supply have a positive short run effect on output. This holds for all definitions of money. The maximum impact of monetary shock on output, differently from developed countries, occurs right after the shock. He has explained this in relation with the Keynesian sticky price and worker's misperception models. He suggested that the later was more plausible for the Ethiopian case. The analysis has also considered the so called price puzzle where expansionary monetary policy could lead to negative initial effect on the price level. The justification given for this case was that if money is used as input to production, changes in money supply may affect the supply side as well leading to such puzzling price changes i.e. the supply side effect dominating the demand.

Abdulaziz's (2008) analysis with higher frequency data, like monthly or quarterly could be of higher essence if done. In addition to the variables he used, external shocks could also be captured using additional variables to the models.

Getaw Tadesse and Atle Guttormsen have tested the impact of speculative storage on price dynamics in Ethiopian grain markets using monthly data for the period 1996-2006. The analysis relies on the classical storage model, modified to account for periodic correlation of shocks and the effects of interest rate change. The predictions of the model are tested using a reduced form threshold autoregression. Several non-linearity tests were adapted. Regime switching normalized maximum likelihood estimation method was formulated. The results showed that speculative storage is detrimental in the price formation process of commodity markets, causing threshold non-linearity and impacts price levels to serially correlate over time. Storage failed to adequately stabilize price volatility. Interest rate change in formal financial markets appeared to have no effect on storage and price dynamics.

CHAPTER THREE

3. METHODOLOGY, DATA SOURCES AND MODEL SPECIFICATION

3.1 Theoretical Specification Based On Type of Goods

To start with, let us look at goods in macroeconomic frame work. All commodities in all markets are either tradable or non-tradable. We assume that the overall price level-p is a weighted average of the price of tradable goods (P^T) and non-tradable goods (P^{NT})

$$\text{LogPt} = \alpha \log P_t^T + (1-\alpha) \log P_t^{NT} \qquad (1)$$

$$\text{Where } 0<\alpha<1$$

The price of tradable goods is determined in the world market and it depends on foreign prices (wp) and on the exchange rate (e), assuming that the purchasing power parity holds.

$$\log P_t^T = \log e_t + \log wp \qquad (2)$$

Hence, a depreciation of the exchange rate in (birr per dollar)[1] or an increase in foreign prices will increase domestic prices and vice versa.

The price of non-tradable goods, on the other hand, is set in the domestic money market, where demand for non-tradable goods is assumed, for simplicity, to move in line with demand in the economy overall. As a result, the price of non-tradable goods is determined by the money market equilibrium condition, where real money supply (M^s/P) equals real money demand ($m^d=M^d/p$)

$M^s/P=m^d$, and rewriting in in logarithmic form

$\text{Log}M_t^s - \log P_t = \log m^d$, rearranging this equation we have

$\log M_t^s - \log m^d = \log P^t$, but price of non-tradable is some proportion of P_t.

Thus,

$$\beta(\log M_t^s - \log m^d) = \log P_t^{NT} \qquad (3)$$

[1] All the exchange rate that we look here after are in birr/dollar

Where, β represents the proportion of the non-tradable or it is a scale factor representing the relationship between economy wide demand for non tradable goods and the prices.

The demand for real money balances is assumed to depend on real income and inflationary expectations. However, in developing countries because of the lack of development of financial markets, the relevant substitution possible is between goods and money (not between financial assets). Therefore, the opportunity cost of substitution between goods and money is the expected inflation rate, not the interest rate. (Ubide, 1997)

$$md = f(y, E(\Pi^e)), \text{ where } \Pi \text{ represents inflation}$$

Where, an increase in real income will lead to an increase in money demand and an increase in expected inflation will lead to a decrease in money demand.

Another reason for including expected inflation in the model is the Lucas critique. As Lucas (1976) argued, rational agents will change their behavior with changes in the policy stances and hence any inference that does not explicitly consider expectation is bound to make systematic predictive error. Expected inflation can be modeled in different ways. A general formulation could be the fallowing:

$$E(\Pi^e) = d(L(\Pi_t)) + (1-d)\Delta \log p_{t-1}$$

Where L(Π) represents a distributed lag learning process for the agents of the country. If all the weights in L(Π) are equal ,then we have adaptive expectations. If the weights decrease with time, we have learning process. Therefore, people will form expectations on the basis of past inflation and past experience in forecasting inflation. To keep it simple we assume that d=0

Substituting and rearranging the above equations will give us an estimable equation:

$$\text{Log}P_t = \alpha_1 \log M_t + \alpha_2 \log y_t + \alpha_3 \Delta \log p_{t-1} + \alpha_4 \log e_t + \alpha_5 \log wp_t + \varepsilon_t \qquad (4)$$

Where we expect that, an increase in money supply, expected inflation, exchange rate and foreign prices will push prices up, while an increase in output will lead to a fall in the growth of prices. The effect of sluggish adjustment because of rigidities can be incorporated by adding the effect of lagged prices to the equation.

3.2 Model Specification Based On Aggregate Demand and Supply of an Economy

To capture the main determining factors of price index, in the long run, standard aggregate demand and supply functions can be one of many. Aggregate demand increases if competitiveness improves (i.e if domestic prices relative to foreign prices of exports decline measured at the same currency): i.e ($\frac{P_x^f E}{P}$) increases. On the other hand, aggregate supply declines if real wages $\left(\frac{W}{P}\right)$ increase and/or if price of imported commodities (capital input) increases $\left(\frac{P_i E}{p}\right)$. Then, long run equilibrium of aggregate demand (Y^d) and supply (Y^s) can be written as

$$Y^d\left(\frac{M}{P}, \frac{P_{ex}^f \cdot E}{P}, \varepsilon d\right) = Y^s\left(\frac{W}{P}, \frac{P_{im}^f E}{p}, \varepsilon_S\right)$$ where, p is domestic price level, W nominal wages, E the exchange rate ($(^{birr}/_{dollar})$), M is money, (P_{ex}^f, P_{im}^f) are the exogenous export price and import prices in the world market; ε_d and ε_s are random demand and supply shocks. Solving the log linear function for price level yields the following long run equation normalized on P (domestic price).[2]

$$P = \alpha_0 E + \alpha_2 W + \alpha_3 P_{ex}^f + \alpha P_{im}^f + \varepsilon_t \qquad (5)$$

Assuming constant elasticity of wage to price in the long run and representing export prices and import prices by world price index (calculated based on the weighted proportion of each in trade) we can reach at

$$P = \alpha_0 E + \alpha_1 M + \alpha_2 Wp + \varepsilon_t$$

$$P = f(E, M, WP)- \qquad (6)$$

The expected signs of $\alpha_0, \alpha_1, \alpha_2 > 0$

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[2] This is done in order to find an estimable function of price index in terms of the factors

In addition to the variables above, Ben Kaluwa (2004) has modeled the inflationary process for Malawi by using both the petroleum price and real gdp. Yet, he dropped the petroleum price because of the high multicollinearity with the exchange rate. Mihe Gaomab II (1998) has also modeled inflation for Namibia using real GDP in the equation. B.Y Kim (2001) for Poland and Mark J.Holmes (2000) for turkey in their analysis of the output trade off for LDC's have done similarly. The inclusion of real GDP captures many factors including population growth rate, rainfall, and war expenditure.

Therefore the price function can be specified as:

$$P=f(Y, M, E, WP, Pet) \qquad (7)$$

Where P, Y, M ,E WP, Pet are price, RGDP, money supply, exchange rate, world price and domestic petroleum price respectively.

Specifying the long run price index in logarithmic form as (Small letters to represent the log levels of the variables)

$$P=\beta_0+\beta 1y+\beta_2 m+\beta_3 e+\beta_4 wp+\beta_5 pet+\varepsilon_t \qquad (8)$$

(For detailed elaboration see Cheng Hoon Lim And Laura Papi, December 1997)

Since equation 4 above is specified in logarithmic form, the estimated coefficients are long run elasticity of the price with respect to each of the corresponding variables. These long run coefficients will be estimated using the Johansen maximum likelihood approach. The cointegrating vector which is obtained from the cointegration analysis will provide estimates of long run coefficients.

3.3 Methodology

Time series data usually show an upward or down ward trending behavior. Hence, any simple ordinary least square regression result will have significant coefficients showing the trending together of the data rather than causality. This is called spurious regression. The serous spurious correlation problem because of non stationary variables is one of the main problems in modeling. This came to be the most important issue after the publication of Davidson and others (1978). A

given time series is stationary if "the joint and conditional probability distribution of the process are unchanged through time." (Charemza and Deadman, 1993:118). This means that if the series is divided at different sections, the mean, variance and covariance of the series must be constant. If all this is not fulfilled, then it is non-stationary. Time series macroeconomic variables do not experience this usually.

Any model that has a non stationary time series variable in it can never be evaluated at the usual standard statistical procedure. The chi-squared, t, f, and R^2- tests are not reliable. Actually, this has been known since old days. Yule (1926) first drew attention to the situation that happens. Granger and Newbold (1974) drew this attention to the problem in econometrics, the article of which attracted great awareness for the spurious regressions in econometrics. Phillips (1986) gave a theoretical explanation of the implications.

Montecarlo experiments with two non stationary variables that are not related and generated on computer have given non-zero coefficient 17,947 times out of 25,000 regressions (Kerry Patterson, 1998). The regression usually gives impressive results of relationship between the variables. In spurious regressions, the interesting note is that the disturbance term from the regressions is also non stationary. Even though this is the case, there are times when the regression of two non stationary variables results in a stationary error term. This is a justification for existence of cointegration or meaningful long run relationship. Two widely known methods for testing cointegration relationship are the Johansen's (1988) maximum likelihood approach and the Engle and Granger (1987) two step procedure. Both are discussed below.

3.3.1 The Engle- Granger two step procedure test of co integration (EG)

Though this study is based on Johansen's procedure because of the limitations of EG described below, the two step Engle and Granger (1987) procedure will be seen as a support. There are two steps to follow. In the first step, the long run model, the non-stationary variables in levels are estimated by OLS. The cointegration equation of the form:

$$Y_t = \beta_o + \beta_1 X_{1t} + \beta_2 X_{2t} + \varepsilon_t \qquad (9)$$

In the second step, residuals from (1) are taken and tested for stationarity. Using augmented Dickey fuller test. $\varepsilon_{t*} = Yt-(\beta_o + \beta_1 X_{1t} + \beta_2 X_{2t})$ is tested to check if it is stationary or not.

If ε_t is found to be stationary, then it can be taken to the ECM model as

$$\Delta Y_t = \beta_1 \Delta X_{1t} + \beta_2 \Delta X_{2t} + \beta 3 (\varepsilon_{t*}) + \varepsilon_t$$

$$\Delta Y_t = \beta_1 \Delta X_{1t} + \beta_2 \Delta X_{2t} + \beta 3 (Y_t - (\beta_o + \beta_1 X_{1t} + \beta_2 X_{2t})) + \varepsilon_t$$

The coefficient of ε_{t*}, $\beta 3$, measures the average speed of adjustment to the long run equilibrium after a temporary shock.

In genera, if the residual is found to be stationary, then the null hypothesis of no cointegration is rejected. This is the only case to pass to ECM and the coefficient $\beta 3$ is consistent and converges to long run parameter rapidly.

Researchers use the Engle and Granger (1987) method because it is simple and convenient. But it has many shortcomings. First, it makes the implicit assumption that the contegrating vector is unique. This means that we are bound to end up with the model that is the linear combination of independent cointegrating vectors. Second it also produces results that differ depending on the direction on normalization (Hafer and Jansen (1991)). That is it starts with one variable on the right sight side assuming dependence of the variable on the regressors.

It should be mentioned that Durbin-Watson test statistic can be used in the procedure to test ε_{t*}. Engle and Granger (1987) have also considered the Durbin Watson statistic for the cointegration regression which is known as the cointegrating regression Durbin Watson (CRDW). CRDW has a probability limit of zero under the null of no cointegration. So, large values of CRDW imply cointegration. Yet, it is sensitive to random walkness of (see foot note under tests of stationarity) the dependent variable and the critical values are not reliable as the number of explanatory variables increase. Both methods of tests for cointegration are necessary if the variables are non stationary.

3.3.2 The Johansen Maximum Likelihood Approach

Rather than estimating an equation with dependent and independent variables as in Engle and Granger, this method does not distinguish them. Rather, it goes on finding different coefficients of the variables that result in a stationary error term. The first step in this approach is, then, the

estimation of a congruent, unrestricted, closed, p^{th} order vector autoregressive in K non-stationary variables.

$$Y_t = \Pi_1 Y_{t-1} + \Pi_2 Y_{t-1} + \ldots + \Pi_p Y_{t-p} + C + \Psi D_t + \varepsilon_t \qquad (10)$$

Where Y_t is vector of non stationary K variables (K rows)

C is vector of deterministic components like constant and time trends

D is vector of dummies

ε_t is vector of error terms.

The VAR is congruent if the residuals of the equation are: not serially correlated, not hetroskedastic, consistent with the hypothesis that shocks are normally distributed. It is unrestricted in the sense that no variable is assumed to be exogenous apriori. It is closed as no variable is left unexplained except the deterministic components and dummy variables. It is p^{th} order or the longest lag is of length p which translates in to a lag of p-1 on ΔY_t in the error correction model (ECM). And there are K equations in the VAR or ECM.

The VAR system in equation (1) above can be reparametrised as error correction (ECM) form of

$$\Delta Y_t = \Pi Y_{t-1} + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \ldots \Gamma_{P-1} \Delta Y_{t-(P-1)} + C + \Psi D_t + \varepsilon_t \qquad (11)$$

This can be simplified to

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{P-1} \Gamma_i \Delta Y_{t-i} + C + \Psi D_t + \varepsilon_t \qquad (12)$$

Δ is first difference operator

$\Gamma_i = -(I - \Pi_1 - \Pi_2 - \ldots \Pi_i)$, i=1,....., p-1

I is the identity matrix

The formulation of the ECM arises from the presumption that the variables in the long run model (cointegration) are non stationary (i.e. have varying mean, variance and covariance) the first

difference of which are stationary and the linear combination of this stationary variables with the stationary cointegration equation is also stationary. The cointegration (ΠY_{t-1}) in ECM is a regressor because it is stationary as implied from the cointegration and the K variables in Y_t do not drift away from each other. Engle and Granger (1987) formally defined as: two time series variables X_t and Z_t are cointegrated of order d and b if there exists a linear combination of these variables which is integrated of order d-b (seen in the residuals) that is stationary. In that case, the resulting linear combination can be written as ECM also. This is because there is important correspondence between the two in the sense that for any set of cointegrated variables there exist valid error correction representations of the data. The advantage of the error correction model so constructed is that it does not impose apriori restrictions about the number of cointegration vectors and separates the long run and short run effects.

In Johansen procedure, the error correction properties are associated with the matrix Π in equation 2 and 3. II is a (KXK) matrix, where k is the number of cointegrating variables in Y_t. The rank of II, which is the number of significant Eigen values in the matrix II[3], represents the number of independent rows that are cointegrating vectors.

When the number of independent rows (rank) of II is equal to K (the number of time series variables) we need not formulate ECM. This basically implies that the variables are stationary in level -with out differencing.

If the rank of π is zero (there is no raw of coefficients that makes the non stationary variables combination stationary), called null matrix, then ΠY_{t-1} in equation two above will be zero and the variables are not cointegrated.

Hence, cointegration of the variables happens only when the rank (r) of II is less than k (the number of variables) in the VAR. shortly,

r=k→ full rank-the variables are stationary in levels

r=0→ null matrix- the variables are not cointegrated

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[3] The number of significant Eigen-values- the number of rows in Π that significantly make the error term statioinary and cointegrated.

r is less than k → r statistically significant cointegration vectors.

Johansen has suggested two likelihood ratio test statistics (Lambda trace and Lambda max) to determine the rank of II. Lambda trace statistic is with the null hypothesis that there are at most r cointgrating vectors beginning with r=0 against r>0. Lambda max, on the other hand, tests the existence of r co-integrating vectors with the null against the alternative of r + 1 vector.

If r is less than k, the matrix II can be written as $\Pi = \alpha\beta'$ where β represents the cointegrating vector of coefficients and α is a matrix of error correction parameters that show the 'average' speed of adjustment towards equilibrium position $\beta'Yt$ (Cheremza and Deadman, 1992). Both α and β are (KXr). $\beta'Yt$ is I(o). i.e $\beta'Yt$ is stationary with the cointegrating vectors $\beta_1, \beta_2 \ldots \beta r$ are columns of β's(rows in Eviews). If there exists cointegration of the variables, one of the β's is normalized to be equal to one followed by long run parameters relating the variables in their equilibrium situation. But, Johanson (1988) indicates that one should be cautious in interpreting the result that it is not estimated in the way that one of the variables is dependent and others not as in OLS.

3.3.3 The Error Correction Model.

Any combination of non stationary I(1) time series variables that are cointegrated have an error correction representation that explains the short run relationship including the correction to the stable long run relation after deviation from it. The first difference of all I(1) variables is stationary, consequently, this involves a regression of this stationary variables. Since the lag length of the first differences that describes the data best cannot be known apriori, it can be rewritten in a general autoregressive distributed lag (ADL) form. Using the model specified based on aggregate demand and supply above (equation 7):

$$Pt = \beta_0 + \sum_{i=1}^{p} \alpha_{1i} p_{t-i} + \sum_{i=0}^{p} \alpha_{2i} y_{t-i} + \sum_{i=0}^{p} \alpha_{3} m_{t-i} + \sum_{i=0}^{p} \alpha_{4i} e_{t-i} + \sum_{i=0}^{p} \alpha_{5i} wp_{t-i} + \sum_{i=0}^{p} \alpha_{6i} pet_{t-i} + \varepsilon_t \qquad 13$$

The appropriate lag length to be included for each of the explanatory variables is not known apriori. It is determined from the data based on Schwartz information criteria, Akaike information criteria and/or based on absence of serial correlation in the residuals (LM test).

Eviews-5 gives the best lag structure to be chosen based on 5 criteria including these three. This will be seen in the next chapter empirically. Adding and subtracting terms appropriately and including a single dummy for years of drought and war equation can be written in the error correction form as:

$$\Delta Pt = \beta_0 + \sum_{i=1}^{r-1} \theta_{1i} \Delta p_{t-i} + \sum_{i=0}^{r-1} \theta_{2i} \Delta y_{t-i} + \sum_{i=0}^{r-1} \theta_{3i} \Delta m_{t-i} + \sum_{i=0}^{r-1} \theta_{4i} \Delta e_{t-i} + \sum_{i=0}^{r-1} \theta_{5i} \Delta wp_{t-i} + \sum_{i=0}^{r-1} \theta_{6i} \Delta pet_{t-i} + \theta_6 ecm_{t-i} + \theta_7 DU + \varepsilon_t \quad 14$$

Where, ε_t = the disturbance term

Δ = first difference operator

B_0 = constant

Du = is a dummy variable for years of drought & war

ecm = the error correction term

Equation (14) above contains both the short run and long run information. The long run information is contained in the error correction term (ECM_{t-i}). The coefficient of this term is apriori expected to be negative. This is because; if the process is more than the long run equilibrium it has to decrease to the equilibrium or vice versa. That is, the process has to converge to its long run equilibrium. The magnitude of the coefficient of this term measures the rate at which the deviation from the long run equilibrium is being corrected. A positive coefficient of ECM implies a diverging rather than converging process. As all the variables are in logarithm each of the first differenced variables represent percentage. And accordingly, ΔPt is the inflation rate. The coefficients of the first differenced variables represent the short run relationship of inflation to its determinants. Both the cointegration and error correction estimations are necessitated by the non stationarity of the variables. But how do we know the non stationarity?

3.3.4 Testing For Stationarity of the Time Series Variables

A stochastic process is said to be stationary if the means and variances of the process are constant overtime while the auto covariance between two periods depends only on the gap between those periods but not on the very time at which the covariance is calculated (Enders, 1998). Hence, if a given time series variable has the tendency to return to it mean or variance, then it is stationary. If this is not the case, then it is non-stationary. If a non stationary variable has to be differenced d times so that it becomes stationary, it is integrated of order d, denoted as I(d). Therefore, before modeling any time series variables, the time series properties of the variables need to be analyzed. The most commonly used tests for the order of integration are the Dickey-Fuller (DF) and augmented Dickey- Fuller (ADF) test statistics. This study makes use of it. Even though numerous methods are available for the test, they have many draw backs (Enders, 1995)

The DF test assumes that the variable Z_t is a random walk process, i.e

$Z_t = \rho Z_{t-1} + \varepsilon_t$, where εt is an error term with zero mean and constant variance.

Deducting Z_{t-1} from both sides

$Z_t - Z_{t-1} = (\rho-1) Z_{t-1} + \varepsilon_t$

$\Delta Z_t = \alpha Z_{t-1} + \varepsilon_t$, where $\alpha = \rho-1$

Since $\alpha=\rho-1$, testing $\rho=1$ is the same as testing $\alpha=0$. If $\alpha=0$, $\Delta Z_t = \varepsilon_t$ and we have defined ε_t to be white noise process and hence stationary. This means that the first difference of the variable is stationary implying that the variable is integrated of order 1 (I(1)) at its level.

To test for the presence of unit root[4], with the null hypothesis of $\alpha=0$ against the alternative $\alpha<0$, Dickey and Fuller (1979) have considered three cases of specification.

$$\Delta Z_t = \alpha Z_{t-1} + \varepsilon_t \qquad \text{(a)}$$

[4] Non stationary time series is said to be integrated of order one (has unit root), if the series of its first difference is stationary.

$$\Delta Z_t = b_0 + \alpha Z_{t-1} + \varepsilon_t \qquad (b)$$

$$\Delta Z_t = b_0 + \alpha Z_{t-1} + b_1 t + \varepsilon_t \qquad (c)$$

The first is a pure random walk while the second is named a random walk with drift and the third a random walk with drift and trend[5].

Which ever may the case be, it is testing if $\alpha = 0$. If $\alpha = 0$, the variable is integrated of order one. To get the estimated value of α and the standard error, OLS is applied to the above equations based on the data generating process of the variable. The DF test involves comparison between the estimate t-statistics and the appropriate critical values in the DF tables. If the value of the estimated t-statistic is more negative than the critical t-value reported in DF table, the null hypothesis of unit root is rejected and thus the variable is stationary. A sample value less negative than the critical value is I(1). In general, "a fortiori a positive sample value would imply non-rejection of the null hypothesis.(Kerry Patterson, 2000, p.229)

The simple DF test for unit root is simulated under the assumption of white noise residuals i.e the error term is assumed to be identically and independently distributed with zero mean and constant variance. However, there is the possibility that ΔXt is likely to be an ARMA(auto regressive moving average) process in which case the error term is likely to be auto correlated. If the assumption about the error term is wrong, then the limiting distributions and critical values obtained by Dickey and Fuller cannot hold. In this case the autoregressive structure can be dealt with by augmenting the regression equation with lagged ΔZ_t variables so that the error term will be white noise.

This is what was named augmented Dickey fuller (ADF) test. It is just augmenting equations (1-3) above by lags of ΔZ_t. i.e

$$\Delta Z_t = \alpha Z_{t-1} + \sum_{i=1}^{k} \Delta z_{t-i} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots a^*$$

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[5] A series yt is a random walk process, if $y_t = y_{t-1} + \varepsilon_t$, where $y0=0, \varepsilon_t \rightarrow iid(0,\varepsilon 2)$ adding a constant a to this equation we get a random walk with drift. if the process has a trend parameter additionally, i.e , $y_t = a + \beta t + y_{t-1} + \varepsilon_t$, it becomes a random walk with drift and trend.

$$\Delta Z_t = b_0 + \alpha Z_{t-1} + \sum_{i:1}^{k} \Delta z_{t-i} + \varepsilon_t \quad \ldots\ldots b^*$$

$$\Delta Z_t = b_0 + \alpha Z_{t-1} + \sum_{i:1}^{k} \Delta Z_{t-i} + b_0 t + \varepsilon_t \quad \ldots\ldots c^*$$

Test is if $\alpha = 0$ or not. $\alpha = 0 \rightarrow I(1)$.

3.4 The Data

The data for this study were collected from National bank of Ethiopia (NBE), central statistical Authority, Ministry of Economic development and cooperation, IMF and WB publications (IFS). This study covers the period from 1992/3:1 to 2007/8:2 and quarterly data will be used. For variables with no availability in quarters, interpolation[6] from the annual data will be done. The detailed mathematical formulation of the mechanism of interpolation is attached to the appendix (appendix 1). The data that are not available quarterly are real GDP and government expenditure. These annual series are obtained from MoFED. The price index used is the national consumer price index. The first difference of the natural logarithm of the consumer price index will give the inflation rate. Quarterly monetary aggregates (M_1 and M_2) and exchange rates (parallel market, official, real effective and nominal effective/are obtained from the national bank of Ethiopia.

The accuracy and consistency of macroeconomic time series data, in general, are serious problems in developing countries. In relation with this, the base year for the consumer price index and real GDP has been changed three times in the past two decades. For the consumer price index the quarterly index with 2006 base year was available. For the real GDP, the correct series since 1997/8 is officially available with 2006 base year. But since the growth rate of real GDP was the same which ever the base year may be, the growth rate was used to get the preceding few years of 1997/8 for accuracy with the same base year. (MoFED)

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6 This method depends on the fact that any three consecutive points in a plane can be represented by a quadratic function. Hence, we can get the rest of the values at any point in between the points. But it should be noted that the limitation of this is that the values are not realistic values but approximation of the reality

ADDIS ABABA

CHAPTER FOUR
EMPIRICAL ANALYSIS

4.1- Test for Order of Integration

Analysis of time series variables should always start with the test of the order of integration. If that is not the case, the results are not actual but seemingly impressive. Thus before conducting cointegration tests one needs to first investigate the time series properties of the variables to be included in the model. A variable is said to be integrated of order d, I (d) if it has to be differenced d times before it becomes stationary.

The cointegration analysis and the following error correction model are among the latest solutions to the problem of estimating the relationships among variables that have stochastic time trends or unit roots. While testing for order of integration, it is assumed that higher orders dominate the lower (Dickey and Pantula, 1987).The test for the presence of unit roots in the logarithm of each variable is conducted in line with the Pantula principle, then. We first check whether there are two unit roots I(2), and if this is rejected, the presence of unit root is tested. Estimation of cointegration, using OLS, requires the variables to be of order one. The most common tool of the test is the augmented Dickey-fuller (1981). The values of the ADF test statistics for all the time-series variables included in the estimation are presented in table (1) below. But first it is good to make visual inspection of each series. There is a striking graphical difference between I(0) and at least I(1) variables. Almost all unit root series follow an upward or downward trending movement and so do the variables under tests. The graphs of p, y, m2, e, wp and pet (all in logarithm) in figure 1 and the graphs of the first difference of each including inflation (dlp) are as in figure 2 below. First differences of variables show movement around some constant mean, except for existence of outliers (stationary) as figure 2 implies. The labels for each of the variables are in the key below table 1.

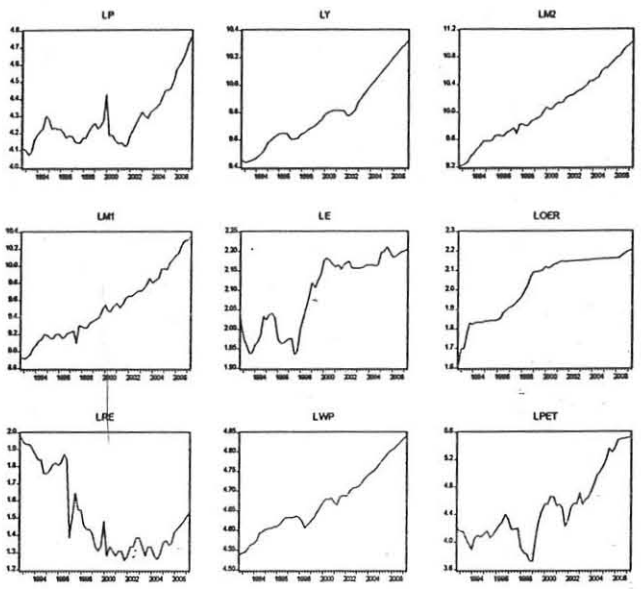


Figure 1 Graphs of variables in levels

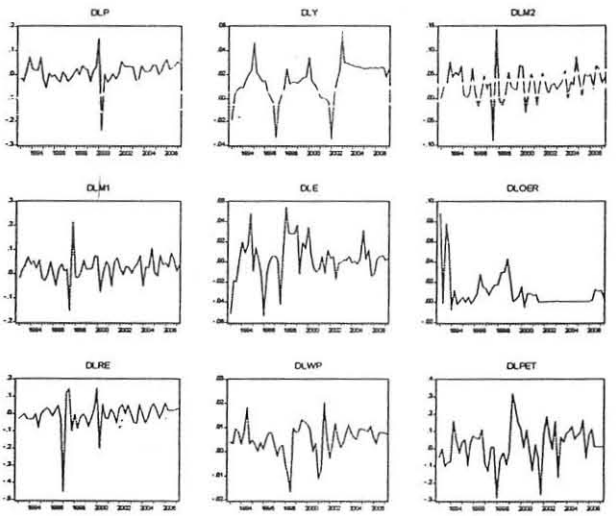


Figure 2 Graphs of variables in First differences

All the variables in figure 1 display that the series of variables display an upward or down ward trending implying that they are probably I(1) variables. But this cannot be the end unless empirically proved by one of the tests. On the other hand, looking at figure 2 we see that all the variables appear to have a fixed constant mean around which they are distributed, hence,

stationary. The visual inspection does not end the test necessitating the test using ADF as follows.

Table 1 ADF tests for unit roots (order of integration)

Variables	Test statistic	Longest lag-included	Order of integration
LP	0.759159	1	I(1)
DLP	-8.206918**	1	I(0)
LY	0.616932	1	I(1)
DLY	-3.769474**	1	I(0)
LM2	0.133628	3*	I(1)
DLM2	-5.765048**	2	I(0)
LM1	2.2476	3*	I(1)
DLM1	-6.71718**	2	I(0)
LE	-1.250951	1	I(1)
DLE	-5.827023**	1	I(0)
LOER	-2.471140	1	I(1)
D LOER	-7.306265**	0	I(0)
LRE	-2.1151	0	I(1)
DLRE	-7.761839**	1	(0)
LWp	0.499711	1	I(1)
DLWp	-5.2023**	0	I(0)
LPET	0.389309	0	I(1)
DLPET	-5.804018**	0	I(0)

Key:P-price index, Y-real gdp, M2-broad money, M1- narrow money, E- parallel market exchange rate, OER- official exchange rate, RE-real effective exchange rate, WP-world price, PET-petroleum price, L-logarithm, D-first difference.[7]

7 For the testing procedure of unit root see R. Harris (1995), chapter (2). The entire unit root test estimation was done with the use of the econometric package Eviews-5

- The sample size is 1992:4 to 2007:2 {T=59} for levels, and 1993:1 to 2007:2 (T=58) for differences.
- In testing M2 and M1 the trend and constant was found to be significant, the rest of the variables have significant constant. (Visual inspection of M2 is possible from the graph.)
- The ADF critical values at 1%, 5%, and 10% are -3.548208, -2.912631, -2.594027 for those with constants and -4.124265, -3.489228, and -3.173114 for with trend respectively
- The unit root presented in the above table includes a constant term and the lag length suggested by Schwarz information criteria and significance of the trend constant. For each case visual inspection of the behaviors of the graphs is comparable with the graphs.

All the variables tested are showing that all have unit root in level and stationary in first difference,

Though it is not problem in this study, different critical values have been written in econometrics books with respect to the test of unit root. Kerry Patterson (2000, p.229) reports that any positive value should be accepted as having a unit root while as to Charemze and Deadman (1992), "the null hypothesis of the existence of unit root is rejected when the value of the ADF test statistic is negative with an absolute magnitude greater than the absolute value of the given critical value".

In the table above, testing for first difference of the variable showed all are stationary. This exactly means that the variables need not be differenced twice and are not stationary in levels. Differencing them only once is enough to make them stationary. In other words, testing the first difference series for unit root is testing if the levels are I(2) or not. None of the variables were found to be I(2). Specifically, all the variables have unit roots in their levels- I (1), and all the first differences are stationary. Here, we are now allowed to pass to test for cointegration and error correction.

4.2 Tests of cointegration of the consumer price index Using Johansen Procedure

Studies on price indices, as was shown in model specification, indicate that there exists stable long run equilibrium between price and its determining variables (output, money supply, exchange rate and world prices). In this section we will examine if this relationship works with Ethiopian data. The existence of this cointegrating relationship will be considered using Ethiopian CPI, interpolated GDP(Y), money supply (M2), official exchange rate (OER) and

world price index(WP-weighted price index of Ethiopian trade partners). The official rate rather than the parallel market exchange rate used and the petroleum price dropped for reasons explained below.

As was seen in the graph of parallel market exchange rate, there is no as such a very clear trend in the data through the study time. This could have happened because of the poor data, or the way it was collected. Consequently, all the cointegration analysis made using it was totally meaningless and unsatisfactory. Yet, it should be mentioned that the parallel market exchange rate better explains the economy. On the other hand, viewing the official exchange rate, there is clearer look of the data trend. This was found to explain the cointegration relationship between the variables in a better way.

In relation with petroleum products price the following are justifications:

- The world price index was highly correlated with world price per barrel of petroleum.
- The domestic price of the subset commodities in petroleum are highly subsidized: i.e. kerosene gasoil and fuel oil
- The macroeconomic models, often, do not explicitly include price of petroleum as it is already included as part of cost of production.
- According to Ethiopian petroleum enterprise, they used to be refined at Assab and the prices of the products started to be recorded only recently.
- There is no one index, domestically, to represent them.

Now, to employ the Johansen (1988) and Johansen and Juselius (1990) procedure for cointegration tests in the multivariate setting and to compare the results obtained with that of Engle and Granger, the first step is to estimate the reduced form of vector autoregression (VAR) of P, Y, M, OER, and WP in their logarithms. As all the variables are interdependent, the vector auto regression that represents the variables best, chosen based on the different criteria must be selected. This choice is from different lag lengths of the variables. This lag length is used for the cointegration relation decision. The trial and error process for lag decision of the VAR system

starting with lag-5 has shown that lag two best describes the data. This is necessary because of the fact that it is not only the contemporaneous but also the past values of the variables affect the present value. That means, for example, the money supply in the beginning of the year affects the price level by the end of the year as it takes time to be in all the market process. This was made by loglikelihood ratio, Final prediction error test, Akaike information criteria, Schwartz information criteria, and Hannan-Quinn information criteria. The following table shows lag order selected by each criterion.

Table 2 VAR Lag Order Selection Criteria, and Johanson cointegration tests

VAR Lag Order Selection Criteria, Endogenous variables: LP, LY, LM2, LOER, LWP, Sample: 1992Q4 2007Q2,Included observations: 54

Lag	LogL	LR	FPE	AIC	SC	HQ
0	413.5894	NA	2.22e-13	-14.94775	-14.57942	-14.80570
1	768.4864	617.7838	1.10e-18	-27.16616	-25.87701*	-26.66899
2	807.9719	61.4217*	6.65e-19*	-27.70266*	-25.49268	-26.85036*
3	832.9303	34.20225	7.17e-19	-27.70112	-24.57031	-26.49369
4	858.7872	30.64525	7.99e-19	-27.70086	-23.68122	-26.17030
5	880.7382	21.95098	1.14e-18	-27.61993	-22.64747	-25.70225

*indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

As can be observed lag 2 is the most chosen of all. Hence, the cointegration vectors are associated with two lag length. Now, let us look at the cointegration result using the variables in log levels. The following tables show the lambda-trace, lambda-max, unrestricted cointegrating and adjustment coefficients respectively.

Sample (adjusted): 1993Q3 2007Q2

Included observations: 56 after adjustments

Trend assumption: No deterministic trend

Series: LP LY LM2 LOER LWP

Unrestricted Cointegration Rank Test (Trace)

HypothesizedNo. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.465722	77.71192	60.06141	0.0008
At most 1 *	0.360881	42.60895	40.17493	0.0279
At most 2	0.212179	17.53976	24.27596	0.2780
At most 3	0.068808	4.184655	12.32090	0.6842
At most 4	0.003431	0.192450	4.129906	0.7159

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.465722	35.10298	30.43961	0.0122
At most 1 *	0.360881	25.06919	24.15921	0.0376
At most 2	0.212179	13.35511	17.79730	0.2058
At most 3	0.068808	3.992205	11.22480	0.6297
At most 4	0.003431	0.192450	4.129906	0.7159

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LP	LY	LM2	LOER	LWP
-0.982624	-23.20476	7.451703	-3.352770	34.35603
-11.68134	37.53168	-6.239753	-2.748376	-53.54040
-9.999856	-9.362144	12.11396	-22.59914	12.51149
-5.794935	7.663249	-3.678805	-5.270558	-0.631392
-19.00125	7.627015	0.262731	-1.292689	1.354024

Unrestricted Adjustment Coefficients (alpha):

D(LP)	0.000532	0.001536	0.014491	-0.008413	4.47E-05
D(LY)	-0.001479	-0.005636	0.000936	-0.001065	-0.000194
D(LM2)	-0.010906	-0.003992	0.005239	-0.002796	0.001054
D(LOER)	-0.004328	3.48E-06	0.003836	0.000861	-0.000247
D(LWP)	-0.003278	0.000316	-0.000817	-0.000795	-4.95E-05

1 Cointegrating Equation(s): Log likelihood 800.0429

Normalized cointegrating coefficients (standard error in parentheses)

LP	LY	LM2	LOER	LWP
1.000000	23.61510	-7.583472	3.412057	-34.96355
	(6.85058)	(2.61054)	(3.28851)	(10.2531)

As the can be seen, the Johansen lambda-max and lambda-trace[8] values in the first two tables show that there are two long run cointegrating function coefficients that can represent the relationship at 5% critical value. This result can be compared with Osterwald-Lenum table. The comparison reveals that the existence of 'no cointegration relationship' is rejected at one percent critical level while the existence of only one cointegration relationship is rejected at 5%critical level. Hence, we can not reject the existence of two cointegrating relationships.

Then we can take the first two rows (related to the first two Eigen vectors) of the unrestricted cointegrating coefficients as representing the long run relationship between the variables in the long run. The coefficients in the first raw have all the expected signs except the unexpected-but not surprising sign of the exchange rate. Normalizing all the coefficients on P we get the first cointegration relationship to be: (with the standard errors in parenthesis)

(LP + 21.6151LY - 7.583472LM2 + 3.42057LOER - 34.96355LWP) = ECM1

(6.85058) (2.61054) (3.28851) (10.2531)

All the coefficients except that of the OER are with the expected sign. But, looking closely at the coefficients with their standard error, we find out that the coefficient of the official exchange

8 The associated null and alternative hypothesis is explained in chapter three under Johansen procedure.

error is insignificant with a t-ratio of (-1.04) while the rest are significantly different from zero at 5% critical value. But these t-values should not be looked at strictly as if it were estimated by OLS. In the long run, increase in output decreases the price level while the increase in money supply and world price result in the increase of the domestic price. Here we notice the elasticity of domestic price to world price to be highest as we depend on import of capital goods for production. In addition, because of the less than potential production level the increase in money supply, though affecting the price level significantly will also increase the output to reduce the price.

Now, let us consider the second cointegrating vector. Normalizing this second raw of the unrestricted coefficients on price variable we will end up with the long run relationship of the form with all the coefficients with wrong sign theoretically. In addition, the relationship is with a positive adjustment coefficient (not in the table above) showing that the relationship is explosive or is not stable equilibrium with respect to that vector. In order, for a long run relationship to be stable the long run restricted adjustment coefficient must be negative. This is so because of the meaning attached to it. I.e. if there is disequilibrium, the disequilibrium widens indefinitely. But for the first cointegrating vector not only the signs but also the adjustment coefficients are meaningful.

The negative sign of the exchange rate with, of course, insignificant t-value in the first cointegrating relationship is not surprising. Agenor (1995) has found that in developing countries the exchange rate does not have a serious long run relationship with the price index. This is because of the fact that the exchange rate affects price only indirectly through world price of commodities.

The other point is that, the exchange rate in Ethiopia is not totally decided by market mechanism (is not freely floating) and as a result the mechanism of the movement is subject to management of it. Moreover, the official exchange rate used here is the birr/dollar value assuming purchasing power parity holds.

The *unrestricted adjustment* coefficients matrix shows the coefficients by which each of the variable enter in the error correction model as feed back effect. The *restricted* adjustment

coefficient in our long run relationship was negative as it should be. This means it is stable long run relationship .So, we say that when estimating the ECM , the cointegrating vector residual being explicitly put in the equation will have a negative coefficient.

Though it is known that the two step Engle and Granger (1987) method for testing of cointegration is deficient, it is usually used (Hafer and Jansen (1991), Ericson and Sharma (1996). But it is useful to check for the existence of the cointegration using Engle and Granger methodology. Yet it should be noted that the result with the Engle and Granger is totally depending on the contemporaneous log- level of the variables. First, the lags of the variables in describing each other (as all are interdependent) are not considered though they strictly matter. In addition, the methodology considers the variable on the left as dependent and the right side as independent. But this is not the case. The lag length decision is necessary as we did above in Johansen procedure. In other words, this quarters output, say for agriculture will affect the price in the market after it is made available to the market and this takes time. The same applies to money supply. It takes longer for the exchange rate and world price to affect inflation. This then necessitates the consideration of the lags.

The Engle and Granger (1987) procedure is a very simple two step procedure. In the first step we run a cointegration regression-by OLS-for all the variables of interest that are proved to be integrated of order one. In the second step, the residual from the first step is tested for stationary using the augmented Dickey-Fuller (ADF) statistics. If the residual is found to be stationary, we reject the null hypothesis of unit root and hence the null of no cointegration (stationarity implies cointegration). On the other hand, if the residual is non-stationary we cannot reject the null of unit root implying no cointegration relation.

So regressing LP on LY, LM2, LOER and LWP using OLS yields the following result

Table 3 Engle - Granger Cointegration test

Dependent Variable: LP
Method: Least Squares
Sample: 1992Q4 2007Q2
Included observations: 59

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LY	0.574081	0.278418	2.061936	0.0441
LM2	0.454194	0.270071	1.681754	0.0985
LOER	-0.784549	0.204559	-3.835312	0.0003
LWP	-1.475560	1.263015	-1.168284	0.2479
DU	-0.029905	0.021449	-1.394221	0.1691
C	2.589687	3.667181	0.706179	0.4832

R-squared	0.837490	Mean dependent varia	4.283120
Adjusted R-squared	0.822159	S.D. dependent varia	0.162242
S.E. of regression	0.068419	Akaike info criterion	-2.430177
Sum squared residua	0.248104	Schwarz criterion	-2.218902
Log likelihood	77.69023	F-statistic	54.62684
Durbin-Watson stat	0.530384	Prob(F-statistic)	0.000000

Now we take the residuals from this regression and test it for existence of unit root in these residuals. Note here that we do not need constant as it was already accounted for in the first step. The ADF statics is more reliable without constant unless the series forces to do so. (Enders, 1995). The result of the ADF from Eviews-five is the fallowing:

Null Hypothesis: RESID has a unit root
Exogenous: None
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.956194	0.0038
Test critical values:	1% level	-2.605442	
	5% level	-1.946549	
	10% level	-1.613181	

*MacKinnon (1996) one-sided p-values.

So we reject the unit root at all standard levels in favor of the alternative concluding the existence of cointegration. But looking at the coefficients we see the differences from that of Johansen. This is emanating from the EG's imposing 'common factor restriction' on the dynamics (Ericsson and Sharma, 1996). The visual inspection of the residuals distribution of the error term from both methods increases the appreciation of the Johansen procedure.

4.4 An Error Correction Model of Inflation

4.4.1 A General to Specific Modeling

Hendry's general to specific modeling strategy starts with as many variables as possible (many lags and explanatory variables) to explain a model. Then, step by step, the insignificant variables in the model are removed using the F-test and information criteria. By the end of the steps, the best and parsimonious model will be found. Accordingly, general to specific modeling strategy begins with an auto regressive distributed lag (ADL) model of the variables in the cointegration analysis. So starting with the six lags of each variable we reduce the model to achieve parsimonious ECM (PECM). The variables are the log levels of P, Y, M2, OER, and WP. The visual inspection in the residual has necessitated the inclusion of a dummy variable for the years of instability in the system. The dummy was not significant though. Auto regressive distributed lag (ADL) helped us choose the length to start with.

Having obtained the long run cointegration using Johansen approach it is possible to reformulate the model and estimate VECM with error correction terms explicitly included in the model.(Harris, 1995,p.33). That is to mean the cointegration relationship residual

(LP + 23.6151LY-7.5834722LM2 +3.1412057LOER -34.96355LWP)

Which we named ECM1 and

(-11.68134LP + 37.53168LY -6.239753LM2 – 2.748376LOER -53.5404LWP)

Which we named ECM2 enter the error correction model. In the analysis of the cointegration we have found that there were two significant long run relationships. These residuals are the residuals from the first and second cointegration equation respectively. Even though the second equation is not meaningful we still have to make use of the residuals in the ECM.

After getting ECM1 and ECM2, 'OLS is still an efficient way to estimate each equation in VECM (Harris, 1995 p.134)'. So we estimate the inflation equation accordingly. Estimating the multivariate model in such a way confirms to the weak exogeneity test. That is checking the overall significance of the coefficients of the six lags of each variable using F-test (Wald test). The following table is the result of the OLS using six lags of each variables, ECM1, ECM2, and dummy variable. Consistently with the cointegration we do not need the constant as its existence was rejected there.

Table 4 A Vector of error correction model

Dependent Variable: DLP Method: Least Squares
Sample (adjusted): 1994Q3 2007Q2, observations: 52 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLP(-1)	-0.397440	0.200693	-1.980338	0.0663*
DLP(-2)	-0.065620	0.193705	-0.338762	0.7395
DLP(-3)	-0.315742	0.303675	-1.039740	0.3149
DLP(-4)	-0.342573	0.316846	-1.081197	0.2967
DLP(-5)	-0.207057	0.238841	-0.866925	0.3996
DLP(-6)	0.081840	0.206095	0.397097	0.6969
DLY	1.923300	0.661830	2.906033	0.0109*
DLY(-1)	-0.044552	0.818621	-0.054423	0.9573
DLY(-2)	-1.199533	1.022428	-1.173220	0.2590
DLY(-3)	0.245544	0.662822	0.370452	0.7162
DLY(-4)	0.211449	0.649466	0.325573	0.7492
DLY(-5)	-0.217298	0.789023	-0.275402	0.7868
DLY(-6)	-0.446214	1.001414	-0.445584	0.6623
DLM2	0.819578	0.405334	2.021980	0.0614*
DLM2(-1)	0.922353	0.424120	2.174744	0.0461*
DLM2(-2)	0.912784	0.534935	1.706347	0.1086*
DLM2(-3)	1.283954	0.744634	1.724274	0.1052*
DLM2(-4)	1.068672	0.764825	1.397277	0.1827
DLM2(-5)	1.637215	0.833669	1.963867	0.0684*
DLM2(-6)	0.521562	0.521133	1.000823	0.3328
DLOER	4.153416	2.008296	2.068129	0.0563*
DLOER(-1)	-1.292322	1.240946	-1.041401	0.3142
DLOER(-2)	-0.276356	1.277440	-0.216336	0.8316
DLOER(-3)	0.077306	1.266774	0.061026	0.9521
DLOER(-4)	1.571859	0.733934	2.141690	0.0490*
DLOER(-5)	-0.817543	0.641463	-1.274498	0.2219
DLOER(-6)	-1.644679	0.865469	-1.900332	0.0768*
DLWP	1.420325	2.232887	0.636094	0.5343
DLWP(-1)	-1.706747	2.284329	-0.747155	0.4665
DLWP(-2)	1.565013	1.886884	0.829416	0.4199
DLWP(-3)	-2.764542	1.425644	-1.939154	0.0715*
DLWP(-4)	-3.039580	1.430755	-2.124458	0.0507*
DLWP(-5)	-1.061466	1.009093	-1.051901	0.3095
DLWP(-6)	-4.144066	1.367772	-3.029792	0.0084*
ECM1	-0.045174	0.024986	-1.807958	0.0907*
ECM2	0.025903	0.028631	0.904746	0.3799
DU	-0.027500	0.031271	-0.879410	0.3930

R-squared	0.884704	Mean dependent variab	0.010699
Adjusted R-squared	0.607992	S.D. dependent variab	0.048702
S.E. of regression	0.030493	Akaike info criterion	-3.962782
Sum squared residua	0.013947	Schwarz criterion	-2.574397
Log likelihood	140.0323	Durbin-Watson stat	2.045279

This unrestricted error correction model is interesting since it contains both the long run and short run information where the long run information is contained in ECM1 in our case. Since all the variables, including the error correction terms are stationary statistical inferences based on t and F statics are valid.

Very interestingly, the model has the first lag of each variable to be significant except for the world price. Specifically, we got the first lag of the price level to be significant with negative sign. We will see this variable in the parsimonious model after a while.

Now parsimony and economically interpretable ECM can only be achieved by removing the insignificant regressors and testing whether this reduction in the model is supported by an F-test and/or Schwartz information criterion. This is in line with Hendry's general to specific modeling strategy.

Dropping all the insignificant variables at 10% probability (in the above equation without stars) we started reducing from the largest lag to the smallest. All the coefficients with the p-value above 0.1 are tested of being equal to zero step by step using an F-test and/or Schwarz criterion. In F-test for model reduction the null hypothesis is that the coefficients of the excluded variables are zero and thus irrelevant to the model. If we do not reject the null then the reduction is valid and the reduced model is justified. But if it is otherwise then the reduced coefficient of the excluded variable is not zero and should not be dropped (Doornik and Hendry, 1994b). The following table shows the results after the test. This is the parsimonious ECM we reached at finally.

Table 5 Parsimonous error correction model

Dependent Variable:DLP
Method:Least Squares
Sample(adjusted):1994Q32007Q2
Included observations: 52 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLP(-1)	-0.479956	0.105438	-4.552000	0.0001***
DLY	0.915031	0.305287	2.997281	0.0048***
DLM2	0.666602	0.139286	4.785845	0.0000***
DLM2(-1)	0.887325	0.182980	4.849303	0.0000***
DLM2(-2)	0.504406	0.146369	3.446138	0.0014***
DLM2(-3)	0.307974	0.138747	2.219672	0.0327**
DLM2(-5)	0.375922	0.144387	2.603564	0.0132***
DLOER	1.637963	0.582492	2.811992	0.0078***
DLOER(-2)	-1.392256	0.567603	-2.452870	0.0190***
DLOER(-4)	0.677480	0.346156	1.957152	0.0579**
DLOER(-6)	-1.322970	0.267799	-4.940167	0.0000***
DLWP(-1)	-2.192671	0.823242	-2.663459	0.0114**
DLWP(-4)	-2.240970	0.698940	-3.206238	0.0028***
DLWP(-6)	-3.042315	0.702464	-4.330916	0.0001***
ECM1	-0.013867	0.004903	-2.828252	0.0075***

R-squared	0.752312	Meandependnt variab	0.010699
Adjusted Rsquared	0.658593	S.D.dependent variab	0.048702
S.E.ofregression	0.028457	Akaikeinfocriterion	-4.044274
Sumsquaredresidua	0.029962	Schwarz criterion	-3.481415
Log likelihood	120.1511	Durbin-Watson stat	1.843322

***significant at1% ** significant at 5%

4.4.2 Overall, Coefficient, Residual and Stability Diagnostics of the PECM

Overall: The weak exogeneity tests of the dependent first differences of the variables (test of being a determinant variable in ECM) with all the lags approved their being so at standard critical value except for GDP which is on border line. Specially, if we were interested in more than one cointegrating vector, this test would indicate the lags of which of the variables should not be included in the error correction model by restricting the respective alpha-coefficients of the variables to zero.

The overall reduction with the null hypothesis of all the 22 coefficients equal to zero resulted in F (22, 37) =0.782911, and chi-square (22) =17.22. This confirmed to the removal of all the variables. Comparison of the first unrestricted model and the second parsimonious model was also made. Obviously, the R^2 in the PECM is smaller as any decrease in variables in any model does while the adjusted-R^2 is higher. The standard error of the regression has also declined strengthening to the robustness of the model. In addition to the F and chi-square tests, the reduction to PECM was further confirmed by the Akaike and Schwartz information criteria reported under the table. The Durbin Watson value which is a little less than two implies no serial correlation

Coefficients: all the individual restriction on each coefficient is rejected as can be seen. The restrictions made on the coefficients equality to zero for each lag of each variable in the model was highly rejected. The overall significance test using the F-statistic hypothesizing all the coefficients to be zero resulted in F (15, 37) =7.982(prob. 0.000) and chi-sq (15) =119.73. All the tests including the inspection of the confidence ellipse of the coefficients approved the PECM.

Residuals: All the serial correlation tests up to lag 5 of the residuals using the Breusch-Godfrey LM test indicated their non-existence. The whites test for hetroskedasticity with the null hypothesis of no cross terms could not be rejected with F-statistic of 1.035(prob. 0.4757). So we proved the homoskedasticity of the residuals. Moreover, the ARCH test (Engle, 1982) shows the absence of autoregressive conditional hetroskedastic errors with F=0.45253(prob. 0.5043). The general misspecification test of the estimated PECM using Ramsey's RESET test with the null of correct specification could not be rejected at 10% critical value. Jarque-Bera test of normality, using the F-statistics confirmed normal distribution of the residuals. The PECM explained 75% (R^2) of the variation in price index (inflation). Based on this we can say the model is sufficiently satisfactory. But, the seemingly low R^2 of 75% indicates that other factors like the marketing behavior, storage, rainfull, transportation of products and the information transmission mechanism effects need to be studied.

Next further diagnostics in the graphs of the actual, fitted and residuals of the inflation model are graphed next.

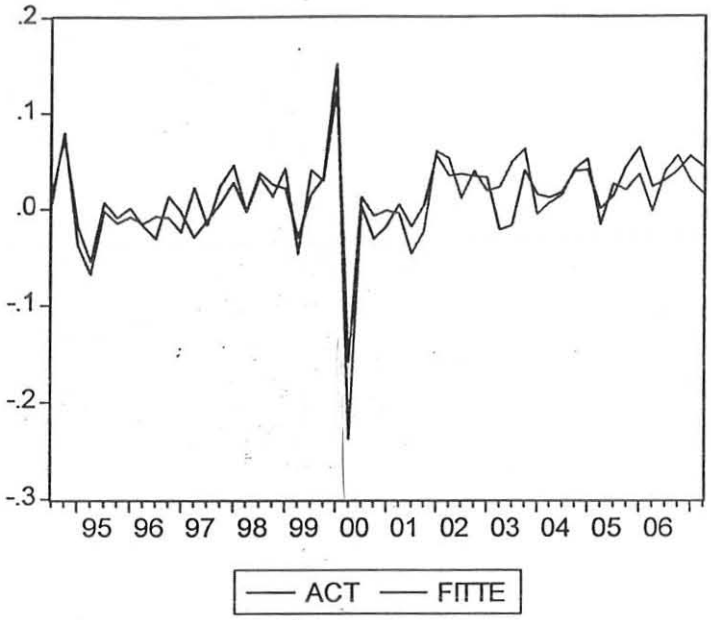


Figure 3 Graph of actual and fitted inflation model

The above graph shows how closely the fitted value follows the actual. The visual inspection this graph is consistent with the above diagnostics and the following residual graph.

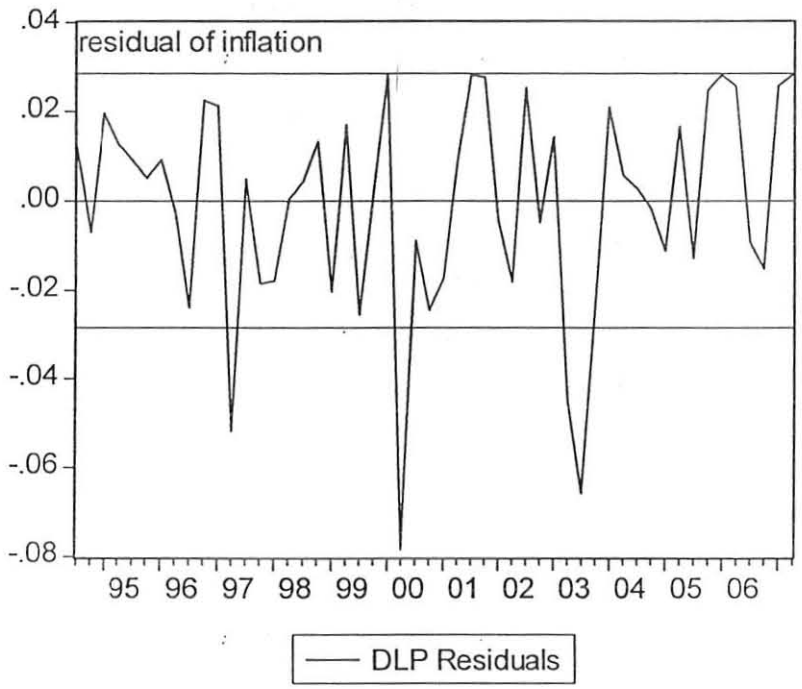


Figure 4 Graph of the residual of the infilation model

Stability Tests of the Inflation Model (PECM): The stability of the inflation model is essential for any conclusion and policy implication to be derived. Hence, it deserves considerable emphasis. Unless the coefficients are stable, the empirical model is useless for any conclusion and forecast.

The empirical PECM showed us that the coefficients are highly significant. It implicitly assumed that the coefficients in the model have remained stable over the estimated period. But if this does not hold, inferences based on the model are not reliable. Therefore, checking for parameter constancy is invaluable. In addition, the constancy of the estimated coefficients is a proof of the weak exogeneity of the variables.

In line with this, we will make the Chow Break Point test, Chow Forecast Test and recursive estimation of the coefficients and residuals. Chow Break Point tests whether the model is different before and after some selected period. This is made based on the F-tests by comparing the residuals before and after the selected period with that of the unrestricted model (PECM). On the other hand, chow forecast tests if we can forecast the inflation in some part of the series based on the estimated coefficients in the other part of the series. Here also the residuals of the forecasted period together with the other fixed period will be compared with the PECM residuals. If we cannot forecast the coefficients of the selected period based on the other, then the two periods are explained by different models and the original PECM is not stable.

The following table shows chow break point and forecast tests with their respective F-static and probability values.

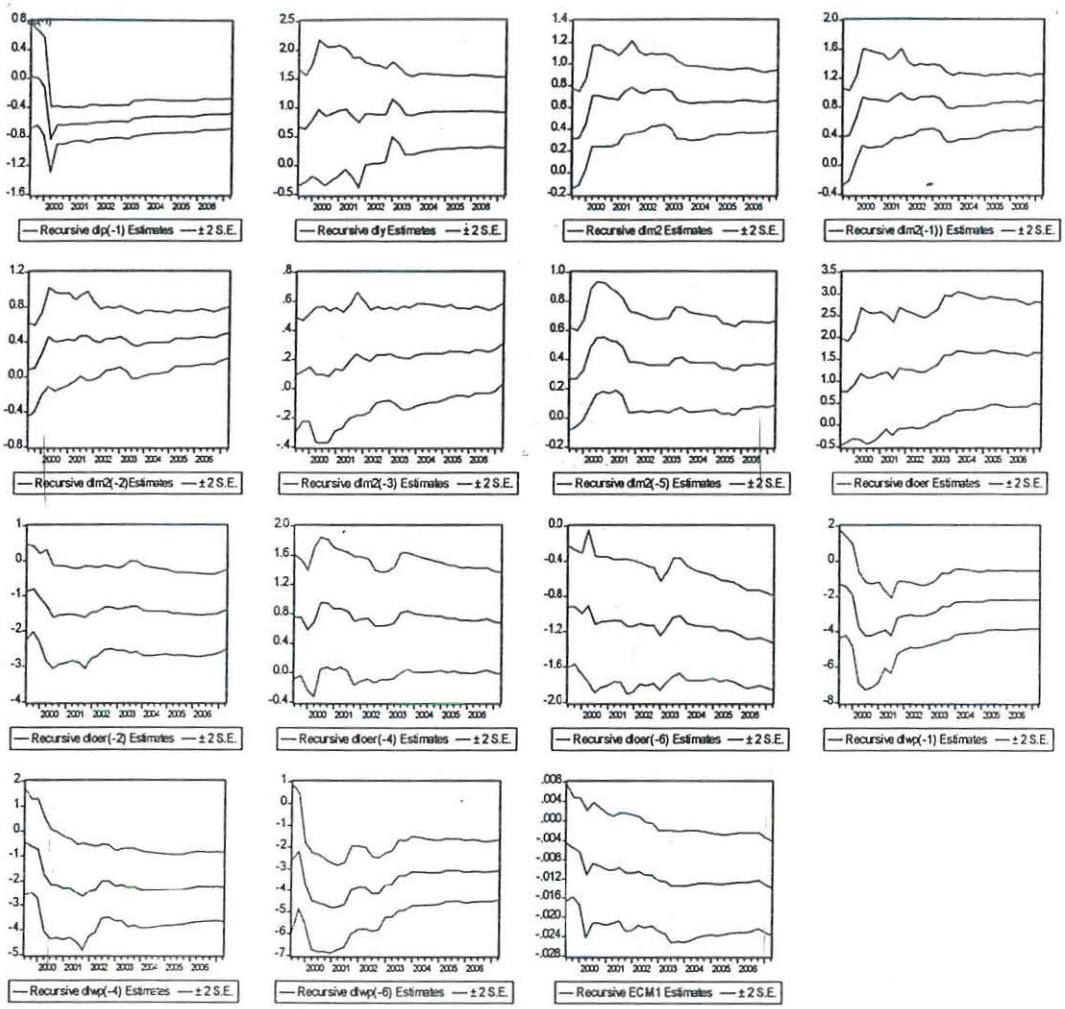
Table 6 Stability and forecast tests of parsimonious error correction model

	Year	F-Statistic	Probability
Chow break point test	1999:q1	0.73	0.7263
Null: the coefficients are the same before and after the specified time	2000:q1	0.82	0.6437
	2001:q1	1.97	0.0716
	2002:q1	1.26	0.3037
Chow forecast test(s)	1999:q1	1.49	0.4233
Null: the coefficients can forecast coefficients of post given period	2000:q1	1.80	0.2131
	2001:q1	0.93	0.5857
	2002:q1	0.76	0.7216

All the results consistently indicate that we cannot reject the null hypothesis of constancy at 5% critical value.

The important limitation of the chow test is that it does not allow for any kind of difference between the sections of the series.(Wooldrige, 2004, p.232).The chow tests can be computed for more than two subsections of the series because of the limitation of the number of the series and tedious calculations associated with it.(Wooldrige, 2004, p.414)

To further strengthen to the stability conclusion, and hence reliability of the model we have put the graphs of the recursive coefficients and residuals along with the two standard error boundary of the estimates.



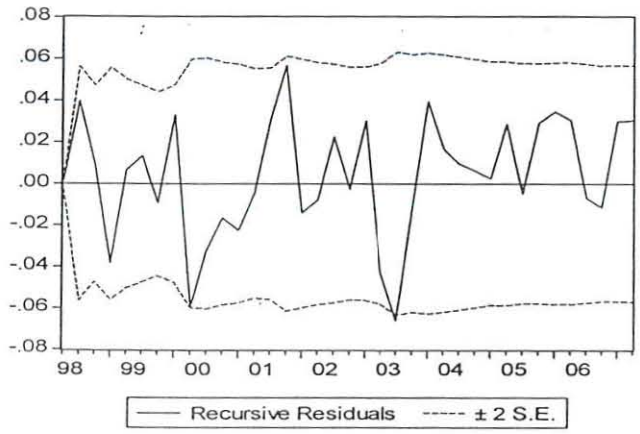


Figure 5 Graphs of recursive coefficients and residuals with two standard error boundary

4.4.3 Results and Interpretations of the Model

After justifying the reliability of the model based on the residuals and coefficients tests we have proved the stability of the model. Now we can make inferences from the model and conclude the policy implications.

The negative coefficient of lagged inflation, $\Delta p(-1)$, in PECM suggests that inflation expectation has a negative effect. This is contrary to the apriori expected result. This coefficient was assumed to represent the expectation of inflation in model specification part. But, considering the realistic situation in Ethiopia, quarters of good rainfall are followed by quarters of lower inflation. The price of the food items decreases after rainy period (comprising the highest percentage of the price index). The prices are highest in July, August and September while the lowest in January, February and March-in a given year. Practically expectations are made based on rainfall rather than the neoclassical theory specifying 'we have inflation because we expect inflation.'

To elaborate more, based on the quarter in which we are, we expect the price in opposite direction of what prevails by that quarter. During the seasons of the year when the crop is on farm, the prices are higher. But we expect the price to fall by the immediate consecutive quarter as crops will be harvested and supplied to the market. And higher prices will be expected in the next. And the process moves on so.

Higher income, contemporaneously adds to higher inflation. This may be due to the low level of income and/or lesser culture of saving. That is, when income increases, the majority of the increase goes to consumption because of the poverty in the country. On the other hand, the remote lags of output are negatively affecting the current inflation. It is usually the case, as was explained in the first chapter, that years of higher rainfall are followed by years of lower inflation and vice versa. Higher output because of higher rainfall in the last year increases supply of food in this year while decreasing the inflation. The unrestricted ECM shows that the fifth and sixth lags have negative coefficients. This conclusion is similar to Muche's (2007) result which shows years of higher rainfall and good harvest are fallowed by lower inflation.

The result associated with the money supply catches attention that all the coefficients in all the lags have positive sign. The money supply that is contemporaneous with inflation pushes the

inflation by less magnitude than the immediate past. This is related to the velocity of circulation (the number of hands a currency touches in a given time) of currency. The higher effect of money supply is seen after one quarter while the push declines as we move further in the lags as was shown in PECM. In line with the theory all the coefficients were positive in the unrestricted ECM. We have also seen that in the long run (from the cointegration equation) the magnitude of the effect of money supply on inflation is less than the world price (positively) and output (negatively). This is different from the Ethiopian Economic Association (2008) which showed that in the longrun inflation is only a monetary phenomenon. The short run effect of money supply is high. This is because in longer period the money supply contributes to more production also as was explained by Keynesian theory.

Furthermore, the official exchange rate's effect is high and positive contemporaneously and in a year time (four quarters). But we see that its effect is negative in two quarters time. The contemporaneous high, positive and significant effect may be due to the higher demand of exportable commodities immediately during a little increase in the exchange rate(expecting further increase) and the always end of the budget year high imports by government offices to make use of allocated budget. The effect of the latter dies out in six months time. We further have explained that the effect is not direct.

In relation with the world price, we see that the price elasticity is the highest in the long run while the effect in pushing the price index is the least in the short run. Actually all the coefficients in the short run are negative both in unrestricted ECM and PECM.

We have also seen that the adjustment coefficients in the PECM are highly significant and negative as expected. But looking closely, the coefficient is small (about -1.2%).This implies that any past disequilibrium is adjusted to the equilibrium by about 4.8% a year indicating that it takes more than twenty years to go back to perfect equilibrium. The need to consider other variables like the wage rate in the cointegration equation seems to be important to fully explain the situation. We also note that the coefficients of ECM2 and the generated dummy variable are insignificant to contribute to the model.

In general, as can be seen in the unrestricted ECM, the best way out in controlling the inflationary process seems to be the tightening of money supply. But this is never a solution in

the long run. It should also be noted that the long run growth of production is limited when the money supply is limited in countries like Ethiopia as output is far less than the potential. The world price of commodities, being a small country, cannot be affected by the domestic price. But producing or substituting commodities that keeps the economy stabile during world inflationary shocks are essential. This may includes the use of bio-gas fuels to take care against petroleum price shocks which is highly correlated to the world price index. Further, the overall increase in production, especially of food items (large portion of consumer goods basket), possibly through irrigation agriculture, is indispensable way to keep the inflation under control in the long run (implied by the cointegration equation). This partly settles the short run inflationary process.

CHAPTER FIVE

CONCLUSION AND POLICY RECOMMENDATIONS

The objective of this paper was to see the factors that affect the inflation process in Ethiopia and see possible policy recommendation to alleviate the problems associated with it. In the empirical analyses using 59 data series starting from 1992 Q4 to 1997 Q2 we specified possible determining factors based on theories of inflation. To examine the long run relationship we used the Johansen procedure and the Engle Granger to support the decision of the relationship. After the decision of the long run relationship we went on to explore the short run relationship based on the error correction modeling. Based on the unrestricted error correction model we found the parsimonious error correction model.

Cointegration test of the Johannes approach provided the existence of two cointegrating relationship of price, broad money, read output, official exchange rate and the world price index. We could not use expectation of inflation in the long run model because it was proved to be stationary. The long run relationship showed that the world price was the most determining factor followed by the real output and money supply. The effect of the official exchange rate, in the long run was found to be insignificant. Based on theories, any long run relationship has a related short run representation. Accordingly, we estimated an unrestricted model with 39 dependent variables (6 lags of each variable ECM, & du). We found the most significant ones of the 39 dependent variables were only 15. Consistently with the theory, the adjustment coefficient of the residual form the long run had a significant negative sign, but the magnitude of the coefficient was small proving that the disequilibrium from long run takes a very long period to return to the equilibrium.

The parsimonious error-correction model has shown that in the short run the most significant effect on inflation is from the money supply. We hence, concluded that the money supply had the lesser effect on inflation in the long run while the effect is the biggest in the short run. The gross domestic product had positive effect in the short run wile the long run effect was negative. The

world price was found to have a non-positive effect in the short run wile the effect was the biggest in the long run model. So, we proved that the world price index and money supply had the strongest pushes in the long run and short run respectively.

The exchange rate, consistently with the theory, had no significant effect in the long run while the effect was positive in year's time in the short run model.

The stability test using different methods consistently proved the reliability of the model to make inferences. In accordance with the objective, we proved that the relationship of inflation and its determining factors are stable, consistent and reliable.

Different tests were made on the parsimonious model to check the different necessary batteries of tests.

We finally suggest that the best way to control the inflation in Ethiopia in the short run is tightening the money supply. But this is not without limitation; as the resource utilization and further growth of out put are also determined by the extent of money supply there should be a balanced management in accordance with the cost of high inflation in the short run and lower out put in the long run.

It is also the case that the control of money supply can not keep the price level stable in the long run. Rather expanding production through different way including irrigation agriculture and better ways of farming are of invaluable value to control inflation and the excess aggregate demand.

It is also recommendable that substitutes of imported products be produced in addition to widening bio fuel utilization. There was a high correlation between petroleum price and the world price index which was the most significant factor affecting the price index in the longrun in Ethiopia.

Yet, this study has the limitations of not including the rainfall in to the model. There seems to be a high relation between inflation and rainfall. This is deduced based on the negative coefficient of lagged inflation on which expectation is based. In addition, the parallel market exchange rate

seems to be a better demining factor than the official one but data was not reliable because of different reasons.

In addition, though the within sample forecast test was very good, the future forecast of the inflation could not be made because of the limited data series.

Further research that refines the models and addresses these limitations may provide significant payoffs.

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Appendix I The method for the interpolation of the real GDP

This method is just reproduced from Goldestein, M. and M.S. Khan (1976). The only difference being that it is put in the way needed for this analysis.Given three consecutively measured series X_{t-1} , X_t and X_{t+1}being flow variable can be put in a quadratic function. The quadratic function passing through the three points is, say, $at^2 + bt + c$. Then we can represent the three points by the area under the function as:

$$\int_0^1 (at^2 + bt + c)dt = X_{t-1}$$

$$\int_1^2 (at^2 + bt + c)dt = X_t$$

$$\int_2^3 (at^2 + bt + c)dt = X_{t+1}$$

Integrating the functions:

$$\frac{at^3}{3} + \frac{bt^2}{2} + ct \Big|_0^1 = X_{t-1}$$

$$\frac{at^3}{3} + \frac{bt^2}{2} + ct \Big|_1^2 = X_t$$

$$\frac{at^3}{3} + \frac{bt^2}{2} + ct \Big|_2^3 = X_{t+1}$$

2

Solving for a, b and c simultaneously from the three equations, we get the following.

$a = 0.5X_{t-1} - X_t + 0.5X_{t+1}$

$b = -2X_{t-1} + 3X_t - X_{t+1}$

$c = 1.833X_{t-1} - 1.166X_t + 0.33X_{t+1}$

If this is the case, then the first four quarterly series are

First quarter:

$$\int_{1}^{1.25} (at^2 + bt + c)dt = 0.0548X_{t-1} + 0.2343X_t - 0.039X_{t+1}$$

Second quarter:

$$\int_{1.25}^{1.50} (at^2 + bt + c)dt = 0.0077X_{t-1} + 0.2657X_t - 0.0235X_{t+1}$$

Third quarter:

$$\int_{1.5}^{1.75} (at^2 + bt + c)dt = -0.02355X_{t-1} + 0.2657X_t + 0.0078X_{t+1}$$

Fourth quarter:

$$\int_{1.75}^{2} (at^2 + bt + c)dt = -0.039X_{t-1} + 0.2342X_t + 0.0547X_{t+1}$$

But the limitation of this method is that we could have taken four series and assumed cubic distribution or five series and degree four distributions and so on. The choice of the quadratic method is easier to solve. And others could be approximated similarly. We should not totally perceive the result as if it were realistic as it is only an approximation of it.

Appendix-II

P	Y	M2	OER	WP	DU	dummy
61.20000	12794.60	10136.70	5.009100	93.60000	1.000000	devaluation
60.36667	12556.52	10136.90	5.472700	94.00000	1.000000	
58.70000	12601.99	10406.40	5.468400	94.30000	0.000000	
59.83333	12695.17	10735.90	5.913400	95.20000	0.000000	
64.40000	12817.84	11598.70	6.243200	96.00000	0.000000	
66.03333	12939.00	12123.50	6.197200	96.30000	0.000000	
67.40000	13142.41	12818.70	6.273200	97.10000	0.000000	
68.63333	13413.98	13452.00	6.259400	98.90000	1.000000	
73.80000	13733.99	14408.50	6.272200	99.20000	1.000000	
72.46667	14390.71	14516.40	6.305000	99.70000	0.000000	
68.56667	14704.14	14521.10	6.303200	100.0000	0.000000	
69.00000	14978.42	14686.70	6.337400	100.0000	0.000000	
68.33333	15192.58	15654.80	6.325600	100.4000	0.000000	
68.36667	15424.79	15849.60	6.345500	100.5000	0.000000	
67.13333	15503.20	15586.40	6.397400	101.0000	0.000000	
65.03333	15520.99	15777.00	6.580100	101.8000	0.000000	
65.90000	15457.06	16548.80	6.679600	102.6000	0.000000	
65.66667	14941.47	16865.60	6.771000	102.9000	0.000000	
63.73333	14875.27	17581.90	6.816400	102.7000	0.000000	
62.93333	14907.08	16074.00	6.909400	102.9000	0.000000	
63.30000	15015.27	18554.90	7.030000	103.2000	1.000000	ethio-eriteria war

65.06667	15396.59	18482.90	7.152900	102.7000	1.000000	
64.90000	15588.45	18228.70	7.371100	101.7000	1.000000	
67.40000	15807.41	18370.60	7.592500	100.0000	1.000000	
69.16667	16030.88	19399.30	7.928000	101.0000	1.000000	
70.70000	16243.87	19890.10	8.119600	101.8000	1.000000	
68.60000	16496.02	20295.50	8.126800	102.7000	1.000000	
69.63333	16791.77	20686.60	8.148900	104.1000	0.000000	
71.93333	17106.87	22177.80	8.197200	105.4000	0.000000	
83.66667	17706.66	23725.20	8.327900	106.6000	0.000000	
65.96667	17969.76	23010.90	8.283600	107.6000	0.000000	
66.16667	18180.49	23289.30	8.357500	107.6000	0.000000	
64.10000	18313.64	24516.20	8.431100	108.0000	0.000000	
62.90000	18327.78	25416.80	8.492700	106.8000	1.000000	drought
63.16667	18340.08	25083.50	8.560500	106.0000	1.000000	
62.00000	18328.34	25910.60	8.560500	108.2000	1.000000	
62.20000	18267.30	27322.00	8.564300	108.8000	1.000000	
65.76667	17637.20	28152.50	8.569700	108.5000	1.000000	
68.10000	17699.09	28346.90	8.576800	108.9000	0.000000	
70.63333	17957.75	29161.60	8.584500	110.2000	0.000000	
73.13333	18386.04	30090.10	8.592700	110.8000	0.000000	
75.60000	19454.90	30657.40	8.605700	111.0000	0.000000	
73.96667	20046.06	31522.20	8.616600	111.4000	0.000000	
72.73333	20655.40	32707.60	8.624400	112.3000	0.000000	
75.70000	21252.98	34655.90	8.632200	113.6000	0.000000	

76.86667	21857.28	34635.70	8.640800	114.5000	0.000000	
77.80000	22445.53	35882.00	8.648300	115.2000	0.000000	
79.20000	23060.19	36854.00	8.655400	115.8000	0.000000	
82.40000	23667.91	40212.10	8.662500	116.9000	0.000000	
85.86667	24271.57	41833.20	8.670200	118.0000	0.000000	
85.86667	24887.48	42098.90	8.677600	119.1000	0.000000	
87.03333	25545.76	44311.80	8.684700	120.1000	1.000000	election
91.00000	26209.39	46377.40	8.691400	121.4000	1.000000	
97.03333	26905.41	48799.60	8.698600	122.2000	1.000000	
99.30000	27594.12	49811.30	8.719700	122.6000	0.000000	
102.3000	28333.09	53307.80	8.831500	123.6000	0.000000	
106.5000	29081.23	56651.90	8.927500	124.6000	0.000000	
112.5333	29595.96	58479.40	9.034400	125.6000	0.000000	
117.5667	30353.53	61148.80	9.070400	126.5000	0.000000	

Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university, and that all source of materials used for the thesis have been duly acknowledged.

The examiners' comments have been dully incorporated.

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