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EXCHANGE RATE PASS-THROUGH AND INFLATION DYNAMICS IN ETHIOPIA: A MARKOV SWITCHING APPROACH

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Exchange Rate Pass-Through and Inflation Dynamics in Ethiopia: A Markov Switching Approach

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This is to certify that the thesis prepared by Biniyam Kassa, entitled: *Exchange Rate Pass-Through and Inflation Dynamics in Ethiopia: A Markov-Switching Approach* and submitted in partial fulfillment of the requirements for the Degree of Masters of Science in Economics (International Economics) complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

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Abstract

Exchange Rate Pass-Through and Inflation Dynamics in Ethiopia

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Exchange rate movements have been a determinant of inflation for long time and Ethiopia is not an exception. Thus, the study examines the effects of exchange rate variability on inflation in Ethiopia for data covering 1990Q1-2016Q4. Markov-switching methodology with Fixed Transition Probability (FTP) and Time Varying Transition Probability (TVTP) has been employed. Based on FTP the effect of changes in bilateral nominal exchange rate (NER) of Ethiopian birr per US dollar to inflation has been found insignificant. This result indicates absence of exchange rate pass-through to consumer price inflation in Ethiopia. The result obtained from TVTP, which used nominal effective exchange rate (NEER) as an exogenous variable and a determinant for the transition probability found exchange rate pass through to consumer price inflation. This implies that NEER is a better measurement for exchange rate pass-through. The study also attempted to test Taylor hypothesis for two inflation regimes, high and low. However, no evidence is found that supports the Taylor hypothesis in the case of Ethiopia.

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Acronyms and Abbreviations

ADF	Augmented Dickey-Fuller
AR	Auto Regression
ARDL	Auto Regressive Distributed Lag
CPI	Consumer Price Index
CPS	Commodity Price Shock
CVAR	Cointegrated Vector Auto Regression
DGE	Dynamic General Equilibrium
ECM	Error Correction Model
EM	Expectation Maximization
ENSO	ElNino-Southern Oscillation
ERPT	Exchange Rate Pass-Through
ERVR	Exchange Rate Variability
EU	European Union
FGLS	Feasible Generalized List Squares
FTP	Fixed Transition Probability
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
HP	Hodrick-Prescott
IFS	International Financial Statistics
IMF	International Monetary Fund
IPI	Import Price Index

LCP	Local Currency Pricing
MS-ARX	Markov-Switching Auto Regressive model With Exogenous variable
M2	Broad Money Supply
NBE	National Bank of Ethiopia
NPC	National Planning Commission
NOEM	New Open Economy Macro economy
NEER	Nominal Effective Exchange Rate
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Square
PCP	Producer Currency Pricing
PPI	Producer Price Index
PPP	Purchasing Power Parity
REER	Real Effective Exchange Rate
SSA	Sub Saharan Africa
SVAR	Structural Vector Auto Regression
TVTP	Time Varying Transition Probability
VAR	Vector Auto Regression
VECM	Vector Error Correction
WB	World Bank
WCPI	World Commodity Price Index
Y^{Gap}	Output Gap

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Exchange rate fluctuations can be raised as a major macroeconomic problem in many developed and developing countries. In small open economies exchange rate fluctuations affect the behavior of inflation, substantially. This is because most of the trade relationship of small open economies conducted with large economies. Due to this unbalanced relationship any change in domestic price could be the result of exchange rate fluctuation between the exporting large open economy and the importing small open economy. This makes the exchange rate pass-through[1] (ERPT) an important consideration with respect to monetary policy. However, empirical investigations show that the link between changes in exchange rates and domestic prices is weak in some small open economies. For example, Choudhri and Hakura (2001) find zero pass-through to inflation in Ethiopia and incomplete pass-through in other African countries for the period 1997-2000. Deviations of output from its natural level (Output gap) could be the explaining factor for this puzzlingly weak effect on domestic inflation. When output gap is positive it implies that actual output is greater than potential output, this leads to excess demand and creates what we call demand pull inflation.

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1. As defined by Goldberg and Knetter (1997) ERPT is the percentage change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing countries.

Even if the interest to study ERPT is a long time phenomenon, it potentially developed over time. The law of one price (LOP) and convergences across countries were the center of debates until 1980's. But after 1980's industrial organization, the role of segmentation and price discrimination across geographically distinct product markets get the focus of attention on studying ERPT. However, recent debates were over appropriate monetary policies and exchange rate regime optimality in general equilibrium models. These debates over the issue of exchange rate have broad implications on the way we understand the conduct of monetary policy, for macroeconomic stability, international transmission of shocks, and efforts to contain large imbalances in trade and international capital flows, Campa and Goldberg (2002)

Those debates were on the issue of the prevalence of producer-currency-pricing (PCP) (when prices are set in the currency of exporters) versus local currency pricing (LCP) (when prices are set in the currency of buyers) of imports, and on whether exchange rate pass-through rates are endogenous to a country's monetary performance. Low import price pass-through means that nominal exchange rate fluctuations may lead to lower expenditure switching effects of domestic monetary policy. As a consequence of this insulation, monetary policy effectiveness is greater for stimulating the domestic economy, (Campa and Goldberg, 2002). Taylor (2000) also has noted the potential complementarity between monetary stability (when the monetary authority becomes more vigilant and credible at fighting inflation) and monetary effectiveness as a policy instrument. The idea is that if pass-through rates are endogenous to a country's relative monetary stability, periods of more stable inflation and monetary performance also will be periods when monetary policy may be more effective as a stabilization instrument. Then, whether measured degrees of monetary policy effectiveness are fragile and regime-specific if the degree of exchange rate pass-through is highly endogenous to macroeconomic variables is a question to be

answered. The degree of aggregate ERPT and its determinants are therefore important for the effectiveness of macroeconomic policy.

First articulated by scholars of the Salamanca school in sixteenth century Spain, purchasing power parity (PPP) is the disarmingly simple empirical proposition that, once converted to a common currency, national price levels should be equal, Rogoff (1996). Empirically, however, this assumption has found in general little support, at least in the case of small sample of countries because of price rigidity and lesser exchange rate volatility in the short to medium run. In line with this evidence, the theoretical literature developed over the past two decades has provided different explanations why the ERPT is incomplete.

In his seminal paper, Dornbusch (1987) justifies incomplete pass-through as arising from firms that operate in a market characterized by- imperfect competition and adjust their mark-up (and not only prices) in response to an exchange rate shock. Burstein et al. (2003) instead emphasize the role of (non-traded) domestic inputs in the chain of distribution of tradable goods. The role that monetary and fiscal authorities play, by partly offsetting the impact of changes in the exchange rate on prices could also be the reason for incomplete pass-through (Gagnon and Ihrig, 2004). Local currency pricing as a source of reducing the degree of ERPT explored by Devereux and Engel (2001) and Baccheta and Wincoop (2003).

A debate on the causes of low exchange rate pass-through has recently resurfaced. Some writers argue that the ultimate explanation is microeconomic, based on various structural features of international trade, such as pricing to market by imperfectly competitive firms (Corsetti and Dedola 2002), domestic content in the distribution of traded goods (Corsetti and Dedola 2002;

Burstein, Neves, and Rebelo 2000), the importance of non-traded goods in consumption (Betts and Kehoe 2001), or the role of substitution between goods in response to exchange rate changes (Burstein, Eichenbaum, and Rebelo 2002). (Engel 2002 a, b) made the failure of pass-through a macroeconomic phenomenon, related with the slow adjustment of goods prices at the consumer level. Both macroeconomic and microeconomic factors are given a significant weight in the development of exchange rate pass-through estimates, but ultimately more weight is given for the microeconomic explanation, based on the changing composition of imported goods (Campa and Goldberg, 2002)

Empirically ERPT has found to be incomplete for both advanced and emerging economies. The findings are also substantive to deal with the country differential determinants of pass-through. As pointed out by Taylor (2000) exchange rate fluctuations depend positively on inflation. The rationale for this involves a positive correlation between the level and persistence of inflation, coupled with a link between inflation persistence and pass-through. The latter link can be expressed as follows: if inflation could last longer, exchange rate movements will be less transitory because firms might adapt to inflation and respond via price adjustment.

Unlike for developed and other developing countries, little research has been conducted on exchange rate pass-through in sub Saharan Africa (SSA). Volatility of inflation and exchange rate were determined by the level of inflation, which explains cross country differences in pass through in Africa, Choudhri and Hakura (2001). They find zero pass-through to inflation in Ethiopia and incomplete pass-through in other African countries during the period 1997–2000. Canetti and Greene (1992) find that exchange rate movements and monetary expansion affect

consumer price inflation in sub-Saharan Africa (SSA). Helen (2012) find that ERPT is moderate, significant and persistent in the case of import price (the price importers pay to exporters, which have direct link with exchange rate movements) and low and short lived in the case of consumer prices (the price consumers pay to retailers). Since ERPT is one of the most challenging problems in the conduct of monetary policy in developing countries, assessing its degree and relation with inflation is very important. If we said this, small open economies like Ethiopia Should take care in devising policy instruments. Therefore, this paper attempted to analyze exchange rate pass-through and inflation dynamics in Ethiopia with different orientation than the previous papers done on this issue by giving focus on ERPT asymmetry (which can be analyzed with respect to exchange rate depreciation and appreciation and inflation environment, high or low) and by employing a different methodology, Markov-switching model.

1.2 Statement of the Problem

As Ito and Sato (2007) described currency crises, by definition, are accompanied by large devaluation (or depreciation) of the nominal exchange rate. Under normal circumstances (stable economic conditions), gradual real exchange rate depreciation causes net export growth. A large devaluation tends to raise import prices immediately in local currency terms, and later result in consumer price increases. If high inflation follows a large devaluation due to the accommodative monetary policy, then benefits from depreciation in terms of promoting net exports will be lost quickly—and nominal depreciation and high inflation will persist. If inflation is controlled long enough, an expenditure-switching mechanism works, and recovery from a currency crisis will take a form of gradual export growth. Thus, whether domestic inflation after the crisis occurs or not has important implications for the post-crisis recovery process of the country affected by the crisis, (Ito and Sato, 2007).

For countries in sub-Saharan Africa, improving export competitiveness is a pressing policy challenge and the more so under inflationary environments. One case in point in this regard is the Ethiopian economy where, in recent years, observing double digit inflation becomes a norm than an exception. This is important since in such inflationary instances, policy makers often times resort to currency devaluation as a means to improve/maintain export competitiveness. For example, following the recent inflationary pressures, the National Bank of Ethiopia (NBE) has taken various devaluation measures the major one being on October 2010 where the Ethiopian currency (Birr) was devalued by 20 percent against US dollar. Moreover, quite recently, the World Bank is also calling for further devaluation of Birr with the aim of supporting export promotion, (World Bank, 2014).

Having in mind the 2014 call for devaluation, the World Bank still argued that the overvalued real effective exchange rate contributed to the weak export performance in Ethiopia. The World Bank 5th Ethiopia economic update, December 2016, states that the real effective exchange rate (REER) has appreciated in cumulative terms by 84 percent since the nominal devaluation in October 2010. However, the speed of appreciation has slowed down over the past 6 months. This is mainly because of a relative decline in the rate of domestic inflation, and the depreciation of the U.S. dollar relative to other currencies since January 2016. Since the Birr is pegged against the U.S. dollar, it also remained appreciated against other currencies. Still, the Birr remains overvalued, which is hurting international competitiveness. An overvalued currency does not help to improve export competitiveness and is a concern for the economy, especially with exports falling for three consecutive years.

Therefore as the above mentioned economic update explains, maintaining a competitive exchange rate is an important component of maintaining external competitiveness. Compared to its structural and aspirational peers[2], Ethiopia's REER saw substantial appreciation and is overvalued, causing a steady loss of competitiveness over the past year. Ethiopia follows the experience of Latin American economies, which adopted overvaluation with far less success. However, it would be advisable to be in line with the experience of East Asian countries (including China), which used undervaluation during periods of rapid growth. Accordingly, a recent World Bank study shows that a 1 percent real depreciation increases total exports by 0.5 percent and reduces total imports by 0.6 percent. Disaggregation of exports reveals that a 1 percent real devaluation increases manufacturing and agricultural exports by about 1.06 and 0.33 percent, respectively (World Bank, 2016).

Although these devaluation measures seem unavoidable given the alarming inflation rates, to prevent deterioration of trade balance, it is not clear whether such measures add up more to the inflationary pressure rather than helping to improve export competitiveness. Ethiopia imports more than it exports and most of the imports are capital and intermediate goods plus oil, which are not amenable for reduction because they did not have a close or perfect substitute in home production. As a result devaluation makes them more expensive in local currency terms.

2. Ethiopia's structural peers (Uganda, Tanzania, Mozambique, and Kenya) are countries that share similar structural features, while its aspirational peers (Ghana, Zambia, Bangladesh, Cambodia, and Vietnam) are those that set a good development precedent and that the country may aspire to follow (World Bank, 2016).

When they become expensive they will increase cost of production, this in turn leads to inflation. In connection with this Goldeberg and Knetter (1997) concluded that, if countries import share can be assumed to be a good proxy for the import penetration faced by firms, then a country with a larger import share should have greater pass-through of exchange rate and import price fluctuations to domestic price. In addition, both because of a direct effect as well as through a greater pass-through, exchange rate and import prices should be more important in explaining domestic price fluctuation as the import share increase.

The macroeconomic risk (medium to low) of the Ethiopian government's Growth and Transformation Plan (GTP I) was price hikes of basic commodities that increase vulnerability of the poor. One of the mitigation measures indicated was to control inflation and reduce volatility of prices of basic commodities (EU National Indicative Program for Ethiopia, 2014-2020). During the GTP period, the general consumer price index was projected to grow at a single digit rate. However, in the past five years the price growth has been in double digits.

Empirical results expected to reveal the significant factors driving inflation, which should be controlled or monitored by monetary authorities to make inflation-targeting in Ethiopia effective. In particular, an important issue in controlling for inflation is to assess the pass-through. This issue is of particular importance as it affects the whole monetary policy in Ethiopia, where exchange rate is sensitive to capital flows (capital flows in the form of foreign currency) and where shocks in an open economy are often the main reasons for missing inflation targets (international shocks affect domestic price level via exchange rate). The main goal of the present study is to assess and track exchange rate pass-through. If pass-through is systematically related to monetary policy, as suggested by Taylor (2000), this would have significant implications for

the appropriate way to conduct monetary policy in Ethiopia. It is thus of utmost importance to understand and quantify the exchange rate pass-through for any monetary authority with an explicit or implicit goal of price stability. To what extent can a low inflation environment in Ethiopia contribute to a pass-through decline is an important question that still needs to be addressed.

Hence, this paper tries to assess the effects of Ethiopia's monetary policy on both inflation and exchange rate using Markov-switching approach. To the best of my Knowledge, this will be the first paper that allows Markov Regime Changes in the inflation as well as in the Pass-Through in Ethiopia. Following Hamilton (1989), the Markov regime-switching model has been extensively used to study nonlinearities in economic indicators such as inflation process (Blix, 1999). In this study, nonlinearities are important since inflation, in Ethiopia, responds to a shock in a very different way depending on which state the economy is in; i.e. whether the economy is in a low and stable inflation or a high and volatile inflation. The transition from one state to another will be modeled as a regime switch, and the probability of changing regime is inferred from the available data.

1.3 Objectives of the Study

The main objective of this paper is to assess the impact of the exchange rate pass through in an inflationary environment in Ethiopia.

Specific Objectives are:

- To identify macroeconomic and policy related determinants of exchange rate Pass-through and inflation.
- To examine the extent of regime changes in inflation
- To devise policy instruments based on the findings

1.4 Significance of the Study

This is a critical time to investigate exchange ate pass-through to inflation in Ethiopia, the World Bank still continues to press the government of Ethiopia to further devalue its currency. So, determining the extent of exchange rate pass-through is valuable for the country as an input for monetary policy. Inflationary pressures are also increasing from time to time and continue to grow by double digit, even though it showed a relative slow down recently. Therefore policy recommendations will be helpful for policy makers.

1.5 Scope of the Study

When we study inflation by using specific regimes it could be possible to have more than two regimes. What we did in this paper is categorizing inflation in to low and high inflation regimes, but we can add a third regime, a regime between the two extremes a medium inflation regime. Inflation experience in Ethiopia witnessed a double digit inflation rate in recent times and very low inflation rate previously. So limiting ourselves within the two regimes would be reasonable. The Taylor's hypothesis (2000) also put forward a two way relationship between exchange rate and inflation which help us to stick to the two regime analysis.

1.6 Limitation of the Study

Availability of data is a long time problem and it also continued to be a challenging problem for researchers in developing countries like Ethiopia, as it was the limiting factor to undertake this thesis. Due to unavailability of data producer price index (PPI) is dropped, import price index is constructed and quarterly GDP is interpolated. Therefore, the resulting outcome might be handicapped from suggesting a sound economic policy.

1.7 Organization of the Study

The remaining part of the study is organized as follows. The next Chapter reviews different theoretical and empirical literatures written in relation to exchange rate pass-through (ERPT). Macroeconomic overview regarding GDP growth, monetary development, development in consumer prices and exchange rate movements are described in chapter three. Under chapter four data description, source of data and methodology of the thesis which considers fixed transition probability (FTP) and time varying transition probability (TVTP) are presented. Chapter five deals with the results and discussions of the paper. The last chapter presents conclusions and policy implications based on findings obtained from the results.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Literature

The phenomenon of exchange rate pass-through (ERPT) has been thoroughly examined within the paradigm of the "new open economy macroeconomics", which is attributed to the subclass of optimizing dynamic stochastic general equilibrium models conditioned by nominal rigidities and imperfect competition in open economies, (Motukeeva, 2015).

As Goldberg and Knetter (1997, p. 1248) defined "exchange rate pass-through is the percentage change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing countries". Whether exchange rate pass-through is a macroeconomic or microeconomic phenomenon has been a discussion of interest for a long period of time. The micro foundations of exchange rate pass-through were suggested by Goldberg and Knetter (1997) and Goldberg and Hellerstein (2007) from the point of view of import prices.

Recent works examined a macroeconomic perspective, drawing both on the common finding from the microeconomics literature that ERPT tends to be incomplete and on new developments in the open-economy macroeconomics literature. In the new open-economy macroeconomics (NOEM) literature, based mainly on the work by Obstfeld and Rogoff (1995), nominal rigidities and market imperfections are introduced into a dynamic general-equilibrium (DGE), open-economy model with well-specified micro foundations. Although PPP holds and pass-through is complete in the framework originally presented by Obstfeld and Rogoff (1995), Betts and

Devereux (1996, 2000) extended this model to allow for pricing to market, and therefore incomplete pass-through.

Based on the works of (Dornbush 1987, Burstein Neves and Rebelo 2003, and Taylor 2000) we can categorize the determinants of exchange rate pass-through in to three theoretical explanations. Those that seek explanations in competition in the domestic market, those based on the share of marketing and distribution costs in domestic consumer prices, and those that link the level of pass-through to the credibility of monetary policy.

2.1.1 Competition Theories

According to competition theories, more active competition in domestic markets prompts foreign manufacturers to raise import prices less (or makes them less likely to raise them) in the wake of currency depreciation (see, for example, Dornbusch, 1987, and Bacchetta and Wincoop, 2005). As a result, the price of imported goods and consumer goods rises less than it would otherwise and exchange rate pass-through is less pronounced.

It can be concluded from these theories that the exchange rate affects domestic consumer prices through prices of imported consumer goods and competing domestic goods. Presumably, then, the greater the competition in the domestic market the weaker the pass-through.

Based on competition theories, it can also be assumed that exchange rate movements affect domestic consumer prices because they affect the price of imported inputs used in domestic production. Thus, it can be assumed that, the more competitive the domestic input market is, the

less impact exchange rate movements will have on domestic input prices and the less the overall exchange rate pass-through (Dornbush, 1987).

2.1.2 Cost theories

When one percent currency depreciation leads to less than a one percent rise in domestic prices there will be an incomplete pass-through. According to cost theories, incomplete pass-through can be explained by domestic marketing and distribution costs, which are important factors in domestic consumer prices. Penetration from currency depreciation to price increase is, therefore dependent up on marketing and distribution costs relative to the price of the product; that is, the greater these costs are as a share of the product price, the weaker the pass-through will be. According to Burstein, Neves, and Rebelo (2003), for example, marketing and distribution costs for a typical consumer product in the US constitute about 40% of the retail price of that product.

2.1.3 Credibility of monetary policy

Monetary policy plays a significant role in determining the inflation environment and inflation in turn determine the degree of exchange rate pass-through. According to Taylor (2000), lower and more stable inflation is likely to lead to weaker exchange rate pass-through. An example of a model that explains this is Gestsson's (2010) general equilibrium model, where uncertainty about monetary policy affects wage formation and therefore domestic production costs. Increased uncertainty reduces the number of domestically produced goods priced with reference to domestic market conditions. Which means producers will take the power to set prices and domestic market will not have the power to determine prices. This, in turn strengthens the exchange rate pass-through in to prices of imports and consumer goods. Devereux, Engel and Storgaard (2004) came to a similar conclusion. In their model, uncertainty about monetary policy

can affect whether producers decide to determine their prices in domestic or foreign currency. As uncertainty about domestic monetary policy escalates, it becomes more likely that foreign producers will choose to price their goods in their currency in order to avoid domestic price volatility in their products. This, in turn, strengthens the pass-through to the price of imports and consumer goods. These results indicate that the lack of monetary policy credibility exacerbates exchange rate pass-through. The theory is strengthened by the fact that it can be supported using a number of different models.

Exchange rate pass-through could be complete or incomplete (Fabling and Sanderson, 2013). Accordingly, complete ERPT occurs when the change in the exchange rate translates one-for-one in to local currency prices of goods. This is the case when there is a constant elasticity of demand. When elasticity of demand is constant the import prices in the destination currency will change proportionally to the changes in the exchange rate. On the other hand incomplete pass-through occurs when a change in a bilateral exchange rate is not completely transmitted into the local currency price of traded goods. Higher elasticity might be the reason for incomplete pass through (Motukeeva, 2015). Symmetrically, incomplete pass-through implies that some part of the exchange rate movement is absorbed by the exporter, through variation in the received unit price, while complete pass-through implies that the exporter does not absorb any of the exchange rate variation. Whether this has a positive or negative effect on exporters' returns will depend on the direction of the exchange rate change, as well as any impact on the volume of exports (Fabling and Sanderson, 2013).

The choice of currency in which the price of a good is denominated (the pricing behavior of firms) is another determinant of the degree of exchange rate pass-through. The most direct way

of transmitting nominal exchange rate changes into domestic inflation is by altering the domestic currency prices of imported goods. How the exchange rate affects domestic prices via import prices depends to a large extent on the pricing behavior of exporting and importing firms (Motukkeeva, 2015).

Under so-called pricing to market (LCP), exporting firms and/or their importers/distributors fix the import price in the local currency of the market they are exporting to. Exchange rate movements therefore need not be reflected in local currency prices, implying, in an extreme case, a zero pass-through. This case is perhaps more relevant for large industrial economies such as the United States, the Euro area and Japan than for smaller industrial and emerging market economies (Betts and Devereux 1996 and Engel 2002).

As discussed by Betts and Devereux (1996), the other extreme is when prices of imported goods are quoted in foreign currency (PCP) and are sold to consumers for local currency at the ongoing market exchange rate. In such a case, any change in the exchange rate will be automatically transmitted to the consumer prices of the importing country, implying a complete exchange rate pass-through. This might be the case, for instance, in an environment of very high inflation or in highly dollarized economies.

2.2 Empirical Literature

Most of the empirical literatures on exchange rate pass-through focus on three objectives. The first objective is whether exchange rate pass-through is a macroeconomic or microeconomic phenomenon. The second objective is to estimate the degree of exchange rate pass-through. The last one is to investigate what are the determinants of exchange rate pass-through.

Among the research conducted to investigate whether exchange rate pass-through is a macroeconomic or microeconomic phenomenon (Campa and Goldberg, 2002) could be an example. In addition, they also investigate the degree of ERPT. They provide cross country and time series evidence on the prevalence of producer-currency-pricing (PCP) versus local currency pricing (LCP) stability of imports and on whether exchange rate pass-through rates are endogenous to a country's macroeconomic conditions. Their study is based on industry-specific evidence on the pass-through of exchange rate in to import prices across 25 OECD countries. The result proves the Taylor (2000) hypothesis that pass-through in to import prices is lower for countries with low average inflation and low exchange rate variability. Accordingly, as a cross country average import prices in local currencies reflect 60 percent of exchange rate fluctuations in the short run, and nearly 80 percent over the long run. By contrast, exchange rate pass-through in to U.S. import prices is 25 percent in the short run and 40 percent over the long run. For the OECD as a whole, partial pass-through is overwhelmingly the best description of import price responsiveness shortly after an exchange rate movement. In the long run, pass-through elasticities are closer to one, although complete pass-through or producer currency pricing is still rejected for many countries. Macroeconomic variables play a significant but limited role in explaining cross country differences in levels of pass-through elasticities.

Goldberg and Campa (2002) also showed that pass-through rates have been declining over time in some countries. This pattern of pass-through decline has not been a common feature of all OECD countries. Short-run exchange rate pass-through elasticities rise with inflation (or higher money growth rates). The results of disaggregated data imply partial pass-through elasticity to manufacturing products, so both local currency price stability and producer price stability are

rejected for most OECD countries. By contrast, energy and raw material imports appear to have pass-through elasticities closer to one.

Bailliu and Fujii (2004) empirically investigated exchange rate pass-through and the inflation environment in industrialized countries. They used a panel data set of elven industrialized countries over the period 1977 to 2001 and they found evidence to support the Taylor hypothesis (2000) that ERPT declines with a shift to a low-inflation environment brought about by a change in the monetary policy regime. More specifically, the results suggest that pass-through to import, producer, and consumer price inflation declined following the inflation stabilization that occurred in many industrialized countries in the early 1990s, but not following a similar episode that occurred in the 1980s.

Empirical studies conducted on developed countries found evidence which is consistent with Taylor (2000) hypothesis. Takhatamanova (2008) is among them, in a paper that attempted to look for explanations for the weakening in the relationship between the real exchange rate and the CPI inflation. Takhatamanova (2008), empirical investigation for fourteen OECD countries confirms the existence of a decline in the exchange rate pass-through during the 1990s. The study used feasible generalized least squares (FGLS) estimators.

Byrne et. al. (2010) examined the size and nature of exchange rate pass-through to import prices in 14 emerging market economies for sample period of 1980-2004. Panel data analysis is used for the study. The general results under the combined panel indicate that the exchange rate pass-through effect on to import prices is positive although incomplete. They took both linear and asymmetry frameworks for their analysis. Exchange rate pass-through appears to be similar for

all countries within a linear framework. But, when they group countries regionally in to Asia and Latin America, they found a strong support in favor of a relatively weak but homogeneous asymmetry pass-through effect for Latin America in the long run. This suggests that only depreciations of the domestic currency lead foreign firms to increase local currency prices, possibly in an attempt to retain profit margins. For Asian economies, they find evidence of a stronger pass-through effect compared to Latin America for both appreciation and depreciations. Any evidence of strong asymmetric depreciation effects may affect Asian economies differently. Furthermore, their result suggests an important role for marginal costs and demand as determinants of import prices. They also conclude that, to some extent, homogeneity in the long run exchange rate pass-through phenomenon in emerging market economies.

Small open economies are vulnerable to the effects of exchange rate changes because of their openness. Motukeeva (2015) investigated exchange rate pass-through in Kazakhstan by using VAR estimation and the evidence from the impulse-response functions has suggested that the exchange rate pass-through in general is incomplete and small in Kazakhstan. It tends to be higher for import prices and two times smaller for producer and consumer prices than import prices. However, the pass-through rises over time for import and producer prices, while remaining low for consumer prices. The difference in the pass-through effect for import prices and consumer prices may lie in the fact that local distribution costs play a major role in price determination. In addition, the possibility that the goods of the consumer basket are partially produced locally, and, thus, experience less influence from the exchange rate fluctuations. Thus, the degree of pass-through naturally declines down the pricing chain due to the increase of the non-tradable component in the form of distribution costs, rents, etc.

There are also studies that find non-conventional results for example, Mwase (2006). In a study that investigated exchange rate pass-through to inflation in Tanzania it is found that inflation decreased despite exchange rate depreciation, which could be attributed to the effect of macroeconomic and structural reforms. They argue that the findings reflect the impact of increased competition, higher productivity, and tighter monetary policy in the late 1990s anchored by lower inflation expectations. The decrease in the pass-through is partly attributed to the macroeconomic and structural reforms. As it is explained, the results are mainly driven by the deflationary effects of expansion in clothing, furniture production and the household products sectors, predicated on liberalization. The decline in inflation is partly attributed to the opening up of sectors previously sheltered from competition such as furniture production. They also find that sectors facing competition from second-hand market, such as the clothing sector, experienced downward inflationary pressure.

Different methodologies used to investigate the exchange rate pass-through in to domestic prices and the traditional one's are vector auto regression (VAR), Cointegrated vector auto regression (CVAR), structural vector auto regression (SVAR), and Phillips curve analysis. Khemiri and Ben Ali (2012) employed a probabilistic approach to study the effect of exchange rate pass-through on inflation in Tunisia over the period 2001-2009. By using Fixed Transition Probability and Time varying Transition probability Markov-Switching approaches, they investigate the existence of a relationship between exchange rate pass-through and inflation. The results reveal a robust significant relationship between local inflation and the pass-through level. The empirical findings suggest also that for Tunisian economy, variables such as the industrial production

index, the imports and exports unit value seem to be particularly important for the transmission mechanism of upward or downward movements in the exchange rate to inflation.

The mitigating factors for assessing exchange rate pass-through to consumer prices are different for different researchers. The overdependence of The Nigerian economy on imports necessitated (Adeyemi and Samuel, 2013) to examined exchange rate pass through to consumer prices in Nigeria. VECM approach reveals that exchange rate pass through to consumer prices in Nigeria is substantial. Larger exchange rate pass-through can be attributed to the continuous depreciation of the Naira over the whole sample observed. Accordingly, firms and importers are likely to perceive any increase in costs due to exchange rate depreciation as persisting and therefore, pass on to consumers most of the resultant increases in costs.

For sub Saharan Africa (SSA) examining the effect of exchange rate movements on domestic consumer prices helps to devise a viable policy instruments to tackle a soaring inflation. Jombo et.al (2014), analyses the degree of exchange rate pass-through to consumer prices in Malawi using the augmented Philips curve and Vector Auto Regression approaches. The findings of their study indicate a modest influence of exchange rate movements on domestic prices as pass-through elasticities were 0.15 and 0.2 estimated by augmented Philips curve and VAR approaches, respectively. They concluded this is why inflation only crawled from17.3 percent to 37.9 before it starts declining, even though exchange rate moved around 168 per US dollar to scaring levels of 420 per US dollar. However, the dynamic exchange rate pass-through of 0.2 still put exchange rate as a potentially important source of inflation in Malawi.

Even though, extensive research has not been done on the area of exchange rate pass-through in Ethiopia, Mohammednur (2012), Helen (2012), and Negasy (2014) individually investigate the phenomenon. Mohammednur (2012) investigates the exchange rate pass-through to inflation and other macroeconomic variables in Ethiopia for monthly data from July 2002 to June 2011, by applying unrestricted VAR model to estimate the impulse response functions and variance decomposition. The results shows that on average a one percent change in exchange rate will increase the consumer price by 4.75 percent in the first year. The exchange rate pass-through to inflation almost dies out after two years of exchange rate shock.

It is customary to estimate the effect of exchange rate pass-through in to both import and consumer prices. Helen (2012) analyzes exchange rate pass-through to import and consumer prices. Berga employed both symmetric (estimation by a single equation method and exchange rate pass-through effect is the coefficient obtained from regressing changes in price indices to variation in nominal exchange rate) asymmetric (can be analyzed with respect to direction and size of exchange rate change and inflation environment in addition estimation used dummy variables to capture size and direction of exchange rate changes) methods and used SVAR and CVAR models. The SVAR results using impulse response function established that the degree of ERPT to import and consumer prices is incomplete, persistent (in the case of import price) and significant in the short run. It is also found that pass-through to import prices is significantly higher (also) quick than that of CPI and this suggests that pass-through declines along the pricing chain in Ethiopia. The estimated CVAR model shows that the degree of ERPT to import price index is incomplete in the long run. But it indicates absence of ERPT to consumer prices in the long run. The results obtained from the asymmetric model suggest that ERPT to import prices is

higher in periods of Birr depreciation than appreciation which supports the binding quantity constraint theory.

Among the studies conducted on Ethiopia, Negasy (2014) find a different result compared to the above mentioned papers. He employed a Vector Error Correction model and, in contradiction with the other papers, he finds a long run relationship between exchange rate movements and changes in domestic prices. He also found a significant and correctly signed ECM term which supports the long run relationship between exchange rate movement and the change in domestic prices. However, there was a low degree of exchange rate pass-through in the short run as quantified by the impulse response function.

CHAPTER THREE

MACROECONOMIC OVERVIEW OF THE ETHIOPIAN ECONOMY

In this chapter selected macroeconomic variables that could give strength to our analysis will be reviewed. Gross Domestic Product (GDP) growth, monetary development, development in Consumer Price (CPI), and Exchange rate movements are assessed.

3.1 Gross Domestic Product (GDP) Growth

According to World Bank (2016), Ethiopia's double digit growth in 2014/15 slowed down in 2015/16 due to the recent drought. Real GDP grew by 8 percent in 2015/16 compared to 10.4 percent growth in 2014/15. Still, Ethiopia's economy was among the fastest growing in the world showing how well the economy passed through adverse shocks. The growth nevertheless falls short of the Government's own target set out in the Growth and Transformation Plan II (GTP II), which projected at 11.4 percent. Overall, the five year GTP I period (2010/11 to 2014/15) achieved a very high growth rate of 10.1 percent per year, on average. When considering the last dozen years since 2004, real GDP growth averaged 10.5 percent. This translated into an average per capita (in dollar terms) growth of 7.9 percent, which is equivalent to the annual per capita growth rate needed for Ethiopia to reach middle-income status by 2025.

The slowdown in the economic activity during 2015/16 is mainly explained by lower agricultural production and associated negative spillovers on other sectors. The drought caused by the El-

Niño phenomenon caused lower crop production during the main (Meher) harvest season. Main season grain production declined by 1.3 percent, however, recovery in the small (Belg) season production compensated the decline and led to the overall crop production growth of 2.4 percent in 2015/16; still, this is significantly lower than the 6.2 percent growth in 2014/15.Yet, actual crop production is much better than what was originally expected at the time of the drought. The drought also affected other sectors indirectly, for instance, trade and hotels (World Bank, 2016). The contribution of major sectors to GDP at constant basic price over the period 2012-2015 is presented in Table 3.1.

Table 3.1: Contribution to GDP growth by sector at constant basic prices

Sector	2012	2013	2014	2015
Agriculture	2.2	3.1	2.3	2.5
Industry	2.1	2.8	2.2	3.0
Services	4.4	4.1	5.9	4.7

Source: NPC

Construction and the services sectors explain the supply side GDP growth in 2015/16. The construction sub-sector contributed 2.1 percentage points to growth, while the contribution of manufacturing relatively increased to 0.9 percentage points from the previous year. Within services, trade and hotels, at 2.2 percentage points, were the leading sub-sectors to drive GDP growth. The growth of services is also reflected in the growth of the transport and communication sub-sector with a contribution of 0.7 percentage point of GDP. Ethiopian Airlines growth continued with passenger traffic up by 19.5 and cargo services by 12.4 percent in 2015/16 following an expansion of its network and improved capacity.

On the demand side, investment followed by private consumption accounted for most of GDP growth in 2015/16. Total investment contributed 5.9 percentage points to GDP growth in 2015/16, while private consumption growth contribution was 1.5 percentage points. The contribution of public consumption increased significantly (1.0 percentage point) compared to the previous year which could be a result of the Government's increased spending to mitigate the effects of the drought. On the other hand, the growth contribution of net export dragged down growth with -0.8 percentage points of GDP as a result of lower export earnings against a fast increase in imports (World Bank, 2016).

3.2 Monetary Development

Broad money supply (M2) reached Birr 496.3 billion during the second quarter of 2016/17, showing a 25.1 percent expansion over the corresponding quarter of last year. The annual growth in broad money was attributed to 24.7 percent surge in domestic credit (both government and nongovernment) offsetting a 47.6 percent decline in net foreign asset of the banking system. Reserve money was Birr 128.5 billion at the end of the second quarter of 2016/17, showing a 27.1 percent annual growth. Similarly, excess reserves of commercial banks surged by 251.1 percent, due to relatively lower government deposit with NBE. The money multiplier measured both by the ratio of broad money to reserve money and the ratio of narrow money to reserve money tended to decline. The ratio of narrow money to reserve money was 1.5, down from 1.6 last year, while the ratio of broad money to reserve money declined to 1.86 from 1.92 last year, (NBE, 2017).

Component wise, quasi-money supply showed a 26.4 percent annual and 6.9 percent quarterly expansion while narrow money supply increased 23.2 and 7.2 percent, respectively. Narrow money contributed 37.1 percent to the year- on- year growth of broad money, while that of quasi money was 62.9 percent. The growth in quasi-money was the result of increased efforts of banks in expanding their branch network and improved service outreach as well as NBE's monetary policy to maintain price stability.

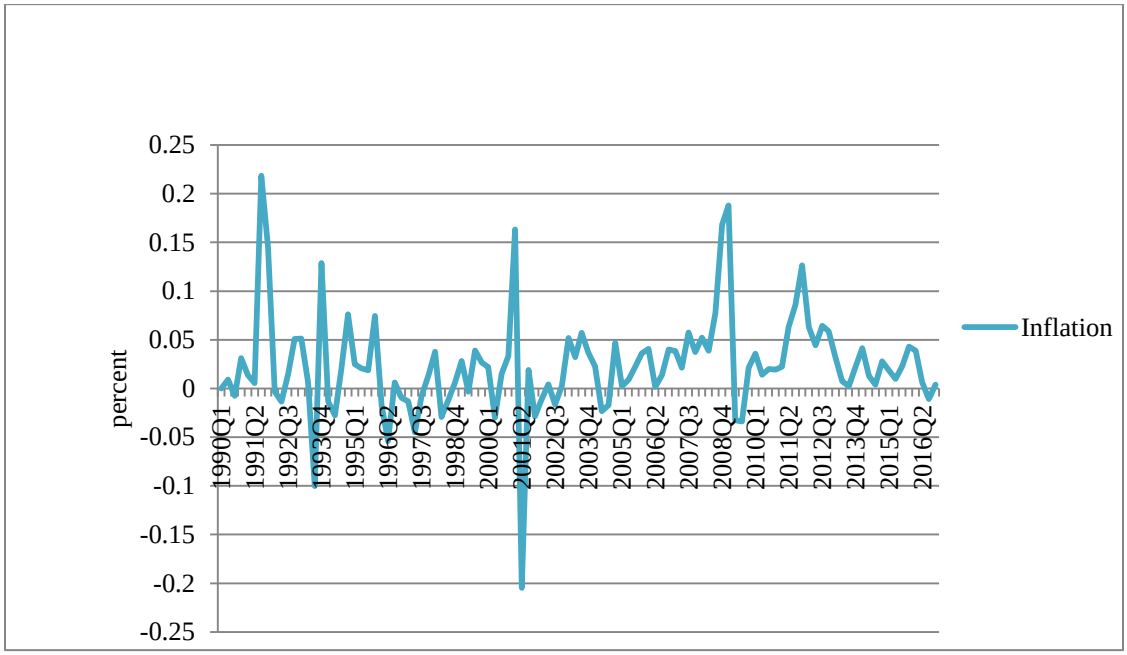
3.3 Developments in Consumer Price

World Bank (2016) states that, while inflation rose temporarily above ten percent over the past year, it is remarkably stable, given the recent drought and even declining; it stood at 5.6 percent in October 2016. Inflation entered to double digits in June 2015 and increased to 11.8 percent one year ago in October 2015; since then it has declined and reached 5.6 percent in October 2016. Food inflation, which constituted about 53 percent of the average household consumption basket, continued to be a major driver of inflation at 3.4 percent, down sharply from its three-year peak of 16.2 percent in October 2015.The food price inflation was originally expected to rise sharply due to expected reductions in crop production arising from the major drought earlier this year. Reasons for the relatively lower de facto inflationary impact are related to the stabilization of prices through large-scale import of wheat, better balancing of supply and demand through strategic cereal reserves, and tighter monetary policy. The global slowdown in commodity prices also contributed to lower inflation of tradable goods.

During the second quarter of 2016/17, headline inflation has scaled down to 0.0 percent from 2.6 percent registered in the previous quarter, but it turned up compared to -0.1 percent a year earlier. The 2.6 percentage point decline in quarterly headline inflation was attributed to 5.2

percentage point decline in food and non-alcoholic beverages inflation, offsetting 0.4 percentage point rise in nonfood inflation. On the other hand, quarter-on-quarter headline inflation showed a 0.1 percentage point increase on account of a 0.3 percentage point rise in non-food inflation. Hence, food and non-alcoholic beverages and non-food inflation each contributed 0.7 percent to the headline inflation of the quarter under review, (NBE, 2017).

Figure 3.1: General inflation for the Period 1990Q1-2016Q4



Source: Own calculation based on NBE data

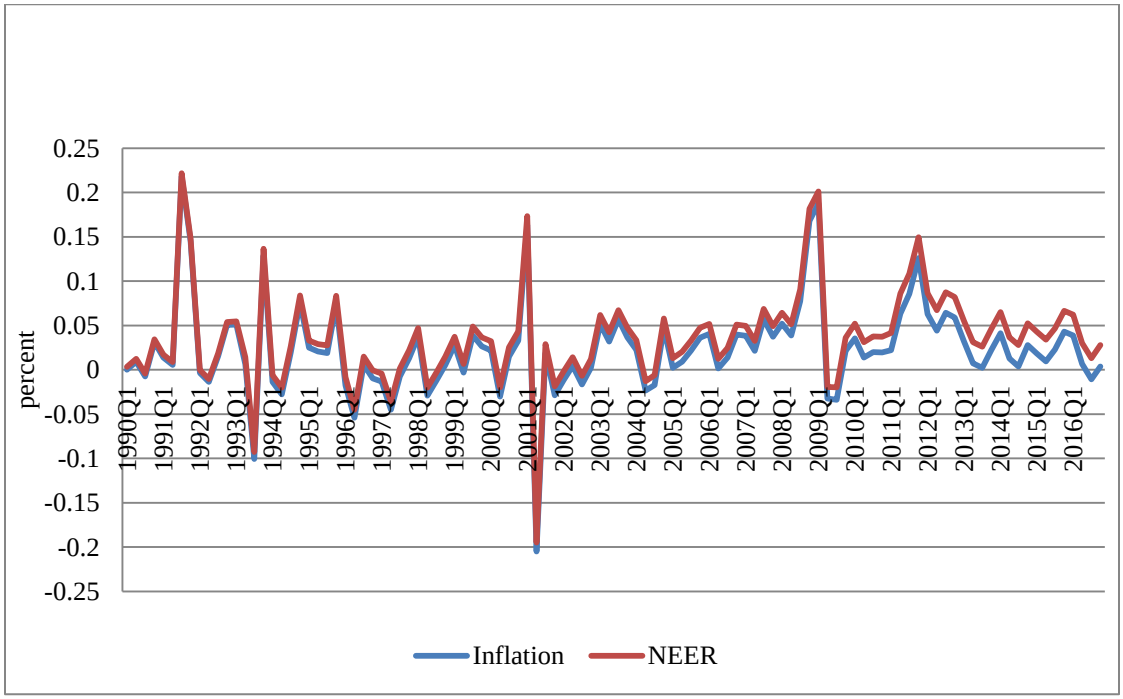
3.4 Exchange Rate Movements

The weighted average official exchange rate of Birr in the inter-bank foreign exchange market reached Birr 22.2228/USD, showing a 6.1 percent annual and 1.4 percent quarterly depreciation during the second quarter of 2017. Likewise, the end of period exchange rate at end of the quarter was Birr 22.4104/USD, which depicted 6.3 percent annual and 1.6 percent quarterly weakening against USD during the same period. The REER appreciated 4.3 percent on annual

basis, mainly owing to relatively higher domestic inflation compared to that of trading partners. On the other hand, the NEER slightly depreciated by 0.04 percent vis-à-vis last year same period and appreciated by 4.3 percent against the preceding quarter due to relatively fast depreciation of trading partners' currencies against the US dollar, (NBE, 2017).

Figure 3.2 shows the relationship between nominal effective exchange rate (NEER) and consumer price inflation for the period under 1990Q1-2016Q4. The figure shows clearly the positive co-movement between inflation and NEER which means inflation increases when nominal effective exchange rate increases (depreciates). The notion of exchange rate pass-through can be inferred from this figure even if, it could be a seldom evaluation of both variables without including the effects of other variables.

Figure 3.2: Movement of NEER versus Inflation



Source: Own calculation based on NBE data

CHAPTER FOUR

METHODOLOGY OF THE STUDY

4.1 Methodology of the Study

Due to the dynamic and non-stationary behavior of inflation, it becomes difficult to characterize inflation by the classical linear models. Therefore, this study makes use of an alternative time-series characterization for inflation that allows for distinct and differing periods of inflationary behavior, each characterized by its own time-series properties depending on a probabilistic process.

This paper builds on an approach introduced in Hamilton (1989) paper for analyzing such discrete qualities of inflation. The method in this paper closely follows Khemir and Ben Ali (2012) who analyzed the Tunisian exchange rate pass-through to inflation. The parameters of the autoregression vector can be subject to occasional discrete shifts. The probability law governing these shifts is also stated explicitly and presumed to exhibit dynamic behavior of its own. Hence, we will determine when the shifts occurred and estimate parameters characterizing the different regimes and the probability law for the transition between regimes.

As Khemir and Ben Ali (2012) stated this approach is appealing for three reasons. First, it fits to the fact that inflation can perform differently in different sub-periods. It is a switching process where sudden changes can occur. Second, the Markov-switching modeling approach we apply in this study imposes a simpler-than-conventional structure on the inflation process within any given regime, but gains power to fit the historical data by allowing regimes to change. The

distinctive feature of this approach is the use of simple equations for inflation, within a framework that allows for discrete regime shifts. Specifically, Markov-switching models allow for two or more processes to exist with a series of shifts between the states occurring in a probabilistic manner, so that shifts occur endogenously rather than being imposed. Third, the Markov regime-switching methodology has also been motivated by the patterns of inflation for Ethiopia that have historically, switched in response to exchange rate shocks as it can be clearly seen from Figure 3.2.

Compared to other switching approaches such as the structural switching method that can only give us the different switching dates of inflation, Markov-switching approach let us through the smoothed probabilities graph, to have a probabilistic approach of the importance of each regime, while explaining inflation by macroeconomic factors, conditionally with all the information of the sample. Markov-switching models are alternative to take into account market changes that can potentially cause changes in parameter estimates of models and, ultimately, improve forecasting accuracy (Khemir and Ben Ali, 2012).

Two main methods for estimating transition probabilities can be distinguished when dealing with Markov-switching process: Fixed Transition Probability (FTP) and Time Varying transition probability (TVTP) that are discussed below.

4.1.1. Fixed Transition Probability (FTP) Approach

The Fixed Transition Probability (FTP) approach is the Markov-switching model in its standard form. Its main feature is that it does not allow the transition probabilities to vary. The basic idea of Markov-switching model is to describe the stochastic process that determines the switch from

one regime to another using a Markov Chain. The Markov Chain is used to model the behavior of a non-observed state variable that determines which regime is current (Hamilton, 1994). As first introduced by Hamilton (1989, 1990), a Markov Chain can be represented as follows: Suppose that the probability of a variable s_t assuming some particular j value, depending only on the previous state s_{t-1}, is given by the following equation:

$$\text{P}\{s_t = j/s_{t-1} = i, s_{t-2} = k \ldots\} = \text{P}\{s_t = j/s_{t-1} = i\} = P_{ij} \qquad (1)$$

This process is described as a Markov Chain with M-states, where probability P_{ij} indicates the probability of state i being followed by state j. We can, thus, build the Markov transition matrix of first order, where probability of transition to the next regime relies only on the current regime. As presented in the seminal paper of Hamilton (1989), two transition probabilities can be distinguished:

p = Pr $(s_t = 1/s_{t-1} = 1)$ is the probability of staying in a high inflation regime.

q = Pr$(s_t = 2/s_{t-1} = 2)$ is the probability of staying in a low inflation regime.

We will estimate the Markov-switching model by maximum-likelihood using the Kittagawa-Hamilton filter (see Hamilton 1990 or 1994 for this filter). Hamilton's filter consists of two stages. First, initial values of the vector of parameters Θ are initialized using the ordinary least square method. Then, the series are sorted, split in M parts on which initial conditional regressions are computed to launch the Maximum likelihood descent. Second, the model is recursively estimated through the expectation maximization (EM) algorithm, which will be

derived latter, starting from the unconditional density of the explained variable y_t calculated by summing conditional densities over possible values for S_t, as follows:

$$\mathrm{f}\left(y_t/I_{t-1},\Theta\right) = \sum_{j=1}^{M} P(S_t = j, y_t/I_{t-1}, \Theta) \quad (2)$$

$$\mathrm{f}(y_t/I_{t-1}\,,\ \Theta) = \sum_{j=1}^{M} P(S_t = j/I_{t-1}, \Theta).f\ (y_t/S_t = j, I_{t-1}, \Theta) \quad (3)$$

EM algorithm stands for expectation maximization as its name suggests it has two stapes (the E-step and the M-step). Hamilton develops an EM algorithm for the case of no autoregressive variables and shows that this model is robust to different starting values of the model parameters. In the case of a linear model with no autoregressive parameters, the EM algorithm yields some intuitive results.

The first step is to maximize the expected log likelihood function

$$L(\psi; Y, \psi^k) = \sum_{S_t=1}^{M} \sum_{t=1}^{T} \log f_{Y,S}\ (y_t, S_t/\mathrm{I}_{t-1}\,; \psi)\Pr(S_t/\mathrm{I}_t; \psi^k) \quad (4)$$

Where ψ^k are the parameter estimates from the (k-1)$^{\text{th}}$ iteration, $f_{Y,S}(.)$ is the joint density of y_t and S_t , and Y=$(y_1, \ldots, y_T)$. It is important to note that y_t and S_t are independent. The density $f_{Y,S}(.)$ can be decomposed as

$$f_{Y,S}(y_t, S_t/\mathrm{I}_{t-1}\,; \psi) = f(y_t/S_t, \mathrm{I}_{t-1}).\ \Pr(S_t/\mathrm{I}_{t-1}), \quad (5)$$

So (dropping I_{t-1} and I_t) the likelihood with two regimes becomes

$$L(\psi; Y, \psi^k) = \sum_{i=1}^{2} \sum_{t=1}^{T} \log[f(y_t/S_t = i; \theta_i)\ .\ \Pr(S_t = i;\ \gamma)]\ \Pr(S_t = i/y_t; \psi^k). \quad (6)$$

The separation of the parameters makes maximization straightforward:

$$\frac{\partial}{\partial \theta_i} L(\psi; Y, \psi^k) = \sum_{t=1}^{T} \frac{\partial}{\partial \theta_i} \log f(y_t / S_t = i; \theta_i) \ \Pr(S_t = i \ / y_t; \psi^k) = 0, \tag{7}$$

This, in the case of normally distributed data, leads to:

$$\beta_i^{k+1} = \left(\sum_{t=1}^{T} \mathcal{X}_t^{'} \mathcal{X}_t \Pr(S_{t=1} = i/Y; \theta^k) \right)^{-1} \left(\sum_{t=1}^{T} \mathcal{X}_t y_t \Pr(S_{t=1} = i/Y; \theta^k) \right) \tag{8}$$

$$\sigma_i^{2^{k+1}} = \frac{\sum_{t=1}^{T} \left(y_t - \mathcal{X}_t^{'} \beta_i^k \right)^2 \Pr(S_t = i/\ Y; \theta^k)}{\sum_{t=1}^{T} \Pr(S_t = i/Y\ ; \theta^k)} \tag{9}$$

$$\mathrm{P}_{i,i}^{k+1} = \frac{\sum_{t=1}^{T} \Pr(S_t = j, S_{t-1} = j/Y; \theta^k)}{\sum_{t=1}^{T} \Pr(S_t = i/Y\ ; \theta^k)} \tag{10}$$

The last equation is obtained by Lagrange optimization with the added constraint that $\sum_j p_{i,j} = 1$

The probabilities $\Pr(S_t = i/Y\ ; \theta^k)$ are the smoothed probabilities. At each M-step of the algorithm, the solutions for β_i^{k+1} and $\sigma_i^{2^{k+1}}$ are OLS estimates weighted by the probabilities of each regime. Also the formula for the transition probabilities $p_{i,i}^{k+1}$ is simply the empirical transition matrix of the Markov chain using the probabilities as counts.

Conditioning by S_t, M different $(p \times 1\ )$ gaussian vectors have to be taken in to account. Thus for a given regime $S_t = j$:

$$\begin{cases} y_t = \mathcal{X}_t \beta_j + \mathcal{Z}_t \delta + \mathcal{U}_t \\ \mathcal{U}_t / S_t = j \sim N(0, \sum_j) \end{cases}$$

Let's note $\mu_{t,j} = \mathcal{X}_t \beta_j + \mathcal{Z}_t \delta$ and let Θ be the $(1, n_\Theta)$ vector of related parameters. Then, the conditional probability density function is:

$$f(y_t/S_t = j, I_{t-1}, \Theta) = (2\pi)^{\frac{-p}{2}} . det\left(\sum_j^{\frac{-1}{2}}\right). exp\left(-\frac{(y_t-\mu_{t.j})'\sum_j^{-1}(y_t-\mu_{t,j})}{2}\right) \quad (11)$$

The maximum likelihood estimate of Θ is obtained by maximizing the log-likelihood as follows:

$$L(\Theta) = \sum_{t=1}^{T} ln\big(f(y_t \setminus I_{t-1}, \Theta)\big) \quad (12)$$

Where Θ is the vectorized matrix of parameters. We define S_t= {1,…,M} as a M-state unobserved variable, following a first order Markov Chain and representing the number of regimes. S_t = 1 (resp. S_t= M), means that the time series are said to be in the "highest" (resp. the "lowest") regime. I_{t-1}= (y_{t-1}…,y_1) is the information set available in t-1, that is the lagged values of the endogenous variable will provide information relevant for the estimation of the Markov-switching model. P_t is the conditional probability related to the state j.

Finally, we conduct an estimation procedure based on equation 2, 3 and 4. In fact, the endogenous variable y_t corresponds in this case to the inflation rate Π_t. The information set (I_{t-1}) corresponds to the lagged value of inflation rate Π_{t-1} . We use the exchange rate variability (ERVR) as the vectorized matrix of parameters Θ. s_t is a two state Markov variable. In fact, a major contribution of the approach used in this paper consists on introducing the exchange rate variability as an explicative factor of the different inflation states. The exchange rate variability (ERVR) is derived by taking the sample variation of the bilateral nominal exchange rate of Birr per US dollar. The main objective is to assess the effect of this exchange rate pass- through on the level of inflation in Ethiopia.

Hence, we can then estimate a Markov-switching autoregressive model with exogenous variable as an MS-ARX model (Hamilton, 1990), specified in the following equations:

Inflation is assumed to follow the following process (Hamilton, 1990):

$$\Pi_t = \beta_0(s_t) + \beta_1(s_t)\Pi_{t-1} + \beta_2(s_t)\text{ERVR} + u_t \quad (13)$$

Where Π is the inflation rate and ERVR is the exchange rate variablity

This model allows β_0 and all the coefficients β_i, $(i = 1,2)$ to vary between two states, s=1, 2. The error term u_t, featured by $u_t \sim \text{NID}(0, \sigma_{s_t}^2)$ is i.i.d sequence of normally distributed variable with zero mean and a variance $\sigma_{s_t}^2 = \begin{vmatrix} \sigma_1^2, if & s_t = 1 \\ \sigma_2^2, if & s_t = 2 \end{vmatrix}$. It is a special case of this process known as i.i.d. mixture distribution (Hamilton, 1994, P 685-686).

4.1.2 Time Varying Transition Probability (TVTP)

Time Varying transition probability (TVTP) is a Filardo (1994) extended version of the Fixed Transition Probability approach (FTP) that allows the transition probabilities to be time-varying. Following Filardo (1994), we allow the transition probabilities to be time-varying and dependent on macroeconomic and monetary policy-related variables. The logistic function for the transition probabilities specification was first introduced by Filardo (1994) and Diebold et al. (1994), then generalized by Filardo (1998), Gray (1996), Beine, Laurent and Lecourt (2003), Isogai, Kanoh and Tokunaga (2004) :

$$P_{i,j,t} = \Pr[S_t = j/S_{t-1} = i, Z_{t-1}] = \frac{exp(\lambda_{i,j,0} + Z'_{t-1}\lambda_{i,j,1})}{1+exp(\lambda_{i,j,0} + Z'_{t-1}\lambda_{i,j,1})} \quad (14)$$

Where, i= 1,2,…,M; j= 1,2,…,M-1; and

$P_{i,M,t}$ = Pr$[S_t = M/S_{t-1} = i, Z_{t-1}]$ = 1- $\sum_{j=1}^{M-1} P_{i,j,t}$, $i = 1,2, \dots, M$ (15)

M is the number of regimes and s_t is a first order Markov variable. $Z_t = [WCPI, Y^{gap}, M2, NEER, IPI]$ is a vector of economic variables explaining the transition from one regime to the other. Following Filardo (1994), the time varying probabilities for two regimes can be described as below:

$$\Pr(S_t = 1/S_{t-1} = 1) = \frac{exp\left(\lambda_{10} + \sum_{j=1}^{n} Z'_{t-1}\lambda_{1\,j}\right)}{1+exp\left(\lambda_{10} + \sum_{j=1}^{n} Z'_{t-1}\lambda_{1\,j}\right)} \quad (16)$$

$$\Pr(S_t = 2/S_{t-1} = 2) = \frac{exp\left(\lambda_{20} + \sum_{j=1}^{n} Z'_{t-1}\lambda_{2\,j}\right)}{1+\exp\left(\lambda_{20} + \sum_{j=1}^{n} Z'_{t-1}\lambda_{2\,j}\right)} \quad (17)$$

Where,

$\Pr(S_t = 1/S_{t-1} = 1)$ is the probability of remaining in a high inflation regime, given that the previous regime is characterized by a high and volatile inflation, $\Pr(S_t = 2/S_{t-1} = 2)$ represents the probability of a low inflation regime, preceded by a low and stable inflation. Z_t is a vector of k macroeconomic and policy-related variables considered to predict the future course of inflation as described in the following subsection. By allowing transition probabilities to vary over time, we can analyze the mechanisms underlying shifts from a high inflation regime (S_t=1) to a low inflation regime (S_t=2) and vice versa. In particular, we will use this econometric framework to determine the effect of macroeconomic and policy-related variables on inflation's shift from one regime to another.

The key parameters affecting the probabilities of transition from one regime to the other are the coefficients (λ). In particular, it is important to examine the sign of these coefficients. For

example, if the coefficient λ_{11} is positive, this means that the corresponding economic fundamental Z is a significant factor in increasing the probability to stay in a high inflation regime (regime 1). However, if the coefficient is negative, this means that the corresponding macroeconomic variable Z lowers the probability of remaining in a high inflation regime and increases the probability to overbalance towards a low and stable inflation (regime 2). Similarly, the coefficient λ_{22} measures how the exogenous variable Z affects the probability of staying in a low inflation regime (regime 2) and eventually the probability of switching to a high inflation regime (regime 1), depending on whether this coefficient is, respectively, positive or negative.

For the two state Markov chain, we write the transition probabilities as:

$$P(S_t = 1/S_{t-1} = 1, I_{t-1}) = P(S_t = 1/S_{t-1} = 1) = p(t) = p$$

$$P(S_t = 0/S_{t-1} = 0, I_{t-1}) = P(S_t = 0/S_{t-1} = 0) = q(t) = q \quad (18)$$

Given the above description of variables the following statistical specification of the time varying transition probabilities presented.

$$\Pr(s_t = 1/s_{t-1} = 1)$$

$$= \frac{exp(\lambda_{10}+\lambda_{11}WCPI_{t-1}+\lambda_{12}Y^{gap}{}_{t-1}+\lambda_{13}IPI_{t-1}+\lambda_{14}NEER_{t-1}+\lambda_{15}M2_{t-1})}{1+exp(\lambda_{10}+\lambda_{11}WCPI_{t-1}+\lambda_{12}Y^{gap}{}_{t-1}+\lambda_{13}IPI_{t-1}+\lambda_{14}NEER_{t-1}+\lambda_{15}M2_{t-1})} \quad (19)$$

$$\Pr(\mathrm{s_t} = 2 \setminus \mathrm{s_{t-1}} = 2)$$

$$= \frac{exp(\lambda_{20}+\lambda_{21}WCPI_{t-1}+\lambda_{22}Y^{gap}{}_{t-1}+\lambda_{23}IPI_{t-1}+\lambda_{24}NEER_{t-1}+\lambda_{25}M2_{t-1})}{1+exp(\lambda_{20}+\lambda_{21}WCPI_{t-1}+\lambda_{22}Y^{gap}{}_{t-1}+\lambda_{23}IPI_{t-1}+\lambda_{24}NEER_{t-1}+\lambda_{25}M2_{t-1})} \quad (20)$$

4.3. Filtered and Smoothed Estimates

Estimates made based on partial information set at (t) are called filtered probabilities and are calculated as (Wang, 2004):

$$(S_t = j/I_{t-1}) = \sum_{i=1}^{2} P(S_t = j/S_{t-1} = i).P(S_{t-1} = i/I_{t-1}) \quad (21)$$

$$(S_t = j/I_t) = \frac{f(y_t/S_t=j,I_{t-1}).P(S_t=j/I_{t-1})}{\sum_{j=1}^{1}(f(y_t/S_t=j,I_{t-1})).(P(S_t=j/I_{t-1}))} \quad (22)$$

The states at time (t) have been estimated based on the information set at (t) in the above procedure. It may be of interest to review the states at a later time when more information is available, or infer the states using the whole information set up to the last observation at time (T). An inference made about the present state using future information is called smoothing, with the inference made with whole information set being full smoothing, or simple smoothing. Smoothing may be of no use to problems such as real time control in cybernetics, but it provides more desirable results when an insightful understanding of the process is the major concern; for example in the economic science for revealing the working mechanism of dynamic economic systems and shaping future policies, Wang (2004) .

$$P(S_{t-1} = i/I_T, S_t = j) = \frac{P(S_t=j/I_T)P(S_{t-1}/I_t)P(S_t=j/S_{t-1}=i)}{P(S_t=j/I_t)} \quad (23)$$

$$P(S_t = j/I_T) = \sum_{j=1}^{2} Pr(S_{t-1} = i, S_t = j/I_t) \quad (24)$$

Where I_T is the full information obtained after estimating the Markov-switching model. Therefore, the smoothed probabilities estimated based on the full information set.

4.2 Data Description and Source of Data

4.2.1 Data Description

Several studies use different macroeconomic and policy related variables to study exchange rate pass-through to inflation. When Ito and Sato (2007) made the ordering of variables, domestic price took the bottom of VAR ordering so that the price variable is contemporaneously affected by all other shocks preceded it (The Nominal Effective Exchange Rate, Money supply, Output

Gap and Oil price shock). This ordering of variables is for VAR approach, which considers both the price variables and the other shock variables as endogenous variables. Among the price variables we may take Consumer Price Index (CPI) as the dependent variable, since all price variables (consumer price index, producer price index and import price index) are affected by the other shock variables.

Within the framework of this paper, the Markov-switching approach describes the inflation process as being governed by two different regimes where switches between them are based on a probabilistic process. Estimates of parameters for the two most likely regimes are generated using maximum likelihood techniques. Consumer price index and bilateral exchange rate with U.S. dollar are our variable of interest variables. Bearing this in mind we state our baseline model, which includes: World commodity price index (WCPI), output gap (Y^{gap}), broad money supply (M2), nominal effective exchange rate (NEER), and import price index (IPI), it is then possible to estimate the probability that our variable of interest (inflation) is following one of the alternative regimes. This involves identifying where in the probability distribution of each regime the observation falls at each point in time. That is, the likelihood is calculated for each possible state.

International supply shocks could possibly affect domestic inflation and many studies use oil price as a proxy (Ito and Sato, 2007). But, our model use world commodity price index as a proxy for the supply shock. Even if Ethiopia is a bulk importer of oil, but it is also true that Ethiopia is highly dependent on imported intermediate and capital goods. So it would be better if we consider WCPI, because it includes both fuel and non-fuel price indices Helen (2012).

Output gap is defined as difference between actual output and potential output, where potential output is the level of output that is consistent with a stable rate of inflation given the productive stock of capital. A sustained positive output gap is indicative of demand pressures and a signal that inflationary pressures are increasing and that policy may need to be tightened. When actual output lies above the potential output a positive output gap creates excess demand, this makes the economy to operate above its capacity in the short run, and this tends to put upward pressure on price. A level of real output below potential, i.e. a negative output gap, has the opposite implication. Demand shocks are identified from the dynamics of output gap. Potential output and the output gap are not directly observable and estimates have to be inferred from the data. Though output gap has its own weaknesses like data revisions and lags and the end point problem, still it provides a reliable estimate (Neiss and Nelson, 2005).

Hodrick- Prescott filter presents unobserved time trend for time series variable. Firstly, this filter was presented by Hodrick and Prescott (1980) for business cycle analysis, but it was published after 17 years of delay in 1997. It is a simple smoothing procedure and is one of the most commonly used methods to estimate the potential output. The main assumption is that the potential output varies smoothly over time, and as such, this method minimizes a combination of the size of the actual output fluctuations around its trend and the rate of change in the trend output for the sample period. Thus, in essence, the Hodrick- Prescott filter selects the potential output sequence which minimizes the squared difference between actual and potential output subject to the constraint that there is no undue fluctuation in potential output (Hodrick and Prescott, 1980).

As it is stated in the Hodrick and Prescott (1980) the HP filter decomposes a time series in to growth and cyclical components $Y_t = Y_t^* + Y_t^c$, where Y_t is the natural log of GDP, and Y_t^* and Y_t^c are the growth and cyclical components, respectively. This decomposition assumes that a series being de-trended does not contain any seasonality and, because the cycle is derived residually, it does not separate the cycle from any irregular movements. The resulting cycle is therefore measured with error. One of the distinguishing features of the HP filter from other filters is the absence of seasonal component, unlike that of Akaikes.

Applying the HP filter involves minimizing the variance of the cyclical component Y_t^c subject to a penalty for the variation in the second difference of the growth component Y_t^*. This is expressed in the following equation.

Min $\sum_{t=1}^{T}(Y_t - Y_t^*)^2 + \lambda \sum_{t=1}^{T}[(Y_{t+1}^* - Y_t^*) - (Y_t^* - Y_{t-1}^*)]^2$

Where Y_t = natural log of actual output

$Y_t^* =$ Natural log of trend output

$\lambda =$ Determines the degree of smoothness

Monetary policy is an instrument by which central banks control inflationary pressures. More credible monetary policy regimes played an important role to reduce inflation rates and create relative price stability. The degree of exchange rate pass-through depends on central bank's credibility to anchor inflation expectation. An increase in central bank's credibility to fight inflation reduces the exchange rate pass-through. Asayehgn (2010) stated that the main determinants of inflation in Ethiopia are depreciation and increase in broad money supply. Supporting this argument Alemayehu (2011) stated that money supply is the prime source of

inflation in African countries. The inclusion of money supply in to the model therefore is to reflect how the monetary policy reacts to price changes. Therefore, Broad Money (M2), which is a measure of domestic money supply which includes M1 and quasi money (saving and time deposits), is used in the model.

Nominal effective exchange rate (NEER) is used as an exogenous variable instead of the bilateral exchange rate vis-à-vis the US dollar, so that the changes in import costs that would influence the domestic price would be captured better (Ito and Sato 2007). NEER is also preferable than bilateral exchange rate because it captures multilateral trade rather than bilateral trade. The nominal effective exchange rate is defined as a weighted average of the bilateral nominal exchange rates vis-à-vis the trade partner's currency. Since NEER is expressed as a ratio of foreign currency to domestic currency, an increase in NEER explains an appreciation of the domestic currency and a decrease in NEER explains depreciation of the local currency. Therefore, in order to be consistent with nominal exchange rate (NER) definition, this study applies the reciprocal of NEER (1/NEER).

As discussed by Burstein, Eichenbaun and Rebelo (2002, 2005), the extent of CPI inflation after a large devaluation depends on (i) the extent of imported inputs being used for domestic production and (ii) the presence of distribution costs. Therefore, we trace out the response of CPI to the import price index (IPI).

4.2.2 Sources of Data

Quarterly time series data, 1990Q1-2016Q4, is used in this research. Data obtained from the National Bank of Ethiopia (NBE), National Planning Commission (NPC) and International

Financial Statistics (IFS) is used. Monthly data for WCPI, with a base year of 2005, which includes fuel and non-fuel price indices, is obtained from IFS. Monthly data is converted to quarterly data by taking the average of the three months. Import price index is calculated based on the methodology used by NBE staffs (see appendix A.2).

Quarterly data for NER, NEER, CPI and M2 are obtained from NBE. The sample variation of bilateral nominal exchange rate is taken to assess the impact of change in the exchange rate to consumer price inflation. Annual Real GDP is obtained from NBE and converted to quarterly data using Eviews interpolation method. The quarterly data of real GDP is then used to calculate the output gap using the above discussed Hodrick-Presscot filter method.

CHAPTER FIVE

RESULTS AND DISCUSSIONS

This chapter presents and discusses the results of the empirical analysis based on econometric frameworks discussed in the methodology section of this thesis. First stationary tests will be undertaken before the switching model is applied then the results of the FTP and TVTP approaches are presented, respectively. In analyzing the TVTP approach the impact of macroeconomic variables listed in the previous chapter are discussed.

5.1 Stationarity Test

Many economic and financial time series exhibit trending behavior or non Stationarity in the mean. To apply standard estimation or testing procedures in a dynamic time series model, it is typically required that the various variables are stationary, since the majority of econometric theory is built upon the assumption of stationarity. For example, regressing a nonstationary variable Y_t upon a nonstationary variable X_t may lead to a so-called spurious regression, in which estimators and test statistics are misleading, Verbeek (2012). Therefore, a stationary data is the basic requirement for time series analysis.

The standard unit root tests are Dickey-Fuller (DF), Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. But, KPSS is different in the null hypothesis of stationarity. When the true process is I(1) that is first differenced and undergoes Markov switching in both trend growth rate and variance Augmented Dickey-Fuller(ADF) tests have approximately the correct size for almost all combinations of transition probabilities. This demonstrates that studies documenting size distortions from a single break in trend growth and variance do not generalize to multiple, probabilistic breaks. Also, tests robust

to a single break in level over reject the null hypothesis when there is Markov switching in variance. When modeling business cycle asymmetry, an alternative to Markov switching in trend growth rate as in Lam (1990) is to allow for Markov-switching "plucks" in the transitory component of GDP as in Kim and Nelson (1999). The ADF test has good power when these "plucks" occur under the alternative hypothesis. However, the ADF test can be oversized when the regime switching occurs under the null, mainly because the "plucks" increase the contribution of the transitory component to the series. This demonstrates that the true nature of business cycle asymmetry has serious implications for the performance of unit root tests on output series (Nelson et.al, 2001).

For this reason we will conduct stationarity test using the standard Augmented Dickey-Fuller (ADF). Schwarz Information Criterion (SIC) is used for ADF test at 5% level of significance. Table 5.1 presents the ADF test result. The ADF test result shows that Inflation and ERVR are stationary at level also Y^{Gap} is stationary at level at 10% level of significance. The other variables are stationary at first difference.

Table 5.1: Augmented-Dickey-Fuller (ADF) Unit root test result

Variable	Level	First Difference	Critical Value at 5%
Inflation	-9.021**	-11.054	-3.452
ERVR	-10.003**	-6.936	-3.455
LWCPI	-2.357	-7.225	-3.452
LNEER	-2.285	-10.205	-3.452
LIPI	-1.594	-16.842	-3.453
LM2	-0.693	-3.254*	-3.454
Y^{Gap}	-3.249*	-4.707	-3.456

**Stationary at 10% level of significance*

***Stationary at level at 5% level of significance*

5.2 Fixed Transition Probability (FTP) Result

The FTP result is based on equation thirteen ($\Pi_t = \beta_0(s_t) + \beta_1(s_t)\Pi_{t-1} + \beta_2(s_t)\text{ERVR} + u_t$) which serves as a benchmark for our study. Where Π is the inflation rate and ERVR is the exchange rate variability. The result is presented in table 5.2.

Table 5.2: Results of FTP-Markov-Switching Approach

	β_0	β_1	β_2	$\text{Log}(\sigma)$
Regime 1				
Coefficient	0.079	-0.082	-0.020	-2.264
Standard error	0.026	0.291	0.028	0.192
z-statistic	3.095	-0.283	-0.073	-11.776
Probability	0.002	0.776	0.463	0.000
Regime 2				
Coefficient	0.018	0.435	0.021	-3.830
Standard error	0.004	0.092	0.014	0.105
z-statistic	3.906	4.715	1.531	-36.266
Probability	0.000	0.000	0.125	0.000
Durbin-Watson stat	1.967			
Akaike info criterion	-3.598			
Hannan-Quinn criterion	-3.497			
Log likelihood	204.305			

The result shows that characterizing inflation in Ethiopia in two states is correct in the sense that the logarithm of standard deviation (-2.264) in the first regime which we called the high inflation regime is larger than the logarithm of standard deviation (-3.830) of the low inflation regime, regime two. This evidence supports the existence of two regimes for volatility. In addition, the robustness of our model reassured by the state dependent means β_0, which are statistically

different and significant in the two regimes. Moreover, there is an economic and significant difference between their magnitudes. Thus, the first is characterized by a high inflation, with a quarterly inflation intercept of 0.079 and a low inflation regime with a quarterly inflation rate intercept of 0.018 percent with Z-statistic 3.095 and 3.906, respectively, which far exceeds the 5% critical value. In addition intercepts of both regimes are significant with probability of 0.02 and 0.000.

The exchange rate variability coefficient is insignificant in both regimes. Which indicates the response of domestic consumer price inflation to the change in exchange rate between Dollar and Ethiopian birr is insignificant. This is to mean that exchange rate pass-through in Ethiopia is zero. Inflation in Ethiopia is affected by other factors than volatile nominal exchange rate between American Dollar and Ethiopian Birr. These other factors will be briefly discussed in the section that presents the result for time varying transition probability (TVTP). The Taylor (2000) hypothesis which suggests high Pass-through during high inflation and low pass-through during low inflation can be rejected for the Ethiopian case. This is consistent with previous studies. Choudhri and Hakura (2001) found zero pass-through to Ethiopia, Helen (2012) also found a low pass-through of exchange rate to consumer prices.

As Helen (2012), noticed pricing chain could be one of the reasons explaining low degree of pass-through in Ethiopia. Because consumer price is the last to be affected by the change in exchange rate next to import price and producer price, the impact will be less when compared to the other prices. Ito and Sato (2006), explained the indirect effect of exchange rate change on consumer prices relative to import price. Import price is the first to be affected by changes in

exchange rate especially if the price of import is quoted by the exporting country then producers use the imported good as an intermediate input for the production of their goods and services. Along this pricing chain consumer price is the least to be affected by the change in exchange rate.

The other reason that might explain insignificant relationship between Birr per U.S. dollar exchange rate variability and inflation is the composition of consumer price index in Ethiopia. Jema and Fekadu (2012), analyzed determinates of the recent soaring food inflation in Ethiopia and stated that in Ethiopia food price accounts for the lion's share of the Consumer Price Index. Along with this most of food items are domestically produced goods plus they are priced in domestic currency. As a result, they give that; any change in the exchange rate couldn't affect the consumer price inflation in Ethiopia.

The AR (1) coefficient is insignificant in the high inflation regime and significant in the low inflation regime. The intuition behind is that during high inflation regime government will try to combat the problem via different mechanisms; because of this the persistence of high inflation will not last long. On the other hand, low inflation is desirable as long as it did not cause deflationary pressures therefore low inflation regime can stay long and one quarter lagged value of inflation could affect present quarter inflation.

Table 5.3a: Fixed Transition Probability Matrix

	Regime 1	Regime 2
Regime 1	0.639770	0.360230
Regime 2	0.080235	0.919765

The transition matrix shows that the probability of staying in a high and volatile inflation regime at time (t), given that the economy was in the same state at time (t-1), is p=0.639770. The probability of staying in a low and stable inflation regime at time (t), given that the economy was in the same regime at time (t-1) is large, q=0.919765. These probabilities indicate if the economy was in one of the regimes it is likely to remain in such a regime. Relying on this, low inflation regime is more prevalent than high inflation regime. This is in line with the result of the FTP lagged value of inflation in low inflation regime. The probability of transitioning from low inflation regime to high inflation regime is (0.080235) smaller than the probability of transitioning from high inflation to low inflation regime (0.360230). This means the economy quickly bounce back to stable and low inflation regime than to high and volatile inflation regime. Figure 5.1 shows the transition probability from one regime to the other. The flatness of the line implies that the transition probability is fixed. This means the transition probability is not governed by any macroeconomic variables. Results for filtered and smoothed probabilities can be inferred from appendix B.4-C.2.

Fig. 5.1: Fixed Transition Probabilities result

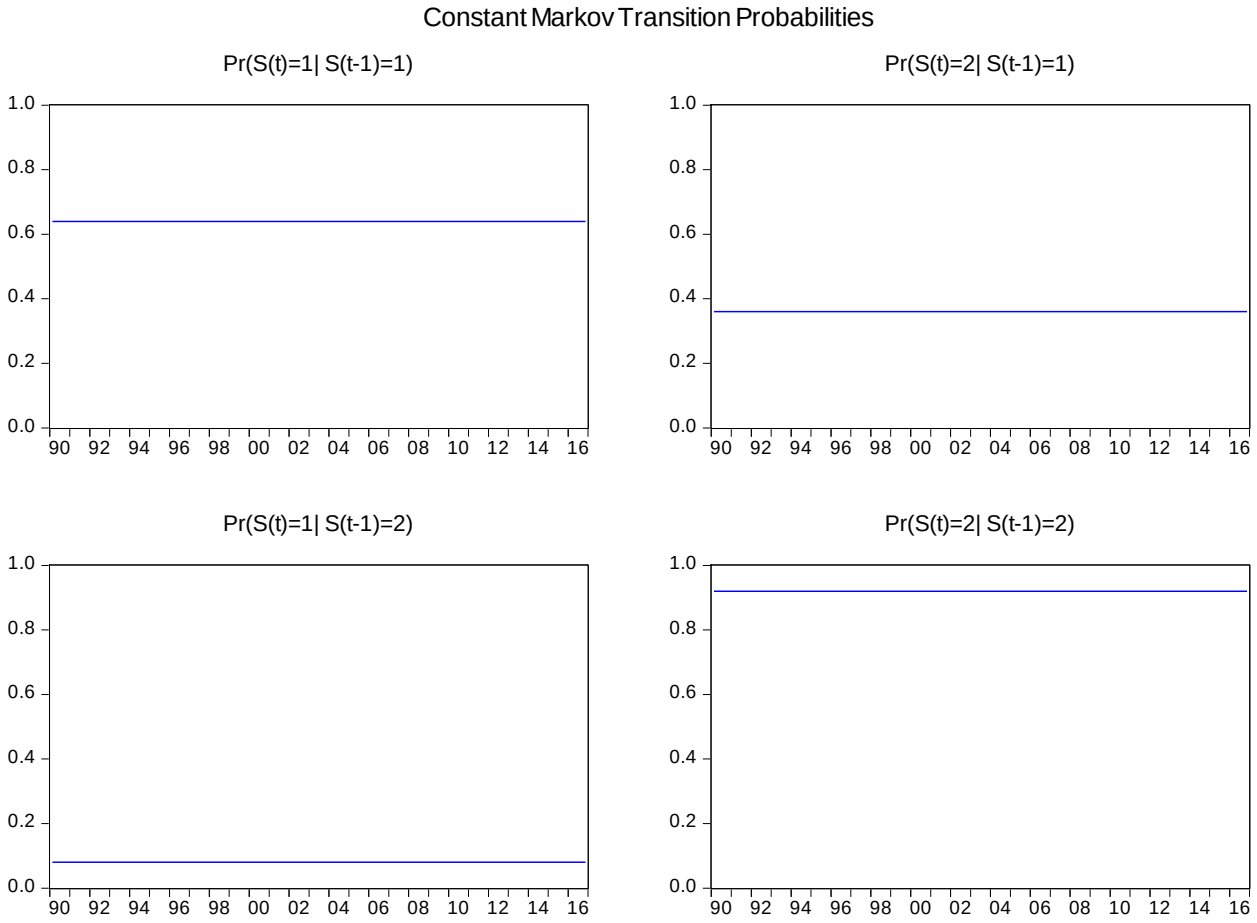


Table 5.3b shows the constant expected duration of both regimes. High inflation regime expected to stay for approximately three quarters and low inflation regime stays for twelve quarters without interruption. Low inflation regime is more prevalent in Ethiopia relative to high inflation.

Table 5.3b: Constant expected durations

Regime 1	Regime 2
2.776001	12.46334

5.3 Time Varying Transition Probability (TVTP)

The extended version of FTP is TVTP. TVTP allows for macroeconomic variables to determine the transition probability from one regime to another regime. So, in addition to the switching regressors which determine the constant (fixed) transition probability, here we will have transition parameters based on which regime probabilities change. Therefore, based on the results of FTP, the basic research focuses on identifying the impact of macroeconomic and policy related variables to highlight the mechanisms underlying the dynamics of inflation in Ethiopia over the period of study.

TVTP instead of being constant like the FTP varies between regimes and the variation in the probability is determined or governed by macroeconomic variables. This fact is presented in Figure 4.2. The transition probabilities are not smooth and there are a lot of up and downs and these up and downs are explained by the macroeconomic variables described.

Figure 5.2: Time Varying Transition Probabilities result

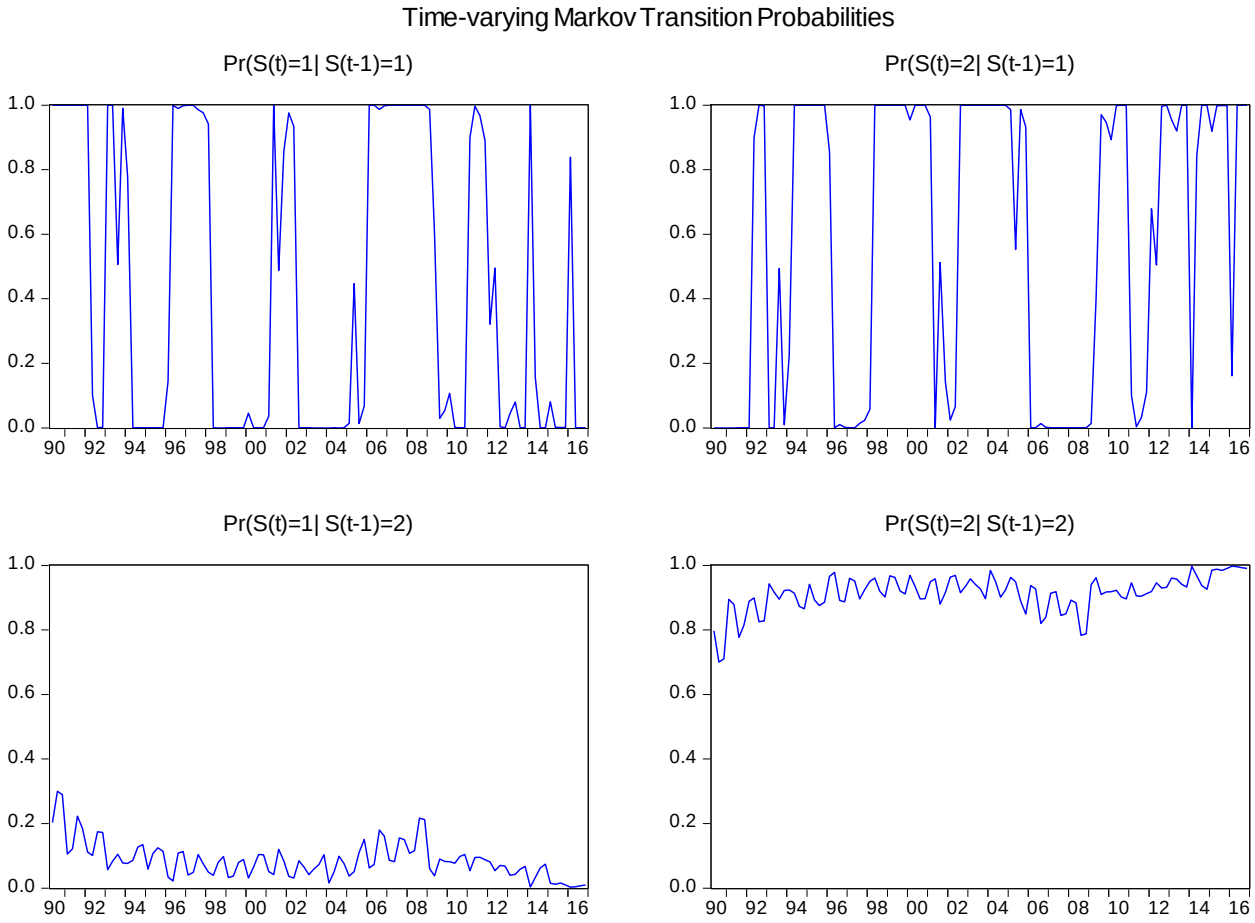


Table 5.4 reports only the TVTP result for regime one because the transition matrix parameter for regime two becomes insignificant other than the regime specific parameters. But the regression result can be found at the appendix. As it can be seen from Table 5.4 the data for all specifications can be split in to two main regimes: a high inflation state with a high volatility and a low inflation regime with low volatility. The exchange rate variability is insignificant for both regimes. The implication is that exchange rate variability does not determine inflation in Ethiopia, which supports the FTP finding. This indicates the robustness of the methodology used because the result is consistent for both FTP and TVTP.

From Table 5.4 we can infer that the inflation intercept for high inflation is 0.077 percent and the inflation intercept for low inflation regime is 0.020 percent with the corresponding Z-statistic of 3.996 and 3.944, respectively, which is far greater than the 5% critical value (1.96). Time Varying Transition Probability estimation is based on equation nineteen and twenty on page 38. The coefficient P_{11} measures the impact of the economic variable in explaining the probability of remaining in the first, high inflation regime $P(S_t = 1/S_{t-1} = 1, I_{t-1})$. The sign of the coefficient is important since it allows us to comment the effect of the variables on staying in the first or second regime (positive sign), or to overbalance to the other regime (negative sign).

Commodity prices are believed to be a deriving factor of inflation for an economy that is a net importer of commodities and local demand for the commodity is significant. This commodity may be an intermediate input, such as oil, or a final good, such as gasoline or food. Therefore, a commodity price shock (CPS) is an inflation shock and has negative effects on income at the same time. For the case of oil inflation rises through the direct effect on the gasoline prices and indirectly through a rises in costs. In addition, an oil price shock is analogous to a negative productivity shock, (Gregorio, 2012). Weather shocks, such as, ElNino can decimate the supply of agricultural products and subsequently increase supply costs. This idea is supported by Brunner (2002) whose analysis indicates that ElNino-Southern Oscillation (ENSO) has economically important and statistically significant effects on world commodity prices. A one-standard-deviation positive surprise in ENSO, for example, raises real commodity price inflation about 3.5 to 4 percentage points. Moreover, ENSO appears to account for almost 20% of commodity price inflation movements over the past several years. ENSO also has some

explanatory power for world consumer price inflation and world economic activity, accounting for about 10% to 20% of movements in those variables.

Table 5.4: Results of TVTP-Markov-Switching Model

	Regime 1			
	Coefficient	Standard error	Z-statistics	Probability
β_0	0.077	0.019	3.996	0.000
β_1	-0.100	0.284	-0.354	0.723
β_2	-0.016	0.053	-0.307	0.758
$\text{Log}(\sigma)$	-2.262	0.197	-11.430	0.000
	Regime 2			
β_0	0.020	0.005	3.944	0.000
β_1	0.448	0.091	4.886	0.000
β_2	-0.004	0.006	-0.642	0.520
$\text{Log}(\sigma)$	-3.821	0.106	-35.950	0.000
Transition Matrix Parameters				
λ_{10}	-279.965	106.480	-2.629	0.008
λ_{11} -LWCPI(-1)	23.154	13.619	1.700	0.089
λ_{12} -Y^{GAP}(-1)	122.428	50.581	2.420	0.015
λ_{13} -LIPI(-1)	9.057	4.657	1.944	0.051
λ_{14} -LNEER(-1)	33.306	13.107	2.541	0.011
λ_{15} -LM2(-1)	-0.607	4.247	-0.143	0.886

WCPI is a combination of Oil and Non-Oil prices. As the sign in Table 5.4 shows WCPI contributes positively to stay in a high and volatile inflation. The probability of being in a high inflation regime given that the previous regime was a high and volatile inflation is positively affected by an increase in the world commodity price. This implies the existence of imported inflation to consumer prices. Helen (2012) found that WCPI explains 9.9 percent of the variation in CPI in the first quarter and increases to 19.5 percent four quarters ahead. A one percent change in WCPI results in to a 23 Percent increase in domestic inflation.

The output gap is a conceptually useful way of thinking about the inflationary pressure coming from the domestic economy. The demand side of the economy is captured by output gap (Y^{Gap}). A way to represent whether the economy is running "hot" or "cold" is to use the output gap. The output gap is the difference between actual output produced in the economy over a given period and the "normal" or "trend" level of output produced in the economy (often called "potential" output) (Citu and Twaddle,2003). Real GDP is decomposed in to potential GDP and the cycle component by using the Hodrick-Presscot filter and output gap is calculated after. Output gap increases the probability of being in high inflation regime in earlier regime and stay in the same state at current regime. A heated economy contributed more to inflationary pressure in the economy. Demand pull inflation is the explaining character here. Excess demand overpasses the available supply and creates a shortage which leads to increase in consumer price.

Import prices, which are based on the Import Price Index (IPI). IPI measures average price changes in goods and services that are imported from abroad. In our model the IPI takes the value of 100 in the year 2011 and inflation is measured from this benchmark (for all other

indices the benchmark year is also 2011). A rise in the index indicates an increase in the price level relative to the base year. Pricing chain reveals that the price of import is the first that transmit imported inflation to domestic economy. IPI is calculated for major import items including Oil. We said earlier that WCPI affect domestic inflation via imported inflation and the prices of imports play a major role in transmitting the effect. A unit percent change in the price of import leads to 9.1 percent increase in consumer price inflation. The probability of remaining in a high and volatile inflation regime, given that the previous state was in the same regime, positively affected by import price.

Most of the debate on the effect of exchange rate on inflation revolves around NEER; even ERPT is analyzed using NEER instead of bilateral exchange rates (Ito and Sato 2006). In our study Nominal Exchange Rate (NER) visa-vis US dollar is used to estimate the pass-through effect. But NEER is considered as an exogenous and a determining variable of the time varying transition probability. This can be considered as an innovation because the methodology enables us to separate the effect of the two variables and clearly show their impact on consumer price inflation. An increase in NEER is defined as a depreciation of the exchange rate. Accordingly an increase in NEER or depreciation contributes positively to stay in a high inflation probability regime. A one percent increase in NEER increases inflation by 33.4 percent. This result evidenced that ERPT is better captured by NEER than NER.

Monetary policy effectiveness differs significantly in different countries. As a consequence, there is no reason to expect that mechanisms of monetary transmission in low-income countries would be similar to those that have been found to operate in high-income ones. The channel through which monetary policy affects aggregate demand depends on a country's financial

structure. Relevant factors include the extent of the country's links with external financial markets, its exchange rate regime, the size and composition of its formal financial sector, the degree of development of its money, bond, and stock markets, the liquidity of its markets for real assets such as housing, and both the costs to its banks of doing business as well as the competitive environment in its banking sector. Indeed, in contrast with results for high-income countries, careful studies of the effectiveness of monetary transmission in low-income countries have often found monetary policy effects that are counterintuitive, weak, and/or unreliable, (Mishra et.al, 2016)

The phenomenon of "Missing Money" (money supply increased fast, but did not lead to inflation) in the U.S. since the 1990's increased. In recent years, a similar phenomenon seems to appear in some developing countries such as China from 2009 to 2013, with moderate inflation rate accompanied by hyper monetary supply and time delay, which became increasingly obviously (Cao, 2015).

When Cao (2015) explains this the continuing slow movement of velocity of money could be the reason behind. If we measure the velocity of money with GDP/M (M, the money supply) in the case of nominal M increase, velocity of money certainly will be smaller. However, this explanation is far from the truth in most situations. In fact, the velocity of money continues to increase, capital flows are faster, capital markets are more efficient, inventory turnovers improves, personal loan balances increases and electronic means of payment develop. But in the Ethiopian case the above mentioned factors are not well developed, therefore slow movement of velocity of money might be a sound reason in the short run. In addition money supply leakage could also weaken the correlation between money supply and CPI. In such cases excess money

supply does not enter in to the real economy, but, instead, flows to capital market or overseas. Even if, flows to capital market might not seem reasonable flows to overseas and corruption can be a significant problem for Ethiopia.

The higher the degree of financial integration (the degree to which the economy does not restrict cross-border financial transaction) the greater the extent to which exchange rate changes reinforce the effects of interest rate changes on aggregate demand, and therefore the stronger the monetary transmission mechanism, Mishra et.al (2016). Since, Ethiopia has a weak monetary transmission more generally (IMF, 2015) and low degree of financial integration the passing of international monetary and financial scenarios in to the domestic demand is limited.

In Ethiopia, Teshome (2011) who studied the source of inflation and economic growth in Ethiopia using statistical analysis supported the above assertions. According to him, between the year 2004 and 2008 the higher desires to spend and higher import price with slow growth of aggregate supply contributed to inflation in the country. He states that, inflation in Ethiopia is not a monetary phenomenon, and to him controlling money supply to reduce inflation will hinder growth of the economy. In addition to this, stopping the injection of money to the economy cannot stop inflation due to high velocity of money caused by growth of financial institution and economic transaction in the economy. The finding of Helen (2012) using the CVAR approach shows that the Sign of M2 is negative and insignificant in determining inflation. These results support the finding of this paper. M2 is negatively signed and insignificant in determining the probability of staying in a high inflation regime given that the previous regime is high inflation regime.

CHAPTER SIX

CONCLUSION AND POLICY IMPLICATION

6.1 Conclusion

Exchange rate variability (ERVR) and its impact on the consumer price inflation in Ethiopia along with other macroeconomic determinants of inflation were examined theoretically and empirically in this paper. To this effect, data covering period between 1990Q1-2016Q4 are under investigation. We saw different literatures, theoretical and empirical, that study the exchange rate pass-through to inflation in different scenarios conducted for both developed and developing countries including Ethiopia. Most of the studies that examine the Ethiopian ERPT to consumer price inflation conclude that it is incomplete.

In chapter three we presented the macroeconomic overview for Ethiopia. Gross domestic product (GDP) growth, monetary development, development in consumer price (CPI), which is used to calculate inflation, and exchange rate movements were examined. It was implied that the Ethiopian economy continued to grow by 8 percent in 2015/16 annually in addition broad money supply also keep increasing relative to excess reserves of commercial banks which is declining. Relatively, consumer price inflation shows a small decrement due to the lowering of world oil price and global slowdown in commodity prices. Finally, we saw exchange rate movements and both nominal exchange rate (birr per dollar) and nominal effective exchange rate (NEER) keep declining relative to the appreciated real effective exchange rate (REER). The relationship between nominal effective exchange rate with inflation also examined and graphic presentation shows that inflation increases when NEER increases.

Mainly Markov-Switching methodology applied to assess the pass-through effect of exchange rate variability on inflation. We used Fixed Transition Probability (FTP) and Time Varying Transition probability-Markov-switching approaches for our analysis. The FTP was our base model to initially investigate the relationship between variation in nominal exchange rate (ERVR) and inflation. TVTP used to identify those macroeconomic variables that determine inflation. Therefore, we investigated the existence of a relationship between pass-through and inflation. We also examined those macroeconomic variables that govern the transition probability in the time varying transition probability.

The empirical findings reveal the fact that nominal exchange rate changes do not cause or contribute to inflationary changes in Ethiopia in both the fixed transition probability and time varying transition probability. Nominal exchange rate variability has found to be insignificant in both estimation methods. But Nominal Effective Exchange changes cause a positive change in inflation. This enables us to conclude that inflation in Ethiopia better explained by changes in NEER rather than by changes in NER between U.S. dollar and ETB. Ito and Sato (2006) explained this idea in the sense that, since NEER is a weighted average of more than one currency it can capture better the change in domestic currency against other currencies.

When we analyzed the TVTP World Commodity Price (WCPI), Import Price (IPI), and Output Gap (Y^{Gap}) were found to have a positive relationship with inflation. They contribute positively to stay in a high and volatile inflation regime. WCPI which is a combination of oil and non-oil prices captures the international supply shock and confirms the existence of imported inflation and a change in the consumer price inflation can be determined by international price changes. IPI as being the first to be affected by international price changes significantly transfer the

imported inflation to domestic economy. Domestic demand side represented by Y^{Gap} conforms to the standard theory of an increase in domestic demand leads to overheated economy and then to inflationary pressure in the country when actual output exceeds the potential economy.

Broad Money Supply (M2) becomes negative and insignificant in determining the transition probability in the high inflation regime. Because of the weak monetary transmission in low income countries and low degree of financial integration with the rest of the world the effectiveness of monetary policy in developing countries differ from those of developed countries Mishra et.al (2016). The occurrence of missing money (money supply increased fast, but did not lead to inflation) in China evidenced that monetary policy might not work as well in developing countries. Based on this Cao (2015) explained the slow move of velocity of money could be the reason for missing Money. Money supply leakage could also be the reason for money supply ineffectiveness. In Ethiopia the finding of Teshome (2011) and Helen (2012) supported the insignificance of money supply in determining inflation.

6.2 Policy Implication

Based on our finding the following policy implications have been drawn:

Nominal Effective Exchange Rate (NEER) should be given emphasis in measuring any impacts of exchange rate movements to inflation in Ethiopia instead of bilateral Nominal Exchange rate (NER). Therefore, our finding suggests that ERPT is a phenomenon of NEER not NER. Ethiopia needs to continue to improve domestic competitiveness, benefitting from policies and investments that support private and financial sector development in this area. To halt the problem of imported inflation from World Commodity Price (WCPI) and Import Price (IPI) both import substitution and export promotion strategies should be employed. Import substitution minimizes the cost and amount of imports. Export promotion enhances our competitiveness and help to increase the volume and value of export and then depreciation will no more be our problem rather our strategy to boost the trade balance and avoid inflation due to exchange rate changes.

Since the probability of being and staying in a high inflation regime is insignificantly affected by broad money supply, using monetary policy to stabilizing instrument is not far from idea. Conditions for effective monetary policy include the use of interest rates to allocate savings and credit, and smoothly functioning secondary markets to influence the value of key financial indicators such as the interbank interest rate. Integration with international markets influences the arbitrage between domestic and foreign financial assets.

In addition, with the existing setting of ineffective monetary policy attention should be given to other domestic stabilizing instruments like narrowing the output gap to avoid demand pull inflation. As the coefficient of the output gap indicates excess demand leads to increased

inflation. To tackle the soaring of inflation domestic supply must be maximized, for example, through cooperatives.

Finally the methodology used in this paper better characterize inflation in Ethiopia and it used to capture ERPT. The Taylor hypothesis is also tested in a better way using both the FTP and TVTP. Having two inflation regime of high and low in combination with exchange rate variability cop up with the Taylor (2000) hypothesis that low inflation lead to lower pass-through and high inflation lead to high pass-through. Future research using Markov-switching in combination with other methodologies such as VAR and ARDL would give a paramount result to study ERPT.

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APPENDICES

Appendix A.1: Inflation (π_t) is constructed (based on NBE method of calculation) as:

$$\pi_t = \left(\frac{CPI_t}{CPI_{t-1}}\right) - 1$$

Where, CPI_t and CPI_{t-1} are consumer price index at time (t) and at time (t-1)

Appendix A.2: Derivation of Import Price Index (IPI) (based on NBE method of calculation) as:

Unit Price (UP) of each commodity (i) at time (t)

$$UP_{i,t} = \frac{VA_{i,t}}{VO_{i,t}}$$

Where $VA_{i,t}$ and $VO_{i,t}$ are the value and volume of commodity (i) at time (t) respectively.

Then the Unit Price Index (UPI) of commodity (i) at time (t)

$$UPI_{i,t} = \frac{UP_{i,t}}{BP_{i,s}} \times 100$$

Where $BP_{i,s}$ is the base year price at time (s)

The weight (W) of each commodity (i) relative to the total commodity at time (t)

$$W_{i,t} = \frac{VA_{i,t}}{\sum_{i=1}^{n} VA_{i,t}}$$

Finally, the overall Import Price Index will be:

$$IPI = \sum_{i=1}^{n} W_{i,t}\, UPI_{i,t}$$

Note: To construct the index the value and volume of; Food and Live Animals, Beverages, Tobacco, Petroleum Products, Chemicals, Fertilizers, Medical and Pharmaceutical Products, Soap and Polish, Rubber Products, Paper and Paper Manufacturing, Textiles, Clothing, Glass and Glass ware, Metal and Metal Manufacturing, Machinery and Aircraft, Road motor vehicles, Electrical materials, Grain, and Telecommunication Apparatus obtained from NBE used.

Appendix B.1: FTP Result

Dependent Variable: INFLATION
Method: Markov Switching Regression (BFGS / Marquardt steps)
Date: 05/27/17 Time: 21:58
Sample: 1990Q1 2016Q4
Included observations: 108
Number of states: 2
Initial probabilities obtained from ergodic solution
Standard errors & covariance computed using observed Hessian
Random search: 25 starting values with 10 iterations using 1 standard deviation (rng=kn, seed=1017679684)
Convergence achieved after 6 iterations

Variable	Coefficient	Std. Error	z-Statistic	Prob.
		Regime 1		
C	0.079763	0.025766	3.095604	0.0020
ERVR	-0.020408	0.027819	-0.733605	0.4632
AR(1)	-0.082683	0.291552	-0.283597	0.7767
LOG(SIGMA)	-2.264530	0.192298	-11.77612	0.0000
		Regime 2		
C	0.018999	0.004863	3.906699	0.0001
ERVR	0.021668	0.014147	1.531625	0.1256
AR(1)	0.435779	0.092404	4.716037	0.0000
LOG(SIGMA)	-3.830852	0.105629	-36.26690	0.0000
		Transition Matrix Parameters		
P11-C	0.574339	0.555068	1.034718	0.3008
P21-C	-2.439074	0.494536	-4.932042	0.0000

Mean dependent var	0.023929	S.D. dependent var	0.052197
S.E. of regression	0.056192	Sum squared resid	0.315752
Durbin-Watson stat	1.967344	Log likelihood	204.3055
Akaike info criterion	-3.598249	Schwarz criterion	-3.349904
Hannan-Quinn criter.	-3.497554		

1: Inverted AR Roots	-.08
2: Inverted AR Roots	.44

Appendix B.2: TVTP Result

Dependent Variable: INFLATION

Method: Markov Switching Regression (BFGS / Marquardt steps)

Date: 05/27/17 Time: 21:56

Sample (adjusted): 1990Q2 2016Q4

Included observations: 107 after adjustments

Number of states: 2

Initial probabilities obtained from ergodic solution

Standard errors & covariance computed using observed Hessian

Random search: 25 starting values with 10 iterations using 1 standard deviation (rng=kn, seed=2071601035)

Convergence achieved after 122 iterations

Variable	Coefficient	Std. Error	z-Statistic	Prob.
		Regime 1		
C	0.077714	0.019447	3.996256	0.0001
ERVR	-0.016521	0.053745	-0.307390	0.7585
AR(1)	-0.100805	0.284365	-0.354492	0.7230
LOG(SIGMA)	-2.262378	0.197915	-11.43108	0.0000
		Regime 2		
C	0.020014	0.005075	3.944043	0.0001
ERVR	-0.004096	0.006377	-0.642260	0.5207
AR(1)	0.448827	0.091843	4.886874	0.0000
LOG(SIGMA)	-3.821723	0.106304	-35.95099	0.0000
		Transition Matrix Parameters		
P11-C	-279.7404	106.4815	-2.627126	0.0086
P11-LNWCPI(-1)	23.14333	13.61691	1.699602	0.0892
P11-Y_GAP(-1)	122.3625	50.57544	2.419406	0.0155
P11-LNIPI(-1)	9.053334	4.657120	1.943977	0.0519
P11-LNNEER(-1)	33.28429	13.10750	2.539331	0.0111
P11-LNM2(-1)	-0.609794	4.245951	-0.143618	0.8858
P21-C	-3.163975	6.109836	-0.517849	0.6046
P21-LNWCPI(-1)	1.514381	2.038403	0.742925	0.4575
P21-Y_GAP(-1)	-0.284609	5.268849	-0.054017	0.9569
P21-LNIPI(-1)	-0.943601	1.311240	-0.719625	0.4718
P21-LNNEER(-1)	0.460324	0.970160	0.474483	0.6352
P21-LNM2(-1)	-0.176767	0.585745	-0.301782	0.7628

Mean dependent var	0.024153	S.D. dependent var	0.052391
S.E. of regression	0.052179	Sum squared resid	0.272269
Durbin-Watson stat	2.176812	Log likelihood	208.5145
Akaike info criterion	-3.491009	Schwarz criterion	-2.994318
Hannan-Quinn criter.	-3.289619		

1: Inverted AR Roots	-.10
2: Inverted AR Roots	.45

Appendix B.3: TVTP Transition Probabilities and expected duration Result

Equation: FINAL_RESULT

Date: 05/28/17 Time: 00:44

Transition summary: Time-varying Markov transition probabilities and expected durations

Sample (adjusted): 1990Q2 2016Q4

Included observations: 107 after adjustments

Time-varying transition probabilities:

P(i, k) = P(s(t) = k | s(t-1) = i)

(row = i / column = j)

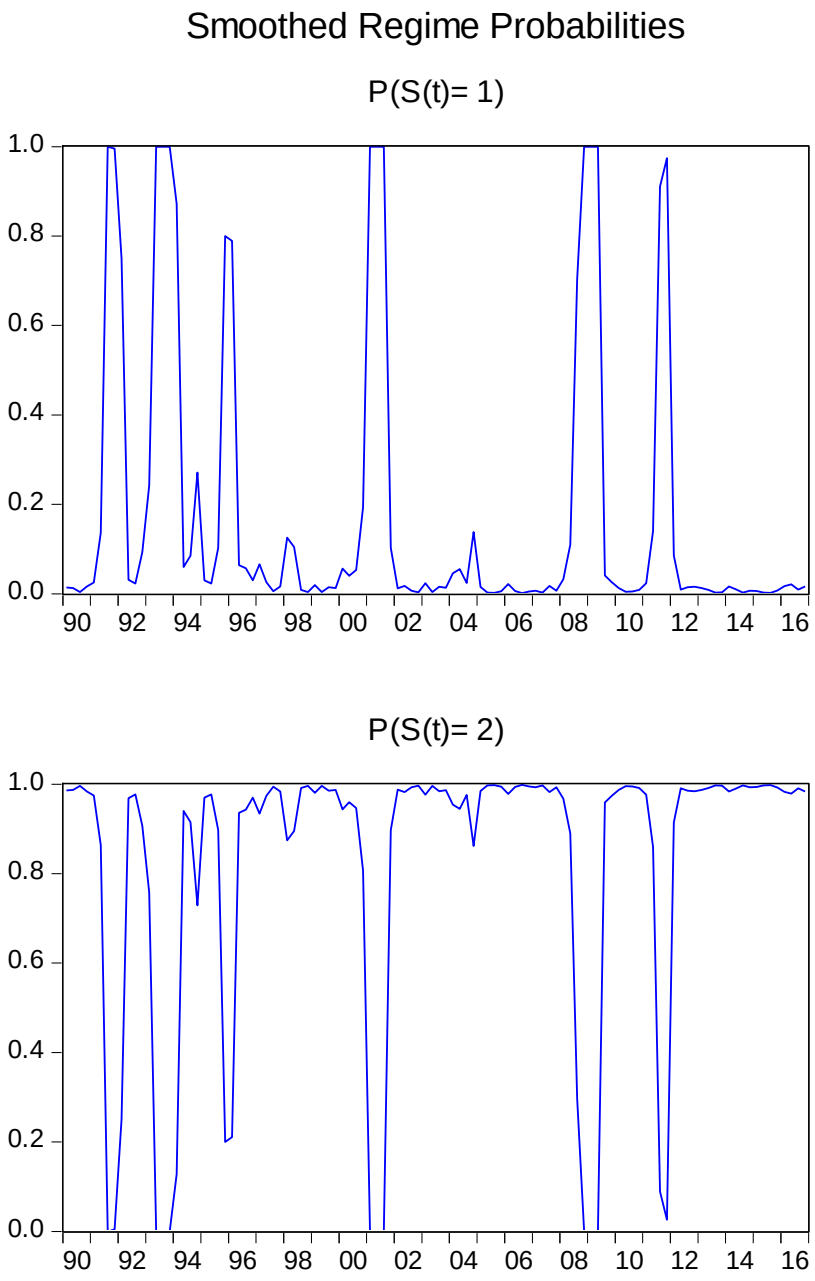
		1	2
Mean	1	0.428383	0.571617
	2	0.085723	0.914277

		1	2
Std. Dev.	1	0.465439	0.465439
	2	0.056393	0.056393

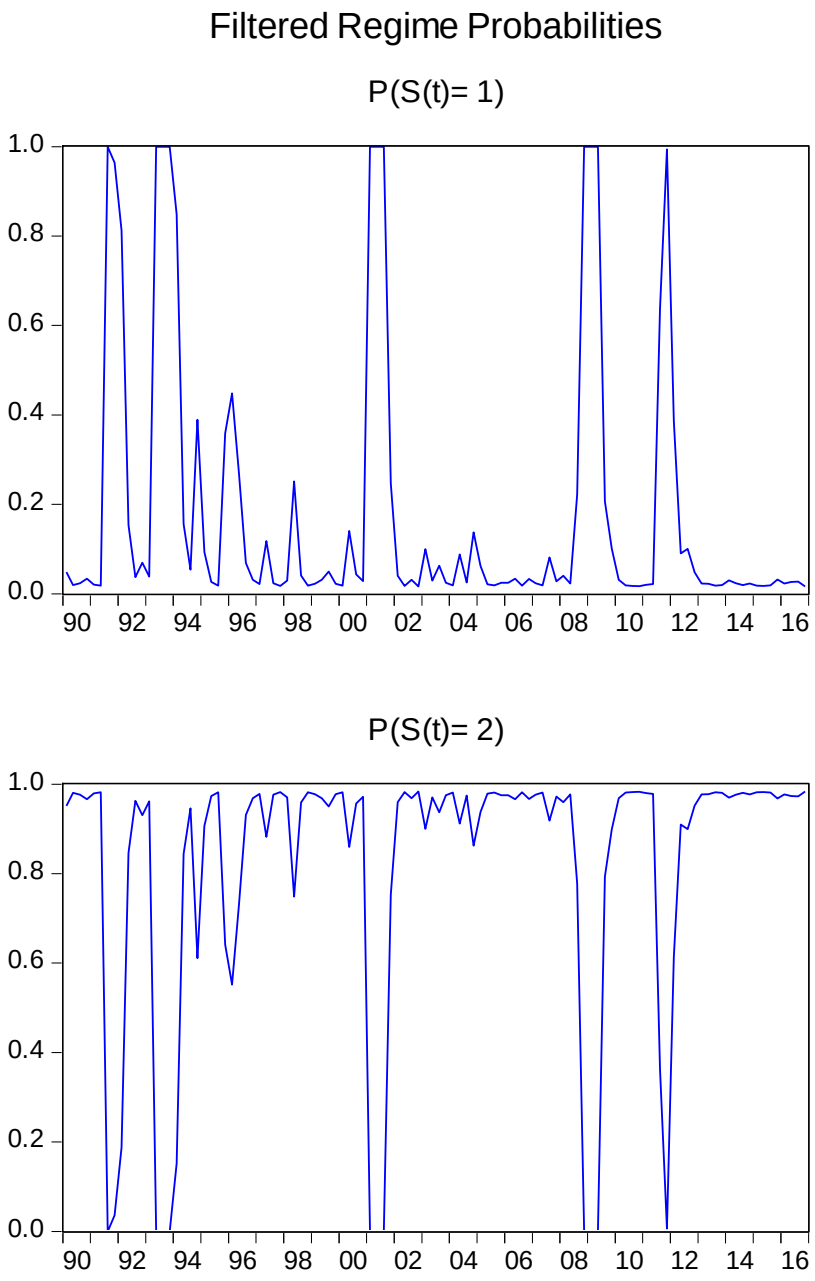
Time-varying expected durations:

	1	2
Mean	NA	27.48975
Std. Dev.	NA	55.11305

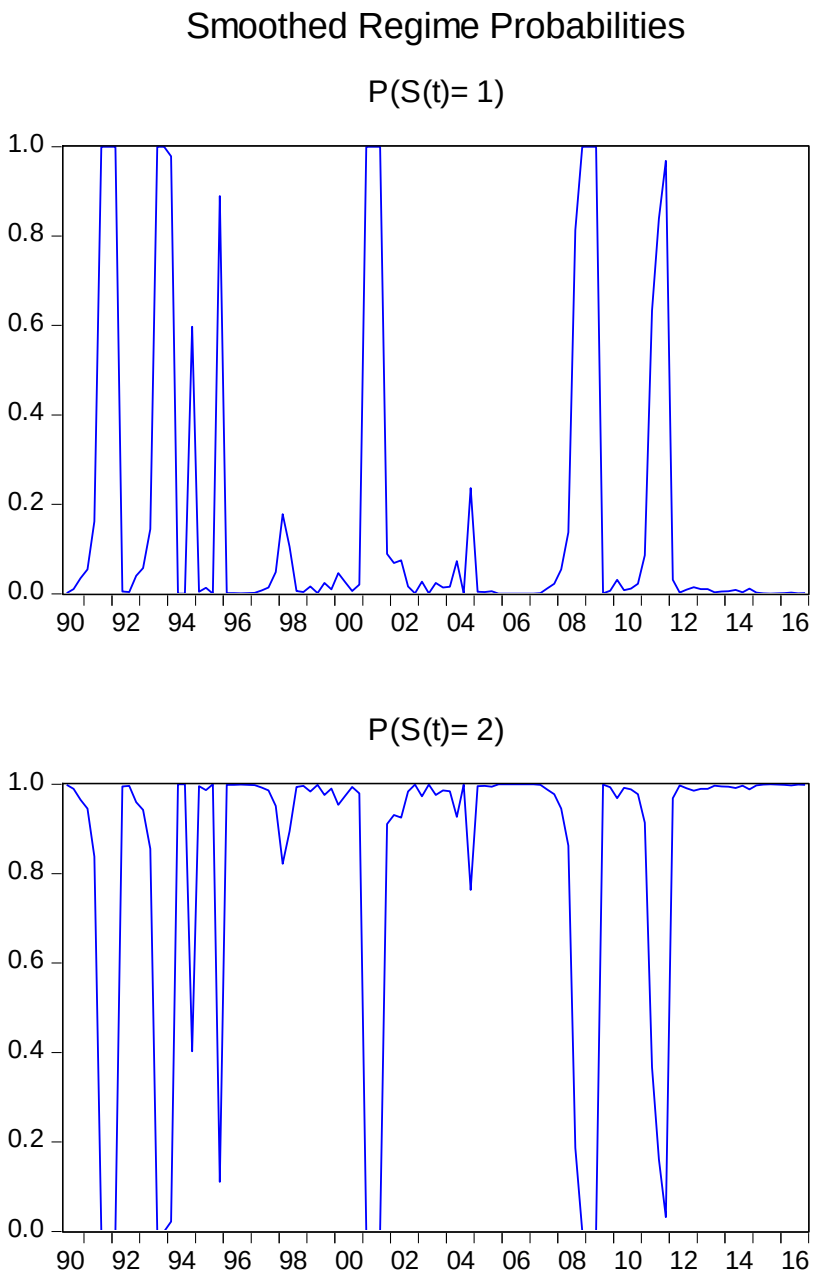
Appendix B.4: FTP-Smoothed Probability



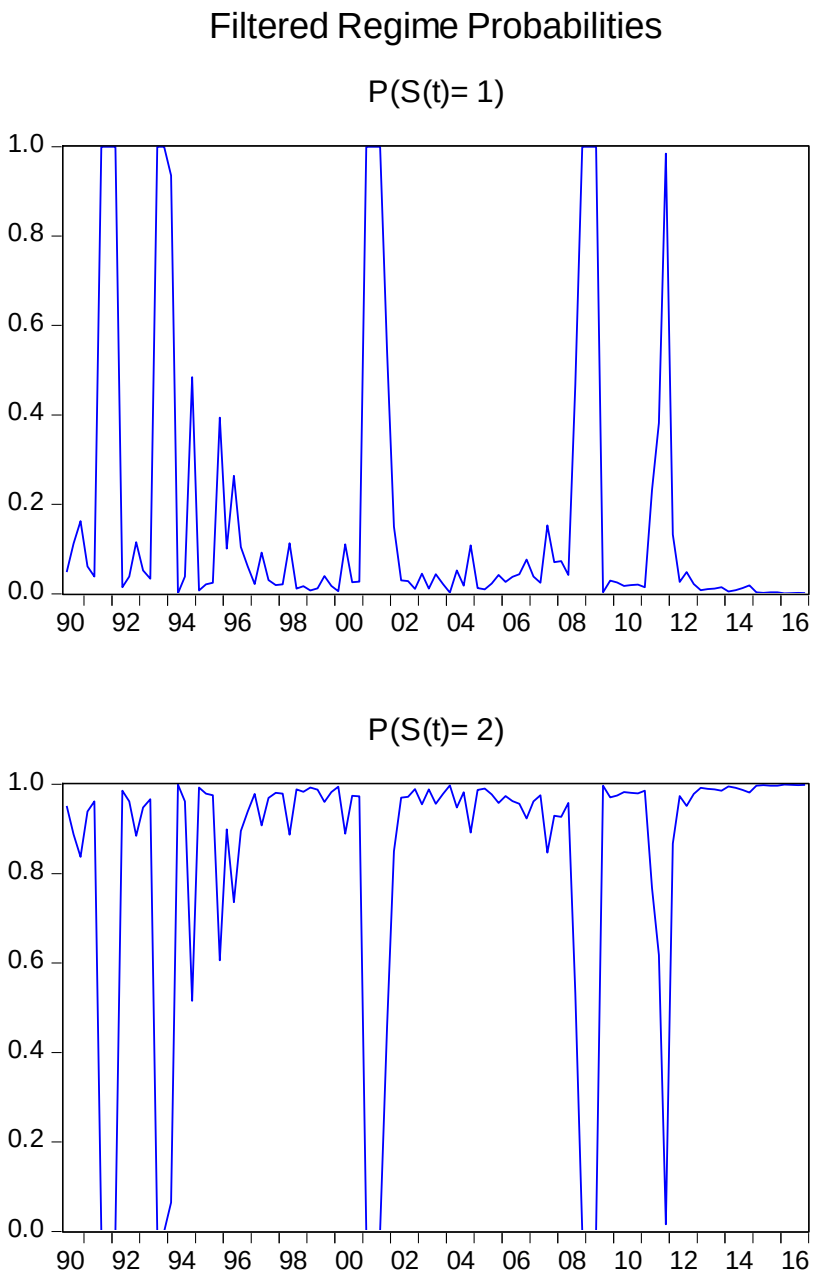
Appendix B.5: FTP-Filtered Probability



Appendix C.1: TVTP-Smoothed Probability



Appendix C.2: TVTP-Filtered Probability



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 duly incorporated.

Declared by:

Name: Biniyam Kassa Zerfu

Signature: _____

Date: _____

Confirmed by Adviser:

Name: Sisay Regassa (Ph.D.)

Signature: _____

Date: _____

Place and date of submission: _____