1. Introduction

Understanding the mechanism of inflation has been a long standing fascination of the economics profession. And several models - from simple quantity theory based to the ones based on dynamic stochastic optimization general equilibrium (eg New Keynesian Phillips curve) - have been suggested and confronted with the data. One common character of all these models is that they are based on the workings of market based economies of the developed countries. Despite this several authors have attempted to take these models and confront them with data from developing countries. One such work is that of Fedderke and schaling (2005) which tested the relevance of the ‘triangular’ model of inflation by Gordon (1982, 85) and Ghali (1999). They found that the mark up view of inflation describes the South African economy well (specifically the mark up of the product market in South Africa is 3 times that of USA). Edwards (1993), on the other hand, states that by ignoring political considerations traditional models of inflation fail to fully understand the dynamics of inflation. Particularly, by citing results from the political economy approach to macroeconomic policy: he demonstrates that factors such as instability, agricultural dominance in the economy etc will lead governments to rely on inflationary financing of their expenditure. This strand of the literature thus takes seignorage as the main source of inflation in such economies.

Inflation in Ethiopian economy has not been high by most developing countries standard. But it shows remarkable year to year variation. And most studies of the economy mention, as a passing remark, that inflation In Ethiopia is a ‘weather phenomenon’. i.e. it strongly mimics the performance of the agricultural sector. But such claims rely on observations of extreme times and do not provide a formal treatment of the issue. The basic aim of this thesis is then to asses whether traditional models will shed a better light on our understanding of the inflation
process in Ethiopian economy. With this spirit, in this thesis I will try to compare the performance of two models of inflation using data from Ethiopian economy. One is the ‘triangular’ model of inflation of Gordon (1982, 85) stated above which emphasizes the real side of the economy in the inflation process and the second is the so called P* model of inflation of Hallman et al (1991). The later emphasizes the role of money in the inflation process and thus can be taken as a test of the claim in Edwards (1993).

The thesis is organized as follows: chapter 2 gives a very brief overview of the macro Economic history of the Ethiopian Economy. Chapter 3 has two parts: part 3.1 discusses the theoretical models and part 3.2 provides the empirical counterparts of those models as well as estimation results. Chapter 4 concludes.

Note: the soft ware used for estimation as well as data organization is Givewin.
2: A brief Macro Economic History of Ethiopia:

The general economic environment covered by the data used in this paper can be grouped into two broad categories: the one ranging from 1974/75 to 1990/91 and the other ranging from 1991/92 to the present.

1974-91

Following the declaration of socialism in 1974 the government extended its control over the whole economy and nationalized all large corporations\(^1\). In the product market (especially agricultural products) price control and rationing was a common feature. For instance in the period between 1976 and 1990 farmers used to be forced to deliver 10 to 50 percent of their grain harvest to the agricultural marketing corporation (AMC) at less than market price. The latter then distributes grains to urban consumers, the military, and public service agencies at a subsidized price (Asfaw Negassa and T.S Jayne (1997)). In the financial market: all the private banks were nationalized in 1975 and form a single monopoly (Commercial bank of Ethiopia) in 1980\(^2\). Several proclamations were also enacted that define the role of the central bank and reduce its independence from the executive body of the government.

“The NBE fixed both deposit and loan rates (both of which were set at low levels), administered the allocation of foreign exchange (all of which has to be surrendered to NBE), and directly financed the fiscal deficit.”(Addison and Alemayehu (2001).

\(^1\) National bank of Ethiopia(http://www.nbe.gov.et/toc.htm)

\(^2\) National bank of Ethiopia(http://www.nbe.gov.et/toc.htm)
In terms of financing the fiscal deficit, the government enacted a proclamation in September 1976 that raised the legal limits of outstanding government domestic borrowing to 25% of the actual ordinary revenue of the government during the proceeding three budget years as against the proclamation 206/1963, which set it to be 15%.

In addition, the exchange rate was fixed to the US dollar (2.07 birr per dollar) throughout the period despite many indicators show that the exchange rate was over valued. For instance, the spread between the parallel and the official nominal exchange rate increased from 0.2 birr per dollar in 1973/74 to 4.6 birr per dollar in 1990/91. The following graph vividly describes the situation.

![Figure 1: Official and Nominal exchange rates (annual average) (source NBE). Note: the exchange rate is expressed as units of birr per dollar](http://www.nbe.gov.et/toc.htm)

The structure of the economy is such that compared to its predecessor (the Imperial regime) the share of the agricultural sector in the Derg regime does not show much change. The contribution of the service sector, on the other hand, shows a minor increase to an average of about 35% compared to about 30% in the previous decade. This increase in the share of the service sector may be an indicator of the expansion of the role the government plays in the economy. In addition, this modest rise in the share of the service sector shows up in a decline of the contribution of the industrial sector to GDP.

One striking feature of the data is that despite the fact that close to 90% (for much of the period) and around 80% in recent times of the total labor force of the country is engaged in the agricultural sector (the actual figure for 2005 is 80.2%), its contribution to the overall economy is just about 50%. This indicates the low productivity that characterizes the sector.

Table 1: Structure of the Ethiopian economy.

<table>
<thead>
<tr>
<th>Period</th>
<th>Agriculture’s share in GDP</th>
<th>Industry’s share in GDP</th>
<th>Service’s share in GDP</th>
<th>Agriculture’s share in total labor force</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-74</td>
<td>54.59</td>
<td>15.19</td>
<td>30.34</td>
<td>90.85</td>
</tr>
<tr>
<td>1975-79</td>
<td>52.01</td>
<td>14.42</td>
<td>33.57</td>
<td>89.91</td>
</tr>
<tr>
<td>1980-84</td>
<td>54.86</td>
<td>12.55</td>
<td>33.12</td>
<td>88.73</td>
</tr>
<tr>
<td>1985-89</td>
<td>49.85</td>
<td>12.80</td>
<td>37.24</td>
<td>87.19</td>
</tr>
</tbody>
</table>

4 for detailed account of the structure of the economy and its comparison with a typical developing country see Alemayehu and Befekadu (2002).
<table>
<thead>
<tr>
<th>Year</th>
<th>Inflation</th>
<th>Unemployment</th>
<th>External Debt</th>
<th>GDP Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-97</td>
<td>52.92</td>
<td>10.53</td>
<td>37.27</td>
<td>89.3</td>
</tr>
<tr>
<td>1999-2005</td>
<td>46.10</td>
<td>13.10</td>
<td>40.00</td>
<td></td>
</tr>
</tbody>
</table>


Note to table 1: the authors used such a sub period classification for the convenience of the subject of their study. Therefore, it should be noted that the classification has no special relevance/meaning in the present context. And for a clear graphic description see the appendix.

1992-present

Following the demise of the Derg regime in May 1991, the successor (EPRDF) commenced the introduction of market-oriented policies in line with structural adjustment programs prescribed by the Bretton Woods (IMF and World Bank) institutes (Alemayehu and Befekadu (May 2002)). The short run macroeconomic component of this reform includes:

“Fiscal policy aimed at raising revenue and reducing fiscal deficit as a source of inflation, structural reforms concentrated on lifting most domestic price controls, reducing import tariffs, and moving to a market-based system of foreign exchange allocation. (Addison and Alemayehu (2001)).”

One instance of such a reform reflected in the product market is the radical transformation of policies concerning grain marketing since 1990 (note: during the last year of its regime the Derg administration has introduced market reforms that can be taken as predecessors for the post 1991 liberalizations). The most notable of these changes are:
Quotas and fixed grain prices were abolished; subsidies on wheat for urban consumers were abolished in 1992. And all controls on interregional grain movement were lifted there by allowing freer market determination of commodity prices (Asfaw Negassa and T.S Jayne (1997).

In the financial market, besides the emergence of private banks and insurance companies to the scene, the central bank’s mandate is redefined in accordance with what is consistent with market economy principles. In addition the exchange rate regime has been changed into what can be termed a managed float. To understand the different phases through which this reform has passed through one can refer to (http://www.nbe.gov.et/toc.htm) or Addison and Alemayehu (2001) and the references there of.

Such marked departures in policy from the previous regime (Derg) that are described above have not shown up in a transformation of the sectoral composition of the Economy: agriculture still contributes close to half the GDP and employs close to 90% of the labor force. The service sector’s share shows a minor rise (reflected in a slight decrease of the contribution of the agricultural sector) while industry is stuck at around 12.5%. Despite inclusion of a decade of data to the study of Alemayehu and Befekadu (2002) the above observation still confirms their conclusion that: “although the share of each sector fluctuates in a very narrow band, it is fundamentally unchanged in the last four decades. Growth performance still hinges in fragile agricultural sector with no structural change in the overall economy.”

As will be indicated later in chapter three, empirical investigations relying on the level of economic activity as an explanatory variable for inflation indicate that using unemployment has an advantage than the use of output gap. Since I will also estimate such a model, it will be interesting
to explore the level and fluctuations of unemployment in Ethiopia. But the reality is that there are several problems complicating the use of the available unemployment data for this study. There are basically two sources of unemployment data: The first is, the number of job seekers registered in the Ministry of Labor and Social Affairs and its branch offices. This data however can not be taken seriously as an indicator of economic activity because people do not usually have incentive to register. The second source is surveys conducted by Central Statistical Authority. These data, though somewhat reliable, are collected on a very long gap and thus are not useful as indicators of short run fluctuations in the unemployment figure. These surveys put in chronological order are: the 1984 Population and Housing Census; the 1994 Population and Housing Census; the 1999 National Labor Force Survey; Report on Bi-annual Employment-Unemployment (2003 onwards). One can see here that annual data can be found only for the post 2003 period. Even these data can be problematic as an indicator of the level of economic activity. For instance, in rural areas disguised unemployment is so severe that a change in the official (open) unemployment may not change the level of output.

However, I have put some of the statistics below in order to give a feel of the general picture.

Table 2. Unemployment rate (urban and rural) in Ethiopia

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>0.4</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.6</td>
</tr>
<tr>
<td>Urban</td>
<td>7.9</td>
<td>22.0</td>
<td>26.4</td>
<td>26.2</td>
<td>22.9</td>
<td>20.6</td>
<td></td>
</tr>
</tbody>
</table>

Source: CSA

Note:a) Unemployment is defined as the percentage of the labor force (those aged above 10) that are looking for work but can not find one at the going wage rate
b) the data for 1984 and 1994 are from respective Population and Housing Censuses; the data for 1999 and 2005 are from national labor force surveys; the data for 2003 and 2004 are from urban biannual employment and unemployment surveys in the respective years.
3: Theoretical and empirical Models

3.1: Theory

3.1.1: Phillips curve

The Phillips curve model of inflation has been a prominent form of modeling the supply side of economies since its conception as an empirical regularity by Phillips (1958). Over the years it has been augmented and formulated in several ways. Initially it was interpreted as showing a trade off facing policy makers that can be exploited continuously as long as the authorities have the appetite for a rising inflation. This concept was convincingly challenged in the late 60’s by the likes of Phelps (1967, 1968)* with the Natural rate hypothesis which implies that the long run (where unemployment reaches its natural rate) Phillips curve is vertical. Later models of the Phillips curve went in the direction of formulating it from ‘micro foundations’. One such attempt is the famous paper of Lucas (1972) which came up with an ‘inverted Phillips curve’ (for extended discussion and empirical test see Bårdsen et al (2005)) based on micro foundation. A more recent version (attempt) along the line of providing micro foundation for a non vertical short run Phillips curve is dubbed as New Keynesian Phillips curve. In these models the Phillips curve is derived from solving the problem of a monopolistically competitive firm choosing its nominal price to maximize its inter temporal profits subject to constraints on the frequency of future price adjustment. Clardia et al (1999) and Roberts (1995) are representative papers in this group. Empirical appraisal of the New Keynesian Phillips curve is given in Bårdsen et al (2005).

In this paper I will follow as a basic working model an alternative empirical version of the Phillips curve dubbed the ‘triangle model of inflation’ as in Gordon (1982, 1985), Stockton and Glassman (1987).
Ghali (1999) has used this model to study the causal direction between wage changes and inflation (price inflation) using modern error correction models. Fedderke and Schaling (2005) have tested the relevance of this mark up view of price setting and inflation process in an emerging market economy, South Africa.

The use of the technique of cointegration as done in Ghali (1999) provides a richer set of relations of the system. But in light of the limited data set available I will direct my attention to formulating a reduced form equation that suppresses the wage variable.

The model drives the expectation augmented Phillips curve equation from the following system of equations: (a full step by step derivation of the model is found in Gordon (1985)).

\[
\Delta(\omega_t - \rho_t) = \alpha_0 + \alpha_1 \pi_t^e + \alpha_2 \chi_t + \alpha_3 s_{wt} \quad (1)
\]

\[
\pi_t = b_0 + b_1 \Delta(\omega_t - \rho_t) + b_2 \nu_t + b_3 s_{pt} \quad (2)
\]

\[
\pi_t^e = C(L) \pi_{t-1} \quad (3)
\]

Where:

\(\pi\) is inflation measured in CPI

\(\rho\) is productivity (expressed in logarithm form)

\(\omega\) is nominal wage rate (`` ` `)

\(\chi\) is excess demand in labor market

\(\nu\) is excess demand in the product market so that \(b_2\) reflects the mark up.

\(C(L)\) is the lag function
Equation 1 describes that wage (adjusted for productivity) inflation is a function of slack in the labor market (with a gradual response to the existence of slack or excess demand in the labor market) and expected inflation. The later guarantees us that in the long run real wage will only be affected by a change in productivity. The equation also adjusts for shocks that can affect the labor market.

Equation 2 describes the price setting mechanism. Firms are assumed to set price as a mark up over labor costs (a productivity adjusted nominal wage). The mark up is a function of excess demand in the product market. Prices are also affected by supply shocks. The main focus in this study will be shocks in food price (agricultural shock).

Inflation expectation (equation 3) is formulated to take the form of a function of past actual inflation.

The reduced form of the system will be:

\[ \pi_t = \delta + \beta(L) \pi_{t-1} + \psi Z_t + \Phi X_t + \epsilon_t \] (4)

where:

\( X_t \) = a vector of demand shocks

\( Z_t \) = a vector of supply shocks
3.1.2: \textit{P* model of inflation}

Edwards (1993) has stressed two important sources of inflation in developing countries based on results from the political economy approach to macroeconomic policy. First, as emphasized in Cukierman et al (1992) political polarization and political instability may imply an inefficient tax system as equilibrium. In addition they also found that the structure of the economy may affect the cost of administrating (collecting) taxes and may also impact the degree of tax evasion. For instance it is more difficult to collect taxes in an agricultural dominated economy than one in which the manufacturing sector plays a significant role. In such circumstances governments will tend to rely on seignorage (tax inflation) as a source of revenue. Reliance on seignorage can also increase during conflicts due to the resulting higher fiscal deficit. For general effect of conflicts on macroeconomic performance sees Gupta et al (2002). Second, He has emphasized the role of credibility in affecting inflation. This is of course a standard argument originating from the works of Barro and Gordon (1983). Developing countries’ governments (central banks) usually lack the reputation of being hawkish to inflation. The majority of them haven’t also adopted a ‘pre commitment technology’ such as inflation targeting. Thus, it is logical to expect them to have a higher than average inflation rate.

These observations (theories) have relevant implications for the economy of Ethiopia. The fact that the economy is dominated by agriculture (about half of GDP) and there have been conflicts for most part of the period under consideration, indicate in the direction of seignorage as source of inflation. The fundamental reason for inflation in this case, the structure of the economy and conflicts, is reflected by a high growth of money. Therefore, a logical thing is to estimate a model that focuses on the role of money (monetarist model). As for the role of dynamic inconsistency, it may affect the average inflation between the
two regimes (Derg and EPRDF) as the degree of independence of the central bank is presumed to be higher in the later.

One representative monetarist model is that of Hallman et al (1991). Bårdsen et al (2005) have evaluated the performance of the model relative to other standard models such as Phillips curve on European data and showed that it can perform on par with other traditional models.

This model relies on two basic assumptions: First, long run velocity of money (broad money) is constant and the second is long run neutrality of money. Then, they defined the long run equilibrium price level as one that will support the current money stock had velocity and real GDP been at their long run equilibrium position.

Using the quantity theory of money expression, \( P_t = V_t M_t \), the above proposition can be expressed as:

\[
(5) \quad P^* = V^* M_t
\]

\( P^* \) Long run equilibrium price

\( V^* \) Long run equilibrium velocity

\( Y^* \) Long run equilibrium (potential) real GDP

\( M_t \) Current stock of Money

Expressing the variables in logarithm form (small letters are logarithm counter parts of the capital letters) and subtracting, we get the identity that:
(6) \((p_t - p^*) = (v_t - v^*) - (y_t - y^*)\)

Equation 6 expresses the identity that 'price gap' is 'velocity gap' minus 'output gap'.

Inflation is then modeled as driving the actual price level to its long run equilibrium position. More specifically, Inflation is a function of past price gap and expected inflation:

\[(7) \pi = E(\pi_t | I_{t-1}) + \beta (p - p^*)_{t-1} \quad \beta < 0\]

To see the role of money in the inflation process in this model, assume that the money stock in this period rises. This implies that the equilibrium price level compatible with the new money stock jumps immediately. But actual price takes time to adjust (assuming prices are sticky). This creates a gap between the actual price level and its equilibrium value which leads to a rise in inflation.

Though the major driving force of the inflation process in this model is the 'price gap', it should be noted that in the short run the dynamics of inflation can be affected by additional factors such as major supply shocks (oil price shock, or more importantly weather shock).
3.1.3: Agricultural prices

The Phillips curve model of inflation is, as it can be seen from its derivation, suited to addressing the evolution of prices in modern sectors of the economy (by modern I mean manufacturing and service sectors). The price in the agricultural sector is likely to evolve in a different set of mechanism. And given that close to half of the CPI in Ethiopian economy is composed of agricultural commodities (more specifically food), and since it is the component of the CPI that matters the most for the vulnerable group of the society (the poor) for price fluctuations, it is paramount importance to understand the process of price fluctuations in the agricultural sector.

In this section I will use a simple demand and supply framework to develop a model describing price changes in the agricultural sector.

Price of agricultural goods, assuming no price control policies in place, is determined, like every other commodity price, by the interaction of demand and supply. While demand for these (agricultural) goods is determined by a host of factors that also determine demand for other goods (except the magnitude of elasticity), supply, especially in traditional agriculture, at least in the short run, is most likely to be determined by factors that affect productivity rather than price.

Demand for agricultural goods can be modeled to be a function of:

Price: a rise in price will lead to a lesser demand for a good and vice versa. The only point that may be stressed is that due to their nature (being a necessity) the elasticity of substitution of agricultural products (with other goods) may be too low. This may lead to a steep aggregate (sectoral) demand curve.
Population: It is clear that more population means more mouths to feed, which entails a rise in demand for food. But the nature of population growth is steady that it may be a factor affecting long run demand for food and other goods. But it is not that volatile in the short run to account for short run variations in demand.

Income: in a developing country set up a rise in income is likely to transform in to an increased demand for food. Although permanent income hypothesis may shed doubt on the impact of a short run fluctuation of income on consumption, and the necessity nature of food is likely to result in a small elasticity, short run aggregate demand fluctuation can affect the demand for agricultural goods as well (may be due to imperfect credit market).

\[ D = f (P, Y) \]

where; P stands for a generic agricultural price

\[ Y \text{ stands for aggregate demand (income)} \]

Supply, in a traditional agriculture which characterizes the majority if not all Ethiopian agricultural production, has a unique feature compared to production in other sectors. In this sector output (supply) has less potential for flexibility for short run price changes and is more influenced by 'real factors' that affect productivity. These factors include:

a) Technology: an improvement in technology of production, given other things, will lead to a rise in output (supply). But technological growth is usually steady, thus is likely to affect supply in the long run. It has little to do with short run variability of agricultural production.

b) Traditional agriculture is notoriously dependent on weather. Fluctuations in whether conditions, which are prevalent in Ethiopia, result
in wide fluctuations in agricultural production ranging from boom to outright starvation.

This entails that we can model the short run supply function as:

\[ S = f(P_{-1}, N) \]

where \( N \) stands for nature, (mainly rainfall), and \( P_{-1} \) is last year's price. Other supply shocks may also play some part.

Combining them gives an expression for the price level.

To capture this idea: suppose demand and supply are both log linear.

\[ D = \alpha P + \beta Y \quad \alpha < 0, \mu > 0, \beta > 0 \]

\[ S = \mu P_{-1} + Z \]

Where all the variables are written in log form and \( D \) is demand, \( P \) price, \( Y \) GDP (or aggregate demand), \( S \) agricultural supply, \( Z \) is a vector of supply shock variables (among which weather shock being the main one).

Market clearing implies:

\[ P = \left( \frac{\mu}{\alpha} \right) P_{-1} - \frac{\beta}{\alpha} Y + \frac{1}{\alpha} Z \]

Or in terms of inflation (since \( p \) is in logarithm form, taking difference gives us an approximation to inflation):

\[ \Delta P = \left( \frac{\mu}{\alpha} \right) \Delta P_{-1} - \frac{\beta}{\alpha} (g_Y) + (1/\alpha) \Delta z \]

\( \Delta P \) stands for a measure of inflation based on agricultural price index.

\( g_Y \) stands for growth of realGDP (aggregate demand)

\( \Delta z \) represents the movement of a host of supply shock variables.
The final equation (D) tells us that a percentage change in price (inflation) of agricultural goods depends on percentage change in aggregate demand, past inflation, and supply shock affecting the agricultural market (presumably ‘weather shock’).
3.2: Empirical models

In this section I will discuss the actual empirical equations that will be estimated based on the theoretical frameworks presented in 3.1.

3.2.1 Phillips Curve

In this section I will formulate the empirical equivalent of the augmented Phillips curve model of 3.1.2.

\[ \pi_t = \alpha_0 + \beta(L) \pi_{t-1} + \theta(L) \hat{Y}_t + \sigma(L)M + \eta F_t + \mu D_t + \varepsilon_t \]  

(12)

**Inflation**: There are two issues with the inflation variable I will use in estimating this empirical equation. First, the price index that would have been most consistent with this mark up pricing formulation is the producer price index. But the data available for this study is only a consumer price index. Thus as a close substitute I will use the ‘core’ (Non food) price index.

Second, all of the ‘right hand side’ variables in the empirical equation are country level compilations. On the other hand, the only available data for CPI in the country before 1995/96 is the Addis retail price index which we can trace it back to 1963. CSA has started to produce urban, rural, and country level price data since 1995/96 in addition to Addis Ababa level data. Since December 2000 it has also started to publish data for all the 11 regions. Based on the new data the weight given to Addis Ababa price in the over all country level data is close to only 7%. The fact that the only data set long enough to empirical estimation exercise is the CPI data for Addis Ababa but it only contributes around 7% to the National price level creates a problem here. However, one can investigate whether Addis Data emulates the country level CPI well enough.
Figure 2: CPI level and inflation for Addis Ababa and country (from 1996-2006). Source NBE

Table (3) Modelling inflation monthly country by OLS-CS (using addis vs country general price index 1997july-2006august). The estimation sample is: 1997 (8) to 2007 (8)

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std.Error</th>
<th>t-value</th>
<th>t-HACSE</th>
<th>t-prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.250148</td>
<td>0.1472</td>
<td>1.70</td>
<td>1.4381</td>
<td>0.092</td>
</tr>
<tr>
<td>Inflation monthly Addis</td>
<td>0.679110</td>
<td>0.1015</td>
<td>6.69</td>
<td>4.9558</td>
<td>0.000</td>
</tr>
<tr>
<td>R^2</td>
<td>0.294994</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DW</td>
<td>1.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean (inflation monthly country) = 0.460734, var (inflation monthly country) = 3.13909
As the above estimation shows the monthly Addis Ababa inflation rate from 1997-2006 has a correlation coefficient of 0.68 with the country level inflation rate which implies that it is reasonable to use it as a substitute for country level data. But here I would like to emphasize one point: the above data is in the period where controls on prices are lax and regional integrations are presumably higher and thus prices in different regions tend to move together. If this is true, then the Addis Ababa price data until 1991 may not fit the country level data as good as the one shown above. This, in turn may affect the empirical results in the next section.

**Demand pressure:** Based on the theory there are two sets of demand pressure variables (i.e. one for labor market and one for product market) that should go in to estimating the inflation equation. But it is most likely that the two sets will end up having a high degree of correlation. This entails that we should use only one of the implied variables. To avoid complications arising from the choice of de-trending techniques, it would be preferable to use the data on unemployment as a demand pressure variable. In addition, taking the result of Roberts (1995) which shows that using unemployment or output gap in the New Keynesian Phillips curve gives the same result and that of Øystein’s finding that unemployment data gives a theory consistent result while output gap fails to perform as expected when tested using the Norwegian data, we can see that unemployment is at least as good as or better than output gap as an indicator of the overall activity in the economy. But it is shown in chapter 2 that it is not practical, due to several problems associated with the data, to use the unemployment figure as an indicator of the level of economic activity in Ethiopian economy. This necessitates sticking to output gap as a demand pressure variable.
Figure 3: Trend and actual real GDP (in log form). The trend is produced using Hp (Hodrick Prescot) filter with \( \lambda = 100 \)

**Supply shock:** Several supply shocks that can affect the inflation process compatible with the theoretical framework of 3.1.1 have been suggested in Gordon (1985). Among these, the most important in a small open economy context will be relative change in foreign price (import price) (M). This requires two sets of data (one price index for domestic goods and the other for import prices) which is not at my disposal. Therefore, I will use the closest variable that is tied to fluctuations in import prices, Nominal devaluation (depreciation) of the domestic currency. The official nominal exchange rate, as discussed in chapter 2 of the thesis, has been fixed to the dollar in the period before 1991/92. But comparison of this rate with the parallel exchange rate against the dollar of the same period shows that there is a significant over valuation in the official exchange rate. Given the fact that there was large control
on foreign exchange availability to traders (which may prompt them to use the ‘black market’), the price of imports is likely to reflect some of the change in the parallel exchange rate as well. The spread between the two rates has been constantly decreasing starting 1991/92 (see Graph1). But for the sake of consistency I will be using the parallel exchange rate as a proxy for relative import price for both periods. The exchange rate, in addition to being a proxy for import prices, can affect prices through the ‘real exchange rate effect’. For instance, if one takes PPP as a crude guide to the long run property of the real exchange rate, depreciation of the domestic currency should be countered by a rise in domestic price. One prominent study in the ppp literature is Rogoff (1996) who concludes that: “……the recent literature has reached a surprising degree of consensus: PPP deviations tend to damp out, but only at the slow rate of roughly 15 percent per annum.”

The Dummy variable (D) is there to capture some institutional differences between the two regimes that may affect the inflation process. These include, among other things: differences in the degree of price control (see chapter two); the existence of conflict (war) which may bring high budget deficit and inflation tax. In this regard the first period (regime) was characterized by a conflict of some kind or another for almost its entire existence while in the EPRDF regime things have been relatively quite except the war with Eritrea around the turn of the new millennium. In addition, as mentioned in chapter 2, the role of the central bank differs between the two regimes. And in so far as central bank independence can influence the average inflation, the second period should show a slight decrease in inflation.

The Second feature of this model is the possibility to test the importance of the role of money in explaining the inflation process. This is done by introducing two identities in to the basic framework.
Identity 1: $\hat{\gamma}_t = \hat{\gamma}_{t-1} + \hat{\gamma}_t \pi_t$

$\hat{\gamma}$ refers to the deviation of real GDP from its trend.

$\hat{\gamma}$ refers to the deviation of nominal GDP growth from the trend growth in real GDP

$\pi$ is inflation

Identity 2: $\hat{\gamma}_t = gm - \phi + v$

$gm$ monetary growth

$\phi$ trend growth in real GDP

$v$ percentage change in velocity of money

According to the Phillips curve hypothesis (that implies only deviation of real GDP from trend as a demand pressure variable) if money enters the inflation equation it is only through the nominal GDP variable (i.e. in conjunction with the velocity variable). Thus, as a test of the model I will, as done in Gordon (1985), estimate two equations: One with nominal GDP growth as the explanatory variable, the other with only money growth as an explanatory variable. The following graph depicts the fact that indeed there is a difference between nominal GDP growth and money growth.
Therefore we end up having three alternative equations to estimate:

\[(13)\] \[\pi_t = \alpha_0 + \beta (L) \pi_{t-1} + \theta(L)\hat{Y}_t + \sigma(L)M_t + \eta F_t + \mu D_t + \varepsilon_t\]

\[(14)\] \[\pi_t = \alpha_0 + \beta (L) \pi_{t-1} + \theta(L)\hat{Y}_{t-1} + \delta(L)\hat{y}_t + \sigma(L)M_t + \eta F_t + \mu D_t + \varepsilon_t\]

\[(15)\] \[\pi_t = \alpha_0 + \beta (L) \pi_{t-1} + \theta(L)\hat{Y}_{t-1} + \delta(L)(g_{m-\varphi}) + \sigma(L)M_t + \eta F_t + \mu D_t + \varepsilon_t\]

\(\hat{Y}_t\) (deviation) real GDP minus trend real GDP

M relative import price change

F\(_t\) relative food price

D\(_t\) Dummy variable (0 before 1991 and 1 after that)
(gm-φ) (adjusted money growth) money growth minus trend growth in real GDP

ŷ (adjusted nominal growth) nominal GDP growth minus trend growth in real GDP

π₉ inflation (Non food price)

Before commencing on estimation based on the model I have used unit root test to check whether each of the variables is stationary or not. The result of this test is given below and the associated graphs are given in the appendix.

Table 4: unit root test.

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF statistics</th>
<th>5% critical value</th>
<th>1% critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviation</td>
<td>-5.287</td>
<td>-2.966</td>
<td>-3.675</td>
</tr>
<tr>
<td>Adjusted money growth</td>
<td>-5.7524</td>
<td>-2.9711</td>
<td>-3.685</td>
</tr>
<tr>
<td>Inflationfoodprice</td>
<td>-4.1686</td>
<td>-2.963</td>
<td>-3.666</td>
</tr>
<tr>
<td>Devaluation</td>
<td>-6.2434</td>
<td>-2.971</td>
<td>-3.685</td>
</tr>
<tr>
<td>DNonfoodinflation</td>
<td>-6.5576</td>
<td>-2.966</td>
<td>-3.675</td>
</tr>
<tr>
<td>Netagrigrowth</td>
<td>-7.8408</td>
<td>-2.971</td>
<td>-3.685</td>
</tr>
<tr>
<td>Dadjustednominalgrowth</td>
<td>-6.9972</td>
<td>-2.98,</td>
<td>-3.708</td>
</tr>
</tbody>
</table>

* The estimation includes an intercept in all the equations.

DNonfoodinflation and Dadjustednominalgrowth are first difference of core (non food) inflation and adjusted nominal growth respectively.
Table 5 A: Modelling DNonfoodinflation by OLS (using Andishdata.in7)

The estimation sample is: 1976 to 2003

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>HACSE</th>
<th>t-HACSE</th>
<th>t-prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNonfoodinflation_1</td>
<td>-0.328286</td>
<td>0.12519</td>
<td>-2.6223</td>
<td>0.019</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.18612</td>
<td>0.65013</td>
<td>-1.8244</td>
<td>0.079</td>
</tr>
<tr>
<td>outputgap</td>
<td>-45.8228</td>
<td>24.630</td>
<td>-1.8605</td>
<td>0.071</td>
</tr>
<tr>
<td>outputgap_1</td>
<td>34.1208</td>
<td>27.043</td>
<td>1.2617</td>
<td>0.160</td>
</tr>
<tr>
<td>devaluation</td>
<td>0.174051</td>
<td>0.071628</td>
<td>2.4299</td>
<td>0.025</td>
</tr>
<tr>
<td>devaluation_1</td>
<td>0.0764292</td>
<td>0.046275</td>
<td>1.6516</td>
<td>0.120</td>
</tr>
</tbody>
</table>

sigma                 5.27249  RSS      611.580485

R^2                  0.436266  F(5,22) = 3.405 [0.020]*

log-likelihood       -82.9041  DW                  2.49

no. of observations  28  no. of parameters  6

mean(DNonfoodinflation) -0.500961  var(DNonfoodinflation) 38.7455

AR 1-2 test:  F(2,20) = 9.7071 [0.0011]**

ARCH 1-1 test:  F(1,20) = 1.3419 [0.2603]

Normality test:  Chi^2(2) = 1.6721 [0.4334]

hetero test:  F(10,11) = 0.31684 [0.9596]

RESET test:  F (1, 21) = 0.83608 [0.3709]

For explanation of what each of these residual based diagnosis tests are see appendix C.
This result based on equation 1 above shows that devaluation (depreciation) has a small but significant coefficient. This may be due to two reasons: either because import price doesn't have a significant pass through or because the nominal exchange rate depreciation is not a good proxy for import price change. It is, unfortunately, impossible to differentiate between the two based on the data at hand.

But the surprising result is that deviation of real GDP from its trend (i.e. output gap) has a negative coefficient (the suspiciously high coefficient of the outputgap variable is due to the fact that it is derived after converting real GDP to its logarithm form). Based on the theory it was supposed to capture the demand pressure in the economy, but it is indicating in the direction of a positive supply shock. One plausible reason for this is the high positive correlation between agricultural output (supply shock) and GDP. In order to test this, I used the non agricultural GDP as a regressor in place of the total GDP series.

Total GDP-Agriculture output= net GDP (or non agricultural GDP).

Table 5 B. Modelling DNonfoodinflation by OLS (using Andishdata.in7)

The estimation sample is: 1976 to 2003

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficients</th>
<th>HACSE</th>
<th>t-HACSE</th>
<th>t-prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNonfoodinflation_1</td>
<td>-0.49733</td>
<td>0.096935</td>
<td>-5.1305</td>
<td>0.000</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.4463</td>
<td>0.53270</td>
<td>-2.7150</td>
<td>0.014</td>
</tr>
<tr>
<td>Devaluation</td>
<td>0.16984</td>
<td>0.068402</td>
<td>2.4830</td>
<td>0.024</td>
</tr>
<tr>
<td>devaluation_1</td>
<td>0.12328</td>
<td>0.044499</td>
<td>2.7704</td>
<td>0.014</td>
</tr>
<tr>
<td>Lnetgdpgap</td>
<td>-39.413</td>
<td>16.206</td>
<td>-2.4320</td>
<td>0.025</td>
</tr>
<tr>
<td>Lnetgdpgap_1</td>
<td>50.009</td>
<td>17.387</td>
<td>2.8763</td>
<td>0.010</td>
</tr>
</tbody>
</table>
Devaluation has the usual sign that depreciation in the exchange rate will translate in to a rise in the price of consumption goods.

Using the nonagricultural GDP in the model doesn’t change the sign of the coefficients. The negative sign on the current ‘net GDP’ implies that growth in GDP is negatively correlated with inflation. And considering the fact that the regressand (the left hand side variable) is the change in core inflation, the positive sign on past GDP strengthens the above statement that GDP growth is contemporaneously associated with inflation. This result may be consistent with either of the following possibilities:
a) The technique of measuring the potential (natural) output does not do a good job of measuring the actual potential output. That means there is always a slack in the economy that leaves a room for growth without pressure on prices.

b) The model is not a good approximation of the inflation process in the Ethiopian economy.

c) Or the quality of data is in question.

While it is hard to ‘test’ possibilities (a) and (c), it is possible to say something about possibility (b). According to the residual based diagnosis tests, the model appears to pass most of the diagnostic tests except residual autocorrelation.

Therefore, taken at face value inflation is ‘counter cyclical’ in Ethiopian economy.

Note that the dummy variable has been insignificant in both equations.

The following two results based on Equation 14 and 15 above are run basically to figure out if money has an independent role to play in the inflation process, within the basic model, in Ethiopian economy. But they can also help me identify a proper ‘demand pressure’ variable.

Table 6: Modelling DNonfoodinflation by OLS (using Andishdata.in7)

<table>
<thead>
<tr>
<th>variable</th>
<th>Coefficient</th>
<th>HACSE</th>
<th>t-HACSE</th>
<th>t-prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNonfoodinflation_1</td>
<td>-0.434779</td>
<td>0.12734</td>
<td>-3.4144</td>
<td>0.001</td>
</tr>
<tr>
<td>Constant</td>
<td>-17.4027</td>
<td>22.868</td>
<td>-0.7610</td>
<td>0.500</td>
</tr>
<tr>
<td>Dadjustednominalgrowth</td>
<td>0.335363</td>
<td>0.18255</td>
<td>1.8371</td>
<td>0.090</td>
</tr>
<tr>
<td>Dadjustednominalgrowth_1</td>
<td>0.084</td>
<td>0.2117</td>
<td>0.4003</td>
<td>0.68</td>
</tr>
<tr>
<td>Lnetrealgdp</td>
<td>-44.5039</td>
<td>13.941</td>
<td>-3.1924</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Lnetrealgdp_1</td>
<td>46.6321</td>
<td>15.107</td>
<td>3.0867</td>
<td>0.001</td>
</tr>
<tr>
<td>Devaluation</td>
<td>0.126044</td>
<td>0.057333</td>
<td>2.1984</td>
<td>0.040</td>
</tr>
<tr>
<td>devaluation_1</td>
<td>0.0463185</td>
<td>0.065412</td>
<td>0.70811</td>
<td>0.580</td>
</tr>
</tbody>
</table>

** sigma ** 4.90235  RSS 456.628211

R^2 0.576369  F(7,19) = 3.693 [0.011]*

log-likelihood -76.4898  DW 2.48

no. of observations 27  no. of parameters 8

When the log-likelihood constant is included:

AIC 6.25850  SC 6.64245

HQ 6.37267  FPE 532.093

mean(DNonfoodinflation) -0.59707  var(DNonfoodinflation) 39.9219

AR 1-2 test:  F(2,17) = 6.2506 [0.0092]**

ARCH 1-1 test:  F(1,17) = 0.092610 [0.7646]

Normality test:  Chi^2(2) = 0.89099 [0.6405]

hetero test:  F(14,4) = 0.13997 [0.9976]

Not enough observations for hetero-X test

RESET test:  F(1,18) = 0.13703 [0.7156]
This result again demonstrates that the deviation of real GDP from trend acts more like a positive supply shock than a demand pressure variable. It also shows that nominal GDP growth is reflected in a rise in inflation. Devaluation (depreciation) has the usual sign.

Table 7. Modelling DNonfoodinflation by OLS (using Andishdata.in7)

The estimation sample is: 1976 to 2002

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>HACSE</th>
<th>t-HACSE</th>
<th>t-prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNonfoodinflation_1</td>
<td>-0.292919</td>
<td>0.14455</td>
<td>-2.0264</td>
<td>0.06</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.55450</td>
<td>1.0203</td>
<td>-3.4837</td>
<td>0.005</td>
</tr>
<tr>
<td>Devaluation</td>
<td>0.163219</td>
<td>0.085001</td>
<td>1.9202</td>
<td>0.08</td>
</tr>
<tr>
<td>Devaluation_1</td>
<td>0.0593897</td>
<td>0.061712</td>
<td>0.96237</td>
<td>0.500</td>
</tr>
<tr>
<td>Adjustedmoneygrowth</td>
<td>0.175839</td>
<td>0.082697</td>
<td>2.1263</td>
<td>0.045</td>
</tr>
<tr>
<td>adjustedmoneygrowth_1</td>
<td>0.100001</td>
<td>0.045153</td>
<td>2.2147</td>
<td>0.040</td>
</tr>
<tr>
<td>Outputgap</td>
<td>-46.5244</td>
<td>25.166</td>
<td>-1.8487</td>
<td>0.090</td>
</tr>
<tr>
<td>outputgap_1</td>
<td>49.0508</td>
<td>29.053</td>
<td>1.6883</td>
<td>0.120</td>
</tr>
</tbody>
</table>

\[ \text{sigma} = 5.19907 \quad \text{RSS} = 513.57629 \]

\[ R^2 = 0.523536 \quad F(7,19) = 2.982 [0.027]^* \]

\[ \log\text{-likelihood} = -78.0764 \quad \text{DW} = 2.48 \]

\[ \text{no. of observations} = 27 \quad \text{no. of parameters} = 8 \]

\[ \text{mean(DNonfoodinflation)} = -0.59707 \quad \text{var(DNonfoodinflation)} = 39.9219 \]

\[ \text{AR 1-2 test: } F(2,17) = 3.7307 [0.0454]^* \]

\[ \text{ARCH 1-1 test: } F(1,17) = 1.4296 [0.2482] \]
Normality test: $\text{Chi}^2(2) = 0.031376 [0.9844]$

hetero test: $\text{F}(14,4) = 0.33333 [0.9445]$

RESET test: $\text{F}(1,18) = 0.64716 [0.4316]$

The coefficients of money growth (on current and one lag) are both significant and have the theoretically expected signs (positive). This, thus, tempts one to conclude that the causation runs from money to inflation. But this result may suffer from the problem of simultaneity. i.e. money may respond to the rise in price level as well. The above two results indicate one useful result though: the nominal variables (money for instance) are better indicators of the pressure on inflation from the demand side.

Rather than delving too much into the issue of causation in its strict (usual) form, I tried to establish the causation of money Vs inflation in a Granger form (Granger causality test).

The estimation results from regressing Nonfood (core) inflation on its lag and past monetary growth reveals that money growth is significant only to a one lag (which of course is reasonable because it may not take more than eight quarters for the effect of money to die out). So, in a sense monetary growth can help in predicting inflation. On the other hand, running monetary growth on past values of itself and past core inflations reveals that past inflation doesn't enter significantly (inflation doesn't granger cause money). This may be explained by the lack of monetary responses from the central bank. These two observations are based on the following estimation results.

However, the fact that the data are annual and short means that the results I just described should be taken with a lot of caution (skepticism).
Table 8: Modeling Nonfoodinflation by OLS (using Andishdata.in7)

The estimation sample is: 1976 to 2003

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std.Error</th>
<th>t-value</th>
<th>t-prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonfoodinflation_1</td>
<td>0.191347</td>
<td>0.2202</td>
<td>0.869</td>
<td>0.393</td>
</tr>
<tr>
<td>Constant</td>
<td>0.0166478</td>
<td>0.01556</td>
<td>1.07</td>
<td>0.295</td>
</tr>
<tr>
<td>adjustedmoneygrowth_1</td>
<td>0.00191315</td>
<td>0.00072165</td>
<td>2.6511</td>
<td>0.014</td>
</tr>
<tr>
<td>adjustedmoneygrowth_2</td>
<td>0.000779376</td>
<td>0.00090</td>
<td>0.866</td>
<td>0.395</td>
</tr>
</tbody>
</table>

\[
\text{sigma} \quad 0.051625 \quad \text{RSS} \quad 0.0639633484
\]

\[
\text{R}^2 \quad 0.317852 \quad F(3,24) = 3.728 \ [0.025]^*
\]

log-likelihood    45.4128  DW    2.02

no. of observations    28  no. of parameters    4

mean(Nonfoodinflation) 0.0525575  var(Nonfoodinflation) 0.00334884
Table 9: Modeling adjustedmoneygrowth by OLS (using Andishdata.in7)

The estimation sample is: 1976 to 2003

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std.Error</th>
<th>t-value</th>
<th>t-prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>adjustedmoneygrowth_1</td>
<td>-0.240760</td>
<td>0.09332</td>
<td>-2.58</td>
<td>0.016</td>
</tr>
<tr>
<td>Constant</td>
<td>6.89096</td>
<td>2.053</td>
<td>3.36</td>
<td>0.003</td>
</tr>
<tr>
<td>Nonfoodinflation_1</td>
<td>0.494553</td>
<td>26.24</td>
<td>0.0188</td>
<td>0.985</td>
</tr>
<tr>
<td>Nonfoodinflation_2</td>
<td>41.3298</td>
<td>24.50</td>
<td>1.69</td>
<td>0.105</td>
</tr>
</tbody>
</table>

\[ \sigma = 6.93294 \quad \text{RSS} = 1153.57525 \]

\[ R^2 = 0.3191 \quad F(3,24) = 3.749 [0.024]^* \]

\[ \text{DW} = 1.61 \]

no. of observations = 28  no. of parameters = 4

mean(adjustedmoneygrowth) = 7.11511  var(adjustedmoneygrowth) = 60.5068

As stated above though the model seems to pass much of the diagnosis, the fact that the main variable presumed to explain inflation in this model (output gap) doesn’t turn out to perform according to the theory plus the nominal variables (especially money growth) do have the expected sign makes it a worth while exercise to test a formal model which bases the explanation of inflation on money. The following section is devoted to such a model (P* model of inflation).
3.2.2. \( P^* \) model of inflation

In this model the expectation term on the right side of equation 3 is meant to capture past information. Because all relevant information provided by the model about the future is included in the equilibrium price (\( P^* \)). Thus it seems logical to replace the inflation expectation term by past autoregressive inflation. In addition as indicated above the short run dynamics of inflation can be affected by several shocks. For instance, severe weather shock in Ethiopian economy implies a significant pressure on all prices specially food prices.

Thus the estimated equation will be of a form:

\[
(16) \quad \pi = \alpha + \beta (p - p^*)_{t-1} + \sum \delta \pi_{t-1} + \varepsilon_t
\]

Before estimating the model I will check weather one of the central tenet of the model-constancy of long run velocity- holds true (i.e weather velocity is stationary).

Table 7: Unit root test (Time series properties of the series)

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF statistics</th>
<th>5% critical value</th>
<th>1% critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lv1</td>
<td>-4.1560</td>
<td>-2.971, -3.685</td>
<td>-3.685</td>
</tr>
<tr>
<td>Lv2</td>
<td>-1.1440</td>
<td>-2.971</td>
<td>-3.685</td>
</tr>
<tr>
<td>velocitygap</td>
<td>-5.3872</td>
<td>-1.953</td>
<td>-2.645</td>
</tr>
</tbody>
</table>

Note:

1: M1 is defined as currency outside banks plus demand deposits whereas M2 is M1 plus Quasi money (saving and time deposit). LV1 is logarithm of velocity of M1 and LV2 logarithm of velocity of M2.

2. The test for the velocity gap doesn’t have an intercept. But the test for the velocity variables includes an intercept.
Table 10: Modelling inflationdeflator by OLS (using Andishdata.in7)

The estimation sample is: 1976 to 2002

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std.Error</th>
<th>t-value</th>
<th>t-prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>inflationdeflator_1</td>
<td>0.112768</td>
<td>0.1832</td>
<td>0.616</td>
<td>0.5440</td>
</tr>
<tr>
<td>Constant</td>
<td>4.10763</td>
<td>1.628</td>
<td>2.52</td>
<td>0.019</td>
</tr>
<tr>
<td>Pricegap_1</td>
<td>-40.4735</td>
<td>14.39</td>
<td>-2.81</td>
<td>0.010</td>
</tr>
</tbody>
</table>

Figure 6: velocity of M1 and its gap. The trend being filtered using HP filter with lambda 100.
Model 8 estimates inflation as a function of past value of itself and past ‘price gap’. The result is consistent with the theory that the coefficient on the price gap should be negative. And the model also passes much of the diagnosis tests. But there is a catch here. The price gap is derived from the GDP deflator components, and the nature of the HP filter is such that future prices are included in deriving the trend variable. It may imply that the model is good just because we are regressing inflation on some version of itself. To somehow overcome this problem, I used the
CPI inflation as the dependent variable and the price gap derived from GDP deflator as a regressor.

Table 11: Modelling InfCPI by OLS (using Andishdata.in7)

The estimation sample is: 1976 to 2002

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>HCSE</th>
<th>t-HCSE</th>
<th>t-prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>InfCPI_1</td>
<td>0.295009</td>
<td>0.11530</td>
<td>2.5586</td>
<td>0.020</td>
</tr>
<tr>
<td>Constant</td>
<td>3.33542</td>
<td>1.5676</td>
<td>2.1277</td>
<td>0.045</td>
</tr>
<tr>
<td>Pricegap_1</td>
<td>-30.1743</td>
<td>11.193</td>
<td>-2.6957</td>
<td>0.0018</td>
</tr>
</tbody>
</table>

sigma        | 6.64039     | RSS   | 1058.27587 |

R^2           | 0.306756    | F(2,24) = 5.31 [0.012]^* |

log-likelihood | -87.8369   | DW    | 2.05    |

no. of observations | 27   | no. of parameters | 3     |

mean(InfCPI)    | 5.45893    | var(InfCPI) | 56.5391 |

AR 1-2 test:    | F(2,22) = 3.1623 [0.0621] |

ARCH 1-1 test:  | F(1,22) = 1.2681 [0.2722] |

Normality test: | Chi^2(2) = 0.025292 [0.9874] |

hetero test:    | F(4,19) = 0.81785 [0.5296] |

hetero-X test:  | F(5,18) = 0.64378 [0.6696] |

RESET test:     | F(1,23) = 0.098649 [0.7563] |
It seems that the model is robust for the choice of the dependent variable we employ. Price gap has the usual sign (negative coefficient) and the model passes much of the diagnosis test. For instance RESET test indicates that the model is well specified.

The model above estimates inflation as a function of a single variable (price gap) only. This may raise the question that the coefficient on the price gap is significant may be due to omitted variable that have high correlation with price. In addition as indicated in the theoretical section, the short run inflation dynamics will be influenced by a host of supply shocks. To address these two issues at the same time, I added a variable that indicates the performance of the agricultural sector of the economy (agriculturegap) as a supply shock.

\begin{align*}
\text{Agriculturegap} &= \text{Agricultural output-trendinagriculturaloutput} \\
\text{(The trend is calculated using the usual HP filter with lambda 100 for annual data).}
\end{align*}

Table 12: Modelling inflationdeflator by OLS (using Andishdata.in7)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>HACSE</th>
<th>t- HACSE</th>
<th>t- prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>inflationdeflator_1</td>
<td>0.215357</td>
<td>0.15910</td>
<td>1.3536</td>
<td>0.190</td>
</tr>
<tr>
<td>Constant</td>
<td>3.45694</td>
<td>1.5352</td>
<td>2.2519</td>
<td>0.035</td>
</tr>
<tr>
<td>Agriculturegap</td>
<td>-54.3347</td>
<td>16.200</td>
<td>-3.3540</td>
<td>0.002</td>
</tr>
<tr>
<td>agriculturegap_1</td>
<td>30.7934</td>
<td>19.355</td>
<td>1.5910</td>
<td>0.135</td>
</tr>
<tr>
<td>Pricegap_1</td>
<td>-32.8905</td>
<td>10.568</td>
<td>-3.1123</td>
<td>0.003</td>
</tr>
<tr>
<td>sigma</td>
<td>5.72254</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSS</td>
<td>720.443661</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R^2 0.523778  F(4,22) = 6.049 [0.002]**
mean(inflationdeflator) 5.05076 var(inflationdeflator) 56.0308

AR 1-2 test:  \( F(2,20) = 3.1699 \ [0.0637] \)

ARCH 1-1 test:  \( F(1,20) = 0.090234 \ [0.7670] \)

Normality test:  \( \text{Chi}^2(2) = 0.67194 \ [0.7146] \)

hetero test:  \( F(8,13) = 0.46910 \ [0.8570] \)

RESET test:  \( F(1,21) = 0.52542 \ [0.4765] \)

The result is consistent with what is outlined in the theoretical section. A rise in the money stock, reflected in a negative ‘Pricegap’, will lead to higher inflation. And in the short run supply shocks such as weather shock (represented by the performance of the agricultural sector) affect the inflation dynamics. A rise in agricultural output beyond the ‘norm’ (trend) leads to a decline in inflation given the price gap.
3.2.3. Agricultural price

\[(17) \pi_t = b_0 \pi_{t-1} + b_1 (g_y)_t + b_2 D_t + z_t + \epsilon_t\]

Inflation in this equation is represented by the percentage change in Addis Ababa food price index data from CSA. The ideal scenario will be to use the country level food price index. But the later is only available from 1995/96 on. Fortunately, the two series move together as shown in part 1 of this chapter.

The dummy variable (0 for the period 1973/74-1990/91 and 1 after that) is intended to capture the effect of institutional changes between the two regimes. Among these effects the most important one, as far as agricultural sector is concerned, is the effect of liberalizing the price controls on commodities that took place in 1991.

\(Z_t\), as discussed in the theoretical section, is presumed to capture the effect of supply shocks that affect agricultural production. Ideal indicator of this shock in Ethiopia would be the weather condition. Unfortunately, the metrological data (on rain fall), as far as I know, is not long enough to cover the period intended to be included in this study. Then the option I will follow is replacing \(z\) with the growth rate of agricultural output. This has a down side that the new supply shock variable may be correlated with \(\pi_{t-1}\). But since the supply shock is important in agricultural production, I believe it is warranted to be included. Another supply shock variable is the relative price of fertilizers. As most of the other variables I do not have a long time series of this variable. Therefore, I will replace this with the depreciation of the nominal exchange rate.

Usually it is claimed that weather condition explains inflation in Ethiopia. This claim has at its background two premises: first, food is the most important item in the consumption basket and second the sole
determinant of fluctuation in the food price is fluctuation of agricultural output which in turn is significantly affected by weather condition. The second premise usually relies on comparison of times where there were extreme weather conditions which don’t necessarily reflect the conditions in normal years.

In the following I will test whether inflation in food prices is solely affected by the fluctuation in agricultural production or there are other variables that have additional explanatory power.

Table 13 A: Modelling inffoodprice by OLS (using Andishdata.in7)

The estimation sample is: 1976 to 2003

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>HACSE</th>
<th>t-HCSE</th>
<th>t-prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>inffoodprice_1</td>
<td>0.414907</td>
<td>0.068965</td>
<td>3.5041</td>
<td>0.001</td>
</tr>
<tr>
<td>Constant</td>
<td>3.18829</td>
<td>1.0773</td>
<td>1.9181</td>
<td>0.065</td>
</tr>
<tr>
<td>Agrigrowth</td>
<td>-0.273436</td>
<td>0.12549</td>
<td>-1.9575</td>
<td>0.060</td>
</tr>
<tr>
<td>Agrigrowth_1</td>
<td>-0.385075</td>
<td>0.15051</td>
<td>-2.7040</td>
<td>0.018</td>
</tr>
<tr>
<td>Agrigrowth_2</td>
<td>0.411011</td>
<td>0.22235</td>
<td>2.2273</td>
<td>0.045</td>
</tr>
</tbody>
</table>

sigma                 7.48878
RSS                1289.88161
R^2                  0.507279
F(4,23) = 5.92 [0.002]**
log-likelihood       -93.3517
DW                       1.82
no. of observations        28
no. of parameters           5
mean(inffoodprice)      5.65477
var(inffoodprice)        93.4955
AR 1-2 test: \( F(2,21) = 1.8147 [0.1875] \)

ARCH 1-1 test: \( F(1,21) = 0.087391 [0.7704] \)

Normality test: \( \text{Chi}^2(2) = 2.8116 [0.2452] \)

hetero test: \( F(8,14) = 0.17703 [0.9905] \)

Not enough observations for hetero-X test

RESET test: \( F(1,22) = 0.023002 [0.8808] \)

To check on the stability of the coefficients I put the restriction that the size of the coefficients on all the ‘agricultural growth variables’ to be equal. The resulting F-test does not reject this hypothesis.

Table 13 B: Modelling inffoodprice by OLS (using Andishdata.in7)

The estimation sample is: 1976 to 2003

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std.Error</th>
<th>t-value</th>
<th>t-prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>inffoodprice_1</td>
<td>0.428784</td>
<td>0.1273</td>
<td>3.37</td>
<td>0.002</td>
</tr>
<tr>
<td>Constant</td>
<td>3.29186</td>
<td>1.593</td>
<td>2.07</td>
<td>0.049</td>
</tr>
<tr>
<td>Agrigrowth+Dagrigrowth_1</td>
<td>-0.35128</td>
<td>0.07891</td>
<td>-4.45</td>
<td>0.000</td>
</tr>
</tbody>
</table>

\( \sigma \) 7.22599 \quad \text{RSS} \quad 1305.37328

\( R^2 \) 0.501361 \quad F(2,25) = 12.57 [0.000]**

Note: agrigrowth+Dagrigrowth_1 = agrigrowth_t + (agrigrowth_{t-1} - agrigrowth_{t-2})
Both results reveal that the performance of the agricultural sector shows up heavily on inflation of agricultural commodity (food) prices. The problem with this result is that it is almost equivalent to stating the obvious: supply of a commodity affects its price. The objective originally was to see the effect of various demand and supply shocks on the price of agricultural commodities. But most of these shocks are incorporated in the agricultural output variable. A couple of explanatory variables that are not correlated significantly with the agricultural output are: money growth (demand side) and currency depreciation (supply shock). I have included these variables to see if they can add explanatory power to the model presented above.

Model 14: Modelling inffoodprice by OLS (using Andishdata.in7)

The estimation sample is: 1976 to 2003

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std.Error</th>
<th>t-value</th>
<th>t-prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>inffoodprice_1</td>
<td>0.488132</td>
<td>0.14750</td>
<td>3.3094</td>
<td>0.005</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.14005</td>
<td>2.1739</td>
<td>-1.4444</td>
<td>0.150</td>
</tr>
<tr>
<td>gm1</td>
<td>0.460846</td>
<td>0.19759</td>
<td>2.3324</td>
<td>0.035</td>
</tr>
<tr>
<td>gm1_1</td>
<td>0.114365</td>
<td>0.12426</td>
<td>0.92035</td>
<td>0.351</td>
</tr>
<tr>
<td>devaluation</td>
<td>0.171917</td>
<td>0.048180</td>
<td>3.5683</td>
<td>0.004</td>
</tr>
<tr>
<td>devaluation_1</td>
<td>-0.08508</td>
<td>0.09435</td>
<td>-0.9017</td>
<td>0.350</td>
</tr>
<tr>
<td>agrigrowth+Dagrigrowth_1</td>
<td>-0.39181</td>
<td>0.04777</td>
<td>-8.201</td>
<td>0.000</td>
</tr>
</tbody>
</table>

sigma        6.28405  RSS        829.276112

R^2          0.683225  F(6,21) = 7.549 [0.000]**

log-likelihood -87.1672  DW        1.87

no. of observations 28  no. of parameters 7
The coefficients in this model show significant sensitivity for the length of the lag in each variable used for the estimation. Using AIC (Akaike information criterion) to determine the appropriate lag length, I found that the above model is the one with the ‘appropriate lag length’ composition.

One fact constantly appearing in this model’s result is that agricultural growth is significant explanatory variable for inflation of food prices no matter what variable is included in the equation. Devaluation (depreciation) (though sensitive to specification) has the theoretically expected sign. As stated in the theoretical section, it affects particularly the price of fertilizers which raises the cost of production of agricultural goods. This then partly transforms into a rise in the price of food items. Replacing the depreciation of the parallel exchange rate with the official exchange rate renders the exchange variable insignificant without affecting the significance of the other variables. One plausible explanation is that the true value of the exchange rate, in a situation where there is exchange control, is more reflected by the parallel exchange rate. This then partly transforms into a rise in the price of food items.
items. I have included the money growth (specifically gm1 stands for the growth in M1 defined as currency outside the banks plus demand deposit) variable to capture the nominal demand pressure. As expected it positively affects inflation.

In addition, inclusion of the dummy variable in any of the specifications shows that it is not significant. This may mean that the price control was not that stringent or there are other institutional changes that have the opposite effect that are not included in the equation thus picked up by the dummy variable.

But importantly, the addition of the demand pressure (substituted by money growth) and a supply shock variable (depreciation of the exchange rate) improves the explanatory power of the model.
4. Conclusions

The aim of this thesis has been to provide empirical assessment of the relevance of a traditional expectations augmented Phillips curve and a somewhat monetarist model-P* model - in explaining inflation in Ethiopian economy.

The basic findings are: the main variable of explanation in the Phillips curve framework-outputgap- does not perform as expected theoretically. This throws the relevance of the whole framework to Ethiopian economy into a big doubt. On the other hand, the p* model's explanatory variable-pricegap- has both the theoretically expected sign and robustness to different price indexes used as well as to inclusion of other relevant explanatory variables. In addition, this model passes most of the residual based diagnosis tests.

Further more, somehow obviously agricultural prices respond heavily to the performance of the agricultural sector. But importantly, these prices are influenced by both demand shocks-monetary developments- and supply shocks (eg currency depreciation).

However, one should notice that there are several shortcomings in this study. First, the data set is very short. And considering the fact that most of the results in econometric theory rely on asymptotes reduces the reliability of the estimates in this thesis. But, the relevant institutions in the country (NBE, MEDAC, CSA…) have started publishing even monthly series on most nominal variables (money, exchange rates, price indices.). The major variable of interest, real GDP or unemployment, data on the other hand is published annually. Thus, managing to reconstruct the GDP series quarterly or so will give a larger data point and may solve this problem. Second, the use of simple OLS method of estimation using just theory to dictate the left hand side and right hand
side variables may encounter the problem of simultaneity. Thus, employing a more sophisticated econometric methodology may shed a better light on the results.

All said and done, I think this thesis should be taken as an exploratory study with the potential to indicate the importance of the role some variables play in the inflation process in Ethiopian economy thereby leaving a wide room for improvement in several directions that future studies can delve into.


Asfaw Negassa and T.S. Jayne (January 1997): “The responsiveness of Ethiopian grain markets to liberalization”, working paper 6, Grain market research project, Ministry of Economic development and co-operation, Addis Ababa


Central Statistical Authority (CSA) of Ethiopia publications


Jeffery J. Hallman; Richard D. Porter; David H. Small (Sep., 1991): "is the price level tied to the M2 monetary aggregate in the long run?" American Economic Review, pp. 841-858.

Kenneth Rogoff (Jun 1996): “The purchasing Power Parity puzzle”, *Journal of Economic Literature; Vol 34, No 2*


Sanjeev Gupta; Benedict Clements; Rina Bhattacharya; Shamit Chakaravarti (Aug. 2002): “Fiscal Consequences of Armed Conflict and Terrorism in Low- and Middle-Income Countries”, *IMF Working Paper No. 02/142* (Washington.)


Appendix

A) graphics

**Figure 2:** Sectoral composition of GDP. Based on data from MEDAC.
nominal GDP growth minus the trend in real GDP growth
B) Data descriptions and sources:

Note: the data are stated following the budget year format (for instance 1996/97 stands for July 1996 to June 1997)

I) Price indices:

Food price is the Addis Ababa food price index.

CPI: Addis Ababa general consumer price index.

For both series the data from 1973/74-1996/97 is based on the old series (i.e. base year 1963 and source is MEDAC). The data from 1997/98 on is based on the new series (base year December 2000 and the source is Central Statistical Authority). The later set is converted to the previous base year by extrapolation based on their period of overlap.

GDP deflator: Nominal GDP divided by real GDP. Since the real GDP series is based on 1980/81 base year, the resulting Gdp deflator is also of the same base year.

II) GDP

The real GDP, and ‘real agriculture’ series used in the study is GDP and agriculture output at constant factor cost (1980/81 as base year). Nominal GDP is GDP at current market prices.

For both series the original source of the data is MOFED. But the data used in this study is the one adjusted by EEPRI staff to make the pre 1980/81 data consistent to the post 1980/81 one.
**iii) Money**

There are two money series published by the national bank of Ethiopia (and used in this thesis).

M1 (Narrow money): is defined as currency outside banks plus demand deposits
M2 (Broad money): is defined as Narrow money + Quasi money
   Quasi money=saving and time deposit.

Source: National bank of Ethiopia

**iii) Exchange rate**

The average annual exchange rate is used for both the parallel and official exchange rates. Source: national Bank of Ethiopia.
C) Diagnosis Tests

Givewin provides diagnosis tests based on the properties of the residuals (The description here relies on the PC Give help section. So, interested parties can check that section for further understanding of these tests).

Significant outcomes at a 1% level are shown by two stars whereas significance at 5% is shown by a single star.

✓ AR: This tests whether the residuals are autocorrelated or not which implies an obvious resemblance to Durbin-Watson statistics.

✓ ARCH test: This tests (important in case of time series data only) whether the variance of the error term varies across time or not. Specifically it tests if $\gamma = 0$ (i.e. the null is no ARCH) in the model:

$$E [u_t^2 | u_{t-1}, ..., u_{t-r}, u_{t-i}^2] = c_0 + \sum_{i=1}^{r} \gamma_i u_{t-i}^2$$

where $u_{t-i}$ is error term of the regression

✓ Normality: tests whether the residuals of the regression are normally distributed or not. The null is that the residual is normally distributed. This implies higher $\chi^2$ value rejects the normality hypothesis.

✓ Heteroscedasticity: In this test the square of the error terms ($U_t^2$) is regressed on the original dependent variables ($x_{it}$) and all their squares ($x_{it}^2$). The null is unconditional homoscedasticity, and the alternative is that the variance of the $\{u_t\}$ process depends on $x_t$ and on the $x_{it}^2$. 

Specifically the test involves checking whether $B=0$ in the model

$$U_t^2 = X_{it}^j B_{ij} \quad j=0,1,2$$

✓ The RESET test (Regression Specification Test) tests the null of correct specification of the original model against the alternative that powers of $Y_t$ (the dependent variable) such as $(Y_t^2, Y_t^3...)$ have been omitted (PcGive only allows squares). This tests to see if the original functional form is incorrect, by adding powers of linear combinations of $x$'s (independent variables) since by construction, $Y_t = x_t^t \beta_t$. 