ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

EXCHANGE RATE PASS-THROUGH TO IMPORT AND CONSUMER PRICES: EVIDENCE FROM ETHIOPIA

By: HELEN BERGA

June, 2012

ADDIS ABABA, ETHIOPIA

Exchange Rate Pass-Through to Import and Consumer Prices: Evidence from Ethiopia

Helen Berga

A Thesis Submitted to the of Department of Economics

Presented in Partial Fulfillment of the Requirements for the

Degree of Master of Science in Economics (International Economics)

Addis Ababa University

Addis Ababa, Ethiopia

June, 2012

Addis Ababa University

School of Graduate Studies

This is to certify that the thesis prepared by Helen Berga entitled: *Exchange Rate Pass-Through to Import and Consumer Prices: Evidence from Ethiopia* and submitted in partial fulfillment of the requirements of the Degree of Masters of Science in Economics (International Economics) complies with the regulations of the university and meets the accepted standards with respected originality and quality.

Signed by the Examining committee:

Examiner _____ Signature _____ Date _____

Examiner _____ Signature _____ Date _____

Advisor _____ Signature _____ Date _____

_____

Chair of Department or Graduate Program Coordinator

Abstract

Exchange Rate Pass-Through to Import and Consumer Prices: Evidence from Ethiopia

Helen Berga

Addis Ababa University, 2012

The fact that Ethiopia adopted managed floating exchange rate policy since 1992 as well as various trade reform measures taken makes the country's import and consumer prices susceptible to the effects of exchange rate movements. Thus, the study investigates the degree of ERPT and its asymmetry to import and consumer prices in Ethiopia between 1991/92 and 2010/11 using two types of VAR models (SVAR and CVAR). Based on SVAR analysis the paper found that ERPT in Ethiopia during the period under review is moderate, significant and persistent in the case of import price and low and short lived in the case of consumer prices. The cointegration analysis shows incomplete ERPT to import price and absence of pass-through to consumer price in the long run. The result obtained from the asymmetric model suggests that ERPT to import prices is higher in periods of Birr depreciation than appreciation. Also, pass-through to import prices is found to be higher in periods of small changes than large changes in the exchange rate. The study also tries to get pass-through estimates in different inflation environments in order to test Taylor's hypothesis. However, no evidence is found which supports the hypothesis in the case of Ethiopia. The fact that ERPT was found to be incomplete has useful implication to policymakers, especially in the design and implementation of exchange rate and monetary policy.

ACKNOLEDGMENTS

First of all, my deepest thanks go to the Almighty God who helps me to finish this paper.

In the second place I would like to extend my most profound gratitude to my advisor Dr. Assefa Admassie who gave me good suggestions and constructive comments for this research paper by reviewing each and every point thoroughly devoting his precious time.

I am also grateful for the financial support from the African Economic Research Consortium (AERC) which is was very helpful to pursue and complete this program. I also wish to thank the staff members of School of Economics, Addis Ababa University for their assistance and good approach.

I am also indebted to my family, for their financial, material and moral support, which were very helpful for the completion of this paper. I also want to thank my friends who made substantial contribution for this research paper.

Finally my special thanks and appreciation goes to the employees of National bank of Ethiopia (NBE), Ministry of Finance and Economic development (MOFED) and Central Statistical Authority (CSA) for their good response and cooperation.

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

Acronyms and Abbreviations

ADF: Augmented Dickey-Fuller

AIC: Akaike information criterion

BOP: Balance of Payment

CPI: Consumer Price Index

CSA: Central Statistical Authority

CVAR: Cointegrated Vector Autoregression

DSGE: Dynamic Stochastic General Equilibrium Models

EEA: Ethiopian Economic Association

ERPT: Exchange Rate Pass-Through

GDP: Gross Domestic Product

HP: Hodrick Prescott filter

HQIC: Hannan-Quinn information criterion

IC: Information criteria

IFS: International Financial Statistics

KPSS: Kwiatkowski, Phillips, Schmidt and Shin

LCP: Local Currency Pricing

LOP: Law of One Price

LR: Likelihood Ratio Test

M2: Broad Money Supply

MoARD: Ministry of Agriculture and Rural Development

MOFED: Ministry of Finance and Economic Development

MPI: Import Price Index

NBE: National Bank of Ethiopia

NEER: Nominal Effective Exchange Rate

NOEM: New Open Economy Macroeconomics

PCP: Producer Currency Pricing

PP: Phillips-Perron

PPP: Purchasing Power Parity

PTM: Pricing-to-market

SBIC: Schwarz's Bayesian information criterion

SAP: Structural Adjustment Program

SVAR: Structural Vector Autoregression

VAR: Vector Autoregression

VECM: Vector Error correction model

VD: Variance Decomposition

WCPI: World Commodity Price Index

1. INTRODUCTION

The degree to which exchange rate movements are passed-through to import and domestic prices holds a central place in international finance and is a much-debated question among policy makers. In fact, a large body of theoretical and empirical research shows that the degree of exchange rate pass-through has important implications for the timing of current account adjustment (Krugman and Obstfeld, 2003), the conduct of monetary policy (e.g., Adolfson, 2001; Smets and Wouters, 2002; Corsetti and Pesenti, 2001; Gagnon and Ihirg, 2004 and Monacelli, 2005), the choice of exchange rate regime and the international transmission of shocks (see, Engel, 2002; Devereux and Engel, 2003; Betts and Devereux, 2001 cited in Bouakez and Rebei, 2006).

Exchange rate pass-through (ERPT) is defined as the change in prices caused by the change in nominal exchange rate. In particular, the percentage by which import, export or domestic prices change when the home currency changes by one percent is called the degree of ERPT. A one-to-one response of prices to exchange rate changes is known as complete ERPT while a less than one-to-one response is known as incomplete ERPT. According to Garcia and Restrepo (2001), the pass-through effect operates broadly through three basic channels: (1) a direct effect through prices of imported goods in the CPI; (2) an effect through prices of imported intermediate goods; and (3) an effect through price setting and expectations which includes the expected responses of monetary policy.

The concept of ERPT has been well known for economists for a long time though it has attracted significant interest after the plaza accord of 1985[1]. After the accord the Japanese yen has been highly appreciated with respect to the US dollar and it was expected that the price of Japanese import in US dollar would be expensive. However, it was observed that the price of Japanese cars and electronic items sold in the US rose only slightly or remained unchanged and in some cases actually declined (Goldberg and Knetter, 1997). Given this important empirical observation, economists began trying to estimate the extent of ERPT as well as its determinants and the corresponding pricing-to-market behavior (Ghosh and Rajan, 2006).

Traditional open-economy macroeconomic models paid little attention to pass-through, given that in such models markets are characterized by perfect competition, prices are assumed to be fully flexible, and purchasing power parity (PPP) holds at all times, implying that ERPT is complete and immediate. There is however, a lot of empirical evidence[2] that indicate changes in nominal exchange rates affect import prices only in incomplete and gradual manner. In response to these, the new open economy macroeconomics (NOEM) literature, based mainly on work by Obstfeld and Rogoff (1995), introduced nominal rigidities and market imperfections into a dynamic-equilibrium open-economy model with well-specified microfoundations. Although PPP

[1] It was an agreement between the governments of France, West Germany, Japan, the United States and United Kingdom to depreciate the US dollar in relation to the Japanese yen and German Deutsche Mark

[2] See, e.g., Campa and Goldberg, 2005; Bailliu and Fujii, 2004; Gagnon and Ihrig, 2004; Bouakez and Rebei, 2008; Choudhri and Hakura, 2001

holds and pass-through is complete in the framework originally presented by Obstfeld and Rogoff, Betts and Devereux (1996, 2000) extended this model to allow for pricing to market, and therefore incomplete pass-through (Bailliu and Fuji, 2004:4).

Although ERPT process is a feature of mainstream open-economy macroeconomic models, until very recently, most of the research in this area was more microeconomic in nature. The micro literature on ERPT analyzes the degree of pass though on firm or industrial level and proposes imperfect competition (such as product differentiation), and firms' behavior of pricing to market as explanation for the occurrence of incomplete pass through. For instance, Yang (1997) and Bacchetta and van Wincoop (2002) show that more differentiated goods may be characterized by higher market power and therefore higher pass-through. In contrast, Campa and Goldberg (2002) found that more differentiated products are characterized by lower pass-through mainly because they involve higher markups and hence higher scope for pricing-to-market.

In recent times however, pass-through has been examined from 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. The idea that pass-through is related to "macro" variables that are directly associated with monetary policy such as inflationary environment was primarily proposed by Taylor (2000). According to his hypothesis, responsiveness of prices to exchange rate fluctuations depends positively on inflation. More specifically, Taylor (2000) argued that a shift to a low-inflation environment causes a decline in the expected persistence of cost and price changes, which in turn results in a decline in ERPT.

Another strand of literature on ERPT explores whether it is symmetric or asymmetric. The different response of prices to the direction and size of exchange rate changes is generally referred to as asymmetric or nonlinear price adjustment (Pollard and Coughlin, 2004). Until recently, the existing empirical research assumed a symmetric long-run relationship between the price level and the exchange rate. It was presumed that appreciations and depreciations and large and small changes in exchange rate are transmitted in the same magnitude to the final price. However well documented downward price rigidities, both at macroeconomic and microeconomic levels make the hypothesis of a symmetric pass-through unrealistic and too restrictive (Delatte and López-Villavicencio, 2010).

Even though there is an extensive empirical literature on ERPT in the case of developed and emerging countries, very few studies have looked at this issue from the perspective of developing countries. However, for developing economies like Ethiopia who import large amount goods and services from abroad, the investigation of ERPT on import and consumer prices is an important issue. This is because the level of ERPT is an approximation of international macroeconomic transmission and thus has implications for the timing current account adjustment and that of monetary policy intervention. The degree and speed of pass-through is important for forecasting inflation and formulating monetary policy responses to inflation shocks. Furthermore, the issue of pass-through asymmetry is very crucial for the conduct of monetary policy. Therefore, the main purpose of this study is to examine the degree of ERPT and its asymmetry in the case of Ethiopia.

1.1 Statement of the Problem

One of the most crucial issues in small open economies like Ethiopia is ERPT. The concept of ERPT holds a central place in international finance and monetary policy where the former is concerned about the role of ERPT in determining the adjustment mechanism of international prices which in turn influence the adjustment of balance of payment (BOP). Regarding monetary policymakers (central banks), they are primarily interested in the extent and timing of ERPT as a key ingredient of monetary policy and forecasting inflation (Frimpong and Adam, 2010).

The degree of ERPT has important implications for expenditure switching effect and hence current account adjustment, which results from the exchange rate movements. If the degree of pass-through is high, the exchange rate changes will change the relative prices of tradables and non-tradables, so that the adjustments in trade balances will be relatively prompt (Ito and Sato, 2006). However, if the degree of pass-through is low, the expenditure switching effect will be dampened due to the low responsiveness of import prices (and hence trade volumes), which thus takes longer time for trade balance to adjust (Krugman and obstfeld, 2003). Furthermore, if domestic prices in general respond to the nominal exchange rate depreciation one-to-one (i.e. pass-through is not only to import prices but to CPI in general), then any export competitiveness from nominal depreciation would be cancelled out. A combination of nominal depreciation and high inflation leaves the export competitiveness unchanged (Ito and Sato, 2006).

The extent of pass-through also influences the choice of the optimal monetary policy strategy in an open economy framework (Devereux, 2001; Adolfson, 2001; Smets and

Wouters, 2002; Gagnon and Ihrig, 2004 and Monacelli, 2005). As it is shown by Adolfson (2001), the optimal policy reaction and its implications are dependent on the degree of pass-through. For instance, incomplete pass through makes the exchange rate channel less effective and the brunt of the adjustment has to be borne by the interest rate channel. Smets and Wouters (2002) also indicated that in the presence of imperfect pass-through, changes in the exchange rate carry a cost due to the relative price variability it creates in the import sector which will reduce the incentive for the central bank to actively use the exchange rate channel.

Moreover, a low ERPT is thought to provide greater freedom for pursuing an independent monetary policy and to make it easier to implement inflation targeting (Choudhri and Hakura, 2001). Adopting inflation targeting regime demands countries to monitor and, wherever possible, influence the determinants of inflation using monetary policy instruments and it is well known that one major determinant of inflation is exchange rate movement.

Furthermore, linearity and possible asymmetry of ERPT are investigated less frequently, even though a question whether they exist is important if not crucial for the monetary authorities (Przystupa and Wróbel, 2009). An important motivation is that if depreciations have different effects from appreciations, then the fact that the central bank ignores it distorts the conduct of monetary policy (Delatte and López-Villavicencio, 2010). Also, it is essential to analyze pass-through asymmetry with respect inflation environment which is basically based on Taylor's (2000) hypothesis which states that responsiveness of prices to exchange rate fluctuations depends positively on the level of inflation.

In Ethiopia, the emphasis on knowing the ERPT is underpinned by the fact that the country imports large amount of primary and intermediate goods which severe as inputs to the manufacturing sector. Also the country imports considerable amount of finished consumer goods. Despite the observed high growth rate of exports, the country suffers from a continuous and significant trade deficit which reached a value of 6.4 billion US dollars in 2009/10 fiscal year (based on Customs Authority data). Thus, the need to make the external sector competitive through appropriate exchange rate adjustments has made the study of ERPT to import and consumer prices in Ethiopia imperative. In addition, the fact that understanding the impact of exchange rate movements on prices would help to determine appropriate monetary policy coupled with the recent inflationary environment in Ethiopia signifies the importance of studying ERPT.

Recent developments in the external sector of the Ethiopian economy revealed that the National Bank of Ethiopia (NBE) devalued the Birr by 10% vis-à-vis the US dollar in January 2009 and by August 2010 it had depreciated the Birr by some 16% since September 2008 (NBE, 2009). In addition, in recent years, the Ethiopian economy is facing high inflation especially in food price. Starting from 2005/06 there is a continuous increase in the price level of goods and services. The highest increase is observed in food items where it is recorded to be 44.2 and 41.5 percent at national level and Addis Ababa respectively in year 2008/09 which is the highest ever. Starting from 2003/04 the country level general inflation rate increased at about 17 percent on average during the past six years (Own computation based on CSA data).

Concerns are what would be the implications of these developments on the extent of pass-through on import and consumer prices. Extensive empirical researches exist on the

theme across the globe with most of them being on the developed or emerging economies. There are of course few studies which are conducted on the issue of ERPT in the African context (see e.g. Mwase, 2006; Daniel, 2007, Siaw and Adam, 2010 and Aliyu, *et al*., 2010). In Ethiopia, Choudhri and Hakura (2003) and Devereux and Yetman (2002) in their cross country study, founds ERPT to be zero between the period 1997-2000 and 1975-1999, respectively. Devereux and Yetman (2008) found a higher (0.35 percent) degree of pass through for Ethiopia by extending the sample period from 1970 to 2007.

Although these studies are informative, there is a need to take further studies in the area in Ethiopian context due to the following reasons. First these studies are basically conducted to see cross country differences in pass-through and hence country specific study is required so as to obtain more evidence. Second, there are many new developments in the Ethiopian economy since 2000, which can affect the degree of pass through and lead to the need to for further study on the issue under consideration.

Moreover these studies apply single equation estimation techniques. However several recent empirical studies suggested the use of Vector Autoregressive models (VAR) in analyzing ERPT. Since the exchange rate and inflation rate are expected to be influencing each other in many theoretical models, it seems more appropriate to estimate a system that would treat both of them endogenous. Thus the use of VAR models would allow the reverse causality from price indices to the exchange rate which avoids arbitrary assignment of variables as endogenous and exogenous. In sight of this argument, this study will analyze ERPT to import and consumer prices in Ethiopia using VAR models.

1.2 Objectives of the Study

The main objective of this study is to examine exchange rate pass-through to import and consumer prices in Ethiopia.

Specific Objectives

- To estimate the degree of ERPT to import and consumer prices
- To check whether ERPT to import price is symmetric or asymmetric with respect to the direction and size of change in exchange rate
- To see the relationship between ERPT to consumer prices and inflationary environment (i.e. pass-though asymmetry with respect to inflation environment)

1.3 Significance of the Study

For developing economies, especially countries with large and persistent trade deficit, the investigation of ERPT to import and consumer prices is an important issue because there is need to appropriately adjust their exchange rates to ensure competitiveness in the international market. Ethiopia is highly dependent on imported primary and intermediate commodities and various technologies which serve as input for the existing industrial sector. The country also import considerable amount of finished consumer goods. Hence, ERPT to import prices is a significant area of study since it has important implication for "expenditure-switching" effects resulting from the exchange rate movements. Furthermore, as import price is one of the principal channels through which the exchange rate affects domestic prices, it is worth examining the pass-through of exchange rate changes to consumer prices. These considerations may ultimately have important

implications for the appropriate outlook towards inflation-forecasting and monetary policy as well as the external policy of an economy.

1.4 Scope of the Study

While the literature on exchange rate pass-through is vast, it is also important to note that there is no uniform definition of the term "pass-through." The expression ERPT is generally used to refer to the effects of exchange rate changes on one or more of the following: (1) import and export prices, (2) domestic prices, (3) investments and (4) trade volumes. Of these four topics, much of the existing research focuses on the relationship between movements in nominal exchange rates and, import and consumer prices. This is because, on the one hand, this is the natural ground for studying the pricing practices of firms and, on the other, a response of import, export and consumer prices to exchange rate change is usually needed before there is any consequence for investment and trade volumes (Darvas, 2001). This paper is thus limited in studying the relationship between exchange rate and aggregate import and consumer price indices.

1.5 Limitations of the Study

For developing countries like Ethiopia, the availability of data continues to be a challenge for researchers, as it was found to be the case in the this study. Due to this some variables in the empirical model had to be excluded (such as producer price index) or constructed (import price index and quarterly GDP). The drawback of such measures is that, the quality of estimated results could be reduced.

1.6 Organization of the Study

The rest of the thesis is organized as follows. Section 2 reviews the theoretical and empirical literature related to ERPT. In section 3 Ethiopia's macroeconomic environment will be briefly discussed by focusing on those which have implications for ERPT. The data used for analysis and the econometric models used for the empirical framework are described in section 4. Section 5 reports the results of the empirical analysis and section 6 provides conclusion and policy implication.

2. LITERATURE REVIEW

2. 1 Theoretical Literature

2.1.1 Definition of ERPT

According to Goldberg and Knetter (1997) ERPT is defined as "the percentage change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing countries". Also according to Adolfson (2001:17) the term ERPT is defined as the percentage change in import price caused by an unidentified shock to the exchange rate. The degree of pass-through possibly depends on whether this exchange rate movement is caused by a 'genuine' exchange rate shock, or whether some other disturbance to the economy generates an implicit exchange rate change.

The above definition which takes ERPT as the change in import price due to change in exchange rate is a narrow definition. A broader definition is the transmission of exchange rate shock to the overall price level, either to the producer price index (PPI) or to the consumer price index (CPI) (see e.g. Devereux and Yetman, 2002). "The pass-through is also dependent on whether one defines it as partial—only measuring the direct effect on the price relation, excluding the effect on other variables—or total—determining the entire effect an exchange rate change causes, working through every interaction of the price determination" (Adolfson, 2001).

Pricing-to-market (PTM), which refers to the pricing behavior of firms exporting their products to a destination market following an exchange rate change, is a closely related term to ERPT. Particularly, PTM is defined as the percent change in prices denominated

in the exporter's currency due to a one percent change in the exchange rate. Thus, the greater the degree of PTM, the lower will be the extent of ERPT. In the case where there is no PTM, import prices will adjust by the same proportion as the change in the exchange rate and ERPT will be complete. On the other hand, if there is full PTM (i.e. if exporters adjust prices in their currency by the same proportion as the exchange rate change but in the opposite direction) ERPT to destination market prices will be zero. More generally, if exporters alter the export prices in their own currency by a proportion smaller than the exchange rate change, then pass-through is said to be incomplete (Ghosh and Rajan, 2006).

2.1.2 Theoretical Models of ERPT

In the previous section, two definitions of ERPT are put forward; namely the narrow and broad definition of ERPT. Much of the theoretical literature on pass-through analyzes the degree of pass through to import prices. Thus, most of the theoretical models which are going to be discussed in this section are based on the narrow definition of ERPT which defines it as the percentage change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing countries.[3] Subsequently, different theoretical models of ERPT will be reviewed.

The starting point to study the link between exchange rate and domestic prices is the law of one price (LOP) which states that the price of identical commodities sold in different market should be the same when it is converted into the same currency (Pilbeam, 1998).

[3] Except McCarthy's (1999) model

The LOP is mathematically expressed as follows;

$$P_t = E_t \, P_t \, * \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.1)}$$

Where P_t is the domestic price index, E_t is the nominal exchange rate (defined as domestic currency per unit of foreign), and P_t^* represents foreign prices. (Relative) purchasing power parity tests use price indices across countries to test whether this relationship holds.

If we consider the LOP in logarithmic form we will have the following;

$$p_t = \gamma e_t + \lambda p_t^* \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.2)}$$

Where p_t, p_t* and e_t are the natural logarithm of import price, export price and nominal exchange rate respectively. The LOP implies that $\gamma = \lambda = 1$ in which case changes in the exchange rate completely pass through to the domestic price of the traded good. This simple expression forms the basis of analyzing the long run pattern of ERPT.

Based on this fundamental relationship various researchers develop different more advanced models to analyze the degree of pass-through. According to Goldberg and Knetter (1997) and Campa and Goldberg (2002) ERPT studies consider the extent to which exchange rate movements are passed-through into traded goods prices, versus absorbed in producer profit margins or markups. Often these studies look at indices of industrial concentration or market power to explain pass-through differences or PTM. Based on this, their analysis starts form the following basic model;

$$P_t = \gamma e_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.3)}$$

Where, ε_t is an error term and γ is the ERPT coefficient. The extent of pass-through coefficient is based on the value of γ. A one to one response of import prices to exchange rate is known as a complete ERPT (γ=1) while the case where pass-through coefficient is less than 1 (γ<1) is known as partial or incomplete ERPT.

However according to Campa and Goldberg (2002) this reduced form equation (whether in log levels or growth rates) is problematic for hypothesis testing because it represents a non-structural statistical relationship. More specifically, Campa *et al*. (2005) indicated that Eq. (2.3) is purely statistical relationship between exchange rates and prices, and does not have a meaningful economic interpretation.

The micro-foundations of pricing behavior by exporters are a better starting point for generating more meaningful specifications based on economic theory that are appropriate for hypothesis testing. Hooper and Mann (1989), Goldberg and Knetter (1997) and Barhoumi (2006) considered a representative foreign firm having some degree of control over the price of its goods in an importing country. They assume that this representative firm establishes the price of its exports to country i in its own currency ($P_t^{x,i}$) at a markup (λ_{it}) over its marginal cost of production (C_{it}^*), that is:

$$P_t^{x,i} = \lambda_{it} C_{it}^* \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.4)$$

The import price in the domestic currency $P_t^{m,i}$ is obtained by multiplying the export price $P_t^{x,i}$ by the exchange rate of the importing country i, E_{it}, that is,

$$P_t^{m,i} = E_{it} P_t^{x,i} = E_{it} \lambda_{it} C_{it}^* \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.5)$$

The markup is assumed to respond to both demand pressure for the exporting country (Y_{it}*) and competitive pressure in the importing country. Competitive pressure in the importing country is measured by the gap between the competitor prices in the importing country market (P_{it}) and the production cost of exporting firm. Therefore, according to Hooper and Mann (1989) the markup λ_{it} is given by;

$$\lambda_{it} = \{ P_{it} / (E_{it} C_{it}^{*})\}^{\alpha} Y_{i,t}^{\beta} \quad 0 < \alpha < 1 \text{ and } 0 < \beta < 1 \ldots\ldots\ldots (2.6)$$

Substituting Eq. (2.6) in to (2.5), we have

$$P_t^{m,i} = (E_{it} C_{it}^{*})^{1-\alpha} P_{it}^{\alpha} Y_{i,t}^{\beta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.7)$$

If we take the logarithm of Eq. (2.7), the ERPT, defined as the partial elasticity of import price with respect to exchange rate, is (1-α). However, this equation has limitation because the pass-through of exchange rate and foreign cost into import price are the same and this restriction does not necessarily hold in practice. Indeed, Bache (2002) argues that exchange rates are more variable than costs, and a reasonable conjecture is that exporters will be more willing to absorb into their markups changes in exchange rates than change in costs, which are likely to be permanent. Moreover, Athukorola and Menon (1995) have provided purely economic reasons to justify that the coefficient restrictions may not hold (Barhoumi, 2006:928).

Campa and Goldberg (2002:5-6) hypothesized a similar, yet more general, model. The pricing equation of an exporter from country *x* -- and its elasticity of response to an exchange rate movement -- depend on the structure of demand and costs confronting the exporter. If the import prices of country $P_t^{m,j}$, are the dependent variables, the pricing rule of the foreign exporters *x* supplying *j* is:

$$P_t^{m,j} = E_t P_t^{x,j} = E_t \lambda_t^{x,j} \left(P_t^{m,j} \Big/ P_t \right) C^{x,j}\left(W_t^j, Y_t, E_t\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.8)$$

Where $\lambda_t^{x,j} = P_t^{x,j}/C_t^{x,j}$, $C_w^{x,j} > 0$, $C_E^{x,j}$, $C_Y^{x,j} > 0$

$\lambda_t^{x,j}$ represents the markup rate of prices over costs for the exporter. Markup rates are industry specific and depend on the demand curve facing exporters *x* in country *j*. This demand depends, in turn, on $P_t^{m,j}/P_t$ the prices of imports relative to prices of country *j* producers. $C_t^{x,j}$ is the marginal cost function of the exporter in his own currency. This exporter marginal cost function is increasing in export market wages, $W_t^{x,j}$, and increasing in country *j* demand conditions Y_t. The exchange rate is an argument in the exporter's cost function to the extent that the exporter relies on imported inputs or has other costs that move with the relative value of the destination market currency.

All the above models of ERPT are fundamentally grounded in partial-equilibrium setups which arise from the problem of a single exporter/importer or from the industrial organization of one industry. This approach ignores the view that exchange rates are endogenous economic variables and looks at the impact that an exogenous exchange rate movement has on the resulting equilibrium price in the industry. However, exchange rates are by definition the relative prices of currencies and are endogenous variables in which their value gets determined within a general equilibrium context, alongside other asset prices. The effect of any movements in exchange rates on prices will therefore depend on three issues: 1) the underlying shock within the economy that induced the exchange rate to move; 2) the mechanisms within the model that lead to a relationship between the underlying shock, the exchange rate and import prices; and 3) the time frame

of interest for understanding the relationship between exchange rates and import prices (Campa *et al*., 2005:3).

The second strand of literature embeds a more general-equilibrium approach, whereby prices are sticky in one currency, i.e. set in advance of the realization of the exchange rate by exporters. In their pioneering work, Obstfeld and Rogoff (1995) introduced nominal rigidities and market imperfections into a micro-founded dynamic general equilibrium model. However, PPP was maintained at all times, and the pass-through was complete. Betts and Devereux (1996, 2000) cited in Bailliu and Fuji (2004) then developed an extended version of the Obstfeld-Rogoff model allowing for PTM. More precisely, whereas the two models feature the same simple form of price rigidity (prices are predetermined for one period), they differ in the assumed pricing strategy of firms. In the Obstfeld-Rogoff-model, nominal prices are set in producers' currencies (PCP) while in the Betts-Devereux model, a fraction of firms is allowed to set prices in destination countries' currencies (LCP).[4] Also, assuming sticky prices and the exchange rate being an endogenous variable, these models demonstrate that ERPT is a function of the underlying shocks in the economy and the given competitive structures of the industries involved.

However, these early models neglected several important aspects. In particular, neither the original Obstfeld-Rogoff-model nor the Betts-Devereux-model explicitly

[4] When prices are determined in the exporter´s currency (PCP) ERPT tends to be much larger than when prices are set in the importer´s currency (LCP). In the extreme case of a purely exogenous exchange rate shock, ERPT would be one under PCP and zero under LCP.

distinguishes different stages of the distribution chain. More recently, a strand in the literature has been established that considers imports as intermediate goods that undergo non-traded production order distribution processes before being consumed. These production or distribution channels may dampen the impact of exchange rate shocks on consumer prices. Hence, imperfect pass-through into consumer prices may be observed even in the case of PCP (Stulz, 2006).

McCarthy (1999) introduced a new analytical approach to examine ERPT which seems to address these issues. He applied the model of pricing along a distribution which captures the endogenous nature of the exchange rate and permits one to track the pass-through from exchange rate fluctuations to each stage of the distribution chain in a simple integrated framework. According to McCarthy, the model has a similar structure to that of Clark (1999), who studies responses of prices at different production stages to monetary policy shocks, which however does not explicitly include exchange rates and import prices[5].

McCarthy's model basically put inflation at each stage-import, producer and consumer-in period t is assumed to be comprised of several components. The first component is the expected inflation at that stage based on the available information at the end of period *t-1*. The second and third are the effects of period *t* domestic "supply" and "demand" shocks on inflation at that stage. The fourth component is the effect of exchange rate shocks on

[5] Also the pricing along the distribution model was used by different previous studies such as Blachand (1983) and Christiano *et al.* (1997) cited in Hahn (2003)

inflation at a particular stage. Next are the effects of shocks at the previous stages of the chain. Finally, there is the shock that belongs to that stage. The shocks at each stage are that portion of a stage's inflation that cannot be explained using information from period t-1 plus contemporaneous information about domestic supply and demand variables, exchange rates, and inflation at previous stages of the distribution cycle. These shocks can be thought of as changes in the pricing power and markups of firms at these stages (McCarthy, 1999:4).

Two features of the model are worthy of note. First, the model allows import inflation shocks to affect domestic consumer inflation both directly and indirectly through their effects on producer inflation. Second, there is no contemporaneous feedback in the model: for example, consumer inflation shocks affect inflation at the import and producer stages only through their effect on expected inflation in future periods.

Under these assumptions, the inflation rates of country *i* in period *t* at each of the three stages —import, producer and consumer — can be written as:

$$\pi^{m}_{it} = E_{t-1}(\pi^{m}_{it}) + \alpha_{1i}\varepsilon_{it}^{s} + \alpha_{2i}\varepsilon_{it}^{d} + \alpha_{3i}\varepsilon_{it}^{e} + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$\pi^{w}_{it} = E_{t-1}(\pi^{w}_{it}) + \beta_{1i}\varepsilon_{it}^{s} + \beta_{2i}\varepsilon_{it}^{d} + \beta_{3i}\varepsilon_{it}^{e} + \beta_{4i}\varepsilon_{it}^{m} + \varepsilon_{it}^{w} \quad \ldots\ldots\ldots \quad (2)$$

$$\pi^{c}_{it} = E_{t-1}(\pi^{c}_{it}) + \gamma_{1i}\varepsilon_{it}^{s} + \gamma_{2i}\varepsilon_{it}^{d} + \gamma_{3i}\varepsilon_{it}^{e} + \gamma_{4i}\varepsilon_{it}^{m} + \gamma_{5i}\varepsilon_{it}^{w} + \varepsilon_{it}^{c} \ldots\ldots\ldots \quad (3)$$

Where π^{m}_{it}, π^{w}_{it} and π^{c}_{it} are import price, producer and consumer inflation respectively; ε_{it}^{s}, ε_{it}^{d} and ε_{it}^{e} are supply, demand and exchange rate shocks respectively; ε_{it}^{m},ε_{it}^{w} and ε_{it}^{c} are import, producer and consumer price inflation shocks, and $E_{t-1}(.)$ is the expectation of a variable based on the information set at the end of the period t-1. The

shocks are assumed to be serially uncorrelated as well as uncorrelated with one another within a period.

To complete the model, McCarthy proceeds by specifying the supply, demand, and exchange rate shocks.[6] In addition the model incorporates the central banks reaction function and money demand to capture the reaction of monetary policy to exchange rate fluctuations. The reaction function relates short-term interest rates (r_{it}) to the previously cited variables in the model as central banks use the short-term rate as their monetary policy instrument. The money demand function relates money growth (Δm_{it}) to the other variables in the model.

$$r_{it} = E_{t-1}(r_{it}) + C_{1i}\varepsilon_{it}^{s} + C_{2i}\varepsilon_{it}^{d} + C_{3i}\varepsilon_{it}^{e} + C_{4i}\varepsilon_{it}^{m} + C_{5i}\varepsilon_{it}^{w} + C_{6i}\varepsilon_{it}^{c} + \varepsilon_{it}^{MP} \ldots\ldots\ldots (4)$$

$$\Delta m_{it} = E_{t-1}(\Delta m_{it}) + d_{1i}\varepsilon_{it}^{s} + d_{2i}\varepsilon_{it}^{d} + d_{3i}\varepsilon_{it}^{e} + d_{4i}\varepsilon_{it}^{m} + d_{5i}\varepsilon_{it}^{w} + d_{6i}\varepsilon_{it}^{c} + d_{7i}\varepsilon_{it}^{MP} + \varepsilon_{it}^{MD} \ldots (5)$$

Finally, to express the model in standard format and to make it plausible for estimation it is assumed that the conditional expectations $E_{t-1}(.)$ in equations (1)-(5) can be replaced by linear projections on lags of the variables in the system (McCarthy, 2000:8).

Generally, given the theoretical underpinnings on the pass-through of shocks on prices, the model of pricing along a distribution chain which considers the effects of shocks

[6] To identify aggregate demand and supply shocks and exchange rate shocks, he made the following assumptions. (1) Supply shocks are identified from the dynamics of oil price inflation denominated in the local currency. (2) Demand shocks are identified from the dynamics of the output gap in the country after taking into account the contemporaneous effect of the supply shock. (3) Exchange rate shocks are identified from the dynamics of exchange rate appreciation after taking into account the contemporaneous effects of the supply and demand shocks.

(exchange rate and other external shocks) on prices at different stages of distribution is of great interest for our analysis.

2.1.3 What Determines ERPT?

Theoretically, several factors have been proposed as determinants of ERPT. Some of these determinants are micro in nature while others are macroeconomic factors. From the micro perspective, behavior of exporting firms, which adopt PTM strategies and specific industry and market characteristics, can be mentioned.

The theoretical literature developed over the past two decades has provided different explanations on why the ERPT is incomplete. One possible explanation for the incomplete nature of ERPT is the fact that exporters adjust their prices to exchange rate change in order to maintain their competiveness in destination market (PTM). PTM is impractical in a perfectly competitive market because in such markets export prices are set to be equal to marginal cost of production. On the other hand, when the exporting firms' margins are positive, PTM can become a sustainable strategy for the exporters, in which case the measured pass-through of exchange rate changes to import and other domestic prices, such as producer and consumer prices, will be less than one. Thus the size of the ERPT will be affected by the ability of exporters to absorb exchange rate shocks within their profit margins (Gaulier *et al*., 2006: 9). PTM and the resulting optimal markup is in turn determined by price elasticity of demand and market share in the destination market.

In addition to PTM another important determinant of ERPT is industry specific and market characteristics. Under this, the degree of competition, relative domestic and

foreign shares in the market (Dornbusch, 1987) or import penetration, the elasticity of import/export demand and supply, product substitutability and differentiation (Menon, 1995 and Yang, 1997), and the perceived reaction of incumbent industry competitors (Dornbusch, 1987) are included. If exporting firms have large domestic and foreign market share for a product, then they are usually willing to absorb a proportion of the exchange rate change so to maintain their market share. This is particularly so if the industry is highly competitive. If the destination market is highly competitive, consumers will be having many substitutes, making them relatively price-sensitive. Thus exporting firms may try to keep their market share by absorbing exchange rate change in their markups. The willingness to accept lower domestic unit prices (due to low markup) in turn leads to lower ERPT. For example, exports to certain competitive industries in the US, such as autos and alcoholic beverages, showed relatively high PTM and corresponding lower ERPT as exporters try to preserve market share (Knetter, 1993).

However, if exporters do not face much competition (i.e. the industry is highly differentiated) their prices may be somewhat less responsive to exchange rate changes. In this situation, PTM will be lower and the corresponding pass-through will be higher. Hence, if firms operate in imperfectly competitive industries and have a large share of imports in aggregate domestic sales, the degree of pass through will be high. In related work Dornbusch (1987) and Goldberg and Knetter (1997) show that markets which are not perfectly competitive may experience a range of pricing responses to exchange rate fluctuations resulting in a greater pass-through effects. Also, Feenstra *et al*. (1996: 188) cited in Daniel (2007) indicated that an exporter with low market share may have less power to absorb exchange rate changes. However, as the exporter's market share and

market power increases the incentive to PTM decreases. In such a case the exporter is likely to pass on any increase in costs brought about by depreciation in the importer's currency, and thus, the ERPT is likely to be high.

The degree of the substitutability of the imported goods in the domestic market is another factor which determines the degree of pass-through. If the imported good has a domestic substitute, regardless of it being a final or intermediate good, the pass-through is smaller, as firms and consumers are eager to buy the cheaper domestic goods. However, this may not realize if a common factor increases both the international and domestic price simultaneously. Therefore, relative price difference and the degree of substitutability become more important in such cases (Yüncüler, 2009). Concerning this Yang (1997) shows the existence of negative relationship between the size of ERPT and the degree of substitution among different products in the industry.

The degree of ERPT into aggregate prices may also be affected by various macroeconomic variables such as the prevailing exchange rate policy or regime adopted by an importing country, inflationary environment, trade openness and the perceived nature of exchange rate change. Theoretically, if a country adopts a flexible exchange rate regime the more will be the exchange rate volatility and the lesser will be the degree of pass through to import prices. This means when exchange rate is highly volatile the degree of pass through will be low due to menu cost and firm's incentive to maintain their market share. In support of this, Barhoumi (2006) found that countries with fixed exchange rate regimes (low exchange rate volatility) experience a higher long-run pass-through than floating exchange rate regimes (high exchange rate volatility).

The trade openness of the importing country is another determinant of ERPT from a theoretical stand point. The more a country is open to trade, the higher will be degree of pass through to import prices due to high competition exporting firms face and low capability to absorb exchange rate changes in their markups. However, the picture becomes more complex once we take into account that inflation could be negatively correlated with openness, as empirically found by Romer (1993). This gives rise to an indirect channel, whereby openness is negatively correlated with inflation and hence with pass-through based on Taylor's hypothesis. The direct and indirect channels go in opposite directions and the overall sign of the correlation between pass-through and openness can thus be either positive or negative (Aliyu *et.al*, 2010).

Another main macro determinant of ERPT is the prevailing inflation environment in the importing country. Since the late 1980s there has been a general decline in the extent of ERPT in many industrial countries. Following this, Taylor (2000) put forward a hypothesis which states that the observed decline ERPT to aggregate prices is the result of a low inflation environment. Taylor explains the link between inflation and pass-through in terms of a model of firm behavior based on staggered price setting and monopolistic competition. As firms set prices for several periods in advance, their prices respond more to cost increases (due to exchange rate depreciation or other sources) if cost changes are perceived to be more persistent. Regimes with higher inflation tend to have more persistent costs. He argued that degree of pass-through is endogenous to a nation's monetary policy and monetary stability.

The degree of pass-through is also affected by the duration (persistence) of exchange rate shock. According to Taylor (2000) if the shock displays non-volatile and persistent

characteristic, then willingness of firms to reflect such a shock onto their prices increases. Otherwise, if the shocks are perceived to be volatile or temporary, then, firms prefer to make adjustment on their profit margins instead of reflecting them on domestic prices. This is because the high costs of changing prices, as well as the possibility that frequent changes in unit sales prices (in the destination market's currency) can adversely affect a firm's reputation, may prevent firms from passing through temporary fluctuations in exchange rates. When exchange rate changes are large or appear to be permanent, however, exporting firms are more likely to pass through the changes to avoid a sharp reduction in their profit margins. In general, the greater the persistency and lower the volatility of the external shocks, the higher will be the degree of pass-through.

Last but not least the size of the economy could also determine the degree of pass-through. The conventional wisdom had long been that for a large country, the inflationary effect of currency depreciation or import price shock on domestic prices is expected to be lower than that for a small economy. The rationale is that a rise in prices will be counteracted by a fall in world prices through lower world demand, thus, reducing the pass-through effect, whereas a small country would have no effect on international price of the good, which leads to a higher pass-through (McCarthy, 2000). More recent studies, on the other hand, have shown that the evidence on sizable difference in the degree of pass-through between small and large countries is not so clear or less than expected (Frankel et al., 2005; Murray, 2008 cited in Yüncüler, 2009).

2.1.4 Causes of Asymmetric Pass-through

Many empirical studies conducted so far assume a symmetric long-run relationship between the price level and the exchange rate. However, there are various reasons (both micro and macro) why the relationship between prices and exchange rate may be asymmetric. Knetter (1994), Peltzman (2000), Pollard and Coughlin (2003), Wickremasignghe and Silvapulle, (2004) and Delatte and López-Villavicencio (2010) examine how asymmetry might arise in the case of ERPT.

On the microeconomic side, market share, binding quantity constraint, product switching and menu cost are identified as causes of asymmetric pass through (Pollard and Coughlin 2003). Knetter (1994) argues that if local and exporting firms that are trying to establish market-share are confronted with trade restrictions, then a currency appreciation of the importing country might cause PTM (in this case, lowering of prices) to be greater than the rise in prices during periods of depreciation. This would imply greater pass-through during episodes of appreciation than depreciation.

The market share model for asymmetric pass-through is also discussed by Pollard and Coughlin (2003). If the goal of a firm is to maintain its market share despite fluctuations in the exchange rate, the firm will try to keep its prices constant by adjusting their mark-ups (Pollard and Coughlin, 2003: 6). Thus, an appreciation of the importing country's currency will give foreign firms the opportunity to lower the import prices and thus to rise their market share, while keeping their mark-ups constant. On the contrary, in order to preserve their market share in the case of depreciation, the firms will have to absorb a part of the inflationary impact that will determine a decline in their mark-ups. Given the

fact that the foreign firms' actions are restricted by the size of their mark-ups, the pass-through will be higher for appreciation than for depreciation which makes pass-through asymmetric (Marston, 1990: 220).

Another explanation for asymmetric pass-through is production switching. Production switching describes the fact that firms will tend to switch towards inputs produced in their own countries when the exchange rate depreciates and switch towards imported inputs when exchange rate appreciates. This is because if the firm's home currency appreciates imported inputs become cheaper and the firm will switch to a production technology that maximizes the use of imported inputs. But, if the home currency depreciates imported inputs become more expensive and the firm will switch to local input intensive production technologies implying zero pass-through[7] (Ware and Winter, 1988). Thus according to the production switching model, ERPT is greater during periods of appreciation than depreciation.

The binding quantity constraints theory of asymmetric ERPT supposes that binding quantity constraints arise when the ability of the exporting firm to increase sales as the importing country's currency appreciates is limited. Quantity constraints faced by firms may arise because of trade restrictions such as quotas that limit imports, or voluntary export restraints. Constraints may also arise because of firm or industry specific factors such as limitations on a firm's ability to expand its production capacity. Under this scenario, when the exchange rate increases, the firm raises its markup to maintain its price in the importing country. Therefore, rather than increasing sales the firm may

[7] assuming the extreme case in which the firm can switch entirely from use of imported inputs to local inputs without cost

increase its profit margins. However, when the exchange rate decreases, the quantity constraint is not binding. The firm may reduce its markup but still allow its price in the importing country to rise. Pass-through is consequently higher when the importing country's currency depreciates than when it appreciates (Pollard and Coughlin, 2003: 8).

The menu costs theory of asymmetric pass-through proposes that a firm may respond asymmetrically depending on the size of exchange rate change (i.e. large and small changes in the exchange rate change). According to Pollard and Coughlin (2004) the cost of changing prices enlarges the probability that firms will adjust the invoice price only if the change in the exchange rate is above some threshold and asymmetry in pass-through depends on the currency of invoice. When imports are invoiced in the importer's currency, a small change in the exchange rate which is below a given "threshold" will not affect local prices because the foreign firm will absorb the change in the exchange rate through the price it receives (expressed in its currency) which results in a zero ERPT. But if the change in the exchange rate is significantly above the "threshold", the firm will adjust its price, resulting in partial or complete pass-through depending on the size of the price adjustment. Therefore, with invoicing in the importer's currency, pass-through will be larger when exchange rate changes are large than when they are small. However when imports are invoiced in exporters currency, small changes in exchange rate result in large pass through than large change in exchange rate (Pollard and Coughlin, 2003: 9).

On the macroeconomic side, monetary policy and business-cycle might result in asymmetric pass-through in the short run. Monetary policy affects the level of pass-through to the general level of prices and might induce asymmetric ERPT. A monetary policy stance that is sufficiently reactive to inflation can insulate consumer price inflation

from the effects of depreciation. More specifically, anti-inflationary monetary policies may imply that countervailing measures are implemented more after depreciation than after an appreciation. Under this assumption, depreciation will affect prices less than an appreciation in the short-run (Delatte and López-Villavicencio, 2010:6).

The position in the business-cycle when the exchange rate variation takes place also triggers asymmetric responses. In fact, if the devaluation takes place in the midst of a recession then prices might increase less than they would decrease after an appreciation. The reason is that devaluations often result from a downward adjustment of the domestic aggregate demand. The resulting recession could act to depress domestic prices, hence implying that domestic prices do not respond much to exchange rate depreciation. (Delatte and López-Villavicencio, 2010:6).

2.2 Empirical Literature

The vast body of literature concerning ERPT can be broadly classified as those done at micro level and those which are conducted at macro level. Studies conducted at micro level focused in examining ERPT into disaggregated import prices of specific domestic industries. On the other hand, those conducted at macro level examined ERPT into aggregate price indices and can be further classified in two categories. The first category examines the degree of pass-through into aggregate import prices while the second one has analyzes pass-through into the consumer prices. Among these, some are conducted on country level while others are cross country comparisons. In general previous studies try to analyze the following basic issues concerning ERPT: 1) estimate the degree of pass-through to various price indices 2) try to explain why pass-through is incomplete and why

it is declining 3) whether it is a macro or micro phenomenon 4) why pass-though is lower for domestic prices than import prices and 5) whether pass-through is symmetric or asymmetric. Against this general background, even if it is impossible to survey the vast literature revolving around ERPT, empirical evidence of a selected industrialized; emerging and developing countries will be briefly discussed in the next section.

Numerous empirical studies have estimated the degree of ERPT to import, and consumer prices. There are also few studies which estimate the degree of ERPT to export prices. Menon (1995) made a comprehensive survey of literatures on ERPT. The empirical studies reviewed in his survey were conducted on industrialized economies, in which most of them are on United States (US). Many of these studies concluded that ERPT is incomplete though its extent varies significantly across countries. The main factors that influence the degree of pass-through across countries are the size and openness of the individual economies. Furthermore, the pass-through relationships were found to be largely stable over time. In some studies the pass-through was asymmetric, which implies that the rate of pass-through is different during exchange rate appreciations and depreciations.

Goldberg and Knetter (1997) found that the response of domestic prices to exchange rate movement is only partial in US. On average only around 60 percent of exchange rate changes are passed on to import prices in the US. However, the response of domestic US price to exchange rate fluctuations vary from sector to sector and a considerable portion of the muted price responses seem to emanate from changes in markups on export prices. Similarly Yang (1997) studies ERPT in US manufacturing industries and its cross-sectional variation. The study shows that pass-through is incomplete (on average 32

percent in the short run and 42 percent in the long run) and varies across industries. In the cross-sectional study ERPT is found to be higher in industries with a higher degree of product differentiation and a lower elasticity of marginal cost. The study also shows a negative relationship between import share and ERPT. Recently, Marazzi *et al*. (2005) investigates ERPT to import price in US. They found a sustained decline in ERPT to US import prices, from above 0.5 during the 1980s to somewhere in the neighborhood of 0.2 during the last decade (1993-2004).

McCarthy (2000) presents a comprehensive study of ERPT on the aggregate level for a number of industrialized countries which include the US, Germany, Japan, France, the United Kingdom, Belgium, Netherlands, Switzerland and Sweden. He estimates a VAR model using import, producer and consumer price data from 1976 up until 1998. The findings of the study show that exchange rates and import prices have a modest effect on domestic price inflation over the post-Bretton Woods era. The pass-through is found to be stronger in countries with a larger import share. The rate of pass-through is, furthermore, shown to be positively correlated with the openness of the country and with the persistence of and exchange rate change, and negatively correlated with the volatility of the exchange rate.

An (2006) also analyzed the extent of ERPT at different stages of distribution - import prices, producer prices and consumer prices - for eight major industrial countries: United States, Japan, Canada, Italy, UK, Finland, Sweden and Spain. The study found incomplete ERPT in many horizons, though complete pass-through is observed occasionally. The study also revealed that the degree of pass-through declines along the

distribution chain. Moreover the time needed for complete pass through becomes longer along the distribution chain.

Campa and Goldberg (2002) using quarterly data from 1975 through 1999 of 25 OECD countries, documented the prevalence of PCP and LCP in short-run and long-run pass-through elasticities respectively. At the level of an aggregated import bundle, the evidence across countries is strongly supportive of incomplete exchange rate pass-through in the short run (defined as one quarter). They also reach at similar conclusions about the prevalence of partial pass-through into import prices at a more disaggregated industry level.

Campa *et al*. (2005) estimated short and long-run pass-through elasticities for European countries between the period 1989 and 2004. The results obtained confirm that ERPT is high, although incomplete, in the short-run, and different across industries and countries. Long-run elasticities are higher, although estimated elasticities are still lower than unity, except for the traditionally more inflationary economies and for commodities. In general, the equality of pass-through elasticities among the different industries in each country or for the different countries given an industry was not rejected in the long-run. They have also tested for structural changes in pass-through rates since the introduction of the euro by braking the sample period into two (from1989 to 1997 and 1998 to 2004). They found apparent decline in the estimated point elasticities for two-thirds of the industries though it is not statistically significant. Based on this they concluded that there is a statistically significant trend towards lower pass-through rates for manufacturing industries.

Proceeding to studies which are conducted on developing countries, Rowland (2003) examines ERPT for Colombia using Vector error correction model (VECM) and found ERPT to be incomplete both to import and domestic prices. He found that import prices respond quickly to an exchange rate change (80 percent within 12 months) while pass-through is modest for producer prices (28 percent) and very limited for consumer prices (less than 15 percent). An exchange rate shock does, therefore, only have little impact on consumer price inflation.

Ito and Sato (2006) analyze ERPT in post crisis Asian economies and found that the degree of pass-through to exchange rate shocks varies across the different price indices: the pass-through effect is the largest on the import price index, the second on PPI and the smallest on CPI. The degree of exchange rate pass-through to import prices was quite high in the crisis-hit countries while the pass-through to CPI was generally low, with a notable exception of Indonesia.

Aziz (2009) estimates ERPT into import, export and domestic prices for Bangladesh over the period 1973 to 2007. The estimated results from the full sample demonstrate that the transmission of exchange rate changes is significant and 'complete' to import, and export prices. However, ERPT to producer and consumer prices is found to be only 'partial' implying that degree of pass through declines along the pricing chain. The recursive VAR suggests that response of domestic prices to exchange rate devaluation is positive and larger in the long-run compared to the short-run. The rolling regressions demonstrate that sensitivities of export and import prices to the exchange rate have been consistently around 1 until the early part of this decade. Chew *et al.* (2009) also analyze ERPT for Singapore. They found that ERPT to import prices is complete, with changes in the

exchange rate fully reflected in import prices by the fourth quarter of the shock. ERPT to consumer prices is found to be fairly modest were 1 percent appreciation in the NEER leads to a 0.1 percent decline in the domestic consumer price in the short run and a 0.4 percent decline in the long run.

Zorzi *et al*. (2007) estimate the magnitude of ERPT in emerging economies. They found that ERPT is higher for import prices than for consumer prices implying that degree of pass through declines along the pricing chain. Also their analysis partly overturns the conventional wisdom that ERPT is always considerably higher in "emerging" than in "developed" economies. Particularly, they found that in low inflation emerging economies (notably the Asian economies) pass-through to consumer prices is rather low just like advanced countries (such as US and Japan) which are included in their study. In addition they test Taylors (2000) hypothesis by simple correlation methods and found that positive and statistically significant connection between inflation and ERPT.

Bhattacharya *et al*. (2011) analyzed ERPT for India using a monthly dataset from 1997 to 2000. They used a CVAR model involving six variables: output, oil price, import price, domestic price, exchange rate and short-term nominal interest rate. The study found evidence of incomplete ERPT. Their finding also shows that, even if interest rates do not affect aggregate demand implying the absence of inflation-output trade-off, the existence of strong but incomplete pass-through shows the fact that interest rate can impact inflation through the exchange rate channel (i.e. the empirical evidence revealed that the policy rate can influence prices through its impact on the exchange rate). Based on this finding they concluded that in India (a country with weak financial development but high

trade integration), the most effective mechanism through which monetary policy impacts inflation runs through the exchange rate.

In Africa, Canetti and Greene (1992) shows that apart from monetary expansion, exchange rate movements affect consumer price inflation in sub-Saharan Africa (SSA). In particular, they find that exchange rates have a significant "Granger causal" impact on prices in Tanzania, Sierra Leone, and the Democratic Republic of Congo, which is linked to the high inflation episodes in these economies. Kiptui *et al*. (2005) found incomplete ERPT for Kenya during the period 1972–2002. Exchange rate shocks account for 46 percent of the variation in inflation in the first year, peaking at 57 percent in the third year. Even if an exchange rate shock leads to a sharp increase in CPI inflation, it dies out after four years. Similarly, Choudhri and Hakura (2001) in their cross country study found incomplete pass-through for African countries during the period 1997–2000.

Mwase (2006) examines the effect of exchange rate changes on consumer prices in Tanzania using SVAR model based on quarterly data covering the period between 1990Q1 to 2005Q1. The empirical results indicated that ERPT to consumer prices is low, significant and persistent throughout the review period. The study also analyzed the effect of change in monetary policy regime on ERPT by the dividing the sample into the periods before and after 1995Q4. Sample 1 (1990Q1 to 1995Q3) captures the period characterized by passive monetary policy with high and volatile inflation and nominal exchange rate movements while Sample 2 (1995Q4 to 2005Q1) captures the period characterized by depreciation and declining and stable inflation. The degree of pass-through in the second sample was found to be very low (almost zero) compared to the first sub sample.

Aliyu, *et al*. (2010) investigates the degree ERPT to import and consumer prices in Nigeria between 1986 and 2007 on the basis of VECM. Using the impulse response function, they establish the degree of pass-through to import and consumer prices in Nigeria during the period under review to be incomplete (low), persistent and significant. They also found that ERPT is slightly higher in the import than in the consumer prices which suggest that pass through declines along the pricing chain in Nigeria. A one percent shock to exchange rate, for instance, results in 14.3 and 10.5 percent pass-through effect to import and consumer prices four quarters ahead, respectively.

Frimpong and Adam (2010) analyzed the effect of exchange rate changes on consumer prices in Ghana using VAR models based on monthly data set covering the period 1990–2009. They found positive and insignificant long run relationship between domestic prices and exchange rate; indicating that the long-run exchange rate pass-through in Ghana is zero. However in the short run they found low but significant pass-through. According to them these findings reflect the impact of increased openness and tighter monetary policy pursue by the central bank.

Several studies analyzed ERPT in relation with monetary policy behavior and inflationary environment which was first emphasized by Taylor (2000). A number of recent studies find some empirical support for the relationship but the evidence is not conclusive. Choudhri and Hakura (2001) test Taylor (2000) hypothesis for 71 countries (where the sample contains set of developed, emerging and developing countries) for the period between 1979 and 2000. In their empirical analysis the long-run inflation rate is used as an indicator of the aggressiveness of monetary policy response to short-run price fluctuations. The use of this proxy is motivated by the plausible assumption that regimes

which make a stronger effort in stabilizing the short-run inflation rate are also able to maintain low inflation rates in the long run. They found strong evidence of a positive correlation between ERPT and average inflation for a large sample of developed and emerging market economies. They also explored the influence of other variables, but found that average inflation dominates in explaining differences in observed ERPT.

Similarly, Devereux and Yetman (2002) estimate simple aggregate pass-through coefficients for 122 countries. In their model, pass-through is determined by the frequency of price changes of importing firms, and this frequency is a function of the monetary policy regime. For countries with very high inflation rates, they found, as in Choudhri and Hakura that aggregate pass-through is very high, and in many cases statistically indistinguishable from unity. They also show that there is a non-linear relationship between estimated pass-through coefficients and average inflation rates, i.e. as inflation rises, pass-through rises, but at a declining rate.

Gagnon and Ihrig (2004) explore the relationship between ERPT, inflation and monetary policy credibility in twenty industrial countries between the period 1971 and 2003. In addition to using a cross-sectional approach, as do Choudhri and Hakura (2001) and Devereux and Yetman (2002), they also test whether pass-through declined in each country in the sample following a change in the inflation regime. The study shows that countries in which either the level or the standard deviation of inflation declined substantially from the first to the second sub-sample tended to have large declines in estimated rates of pass-through. Finally, they test a more direct connection between monetary policy and pass-through by estimating a Taylor-type monetary policy rules using the forward-looking specification of Clarida *et al.* (1998). In a cross-country

regression using the full sample, they find no statistically significant relationship between estimated ERPT and the estimated monetary policy parameters. However, there is a statistically significant relationship between changes in estimated pass-through across the two sub-samples and changes in monetary policy parameters. In general the study concluded that the decline ERPT in industrialized countries is attributed to change in monetary policy towards stabilizing inflation.

Using a panel-data set of 11 industrialized countries over the period 1977 to 2001, Bailliu and Fuji (2004) found evidence to support the hypothesis that ERPT declines with a shift to a low-inflation environment brought about by a change in the monetary policy regime. More specifically, their 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.

Bouakez and Rebei (2006) uses a structural general-equilibrium approach to test the premise that exchange rate pass-through has declined in Canada. They estimate a fully-fledged dynamic general-equilibrium model for Canada over two sub-samples (before and after the Bank of Canada adopt an inflation-targeting regime), and, using impulse response analysis, they investigate whether the implied pass-through has decreased from one sub-sample to the other. Their results show that the shift by the Bank of Canada towards an inflation-targeting regime is largely responsible for the lower degree of pass-through to consumer prices, thus lending support to the Taylor hypothesis. Yelena (2008) also confirms Taylor's hypothesis for 14 OECD countries: Australia, Canada, Denmark, Finland, France, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Sweden, the

United Kingdom, and the United States. The empirical investigation for these countries confirms the suggestion made by other authors about the decline in the ERPT during the 1990s.

Diago (2011) also evaluate the effect of adopting an inflation targeting regime on ERPT in Peru using a SVAR model between the period 1992 and 2011 based on monthly data. To assess time variation in estimated pass through and to see the effect of adopting an inflation targeting regime, the study uses rolling windows of fixed size in estimating the VAR. He founds that the long run pass through effect to import and export prices has declined over the period of analysis in all stages of distribution chain. Based on his finding he concluded that the adoption of inflation targeting regime in Peru has contributed significantly to the reduction of ERPT which consistent with Taylor (2011) hypothesis.

In contrast to these studies, Campa and Goldberg (2002) found that the industry composition of trade is more important than inflation performance in explaining the change in degree of pass-through in OECD countries. According to them although higher inflation and exchange rate volatility are positively associated with higher import price pass-through, microeconomic factors related to the industry composition of trade play a much more important role in determining ERPT. In particular, the move away from energy as a high proportion of the import bundles, to a much higher share for manufactured products, has been the primary driver behind recent pass-through changes into import prices among numerous OECD countries. Similarly, Otani *et al*. (2003) cited in Ghosh and Rajan (2006) highlight the importance of changing product composition as

being among the main factors in explaining differing rates of ERPT over time in Japan, while Marazzi *et al*. (2005) stresses its importance in the case of the US.

More over Reginaldo and Leòn-Ledesma (2010) found result which do not support Taylor hypothesis. They estimate a state-space model of a Phillips curve, allowing for time variation of the ERPT parameter, where ERPT is simultaneously a function of lagged inflation. The study reinforces the view of the previous literature that ERPT has been declining over time. However, Taylors hypothesis that improved inflation environment should help predict a lower degree of ERPT, was not supported by their evidence. Ultimately they concluded that the evidence presented does not necessarily reject a macroeconomic explanation of the reduction of ERPT into consumer prices. Other parallel developments during this period of increased global market integration may have been driving the positive correlation between both variables, including variables related to structural (microeconomic) changes and macroeconomic stability.

Asymmetric ERPT is analyzed in few studies and these studies have taken three different approaches to analyze the asymmetric nature of pass-through. One set has looked at whether pass-through differed during general periods of appreciation and depreciation (see e.g. Mann, 1986). The other set of studies incorporated dummy variables to identify each time exchange rate appreciated or depreciated as well as dummy variables which capture lager and small change in exchange rate (see e.g. Pollard and Coughlin, 2004). The last set of studies constructed a new series which shows application and depreciation episode and large and small change in exchange rate (see e.g. Webber, 1999 and Wickremasignghe and Silvapulle, 2004).

ERPT could be asymmetric depending on the direction and size of change in exchange rate. Previous studies of asymmetry have concentrated almost entirely on testing for asymmetry in the direction of change in exchange rate. Early works on this topic are Mann (1986), Feinberg's (1989) and Goldberg (1995). Mann (1986) used aggregate trade data and he argued that pass-through into U.S. import prices were greater during the period of the dollar's appreciation than during the period of depreciation, although the difference in pass-through estimates was not statistically significant. Similarly Goldberg (1995) who examined U.S. automobile imports from Germany and Japan found asymmetries in consumer prices' reaction to appreciations and depreciations. On the other hand, Feinberg's (1989) study U.S import prices and failed to find any evidence of asymmetry.

Following these studies, Kadiyali (1997), Kanas (1997), Mahdavi (2002) and Olivei (2002) cited in Pollard and Coughlin (2004:9-10) analyzed asymmetry of ERPT in which most of them are on US. Kadiyali (1997) focused on a single industry. He examined U.S. imports of photographic film from Japan and found that pass-through was higher when the dollar depreciated, consistent with the binding quantity constraint theory. Kanas (1997) also found support for the binding quantity constraint explanation. In a study of eight goods exported from the United Kingdom to the US, he found asymmetric responses in six cases. Four of these six cases were consistent with the existence of quantity constraints. In addition, by using aggregate trade data Webber (1999) found strong support for asymmetric pass-through into import prices in five of seven Asian countries. In contrast to Mann (1986), he found pass-through was higher when the

importer's currency depreciated than when it appreciated. This result again supports the binding quantity constraint explanation.

Mahdavi (2002) examined pass-through in a range of U.S. export industries, while Olivei (2002) did the same for U.S. import industries. Mahdavi found evidence of an asymmetric response in of the 12 industries he studied but with no clear direction in the asymmetry. In Olivei's analysis, 9 of the 34 industries studied exhibited some degree of asymmetry and most were consistent with the binding quantity constraint explanation. Knetter's (1994) study of German and Japanese exports found relatively more support for the market share theory than the quantity constraint theory.

Ohno (1989), Marston (1990) and Wickremasignghe and Silvapulle (2004) study asymmetry of ERPT for Japan. Ohno's (1989) findings support the binding quantity constraint model of ERPT asymmetry, whereas Marston (1990) findings support the market share model as well as the production switching model. Wickremasinghe and Silvapulle (2004) also found that the pass-through coefficients corresponding to appreciation and depreciation of the currency to be 98 percent and 83 percent respectively suggesting that pass-through is higher in episodes of appreciation. Similar to Marston the result supports the market share and production switching model of asymmetric pass-through.

Pollard and Coughlin (2004) analyzed asymmetry of pass-through to US import prices for 30 manufacturing industries. They found evidence of asymmetric pass-through with respect to the direction of change in exchange rate for most of the industries. Also, most of the industries respond asymmetrically to large and small currency changes, with pass-

through being greater when the change is large. They also examined both direction and size effects simultaneously and found that the size effect was the most dominant. Based on their finding that even after allowing for lagged effects of the ERPT is rarely complete, they concluded that both strategic factors and menu costs play a role in determining pass-through.

Kumar (2007) found asymmetry in pass-through between appreciation and depreciation, and between sizes of the exchange rate change for India. It was found that the estimated pass-through coefficients are higher for appreciation than depreciation. Also the estimated pass-through coefficients are found to be much higher for small than large changes, and do not vary much between the three alternative threshold levels. This result is explained by the fact that much of the imports of India are invoiced in exporter's currency.

Daniel (2007) analyzed exchange rate asymmetry in South African. He estimated monthly data from 1980 to 2005 by using VECM. ERPT is found to be higher in periods of rand depreciation than appreciation which supports the binding quantity constraint theory. He also found some evidence that pass-through is higher in periods of small changes than large changes in the exchange rate, which supports the menu cost theory when invoices are denominated in the exporters' currency.

Przystupa and Wróbel (2009) analyze linearity and asymmetry of ERPT using Polish data. They do not found strong evidence which supports non-linearity in import prices reaction to the exchange rate and reject the hypothesis of an asymmetric response to appreciations and depreciations. On the other hand, they found an asymmetry of CPI

responses to the output gap, direction and size of the exchange rate changes and to the magnitude of the exchange rate volatility. The asymmetry is mostly visible after exogenous shocks. They also reject the hypothesis of an asymmetric reaction of prices in a high and low inflation environment.

Delatte and López-Villavicencio (2010) by using quarterly data from 1970:1 to 2009:3 examined asymmetric ERPT for four major developed economies, namely, Japan, Germany, the United Kingdom and the US. Their results show that all the countries under study, depreciations are passed more than an appreciation which suggests weak competition structures and supports the binding constraint theory. Also the estimated value of the pass-through within the asymmetric model is found to be significant and higher compared to linear estimations.

In Ethiopia, empirical literature on ERPT is scanty. There is no country level study concerning the issue of ERPT which is conducted in Ethiopian context. There are of course some cross country studies which included Ethiopia in their sample. Among this Choudhri and Hakura (2003) found zero pass-through in Ethiopia over the period 1979 to 2000. In their classification of countries according to inflation regime, Ethiopia is grouped under low inflation category. Their finding implies that, average inflation rate is dominant among other macroeconomic variables in explaining cross-regime variation in pass-through which allows us to argue that the low degree of pass-through in Ethiopia is a result of low inflation environment which prevail in the country over the study period. Devereux and Yetman (2002) and (2008) estimate ERPT for Ethiopia in their cross country analysis and found degree of pass-through to be zero and 0.35 respectively.

3. MACROECONOMIC OVERVIEW OF THE ETHIOPIAN ECONOMY

This chapter provides a brief overview of the Ethiopian macroeconomic environment and policies, emphasizing on those which have implication for ERPT. First, the overall economic performance of the country will be briefly discussed in the review period. Subsequently, attention is given to monetary policy and inflation trends in Ethiopia, to provide a background for the investigation of ERPT in the country. In order to establish the likely channel(s) of ERPT in country, this chapter also reviews the exchange rate policies and trends in Ethiopia. Furthermore, the structure and composition of trade in Ethiopia are reviewed.

3.1 Overall Economic Performance

According to the World Bank's World Development Report (2011), Ethiopia's gross national income per capita in 2010 was estimated to be 380 US dollars which stood at 1010 dollars when it is measured in PPP. Among 215 countries covered under the report, Ethiopia ranked 206th when per capita income is measured on the basis of US dollars and 199th when it is measured PPP. Compared to 2008 the per capita income of the country grew by some 36% when it is measured in terms of US dollar and by 16% when it measured in PPP.

The Ethiopian economy is mainly based on agriculture, which is characterized by underdeveloped farm techniques and low productivity. Around 95% of the country's

agricultural output is produced by smallholder farmers (MoARD, 2010). The agricultural sector is estimated to account about 44% of the GDP, 90% of the total foreign exchange earnings, 85% of the total employment and for about 70% of domestic raw material supply for large and medium size industries (World Bank, 2010). The agricultural sector is highly dependent on rain, leading to frequent droughts and large drop in output whenever weather condition goes wrong. Table 3.1 below shows the average growth rates of GDP and the contribution of major sectors to the GDP over the period this study covers.

Table 3.1: Growth Rate of GDP and the Contribution of Major Sectors

year		1991/92-2000/01	2001/02-2005/06	2006/07-2010/11
Growth in RGDP		4.3	7.2	11.1
Share in GDP	Agriculture	48.9	47.1	43.4
	Industry	10.5	13.6	13.1
	Service	35.5	40.1	44.6
Growth of GDP by major sectors	Agriculture	9.8	8.1	7.3
	Industry	8.1	9.5	10.1
	Service	12.5	10.7	14.3
Growth in RGDP per capita		3.4	6.2	7.6

Source: ***Own computation based on MOFED data***

The above table shows that average annual growth rate of RGDP and RGDP per capita during the period 1991/92-2000/01 are 4.3 and 3.4, respectively. In recent years the Ethiopian economy had registered encouraging but mixed results with negative RGDP growth rate of 3.3% in 2002/03 as a result of drought, followed by positive performance during all the subsequent years. Consequently, during the 2006/07-2010/11, annual real

GDP growth averaged 11.1%. The registered RGDP growth rate, in comparison with the population growth rate of an average of 3.5%, implies that the average annual RGDP per capita growth rate was 7.6%.

Regarding sectoral breakdown of GDP, the agricultural sector holds the leading role in its contribution to GDP for a long time. As we can see from the above table between the period 1991/92-2000/01 and 2001/02-2005/06, on average the agricultural sector contributes 48.9 and 47.1 percent to the total GDP followed by the service sector which contributes 35.5 and 40.1 percent in the respective period. However in recent years the service sector has taken the leading position in terms of its share in GDP. It accounted for 44.6 percent followed by agriculture (43.4 percent) and industry (13.1 percent) on average during the last five years. The most important and growing activities within the service sector are the public, financial, wholesale and retail sectors, hotels and restaurants, and real estate activities. According to EEA annual report (2011) out of the 11 percent growth in RGDP, 6.15 percent (about 55 percent) was the share of the service sector. Wholesale and retail trade, hotels and restaurants, and real estate and renting have together accounted for 36 percent of the 11 percent growth in GDP.

The contribution of the industrial sector to the total GDP is limited, which is below 15 percent throughout the review period. Thus, the high growth rate of the service sector (resulting in high domestic demand) which is not accompanied by supply response from the agricultural and the industrial sector might be one source of the recent inflation (EEA, 2011). One important thing we should note is that even if the share of agriculture in GDP tended to decline over time; it still remains the largest employer, the main source of foreign exchange, and supplier of raw materials and market to domestic industries.

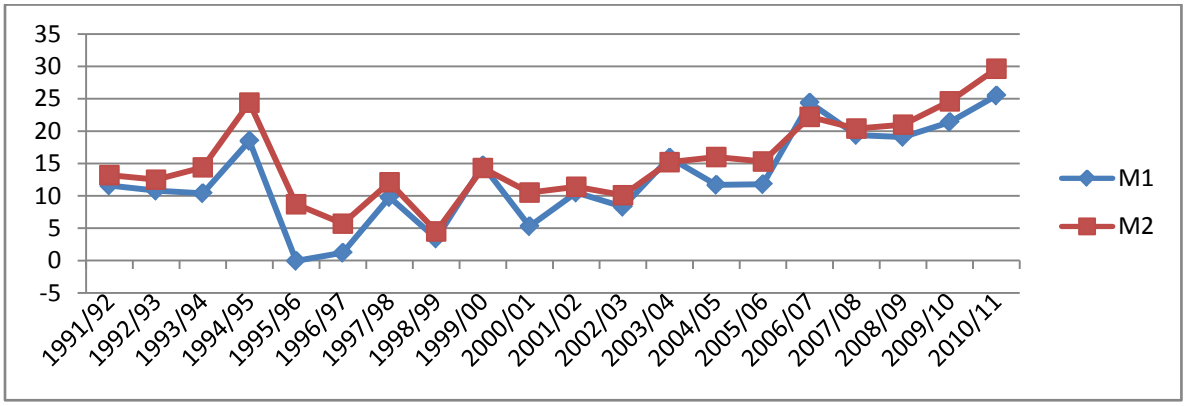
3.2 Monetary Policy

The three main objectives of monetary policy are high employment, price stability and economic growth. In LDCs the objective of monetary policy is mainly related to money and credit control, price stabilization, and economic growth (Ghatak, 1995). The broad objectives of Ethiopia's current monetary policy are to maintain price and exchange rate stability and support sustainable economic growth in the country. The detailed objectives are 1) safeguarding a sound financial system, and ensuring that credit and exchange conditions are conducive to the balanced growth of the economy 2) Preserve the purchasing power of the national currency 3) regulate the supply and availability of money and credit and 4) build international reserves and encourage the mobilization of domestic and foreign savings and their efficient allocation for productive economic activities through the implementation of a prudent market driven interest rate policy. In addition, it aimed at facilitating the emergence of financial and capital markets that are capable of responding to the needs of the economy through appropriate policy measures (NBE, 2009).

If we consider recent monetary situations, to mitigate inflationary pressure witnessed in recent years, the NBE implemented the following measures. It raised the reserve requirement ratio first from 5 to 10 percent (for the second time since July 2007) and then to 15 percent in April 2008. Also, liquidity requirement ratio increased from 15 to 25 percent while interest rate on time and saving deposits increased from 3 to 4 percent in 2007 and currently the minimum interet rate on savings deposits is raised from 4 to 5 percent.

Monetary development is often explained by development in monetary aggregates, reserve money, financial sector which is explained by resource mobilization of banks and development in financial markets. Here we will discuss development in monetary aggregates which are relevant for our study.

Figure 3.1: Growth Rate of Narrow (M1) and Broad (M2) Monetary Aggregates



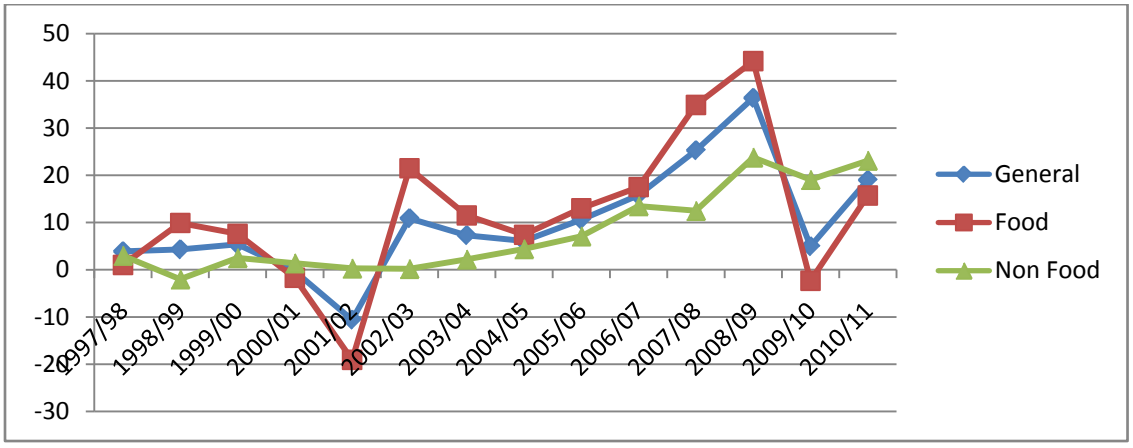
Source: ***Constructed based on NBE data***

The average growth rate of narrow and broad money supply during the current government was around 12 .7 and 15.4 percent, receptively. As we can see form the figure, there is continuous increase in both monetary aggregates beginning from year 2003/04. If we consider the last five years (2006/07-2010/11) broad money accelerated by 23 percent and narrow money increased by 21 percent. According to the NBE this is a reflection of the growing economic activities and improvement in the transaction demand for money. But there is also evidence that part of this continuous increase in money supply is due to the government's attempt to finance its deficit by borrowing from domestic bank and non-bank sources (monetization of deficit) which contributed a lot to the recent inflation. For instance, the use of domestic means of deficit financing as percentage of budget deficit has grown from 34.4 percent in 2002/03 to 63.8 percent in 2006/07 (see Alemayehu and Kibrom, 2008).

3.3 Inflation Trend in Ethiopia

This section examines trend of inflation in Ethiopia and related polices over the review period. When we look at inflation in Ethiopia over the review period, we found that the Ethiopian economy have experienced low levels of inflation relative to most developing countries which are usually characterized by high level of inflation. But this story is starting to change in recent years where the Ethiopian economy is facing high inflation especially in food price.

Figure 3.2 Annual Inflation Rate: (1997/98-2010/11)



Source: ***Constructed based on data obtained from CSA and NBE.***

The period between 1991/92 – 2004/05 experienced an average inflation rate of 5.18 per annum which is considered to be low compared to the experience of most developing countries. The reason for this could be, since early 1990s, which marks a period of transition to market-based economy, the national bank has been at the forefront in formulating and implementing policies that aimed enhancing macroeconomic and financial stability. The coordination of fiscal and monetary policies, over the past fifteen years, has resulted in the achievement of a relative economic progress with price stability.

Maintaining the growth rate of monetary base in line with the growth rate of nominal GDP has been the immediate objective of monetary policies pursued during the reform period, which has helped contain inflationary tendencies (NBE, 2004).

But beginning from 2005/06 there is a continuous increase in the price level of goods and services. The average annual rate of inflation for the period 2005/06-2010/11 was 18.7 percent. Food price in general soared by an average rate of 20.5 percent for the period while non-food inflation was on average 16.5 percent. This high inflation environment is accompanied by double digit growth (see Table 3.1 in section 3.1) in real GDP and specifically 8 percent growth in agricultural component of the GDP.

According to EEA report (2011) food price levels more than doubled (increased by 140 percent) between December 2005 and December 2010. This contrasts with the only 55 percent rise in food prices and 40 percent rise in non-food prices between December 2000 and December 2005. The upsurge in prices in the fiscal year 2008 was typically noticeable. In terms of month-to-month annual inflation, the rates of July 2008 were the highest. Food and general price soared by 92 percent and 64 percent respectively. The price of non-food items during the period rose by 27 percent.

Deflationary trends were observed after 2009 partly due to the move by the NBE to resort to tight monetary policy. This, however, was not sustainable probably due to other policy interventions by the NBE since late 2010 like the devaluation of Birr against the US dollar. In addition, the rise in the price of petroleum pulls price up again. Accordingly, Moth-to-Month annualized general, food and non-food inflation for May 2011 stood at 34.7 percent, 40.7 percent, and 26.2 percent, respectively (EEA, 2011:12-13).

There are many reasons given for this high rate of inflation that the Ethiopian economy is experiencing. Among those, increased money supply, low interest rate, imported inflation such as increase in the price of fuel, steel and fertilizer, supply shock, demand pressure, inefficient market structure, increased money supply from abroad (remittance), high government expenditure and inflationary expectation by market participants can be mentioned (see e.g. Ahmed, 2007 and others cited in Lonening *et al*., 2009).

The high inflationary environment prevailing in the country has its own implication on the degree of ERPT. This is basically related to Taylor (2000) hypothesis which states that ERPT has a positive relationship with the level of inflation prevailing in the country which was discussed several times in previous section. Therefore the high inflation environment observed in Ethiopia is expected to increase the extent of ERPT.

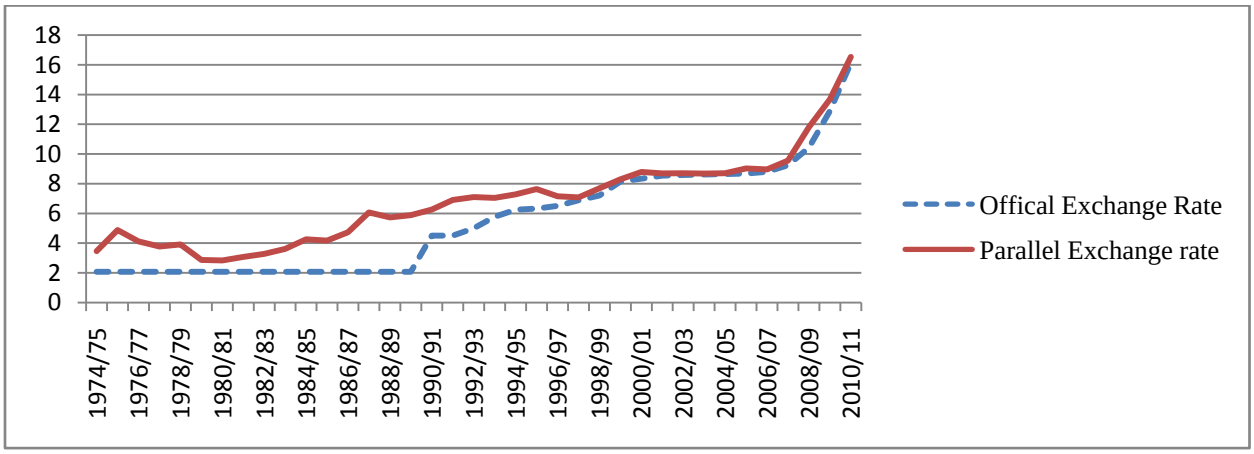
3.4 Exchange Rate Policies and the Behavior of the Birr

The foreign exchange rate is one of the most important prices in an open economy. It links the domestic economy with the rest of the world through both the goods and assets markets. The exchange rate is an important transmission mechanism of monetary policy because it may have a major impact on inflation. Understanding the county's exchange rate policies and the behavior of Birr is essential in order to analyze the degree, speed, persistence and asymmetry of ERPT to import and consumer prices in Ethiopia. Therefore in this section a brief overview of Ethiopia's exchange rate policy and the behavior of Birr between 1974/75 and 2010/11 will be presented.

In Ethiopia, the nominal exchange rate was pegged to the US dollar for over a decade (1974/75-1990/91) and has been administratively fixed at 2.07 per US dollar. The fixed

exchange rate policy, coupled with other restrictive trade polices (such as controlled foreign exchange allocation, import quotas, high tariffs, state owned marketing of exports, export prohibitions, high implicit and explicit export taxation) experienced in Ethiopia for several years resulted in the development of a parallel foreign exchange market.

Figure 3.3 Exchange rate developments (Birr per USD): (1974/75-2010/11)



Source: ***constructed based on data obtained from NBE***

Figure 3.3 shows that the official exchange rate was fixed at 2.07 per us dollar due to the fixed exchange rate policy followed in the socialist period. When we look at the premium it was increasing from time to time under that regime. The increasing trend in premium implies that the official exchange rate was overvalued. The overvalued exchange rate had its own negative effect on exports as well as on imports. On the import side, the overvalued rate made importing cheaper, resulting in low incentive for local production of goods, causing high import dependency of local manufacturing activities and consequently a big pressure on current account. On the export side, it created an anti-export bias, where exporters obtain their inputs at domestic price which in many cases is

inflated for various reasons, but they need to export their output at Birr equivalent of world price which is very low due to the overvalued currency.

Following the Derg regime, reform measures have been taken in the foreign trade sector by the current government in collaboration with the World Bank since 1992. The Structural Adjustment Program (SAP) was adopted at the end of 1992 and the new government has been taking a series of reform measures and policy changes. A major task of the transitional government was found to be geared towards refreshing the external sector.

Accordingly, the following packages of policy measures were undertaken to redress the working of the foreign trade sector. The Birr was devalued by 59 percent in terms of US dollar in 1992, with the objective of improving the country's international competitiveness and a subsequent by-weekly auction of foreign exchange was introduced. In combination of this, the liberalization and deregulation of the domestic marketing, which foster competition and facilitate for such price increase to pass to the producers, there by altering the producers decision either to allocate their resources in the production of exportable goods or direct their market outlet, i.e., a shift from unofficial to official channel as these measure would narrow down the price gap between the two markets (Shewangizaw, 2003).

Due to this the gap between the official rate and parallel rate got narrower over time. On the import side, devaluation via its effect on raising the local price of imports was expected to result in a substitution of import for domestic goods. Moreover, it was supposed to create a pressure on the consumer of importable goods as devaluation made

such goods expensive at local currency. Concerning policy changes, the fixed exchange rate system was replaced by the managed floating exchange rate system which is still practiced.

After the 1992 devaluation of the Birr, another major exchange rate policy intervention was taken by the NBE on August 2010 where the Birr was devalued by some 16% vis-à-vis the US dollar. The bank argued that the action would improve the balance of payment of the country, by boosting export performance and bring about structural change in the economy. However, the effect of devaluation on export performance and trade in general depends on several factors in which the degree of ERPT to import and consumer prices is one of them. Despite the mentioned exchange rate measures taken by the NBE, the level of the country's import is continuing to increase from time to time, while the export share of GDP is still very limited. This shows that devaluation by itself might fall short of addressing the trade problem, which is manifested by low trade share to GDP and an increasing trade deficit.

One reason for this could be that the trade balance will correct only if the response of import and export demand to the price changes induced by the devaluation is sufficiently strong—technically, the sum of the import and export demand elasticities must be greater than one. In the context of a developing country which is importing goods that in many cases have no domestically produced substitutes, and is exporting commodities for which demand tends to be unresponsive to price changes, the sum of the trade elasticities may indeed by less than unity, at least in the short run (Pilbeam, 1998).

Further, the basic nature of the country's import and market structure may work to dampen the impact of devaluation. Much of Ethiopia's imports have no close domestic substitutes which lead to price inelastic domestic demand for imported goods. This gives domestic wholesalers enough power to adjust price (i.e. increase price when exchange rate depreciates) whenever the domestic value of imported goods changes without losing their market share or volume of sale. Thus, it is most likely that, in the case of Ethiopia exporting firms abroad or domestic importing wholesalers will choose to pass the price increase due to devaluation to final consumers; which will increase the consumer price in the devaluing country leading to higher export prices. This will further dampen the international competitiveness of exports which was gained by devaluation.

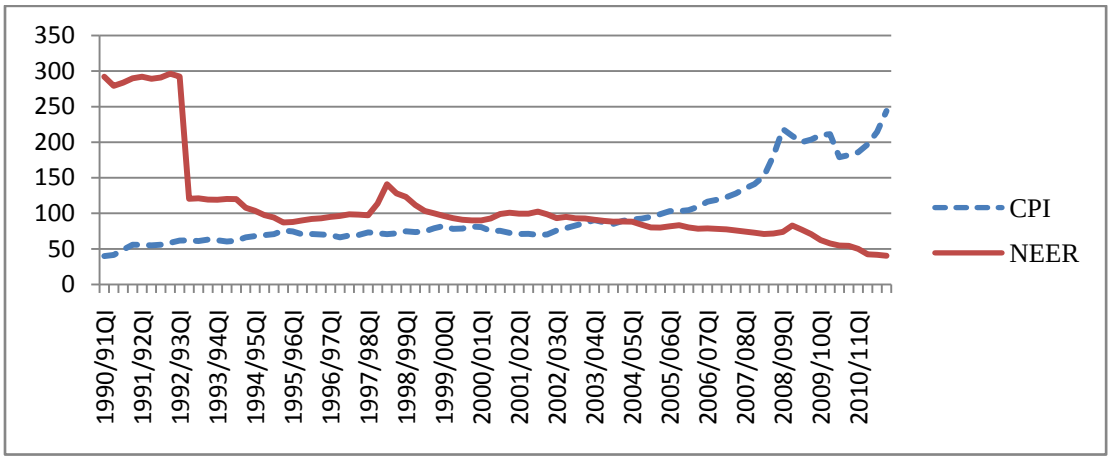
In addition, given the basic nature of imports and supply constrained export of the country; devaluation is unlikely to bear the result it is intended for - correcting trade balance. Rather, it may aggravate the inflationary pressure by increasing the price of imports. Figure 3.8 in section 3.5 shows the structure of Ethiopia's import for two consecutive decades. As we can see from the two figures most of the countries import between 1990/91-1999/00 and 2000/01-2009/10 was capital goods followed by consumer goods and raw materials and semi-finished goods. Also the country imports considerable amount of fuel which is used as input in several sectors of the economy. The high share of capital goods from the total import shows that, just like most developing countries, Ethiopia is highly dependent on imported capital goods and raw materials which serve as input for the existing manufacturing sector. In addition, consumer goods including fuel constitutes considerable amount of the country's import. In particular, the country is

heavily dependent on imported oil and recently the government has lifted the subsidy on oil price.

Generally, the fact that most of the import products of the country are "necessities" such as capital goods and petroleum implies that trying to limit imports by taking different measures such as devaluation might not be a viable option to solve the problem of the persistent and widening trade imbalance. Rather, given the very nature of the country's import devaluation (also depreciation) is most likely to aggravate inflationary pressure in the country.

Saying this, let us continue our review by looking at the relation between movements in exchange rate and consumer prices. Figure 3.4 shows the behavior of the nominal effective exchange rate (NEER) and consumer prices from the 1990/90Q1 to 2010/11Q4. As we can see form the figure below, consumer prices have been increasing as the nominal value of Birr has been decreasing. Starting from the fourth quarter of 2003/04 up to the second quarter of 2008/09 NEER was declining continuously while with the same period CPI was raising. In the subsequent periods there were ups and downs in both NEER and CPI, where by most of the time as former declines the latter rises and vice versa. This suggests the possibility of a significant pass-through resulting from movement in exchange to consumer prices. However visual inspection is, of course, not sufficient to determine the rate of pass-through change in the NEER to consumer prices. The task of investigating the extent and asymmetry of pass-through is left for subsequent chapters.

Figure 3.4: The behavior of nominal exchange rate and consumer price



Source: ***Constructed based on NBE data***

Note: Increase in NEER shows appreciation and vice versa.

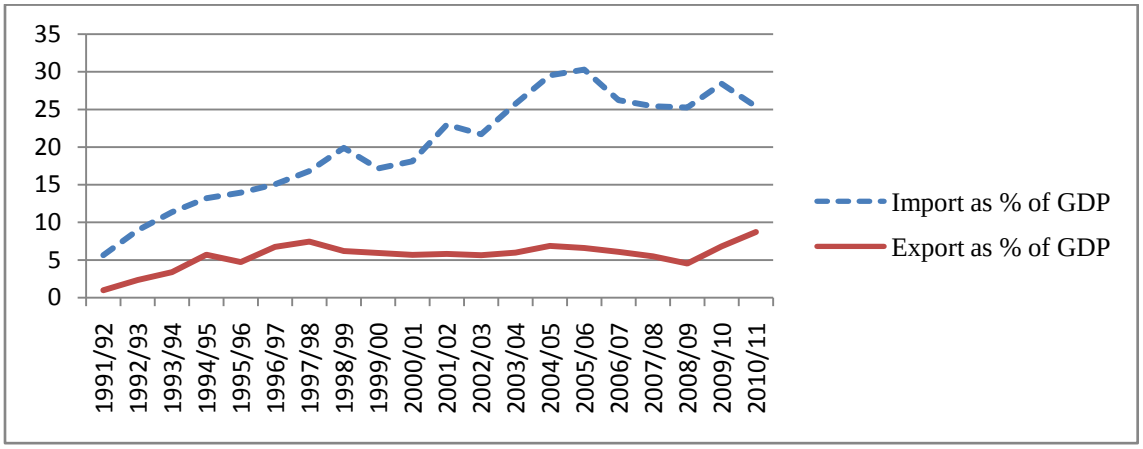
Apart from investigating the relationship between the exchange rate and domestic prices, examining the trade structure of Ethiopia is also worthy in terms giving more information about the extent and possible channels of ERPT in Ethiopia. Thus, in the next section a brief overview of the trade structure of the country will be discussed.

3.5 Trade Structure

The magnitude and speed of pass-through at the aggregate level can also be affected by the trade structure of a country. The size of trade relative to a country's economy or total output is important in assessing the presence and importance of ERPT within that economy. If international trade by a country, that is, importing and exporting activity is minimal, then ERPT will not be important as domestic prices will not be considerably influenced by fluctuations in the country's exchange rate. However, if the ratio of trade to the country's GDP (total aggregate output) is high; the country is likely to experience notable levels of pass-through.

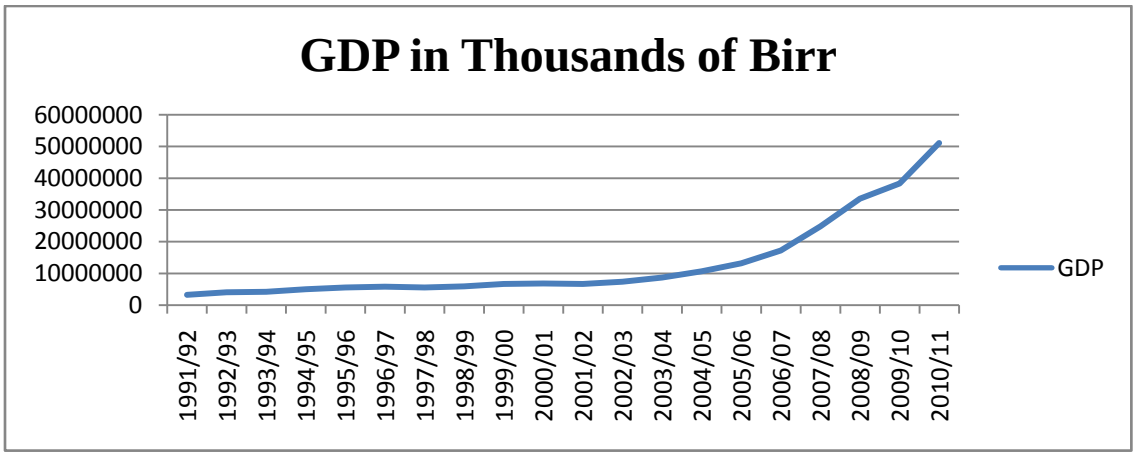
In the case of Ethiopia, trade plays an important role in economic growth. The percentage of total imports to GDP (which can be considered as a measure of import penetration) have been on average 14 percent between the periods 1991/92-2000/01 and increased to 26.1 percent between the periods 2001/02-2010/11. Also, average total exports as a percentage of GDP was 4.9 percent between 1991/92-2000/01 and it marginally increased to 6.1 percent between the 2001/02-2010/11. Figure 3.5 shows that the ratio of imports to total GDP has been trending upwards since 1991/92, implying an increase in the import component of total GDP. Furthermore, the data obtained from MOFED shows that Ethiopia's nominal GDP has been increasing continuously over time which imply the increase in the imports to GDP ratio has increased not because of a decline or stagnation in the level of GDP (see Figure 3.6).

Figure 3.5: The Ratio of Total Export and Imports to GDP



Source: ***Constructed based on data obtained from NBE***

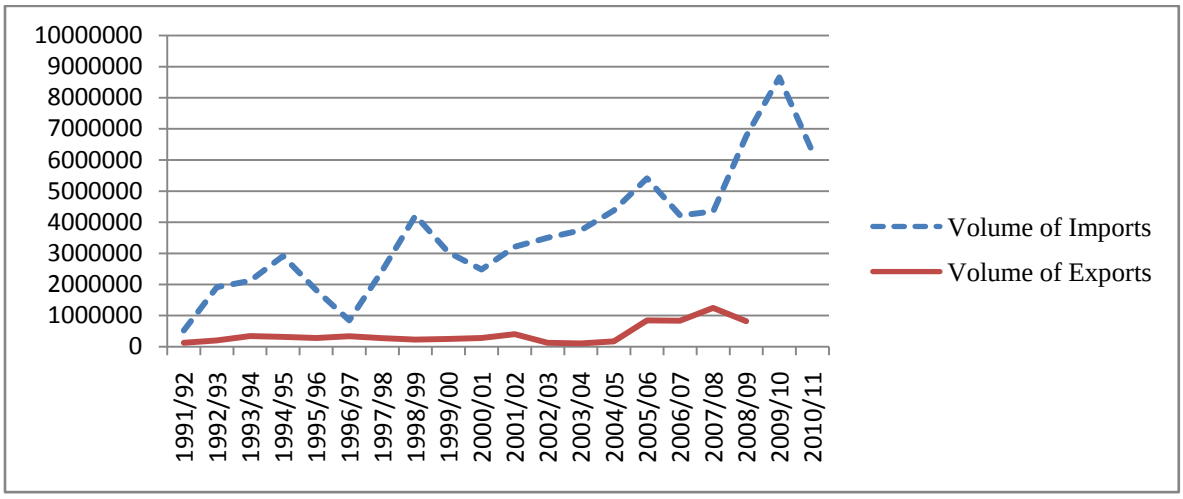
Figure 3.6: Ethiopia's Nominal GDP



Source: ***MOFED***

Although Ethiopian trade strategies over the past twenty years, such as the promotion of export trade through provision of favorable tax and duties on export of goods, revision of tariff regime and the exchange rate measures which have been taken since 1992 are partly aimed at encouraging more growth in export relative to import, the statistics show the reverse. As we can see from Figure 3.5 the contribution of export to the GDP of the country is very limited which was less than 10% throughout the review period. In addition Figure 3.7 shows the total trade volumes in Ethiopia from 1991/92-2010/11 respectively. The figure shows that import volumes has generally outstripped export volume over the review period.

Figure 3.7 Total trade volumes in Ethiopia in Metric Tons



Source: ***Constructed based on data obtained from NBE***

The wide discrepancies between the volume of import and that of export shows that although trade policy reforms taken since 1992 such as the currency devaluation, elimination of state monopolies, rationalization of the tariff structure and liberalization of exchange rate allocation,[8] were helpful in stimulating exports in general to the extent that they reduced the anti-export bias, the effect of such policies were stronger in stimulating imports than export.

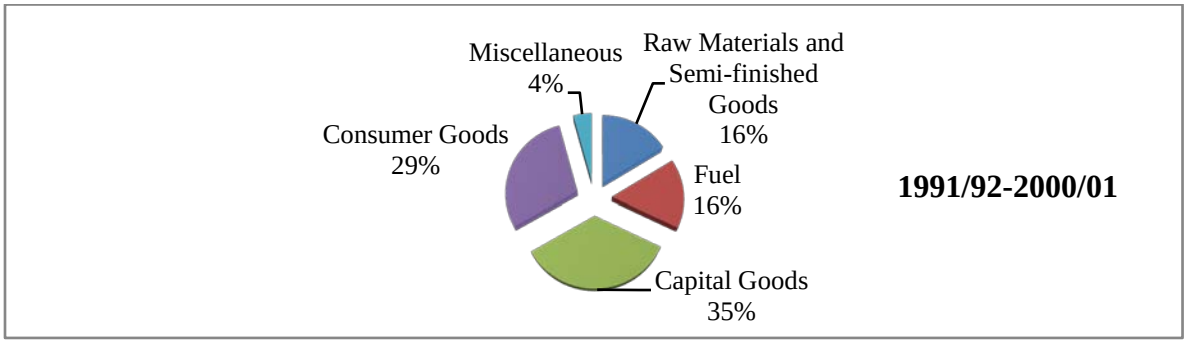
Another important issue that may determine the degree of pass through is the import structure of a country. Particularly, the size and speed of the ERPT will depend on the channel it passes-through as determined by, amongst other factors, the nature of the imported goods and services. If the imported commodities are primarily capital goods and/or raw materials, the pass-through can be depicted as: where depreciation in the NEER will be passed directly to import prices, then producer or wholesale prices, and

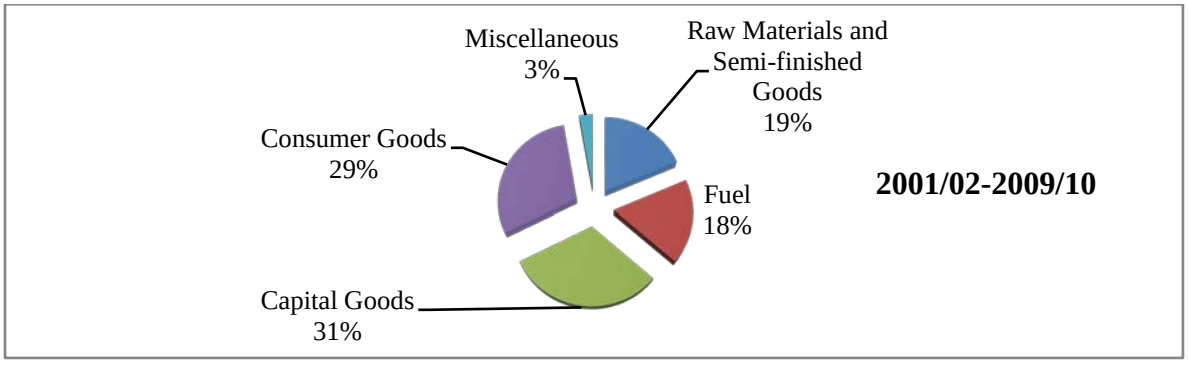
[8] See, e.g. Shewangizaw (2003) for detailed discussions on post 1992 trade strategies

finally consumer prices; as importers pass on some of the costs spurred by the currency depreciation to their customers. Alternatively, if the imported commodities are predominantly finished goods and services for final consumption, the pass-through will be transmitted directly from the change in NEER to import price to consumer price.

Figure 3.8 and 3.9 shows the import structure of Ethiopia. Ethiopia's major imports are food and live animals, beverages, tobacco, petroleum, chemicals, fertilizers, medical & pharmaceutical products, soap & polish, rubber products, paper, textiles, clothing, glass & glass ware, metal products, machinery & aircraft, road motor vehicles and electrical materials. This and other unmentioned products in general can be broadly grouped as raw materials, semi-finished goods, consumer goods and capital goods.

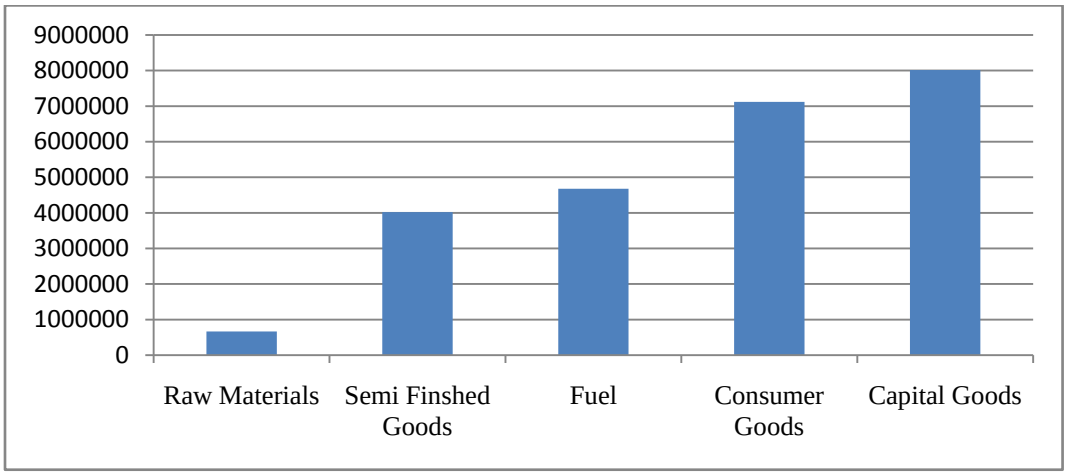
Figure: 3.8 The Structure of Ethiopia's Import





Source: Own Computation based on data obtained from NBE

Figure 3.9: Average Value of Import (1991/92-2009/10)



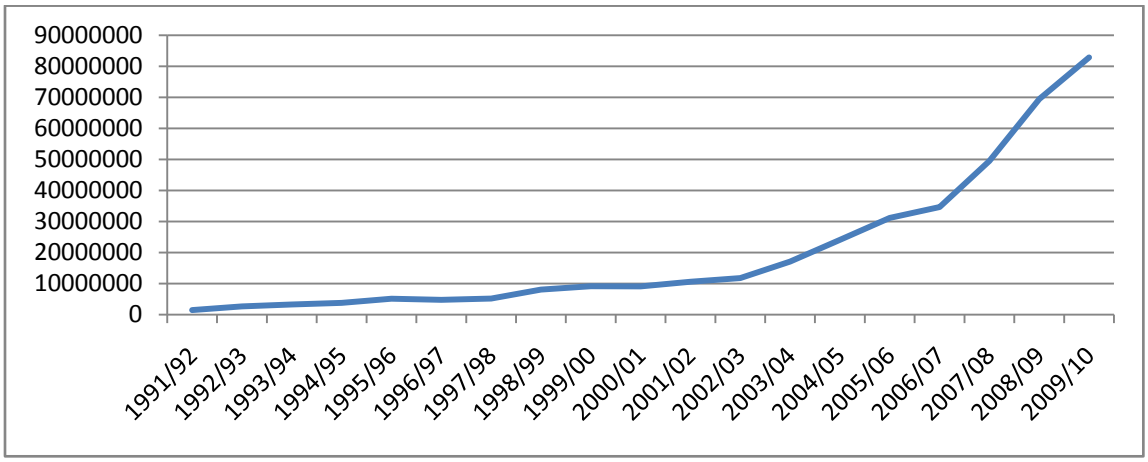
Source: Constructed based on data obtained from NBE

As we can see from Figure 3.8 and 3.9, in terms of value, the majority of Ethiopia's imports where capital goods followed by consumer goods between the periods 1991/92-2009/10. From Figure 3.8, we can observe that capital goods hold the largest share of imported goods in the two consecutive decades. In addition, we can also notice that the share of imported fuel from the total import increases in the consecutive decades, suggesting that domestic prices could be vulnerable to oil price shocks. Generally, the average share of raw materials, semi-finished goods, fuel, consumer goods and capital goods from the total import is 2.2, 16.1, 18.1, 30.5 and 33.2 percent, respectively, between the periods 1991/92-2009/10.

Moreover, Figure 3.10 below shows the trade deficit of the country in thousands of Birr. Ethiopia's trade balance was negative throughout the review period due to the fact that for the entire period the total import of the country exceeds the total export of the country. Due to increasing import value and volume and the limited improvement of the export sector (in terms volume, value and type of export items) the countries trade deficit

is increasing from time to time, which implies that there is a need to take different measures that could improve the trade sector in which crafting appropriate exchange rate policy and taking appropriate exchange rate measures is one them. Among different factors that could shape appropriate exchange rate policy and measures that should be taken by a country, the degree of ERPT is one of them.

Figure 3.10 Trade deficit in thousands of Birr



Source: Constructed based on data obtained from NBE

Generally, the significant growth in the volume of imports suggests that Ethiopia could be prone to the ERPT phenomenon. Theoretically, if we assume that a country's import share is a reliable proxy for the import penetration faced by firms in that country, then countries with a larger import share should have a greater pass-through of exchange rate and import price fluctuations to domestic prices (McCarthy, 2000: 3). Evidently, Ethiopia is heavily dependent on imported capital and consumer goods including fuel. Thus, the pass-through of exchange rate fluctuations to domestic prices in the country would be expected to flow first to import prices and then to consumer prices due to the fact that the majority of the country's imports are capital goods.

4. METHODOLOGY OF THE STUDY

4.1 Data Set and Source of Data

4.1.1 Data Set

The major objective of this paper is to shed light on the transmission of fluctuations in the exchange rate into import prices (MPI) and consumer prices (CPI). Thus, these three variables are the center of our empirical analysis. It is assumed that prices are set along the distribution chain, i.e. exchange rate shocks are initially passed along to import prices and then to producer prices[9] and finally lead to a reaction in consumer prices. Next, the model includes a measure of the output gap (Y^{Gap}) in order to control for domestic economic activity (demand shock). A broad measure of money (M2) is also included which allows to capture the effects of monetary policy. Finally, world commodity prices (WCPI) are considered to capture international supply shocks (imported inflation) which might affect the exchange rate and domestic prices.

The selection of variables for our baseline model is based on the following considerations. First, we include the world commodity price and the output gap in a VAR model following McCarthy (2000), Hahn (2003) and Ito and Sato (2006). In our model, international supply shocks are identified by the world commodity price inflation unlike the above mentioned studies that include oil price inflation as a proxy for supply shock. This is because, even though Ethiopia is highly dependent on imported oil, and hence the change in the price of oil has significant impact on the economy, oil price has been

[9] However our base line model did not include producer price index because data is not available prior the period 2000.

administrated by the government for long time and hence we did not include this variable in the base line model.[10] Instead, world commodity price (WCPI) is used as proxy for international supply shock which is based on the fact that the Ethiopian economy is vulnerable to international commodity price shocks. To capture the demand side effect, we include the output gap which is constructed by applying the Hodrick Prescott (HP) filter to GDP.

Moreover, broad money supply is included in the model to allow for the effects of monetary policy. Neglecting the behavior of monetary policy variables may distort the true consequences of exchange rate variations on consumer prices. A monetary policy that is concerned with keeping domestic inflation within its target range is likely to mitigate the effects of exchange rate fluctuations on domestic prices. This is justified by McCarthy (2000) who found that taking monetary policy in the analysis significantly improves the estimation results of ERPT. As a result, the underlying relationship between changes of the exchange rate and domestic prices, which is of vital interest for our analysis, may be masked if monetary policy is excluded from the analysis (see Parsley and Popper, 1998 cited in Hahn, 2003).

In addition, the inclusion of the money supply allows us to capture the effects of monetary policy on inflation. Studies on the determinants of inflation in Ethiopia show that increased money supply is a significant cause of the recent inflation in the country

[10] The government used to subsidized oil price for a long time. However recently it removed an US$800 million annual subsidy on petroleum products with a rational that the money would be used to stabilize rising grain prices (i.e. the government has decided to subsidies food items instead of oil).

(See e.g. Alemayehu and Kibrom, 2008). The VAR approach enables us to identify monetary policy shocks, which reveals whether domestic inflation was caused by the mismanaged monetary policy or a sharp depreciation of exchange rates.

Third, the nominal effective exchange rate (NEER) is used in our model. Many studies have used the bilateral exchange rate vis-à-vis the US dollar, however the effective exchange rate is the right concept to use when the total effect of the exchange rate changes is attempted to be measured in a country with diversified trading partners (Ito and Sato, 2006). In general we will estimate a 6-variable VAR including two types of price variables (MPI and CPI) together to directly analyze the effects of shocks on prices at different stages of the pricing chain, i.e., how exchange rate and other external shocks are transmitted from one price stage to the next.

4.1.2 Source of Data

The study used quarterly time series data obtained from National Bank of Ethiopia (NBE), Central Statistical Authority (CSA), Ministry of Finance and Economic Development (MOFED), International Financial Statistics (IFS). The period between 1991/92-2010/11 will be covered under this study. Quarterly NEER[11] and Money Supply data are obtained from NBE. Data on CPI is obtained from CSA and IFS. World commodity price index, 2005=100, which includes fuel and non fuel price indices, is

[11] NEER measures the nominal effective depreciation or appreciation of domestic currency against weighted baskets of foreign currencies. Note that an increase in NEER indicates appreciation of Birr and vice versa.

$$NEER = \sum_{j=1}^{n} W_{jt} E_{jt}$$

taken from IFS. Since there is no ready-made import price index data for Ethiopia we are obliged to proxy it by constructing unit value import price index.[12]

Output gap is obtained by taking the difference between actual and potential GDP where the latter is estimated by using the HP filter method[13]. Since quarterly GDP is not available it is constructed by using method introduced by Haile Kibret (2001). Haile (2001) tried to study the behavior of seasonality function of each sectors in its contribution to annual GDP based on seasonality adjustment coefficients. Previously, Yimserech (2005) and Zewdie (2009) generated quarterly GDP from annual GDP by using the quadratic interpolation method which was developed by Goldstein and Khan (1976). However the current study applies Haile's method because it captures country specific issues in a better way compared to other methods.[14] But this method also acts with a sort of limitation such as constant coefficients, ignores private sector's contribution to industry and share to other service sub-sectors (than distributive service sector) are equally divided in to four.

4.2 Analytical Approach

4.2.1 Symmetric Model

As mentioned in Chapter 2, the ERPT literature takes its roots from LOP and the PPP literature. Several advanced models are developed making their starting point the LOP in which most of the empirical studies based on these models are estimated by a single

[12] See appendix A.1 for detailed information on the construction of import price index.

[13] The method decomposes a given time series in to trend and cyclical component

[14] For detailed information about the method, interested readers can refer Haile Kibret (2001)

equation method. In this method a standard way to estimate the pass-through effect is the coefficient obtained from regressing changes in price indices to variation in nominal exchange rate (see e.g. Campa and Goldberg, 2005). This practice, however, is not necessarily well suited as it implicitly suggests that any movement in the exchange rate is exogenous, while failing to control for factors, other than the exchange rate, that determines inflation. Estimates from these kinds of models can also be affected by potential endogeneity of domestic prices and exchange rate, and does not consider the effects of shocks in the world market that may affect the exchange rate and hence domestic prices (Bhattacharya *et al*., 2011).

Moreover, many of the variables in the markup model[15] are not directly observable and need to be proxied. This is clearly the case of the marginal costs, which are often proxied by producer prices or unit labor costs. Last but not least, these models are static in nature; however it is unlikely that prices completely adjust within one period (especially at quarterly frequency), calling for the use of a dynamic model (Bussière, 2007).

The current study will use an alternative modeling strategy; namely, the model of pricing along a distribution chain which was first introduced by McCarthy (1999) to ERPT literature. This methodology permits the tracking of the pass-through from exchange rate fluctuations to each stage of the distribution chain in a simple integrated framework. In this way it examines the pass-through of exchange rate and import price fluctuations to domestic producer and consumer inflation.

[15] See, Hooper and Mann (1989), Goldberg and Knetter (1997) and Campa and Goldberg (2002) in chapter 2

The use of this model has several advantages compared to its alternatives discussed in Chapter 2: First it is well suited to capture both the size as well as the speed of the pass-through. Shocks may affect prices at different stages both directly and indirectly via previous price stages. It allows seeing the possibility of a decline in adjustment speed of prices along the distribution chain which might occur as a result of adjustment lags at the different stages of distribution.

Second, pricing along a distribution chain framework allows one to observe how external shocks are transmitted from one distribution stage to another. Thirdly, the model allows import price shocks to affect domestic consumer inflation both directly and indirectly through their effects on producer inflation. Mark-up models allow measuring the indirect effects of import prices on consumer inflation only, since import prices take place in the model only as a factor cost in the production process. However, import prices may have direct effects on consumer inflation too. Fourth, the model incorporates the dynamics through pricing power and changing mark-up rates, in contrast to mark-up framework, which assumes a constant mark-up over producer prices even if the conditions in the economy change over time. However, firms may have an incentive to change their profit margins by adjusting their mark-up rates due to several factors such as market competition, demand conditions in the economy and the type of external shock they are exposed to (Yüncüler, 2009).

We recall form Chapter 2 that in the model of pricing along a distribution chain, inflation at each stage, i.e. import, producer and consumer inflation, consists of six components. The first component is the expected inflation at that stage where expectations are based on the available information at the period t-1. The second component is the domestic

demand shock at period t. The third and fourth components are supply and exchange rate shocks at period t. The next components are the shocks at the previous stages of the chain. Finally, there is the shock that belongs to that stage. The particular shock of each stage is the part of the inflation at that stage that cannot be explained by shocks of previous stages of the distribution chain and information at period t-1. To complete the model McCarthy considers the following assumptions:

- Supply shocks are identified from the dynamics of oil price inflation denominated in the local currency.
- Demand shocks are identified from the dynamics of the output gap in the country after taking into account the contemporaneous effect of the supply shock.
- External shocks are identified from the dynamics of exchange rate change after taking into account the contemporaneous effects of the supply and demand shocks.
- Finally he also accounted for the reaction of monetary policy to exchange rate fluctuations.

Based on this general background, we specify a six variable VAR model which includes exchange rate, import price, consumer price, output gap, world commodity price index and money supply following McCarthy (1999); Smets and Wouters (2002); Hahn (2003); Ito and Sato (2006), Bhattacharya *et al*. (2011) and others as shown in equation 4.1.

$y_t = [WCPI, y^{Gap}, NEER, MPI, CPI, M2]$ ..... (4.1)

Where, all the variables are as defined earlier.

4.3 Econometric Approach

The econometric techniques that have been utilized to model ERPT can be broadly divided into four categories: single equation econometric methods, VAR models, structural macroeconometric models, and dynamic stochastic general equilibrium (DSGE) models (Mwase, 2006). Most studies applied single equation econometric methods to estimate the pass-through with aggregated data[16]. This approach is however problematic in the sense that it does not account for non-stationary and endogeneity problem. One mechanism to solve this difficulty could be to use a multivariate time series models such as VAR.

Use of VAR model helps to account for spurious correlations, and exogeneity bias as it is designed for non-stationary time series and requires no endogenous - exogenous division of variables. A number of papers use variants of the VAR models to analyze the effect of exchange rate and other exogenous shocks on domestic prices. Among this some use Structural VAR (SVAR) models to capture the dynamic impact of exchange rate disturbances on inflation while others utilize the VECM to capture the response of prices to exchange rate movements under the assumption of cointegration[17].

[16] See e.g. Goldberg and Knetter, 1997; Campa and Goldberg, 2002; Choudhri and Hakura, 2001 and Barhoumi, 2006

[17] See McCarthy, 1999, Hahn (2003) and Ito and Sato (2006) and others on SVAR, and Bhattacharya *et al*. (2011) on CVAR

In contrast to analyzing ERPT using a single price by employing a single-equation-based approach, a VAR approach allows us to investigate ERPT into a set of domestic prices along the pricing chain. In addition, since the exchange rate and inflation rate are expected to be influencing each other in many theoretical models, it is most appropriate to estimate a system that would treat both of them endogenous. VAR models are useful that allow for such interaction between exchange rate and domestic variables (Ito and Sato, 2006). The current study will use two estimation methods namely: the SVAR and the CVAR. The first one is powerful in analyzing short run issues while the latter integrates the short run dynamics with the long run relationship and it is preferable for analyzing long run issues concerning ERPT (long run effect of exchange rate on prices).

4.3.1 Structural VAR

The baseline empirical model is estimated as a VAR with six endogenous variables. The SVAR form representation of the model may be written as:

$B_0 y_t = B_1 y_{t-1} + \ldots\ldots + B_p y_{t-p} + \varepsilon_t$ ……. (4.2)

Where y_t= $[\Delta wcpi, y^{Gap}, \Delta neer, \Delta mpi, \Delta cpi, \Delta m2]$ vector of k = 6 variables. B_0 is an invertible $(n \times n)$ matrix of coefficients of contemporaneous relations on the endogenous variables; B_i 's are $(n \times n)$ matrices which captures dynamic interactions between the *k* variables in the model, ε_t denotes a mean zero $(n \times 1)$ vector of structural error terms, also referred to as a structural innovation or structural shock and *p* is the number of lags.

Equivalently the model can be written more compactly as:

$B\ (L) y_t = \varepsilon_t$ …… (4.2a)

Where $B\ (L) = \ B_0 \ - \ B_1 L + B_2 L^2 \ \ldots\ldots + B_p L^p$ is the autoregressive lag order polynomial[18]. The variance-covariance matrix of the structural error term is typically normalized such that: E $(\varepsilon_t \varepsilon_t^{'}) = \Sigma_\varepsilon \ = \mathrm{I}_k$

In order to allow estimation of the structural model we first need to derive its reduced-form representation (since the structural model is not observable). This involves expressing y_t as a function of its lags. To derive the reduced form representation, we pre-multiply both sides of the structural VAR representation by B_0^{-1}:

$B_0^{-1} B_0 y_t = B_0^{-1} B_1 y_{t-1} + \ \ldots\ldots + B_0^{-1} B_p y_{t-p} + \ B_0^{-1} \varepsilon_t$ …… (4.3)

Hence, the same model can be represented as:

$y_t = A_1 y_{t-1} + \ \ldots\ldots + A_p y_{t-p} + \ u_t$ ……. (4.4)

Where $A_i = B_0^{-1} B_0$, i=1, …, p, and $u_t = B_0^{-1} \varepsilon_t$. Equivalently the model can be written more compactly as:

$A\ (L) y_t = u_t$ …….. (4.4a)

Where $B\ (L) = \ I - \ A_1 L + A_2 L^2 \ \ldots\ldots + A_p L^p$ and E (u_t) = 0 and E $(u_t u_t^{'}) = \Sigma_u$ denotes the autoregressive lag order polynomial. Standard estimation methods allow us to obtain consistent estimates of the reduced-form parameters A_i, i=1,…, p, and the reduced-form errors u_t, and their covariance matrix E $(u_t u_t^{'}) = \Sigma_u$ (Kilian, 2011:2).

[18] In the notation of (4.2 and 4.2a), deterministic terms (i.e. the constant) is suppressed for simplicity.

The structural model represented by system (4.2) must be identified for the purpose of policy analysis and must be given economic interpretation. The fundamental problem here is that ε_t is not directly observed but needs to be identified (Stulz, 2006). The next question is how to recover the elements of B_0^{-1} from consistent estimates of the reduced-form parameters, because knowledge of B_0^{-1} would enable us to reconstruct ε_t from $\varepsilon_t = B_o u_t$ and B_i, $i = 1 \ldots \ldots p$ from $B_i = B_0 A_i$

By construction, $u_t = B_0^{-1}\varepsilon_t$. Hence, the variance of u_t is:

$E(u_t u_t') = B_0^{-1} E(\varepsilon_t \varepsilon_t') B_0^{-1'}$

$\Sigma_u = B_0^{-1} \Sigma_\varepsilon B_0^{-1'}$ but, $\Sigma_\varepsilon = I$

$\Sigma_u = B_0^{-1} B_0^{-1'}$

One popular way of recovering the structural innovations ε_t from the reduced-form innovations u_t is to apply Cholesky orthogonalization to the reduced-form residuals. Mechanically, this can be accomplished as follows. Define a lower-triangular K×K matrix S with positive main diagonal such that $SS' = \Sigma_u$. It follows immediately from the condition $\Sigma_u = B_0^{-1} B_0^{-1'}$ that $B_0^{-1} = S$ is one possible solution to the problem of how to recover u_t. Thus, the Cholesky decomposition encompasses the decomposition of the variance covariance matrix Σ_u of the reduced form residuals in a lower triangular matrix S and an upper triangular matrix S' which allows as recovering the structural shocks[19]

[19] The Choleski decomposition of Σ_u implies $\Sigma_u = PP'$ where the Choleski factor, *P*, is a lower-triangular matrix. Since E (uu_t') = SE($\varepsilon\varepsilon_t'$)$S' = SS'$ (where structural disturbances are assumed to be orthonormal, i.e., E($\varepsilon_t \varepsilon_t'$) = *I*, the lower-triangular matrix *S* is equal to the Choleski factor *P*.

(Ito and Sato, 2006:11). Accordingly, the relationship between the reduced-form VAR residuals and the structural disturbances can be written as follows:

$$\begin{bmatrix} u_t^{WCPI} \\ u_t^{yGap} \\ u_t^{Ex} \\ u_t^{MPI} \\ u_t^{CPI} \\ u_t^{M2} \end{bmatrix} = \begin{bmatrix} s_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ s_{21} & s_{22} & 0 & 0 & 0 & 0 & 0 \\ s_{31} & s_{32} & s_{33} & 0 & 0 & 0 & 0 \\ s_{41} & s_{42} & s_{43} & s_{44} & 0 & 0 & 0 \\ s_{51} & s_{52} & s_{53} & s_{54} & s_{55} & 0 & 0 \\ s_{61} & s_{61} & s_{63} & s_{64} & s_{65} & s_{66} & 0 \end{bmatrix} \begin{bmatrix} \varepsilon_t^{WCPI} \\ \varepsilon_t^{Gap} \\ \varepsilon_t^{Ex} \\ \varepsilon_t^{MPI} \\ \varepsilon_t^{CPI} \\ \varepsilon_t^{M2} \end{bmatrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4.5)$$

Where ε_t^{WCPI}, ε_t^{Gap}, ε_t^{Ex}, ε_t^{MPI}, ε_t^{CPI} and ε_t^{M2} are the structural disturbances, that is, world commodity price, output gap, NEER, import price, consumer price and money supply shocks respectively, while u_t^{WCPI}, u_t^{Gap}, u_t^{Ex}, u_t^{MPI}, u_t^{CPI} and u_t^{M2} are residuals in the reduced form of equations.

The structural model is identified because the k (k −1)/2 economic restrictions, necessary to identify the structural model, are imposed as zero restrictions on the matrix S, which links the reduced form and the structural residuals. The resulting lower-triangular matrix S implies that some structural shocks have no contemporaneous effect on some endogenous variables given the ordering of endogenous variables. Economic interpretation is attached to this model by the selected ordering of the variables, as the ordering indicates which shocks are not allowed to contemporaneously affect which variables (Hahn, 2003 and Ito and Sato, 2006).

In order to identify shocks or their respective impulse-response functions via Cholesky decomposition, the variables need to be given a plausible ordering. Following McCarthy (2000), Hahn (2003) and Ito and Sato (2006) we assume a recursive ordering. The

aforementioned studies apply different ordering depending on the characteristics of the country/ region under consideration and the problem explored. McCarthy (2000) applies the following ordering: the change in oil prices is ordered first because the reduced-form residuals of oil prices are unlikely affected contemporaneously by any other shocks in the system while oil price shocks are likely affect all variables in the system contemporaneously. The output gap is ordered next as he assumes that the output gap is contemporaneously affected by only oil price shocks while output gap (demand) shocks have a contemporaneous impact on other variables except oil prices. The exchange rate is ordered third followed by domestic prices which are ordered according to the distribution chain (i.e. MPI, WPI, and CPI). Finally, the monetary variable is ordered last assuming that monetary policy may react to exchange rate fluctuation.

Hahn (2003) and Ito and Sato (2008) follow the same ordering as McCarthy but the monetary policy variable[20] is ordered prior to exchange rate and prices by assuming that monetary policy reacts not to realized inflation but to expected inflation. The difference between the two authors's is that Hahn orders the monetary policy variable prior to out gap while Ito and Sato ordered it next to output gap.

Against this background we assume the following order for Ethiopia.

$$\Delta wcpi \rightarrow y^{Gap} \rightarrow \Delta neer \rightarrow \Delta mpi \rightarrow \Delta cpi \rightarrow \Delta m2$$

For small open economies like Ethiopia, world commodity prices are assumed to be exogenous because the country has insignificant power in the world market to affect international prices. Thus, changes in world commodity price are ordered first because

[20] Where the former use interest rate while the latter use money supply to proxy monetary policy

the reduced-form residuals of commodity prices are unlikely affected contemporaneously by any other shocks except commodity price shocks per se, while world commodity price shocks would likely affect all variables in the system contemporaneously. We therefore model the world commodity price shock as independent to the shocks to other variables.

Excess demand shocks which are proxied by output gap are assumed to be influenced by exogenous factors, such as adverse weather conditions. This is manifested by the fact that the Ethiopian economy is highly dependent on agriculture and in turn the agricultural sector is highly dependent on the prevailing whether condition (rain feed agriculture). Thus, output gap is ordered next, as we assume that the output gap is contemporaneously affected by only world commodity price shock while output gap (demand) shocks have a contemporaneous impact on other variables except world commodity prices.

Shocks to the exchange rate largely reflect exogenous factors, such as unexpected surge in aid inflows and terms of trade improvements which increase the country's foreign reserve and policy interventions which are assumed to be independent of other disturbances (money supply and domestic prices) in the model. Ethiopia has adopted a managed float exchange rate regime since 1992 and is still maintained with the NBE intervening in the foreign exchange market to smoothen excessive fluctuations. Thus NEER is ordered third, which implies that the NEER responds contemporaneously to world commodity price and output gap (demand) shocks. The exchange rate shocks are assumed to have a contemporaneous effect on money supply and domestic inflation.

Import price is ordered in the fourth place followed by consumer price index based on the pricing chain. The order of the monetary variable is somehow controversial in which

different researchers give different ordering for this variable. Some (such as McCarthy) order it last assuming that central banks react to changes in the exchange rate and prices indices (i.e. assuming reactive nature of monetary policy). Others (such as Hahn and Ito and Sato) order it prior to exchange rate and prices by assuming that monetary policy reacts not to realized inflation but to expected inflation (forward looking behavior). This one lets prices react to central bank policy, i.e. central banks set the target of M2 after observing leading indicators for inflation like oil prices, output changes etc. The current study orders M2 last in the base line model assuming monetary policy in Ethiopia is reactive (passive) rather than forward looking[21].

Given these, the size and speed of pass-through will be estimated using impulse response functions and variance decompositions are computed to point out the relative importance of various shocks in explaining fluctuations in the price indices.

4.3.2 Cointegrated VAR

As an alternative to the SVAR model, we estimate a Cointegrated VAR (CVAR) model in order to capture the long-run relationships between exchange rate and price indices. As discussed in the previous section, the standard ERPT literature deals with I (1) variables by estimating a SVAR model in first differences (McCarthy, 1999; Ito and Sato, 2008). However, this approach leads to loss of information concerning the long-term relationships between the series (Bhattacharya *et al*., 2011). The theory of cointegration addresses this issue by integrating short-run dynamics with long-run equilibria.

[21] However in alternative models we gave different order for M2 to check the sensitivity of estimated pass-through coefficients to change in the order of this variable

Thus, the long-run relationship between the exchange rate behavior and the price level will be investigated using a cointegrating approach. According to Masten (2004) estimation of pass-through effect with CVAR has two main advantages. First, since most financial series such are price become stationary at least after differenced once, the test for cointegration is vital. Also, in economics we are usually interested about long run relationship between price and exchange rate (any variables) and hence neglecting cointegration will be neglecting the intrinsic meaning of equilibrium long run relationship between variables under consideration. The second important advantage of estimation with a CVAR is that it enables us to distinguish between permanent and transitory shocks. This is an important distinction because permanent shocks usually have non zero long run equilibrium pass-through effect, while transitory shocks rarely induce significant short run changes in pricing behavior, if firms face costs associated with frequent price changes.

VECM embodied in the CVAR technique, distinguishes clearly between long- and short-run impacts and responses, providing a suitable tool for policy analysis. Defining a vector of potentially endogenous variables, it is possible to specify the following unrestricted VAR model involving up to k-lags of y_t;

$$y_t = \alpha_0 + \sum_{i=1}^{k} A_i y_t + u_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.6)$$

Where $u_t \sim$ IN (0, Σ)

Where, y_t is an (nx1) matrix containing endogenous variables in the system and A_i is an (nxn) matrix of parameters. The system is in reduced form with each variable in y_t

regressed on only lagged values of both itself and all the other variables in the system (Enders, 1995). As such, the error correction representation of a standard VAR is given as follows:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + \Pi y_{t-1} + u_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.7)$$

Where $y_t \sim$I (1) and $u_t \sim$ IN (0, Σ)

As defined above, y_t is the vector of I(1) variables, Δ is the first difference operator, Γ_i is a (n x n) coefficient matrix and Π_i is a (n x n) matrix whose rank determines the number of cointegrating relationships among the variables. This way of specifying the system contains information on both the short and long-run adjustment to changes in y_t, via the elements Γ_i and Π respectively. If Π is of full rank, that is, r = n, this suggests that the variables are level stationary, and if r = 0, this means that there are no cointegrating vectors. However, if Π has a reduced rank r ≤ (n - 1), then it can be decomposed to the following form, $\Pi = \alpha\beta'$ where α represents the speed of adjustment to equilibrium, while β is a matrix of long-run coefficients such that the term $\beta' y_{t-k}$ embedded in the ECM represents up to (n-1) cointegration relationships in multivariate model which ensures that y_t converges to their long run steady-state solution (Harris, 1995).

4.4 Asymmetric Model

Although exhaustive, a linear CVAR estimates obtained from a long-run relationship as the one in Equation (4.7) assumes a symmetric long-run relationship between the price level and the exchange rate. However there are various reasons why the relationship between prices and the exchange rate may be asymmetric which are discussed in previous chapters. Pass-though asymmetry can be can be analyzed with respect to (1) direction of exchange rate change (appreciation and depreciation), (2) the size of exchange rate change (small and large change) and (3) inflation environment (high and low inflation environment).

There are two methods to be considered in analyzing the asymmetric nature of ERPT with respect direction and size of the change in exchange rate. The first one is introduced by Pollard and Coughlin (2004) where they include dummy variables that capture a range of changes in exchange rate regarding direction and size. To determine if pass-through is asymmetric with respect to the direction of the change in the exchange rate, two dummy variables are created that separate quarters in which the US dollar appreciated from those in which it depreciated. Similarly, to determine if pass-through is asymmetric with respect to the size of the change in the exchange rate, two dummy variables are which separate small change and large change in Exchange rate. Then, the dummy variables are interacted with the exchange rate term and included in the model. The dummies are:

A_t= 1 when $\Delta \ln E_t > 0$ D_t=1 when $\Delta \ln E_t < 0$

0 otherwise 0 otherwise

Where A_t and D_t are appreciation and depreciation of exchange rate respectively

L_t=1 when /ΔlnEt/ >=3% S_t=1 when /ΔlnE_t/ <3%

0 otherwise 0 otherwise

Where L_t and S_t are large and small change in exchange rate respectively

Webber (1999) and Wickremasinghe and Silvapulle (2004) use a different approach to investigate the extent of pass-through under exchange rate appreciations and depreciations. Instead of introducing a dummy variable, they construct a new series which captures appreciation and depreciation of exchange rate separately.

According to Webber (2000:8) the exchange rate at time *t* can be expressed as:

$E_t = E_0 + E_t^A + E_t^D$

Where, E_0 is the initial value of the logarithm of the exchange rate series and

$E_t^A = \sum_{i=1}^{t} \theta_i (E_i - E_{i-1})$, θ_i= 1 for $E_i > E_{i-1}$ and θ_i= 0 for $E_i < E_{i-1}$ while

$E_t^D = \sum_{i=1}^{t} \theta_t^* (E_i - E_{i-1})$, θ_t^*= *1* for $E_i < E_{i-1}$ and θ_t^*= *0* for $E_i > E_{i-1}$

The variable E_t^A represents the accumulated sum of the appreciation episodes and E_t^D the accumulated sum of the depreciation episodes. The current study will use this approach to analyze asymmetry with respect to direction of change in exchange rate.

To examine size asymmetry we combine the two approaches mentioned above. Although there is no standard measure of a large or small change in the exchange rate, the construction of the large and small exchange rate change series is similar to that of Pollard and Coughlin (2004), where large changes is defined as being 3 percent and above, while a small change is below 3 percent. Based on this definition we construct new series which captures large and small change in exchange rate based on Webber's approach:

$E_t^L = \sum_{i=1}^{t} \theta_i \, (E_i - E_{i-1})$, $\theta_i = 1$ for $(E_i - E_{i-1}) \geq 3$ and $\theta_i = 0$ for $(E_i - E_{i-1}) < 3$ while

$E_t^S = \sum_{i=1}^{t} \theta_t^* \, (E_i - E_{i-1})$, $\theta_t^* = 1$ for $(E_i - E_{i-1}) < 3$ and 0 otherwise

Where E_t^L and E_t^S represents the accumulated sum of large and small exchange rate change episodes, respectively.

The possibility of pass-through asymmetry with respect to the level of inflation (inflationary environment) is basically associated with Taylor's (2000) hypothesis which states that, responsiveness of domestic prices to exchange rate fluctuations depends positively on inflation. More specifically, he argued that a shift to a low-inflation environment causes a decline in the expected persistence of cost and price changes, which in turn results in a decline in ERPT. The effect of change in the inflation environment on ERPT to CPI can be captured by introducing dummy variables in the system. This is done by constructing a dummy variable which capture a shift in inflation environment in our sample. The dummy variable will take the value one starting in the period in which the country experienced high level of inflation, 2003/04Q1[22] (and for all subsequent years), and zero otherwise. Then the dummy variable will be interacted with the exchange rate term and included in the model following (Bailliu and Fujii, 2004). Thus, the coefficients on these interaction terms capture any change in pass-through that occurs as a result of a transition to new inflation environments. The asymmetric model will be estimated by using the CVAR approach.

[22] Even if the inflationary environment strongly felt starting around 2005/06 it begins to appear as a problem in post 2002/03 period (see, Alemayehu and Kibrom, 2008)

4.5 Important Econometrics Issues

4.5.1 Stationarity and Cointegration analysis

4.5.1.1 Test for Stationarity

In the analysis of time series data, the notion of stationarity plays an important role. Proper estimation of a time series model requires a stationary data. Conducting time series analysis on non-stationary data will results what is called “spurious” or “nonsense” regression, i.e., a situation where the estimated regression has a high R^2 and significant t values without any economic relationship between the variables. Although there are several tests for stationarity, in this paper, the stationarity of each series is checked using the standard Augmented Dickey-Fuller (ADF), the Phillips-Perron (PP), and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests.

A test of stationarity (or non stationarity) that has been become popular over the past several years is the unit root test. The DF and the ADF tests are the most usually used tests for unit root (Gujarati, 2004). The actual procedure of conducting the DF test involves three important equations which are derived from the following basic equation:

$$y_t = \rho y_{t-1} + u_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\ 4.8$$

In the literature equation (4.8) is known as autoregressive process of order one (AR (1)) model. In conducting the DF test, to allow for various possibilities of non-stationary time series, the test is estimated in three different forms:

$$\Delta y_t = \delta y_{t-1} + u_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\ 4.8a$$

$$\Delta y_t = \beta_1 + \delta y_{t-1} + u_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\ 4.8b$$

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + u_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots 4.8c$$

Where Δ is the first difference operator ($\Delta y_t = y_t - \Delta y_{t-1}$), δ = ρ – 1, t = time or trend variable and u_t is the white noise error term. In each case, the null hypothesis is that δ = 0, that is, there is a unit root – the time series is non-stationary. The alternative hypothesis is that δ is less than zero; that is, the time series is stationary.

The extended version of the DF test is usually called the ADF because the regression has been augmented with lagged changes, Δy_{t-h}. The inclusion of the lagged changes in the above three equations is intended to clean up any serial correlation in the error term. The test is conducted by 'augmenting' the preceding three equations by adding the lagged values of the dependent variable y_t. For example if we take equation (4.8c) and augmentation is up to 'm' lags, the ADF takes the form:

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \sum_{h=1}^{m} \alpha \Delta y_{t-h} + u_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots 4.8d$$

Where, u_t is a white noise error term and Δy_{t-1}= (y_{t-1} - y_{t-2}), Δy_{t-2}= (y_{t-2} - y_{t-3}) etc.

Phillips and Perron (1988) suggested an alternative to the ADF tests. Instead of adding additional lags in the regressions to obtain an error term that has no autocorrelation, they stick to the original DF regressions but make nonparametric adjustment to the DF statistics to take into account potential autocorrelation pattern in the error. PP tests are nonparametric in nature and applicable to a wide class of dependent and heterogeneously distributed innovations (Enders, 1995).

Kwiatkowski, Phillips, Schmidt and Shin (1992) propose an alternative test for stationarity in which unlike ADF and PP test, stationarity is the null hypothesis and the existence of a unit root is the alternative (Stock, 1993). The rejection rule for both ADF and PP test is that, we reject the null hypothesis, if the computed tau statistic less than the critical value, the time series is stationary. On the other hand, if the computed tau statistic is greater than the critical tau value, we failed to reject the null hypothesis; i.e. time series is non-stationary. In the case of KPSS, if the calculated statistic is less than the given critical values, the null hypothesis is accepted and it can be concluded that the series is stationary. The opposite holds true for a non-stationary series.

4.5.1.2 Cointegration

The notion of cointegration, which was given a formal treatment in Engle and Granger (1987), makes regression involving non stationary time series or what is called an integrated of order one, I (1) variables potentially meaningful. It is a notion that a linear combination of two series, each of which is an integrated of order one; I (1) is integrated of order zero, i.e. stationary (Wooldridge, 2003). We are concerned about the concept of cointegration because making a variable stationary by differencing only gives the short run dynamics while we are also interested in knowing the long run relationship. Economically speaking, two variables will be cointegrated if they have long run relationships between them. In CVAR models the test for cointegration is vital because if there is no cointegration relationship between the variables under consideration then there is no point in estimating VECM.

A simple approach to testing for the existence of cointergation is the Engle-Granger (1987) two-step approach. Though this procedure is easily implemented, it has several important limitations.[23] One crucial limitation of the method is that it has no systematic procedure to identify the existence of multiple cointegrating vectors. An alternative approach which addresses the drawbacks of the two step Engle-Granger approach was proposed by Johansen (1988), who developed the maximum likelihood estimation procedure that also allows one to tests for the number of cointergating relationship. The Johansen (1988) maximum likelihood estimators overcome problems associated with the use of two step estimators. Most importantly it can detect the presence of multiple cointegrating vectors. Moreover, the test allows testing restricted versions of the cointegrating vector(s) and the speed of adjustment parameters (Enders, 1995).

Given equation 4.7 in section 4.3.2, the test for a reduced rank is conducted as follows. As it is mentioned earlier the rank of Π is equal to the number of independent cointegrating vectors. The number of distinct cointegrating vectors can be obtained by checking the significance of the characteristic roots of Π (i.e. the rank of the matrix is equal to the number of its characteristic roots that differ from zero) which is given by λ (Harris, 1995).

In practice, we can obtain only the estimate of Π and its characteristics roots. The test for the number of cointegrating vectors or the number of characteristic roots that are insignificantly different from unity can be conducted using the following two test statistics: the λ_{trace} and λ_{max} tests which are provided by Johansen (1988). The trace

[23] See Enders (1995) on page 385 for detailed discussion on the limitation of Engle-Granger method

statistic is based on testing whether the (m-r) smallest eigenvalues are jointly zero and is given by:

$$\lambda_{\text{trace}} = -T \sum_{i=r=1}^{n} \ln(1 - \hat{\lambda}_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.9a)$$

Another test of the significance of λ_r is the maximal eigenvalue or λ_{max} statistic which is based on the estimated $(r + 1)^{th}$ largest eigenvalue given by:

$$\lambda_{\text{max}} = -T \ln(1 - \hat{\lambda}_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.9b)$$

The trace test (λ_{trace}) is a joint test where the null hypothesis is that the number of cointegrating vectors is less than or equal to r, against an unspecified alternative that there are more than r. On the other hand, the maximum Eigenvalue test (λ_{max}) tests the null hypothesis that the number of cointegrating vectors is r against the alternative of r+1. Johansen and Juselius (1990) provide critical values for both λ_{trace} and λ_{max}. If the test statistic is greater than the critical values, the null hypothesis that there exists r cointegrating vectors against the alternative hypothesis that there more than r (for λ_{trace}) or are r + 1 (for λ_{max}) is rejected (Enders, 1995: 391).

4.5.2 VAR Lag Length Selection Criteria and Diagnostic Tests

4.5.2.1 VAR Lag Length Selection Criteria

Before estimating the VAR, we have to decide the maximum lag lengths, to generate the white noise error terms. To determine the optimal lag length different information criteria can be employed. The objective of the information criteria (IC) method is to select the

number of parameters which minimize the value of the IC. The most popular ICs are the Akaike (1974) information criterion (AIC), Schwarz's (1978) Bayesian information criterion (SBIC) and the Hannan-Quinn information criterion (HQIC). Practically the lag length which is selected by most of these criteria will be included the in the VAR system.

4.5.2.2 VAR Diagonstic Tests

After estimating VAR models there are some diagnostic tests which are vital for ensuring that the results obtained from VAR estimation can be used for forecasting or policy analysis. Important post-estimation tests which are mostly performed on the residual of the VAR are LM test for residual autocorrelation, Jarque-Bera test for residual multivariate normality, White test for the presence of heteroscedasticity in the VAR's residuals and test for VAR stability. Testing for autocorrelation helps to identify any relationships that may exist between the current values of the regression residuals and any of its lagged values (Brooks, 2002). The null hypothesis of the LM test for autocorrelation is that the residuals are not serially correlated, while the alternative is that the residuals are serially correlated. If the P-value is less than 0.05 then we reject the null hypothesis (Harris, 1995).

The Jarque-Bera normality test is used to determine whether the regression errors are normally distributed. Under the null hypothesis of normally distributed errors, the test statistic has a Chi-Square distribution. Thus, if the Jarque-Bera statistic is significant, that is, the p-value is less than 0.05; the null of normality is rejected at the 5% level of significance (Brooks, 2002: 181). Furthermore, the test for heteroscedasticity investigates whether the variance of the errors in the model are constant or not. In White's (1980) test

for heteroscedasticity the null hypothesis states the residuals are homoscedastic and independent of the regressors, and that there is no problem of misspecification. If the White test statistic is significant, that is, P-value is less than 0.05; the null hypothesis of homoscedasticity and no misspecification will be rejected (Brooks, 2002: 445). Lastly, the test for VAR stability is vital if the system is supposed to be use for forecasting and policy analysis. The test for stability checks whether the roots of the characteristic polynomial lies inside the unit circle. If all roots lie inside the unit circle then the VAR is considered as stable and can be used for policy analysis.

4.5.3 Impulse Response Function

An impulse response function traces the effect of a one standard deviation shock to one of the innovations on current and future values of the endogenous variables. A shock to the i-th variable directly affects the i-th variable, and is also transmitted to all of the endogenous variables through the dynamic structure of the VAR (Stock and Watson, 2001). Thus, for each variable from each equation, a unit shock to the error is analyzed in order to determine the effects upon the VAR system over time. In the case of this study, the impulse response function will be able to reveal the sign, size and persistence of shocks from the exchange rate and import prices and consumer prices.

Two approaches are commonly used in the econometrics literature to estimate impulse responses. These are the generalized impulse response and the Cholesky decomposition. The main advantage of the generalised impulse response is that it does not require orthogonalization of innovations and is invariant of the ordering of the variables in VAR (Pesaran and Shin, 1998 cited in Stulz, 2006). However this study uses the Cholesky

decomposition in the base line model[24] because, it incorporates a small sample degrees of freedom adjustment when estimating the residual covariance matrix used to derive the Cholesky factor (Lutkepohl, 1991). Furthermore the ordering of the variables is important because the model assumes that causality runs from the NEER to import prices, and finally consumer prices, and that the degree of endogeneity increases in that order.

4.5.4 Variance Decomposition

While impulse response functions trace the effects of a shock to an endogenous variable on the variables in the VAR, variance decomposition decomposes variation in an endogenous variable into the component shocks to the endogenous variables in the VAR. More specifically, it highlights the proportion of the movements in the dependent variables that are a result of their own shocks, versus shocks from the other variables (Stock and Watson, 2001). This gives information about the relative importance of each random innovation to the variables in the VAR. In our case, variance decomposition shows the importance of shocks within the import and consumer prices themselves versus shocks from the exchange rate and other variables in the system.

[24] However as a robustness check, generalized impulse responses are also conducted

5. EMPIRICAL RESULTS AND ANALYSIS

This chapter presents and discusses the results of the empirical analysis based on econometric frameworks given in the previous chapter. First, the results of various preliminary tests that should be undertaken before and after the estimation of the VAR models are presented. Subsequently, based on the SVAR approach, the size and the speed of the ERPT to import and consumer prices are analyzed using impulse response functions. In addition, the relative importance of the exchange rate and other shocks for fluctuations in the price indices is investigated by applying variance decompositions. The results of alternative specifications are also presented to check the robustness of the base line model. Moreover, the long run ERPT is analyzed using CVAR approach. Finally, we investigate the asymmetric properties of ERPT in terms of direction and size of change in exchange rate and inflationary environment.

5.1 Test for Stationarity

In analyzing time series data testing for stationarity is a vital condition. As it is mentioned earlier, the results obtained by using non-stationary time series may be spurious in that they may indicate a relationship between variables which does not exist. In order to receive consistent and reliable results, the non-stationary data needs to be transformed into stationary data. In contrast to the non-stationary process that has a variable variance and a mean that does not remain near, or returns to a long-run mean over time, the stationary process reverts around a constant long-term mean and has a constant variance independent of time.

Before one pursues formal tests for stationarity, it is always advisable to plot the time series under study because visual plot of the data is usually the first step in the analysis of any time series. Such a plot gives an initial clue about the likely nature of the time series. The plots of the variables included in our model are provided in appendix A.2. The first impression that we get from these graphs is that at level most of the time series shown in the figures seem to be "trending" either upward or downward, albeit with fluctuations[25]. WCPI, M2 and CPI plots shows upward trend, while that of NEER show a downward trend. MPI seem to have upward trend with very significant fluctuation. This suggests that the mean of all the above variables might be changing which perhaps implies they are not stationary at level. Such an intuitive feel is important starting point for more formal tests of stationarity. Thus, as explained in the previous chapter, formal testing for stationarity and the order of integration of each variable are undertaken mainly using three standard methods (ADF, PP and KPSS).

Consequently, all series are examined for stationarity using the three test types and the results are summarized in Table 5.1. The lag length for each variable is automatically selected by Schwartz Information Criterion (SIC) and both intercept and trend are included in test equation for all variables. In Table 5.1 LWCPI, LNEER, LMPI, LCPI and LM2 shows the natural logarithm of world commodity price index, nominal effective exchange rate, import price index, consumer price index and broad money supply respectively.

[25] Except output gap which is stationary by construction

Table 5.1: Unit root test results

Variable	ADF		Phillips-Perron		KPSS		I(d)
	Level	**Differenced**	**Level**	**Differenced**	**Level**	**Differenced**	
LWCPI	-1.6268	-7.3302	-1.6882	-5.9132	0.2701	0.0486	**I(1)**
LNEER	-2.4610	-8.3791	-2.3050	-8.3742	0.1285	0.1025	**I(1)**
LMPI	-2.4777	-14.4483	-3.1465	-8.6751	0.1619	0.1338	**I(1)**
LCPI	-1.3991	-5.8944	-1.1361	-5.5529	0.2464	0.1368	**I(1)**
LM2	1.9852	-5.0509	2.0384	-8.0157	0.2779	0.1086	**I(1)**
YGap	-4.5577	-	-5.2608	-	0.0329	-	**I(0)**

Note: ADF and PP critical values are -3.4566 and -3.1593 at 5% and 10% level of significance respectively. The KPSS critical values are 0.146 and 0.119 at 5% and 10% level of significance respectively.

As we can see from table 5.1 each of the three test shows that all variables except output gap (Y^{Gap}) are not stationary at 5% level of significance. Hence, we continue the analysis by taking the first difference, so that we may determine in which order the variables become stationary. When we look the results of ADF and PP tests conducted on the difference of the variables, the null hypothesis of unit root is strongly rejected. Similarly the result of the KPSS test shows that all variables are stationary at first difference since we failed to reject the null hypothesis of stationarity. Thus we can conclude that all the variables (except Y^{Gap}) are stationary at first difference.

5.2 ERPT to Import and Consumer Prices: SVAR Approach

This section presents and discusses the empirical results derived from the VAR model. The SVAR is estimated in first difference of the variables and hence the estimated results represent short-term dynamics as opposed to long-term equilibrium relationships between variables. In this regard, impulse response functions of import price and consumer prices to each shock in the system are presented in Section 5.2.1. In Section 5.2.2, variance

decomposition is utilized to assess the relative importance of the exchange rate for variation in import and consumer price indices. Section 5.2.3 presents an analysis on robustness of results to changes in the order of variables and use of different methodology.

Choosing appropriate lag length is vital before estimating a VAR model because the VAR results could be highly sensitive to the number of lags included for the endogenous variables in estimation. The optimal lag order is determined partly by using lag length selection criterions of LR, FPE, AIC, SIC and the HQ and partly by taking the size of the data into consideration. Considering the potential small size of the data and the number of variables included in the model, we chose to refrain from basing the analysis on larger lags. Therefore, four lags are chosen to be the maximum lag. As given in appendix B.1 two lags are selected by most of the criterions when a maximum lag of four is included at the 5% level of significance

Even if the lag order selection criteria choose two lags to be included in the model, it may also be possible for some of the lags (of some endogenous variables) that are chosen as optimal to have insignificant contribution in the model. Therefore, it should be checked whether the two lags (chosen as optimal) of all variables are jointly important and hence should be included in the estimation of the VAR model. This was done using the Wald lag exclusion test (which is asymptotically chi-square distributed) and the results are reported in appendix B.1. Based on the joint hypothesis for lag 2, we reject the null hypothesis which states that the restricted model is viable (model without lags) and accept the model with lags because the first and the second lags of all endogenous

variables are jointly significant. This suggests that the use of the two lags in the model is suitable. The VAR model therefore is estimated with a constant and two lags.

The next step is to undertake various post-estimation diagnostic tests which are of crucial importance for further analysis. This is because the results obtained from such tests could affect the validity and robustness of the impulse response and variance decomposition results. Based on this, test for VAR stability, autocorrelation, normality and heteroscedasticity is undertaken and the results are reported in appendix B. The test for stability shows that all roots of characteristic polynomial lie inside the unit circle which suggests that the VAR is stable. Stability of the system confirms that impulse response functions can be used to examine the pass-through of exchange rate shocks into price indicators. Concerning other diagnostic tests, the LM test indicates that the model is free from autocorrelation problem while White test for heteroscedasticity fails to reject the null hypothesis of homoscedastic variance. However the Jarque-Bera test rejects the null hypothesis of normality indicating residual normality problem[26].

[26] Econometrics theory states that the existence of normality problem does not affect and distort the estimators' unbiasedness and consistency property, because the main purpose of normality tests is for inference (testing hypothesis about the population parameter) (see Enders, 1995). Therefore the in-existence of vector normality in our model doesn't affect our estimates.

5.2.1 ERPT to Import and Consumer Prices: Impulse Response Analysis

This subsection discusses to what extent exchange rate shocks are passed through into import and consumer prices in Ethiopia. Based on the fact that the model passed important diagnostic tests, we perform impulse response analysis with Cholesky orthogonal shock structure from the estimated baseline model including WCPI, NEER, Y^{Gap}, MPI, CPI and M2. Figures 5.1 and 5.2 shows the estimated orthogonalized impulse response functions for import and consumer price inflation to a one standard deviation innovation in NEER[27.] The accumulated impulse responses (solid line in the Figures) are presented over a time horizon of twelve quarters. The dotted line in figures denotes a two standard error confidence band around the estimates.

The impulse response functions indicate a moderate degree of ERPT to import price inflation and a low degree of pass-through to consumer price inflation. Figure 5.1 shows response of import price to one standard innovation in NEER. A positive exchange rate shock (i.e. an exchange rate appreciation) results in a decrease in import price for the entire forecast horizon. Concerning the speed of pass-through, import price quickly responds to exchange rate shock. As indicated by the confidence bands, the responses are significantly different both from zero and one, over the whole time horizon considered implying ERPT to import price is incomplete. Figure 5.2 tracks the pass-through of a one standard deviation shock in the exchange rate into consumer price inflation. As we can see from the figure, the response of consumer prices to exchange rate shock is low which

[27] The response of MPI and CPI to other variables is given appendix C

dies shortly after 5 quarters. This implies that ERPT to consumer price inflation is low and transitory.

Figure 5.1: Exchange rate pass-through to import prices

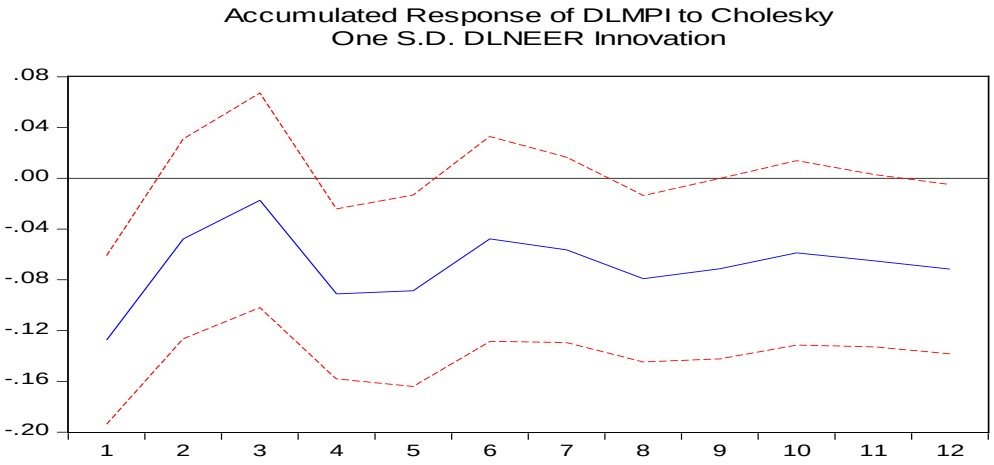
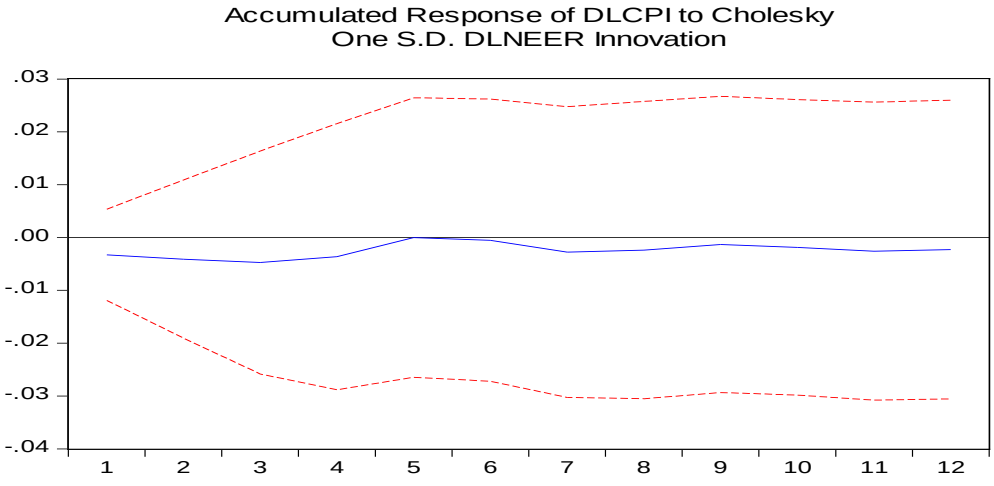


Figure 5.2: Exchange rate pass-through to consumer prices



The estimates of the cumulative pass-through coefficients are derived from the impulse response functions. In order to measure the pass-through coefficients, the shocks should be transformed from one standard deviation to one percent. This is done by dividing the cumulative impulse responses of each price index after j quarters by cumulative response of the exchange rate to its own shock after j quarters. The coefficients therefore show the

estimated response of prices to an exchange rate shock after accounting for the disturbances of the other endogenous variables in the model[28].

Table 5.2: The response MPI and CPI to one percent change in NEER

Horizon	MPI	CPI
T=1	-0.489	-0.013
T=2	-0.179	-0.015
T=3	-0.065	-0.018
T=4	-0.332	-0.014
T=5	-0.322	-0.0001
T=6	-0.177	-0.002
T=7	-0.208	-0.010
T=8	-0.29	-0.009
T=9	-0.262	-0.005
T=10	-0.217	-0.007
T=11	-0.239	-0.009
T=12	-0.263	-0.008

Table 5.2 presents the response of import price and consumer prices to one percent change in exchange rate. Concerning ERPT to MPI, a positive exchange rate shock is passed-through to import price by about 0.49 percent after one quarter, by 0.33 after one year, and amounts to about 0.26 percent after three years (12 quarter)[29]. This indicates in Ethiopia, ERPT to import price is moderate[30] and declines slowly as the estimating

[28] The pass-through coefficient is defined as:

$PT_{t,t+j} = P_{t,t+j} / E_{t,t+j}$

Where, $P_{t,t+j}$ is the cumulative change in the price is level and $E_{t,t+j}$ is the cumulative change in the nominal exchange rate between quarter t and t+j (see, Leigh and Rossi ,2002; Hyder and Shah, 2004; An, 2006 and Minh, 2009)

[29] Note that exchange rate shocks refer to an appreciation in the exchange rate

horizon increased. For instance, a 100 percent exchange rate appreciation results in a 49 percent decrease in import price at the first quarter and about 26 percent decline after 3 years. This shows that ERPT to import price is persistent in the case of Ethiopia.

Compared with the ERPT to import prices, pass-through of exchange rate to consumer prices is low. A one percent positive shock in exchange rate leads to 0.013 percent decline in CPI inflation in the first quarter, 0.014 percent after one year (four quarters ahead) and become almost zero in the fifth quarter (and in all subsequent periods). The estimated pass-through coefficient is somehow higher compared to the finding of Choudhri and Hakura (2003) and Devereux and Yetman (2002). The aforementioned studies obtained zero ERPT to consumer prices for Ethiopia between the periods 1997-2000 and 1975-1999, respectively as it is discussed in previous chapters. In our study even if the degree of pass-through to CPI is low it is significantly different from zero up to one year. This different result could be partly caused by different estimation methodology and partly due to different sample size used.

Various reasons can be given to explain the low pass-through of exchange rate to consumer prices. First, in the model of pricing along the distribution chain the impact of exchange rate dies out along the price chain. That is the impact of the exchange rate change is primarily transmitted to import price then to producer price and finally to consumer price. Concerning this Ito and Sato (2006) argue that the impact of the exchange rate on CPI is much more indirect and remote than that of imported prices. Thus, it is reasonable that the response of CPI is smaller than that of MPI. The level of pass-through from exchange rate to CPI could also depend on monetary policy and the resulting inflation environment. As hypothesized by Taylor (2000) a lower inflationary

environment generally leads to lower degree of pass-through. Therefore, the low inflation environment that Ethiopia experienced for a long time (expect the recent situation) can explain the lower degree of ERPT to consumer prices.

Additional reasons may also be given to explain why the rate of pass-through to consumer prices is low compared to import prices. According to Bailliu and Fujii (2004), the extent of pass-through to consumer prices will depend on the rate of pass-through to import prices and the share of imports in the consumer price index. The extent of ERPT to import prices is found to be moderate through the entire forecast horizon. This could be then another reason why pass-through to consumer price inflation is low in Ethiopia.

Two other reasons may explain why the rate of pass-through to consumer prices is relatively smaller than that to import prices. First, the structure of domestic market and local distribution costs such as transportation costs, marketing, and services can drive a wedge between import prices as measured in the import price index and the prices of these goods as reflected in the CPI. For instance, if there is complete pass-through to import prices following appreciation (i.e. if import price decreases by one percent following one percent appreciation of exchange rate), consumer prices will decrease by less than one percent given the structure of the market. In imperfectly competitive markets domestic importers might be less responsive to exchange rate appreciation and hence the full effect of decrease in import price might not be reflected in the final price consumers pay.

In second place, as discussed in Bacchetta and van Wincoop (2002), differences in the optimal pricing strategies of foreign wholesalers and domestic retailers can also explain

why pass-through to consumer prices is lower than that of import price. Indeed, this discrepancy can occur if foreign exporting firms price their goods in the exporter's currency, while domestic retailers resell these goods priced in domestic currency which is indeed the case in Ethiopia.

Finally, the low ERPT to consumer prices suggests that inflation is most likely affected by other factors than the exchange rate in Ethiopia. Among the variables included in our model, consumer price inflation responds significantly to shocks in world commodity price, money supply and shock to CPI itself. For instance, increase (positive shock) in WCPI results in significant increase in CPI inflation implying that the country is vulnerable to international price shocks (imported inflation). Also CPI inflation shows significant response to M2 after one year (four quarter) and in all subsequent periods. Furthermore, the significant and persistent response of inflation to its own shock shows the existence of adaptive expectation and inflation inertia.[31]

5.2.2 The Relative Importance of Exchange Rate and Other Shocks for Variation in MPI and CPI

While impulse response functions provide information on the size and speed of the pass-through, they give no information on the importance of the respective shocks for the variance of the price indices. In contrast, variance decompositions (VD) indicate the percentage contribution of the different shocks to the variance of the T-step ahead forecast errors of the variables. Hence, the relative importance of different shocks for the development of the price indices may be assessed using VD analysis.

[31] For impulse response of consumer prices to other variables see appendix C

The results of the VD analysis complement the results from the impulse response analysis. Since our main objective is to analyze the degree of ERPT to import and consumer prices, Table 5.3 reports only the VD results for MPI and CPI.

Table 5.3: Variance decomposition analysis

The relative importance of exchange rate and other shocks to variation in MPI and CPI							
	Period	WCPI	Y^{Gap}	NEER	MPI	CPI	M2
VD Of MPI	T = 1	0.162336	0.391894	16.59516	82.85061	0.00000	0.000000
	T = 4	4.925207	7.377324	14.65767	66.86527	4.916063	1.258473
	T = 8	5.743395	9.145884	13.90118	63.42031	6.526990	1.262244
	T = 12	5.830135	9.400638	13.82277	62.97437	6.698974	1.270732
	T = 16	5.841488	9.434606	13.81774	62.91840	6.715913	1.271861
	T =24	5.842803	9.439305	13.81701	62.91125	6.717674	1.271958
VD Of CPI	T = 1	9.864119	3.993058	0.607052	0.018242	85.51753	0.000000
	T = 4	19.47688	12.33309	0.474939	5.684429	60.72456	1.306105
	T = 8	18.95365	12.91174	1.081356	7.737759	57.33358	1.981919
	T = 12	18.87306	12.95291	1.144462	8.030774	57.00711	1.991685
	T = 16	18.86299	12.95545	1.152082	8.066227	56.97243	1.991059
	T =24	18.86173	12.95571	1.152715	8.070648	56.96824	1.990952

The VD analysis for the MPI shows that in the first quarter, a shock to the exchange rate contributes 16.6 percent variation to the MPI series, while the M2 and output gap has only a zero and 0.39 percent contribution, respectively. After four quarters (one year) the contribution of exchange rate declines to 14.7 percent, while that of money supply and output gap increases to 1.3 and 7.4 percent respectively. WCPI contributes 0.16 percent of the variation in MPI in the first quarter while its contribution increases to around 5.8 percent in the remaining quarters. MPI contributes much for its own variation which amounts to be 82.9 percent in the first quarter and it becomes around 63 percent as the forecast horizon is extended.

The exchange rate has a contribution to the variation in CPI of 0.61 percent and 1.2 percent in one quarter and twelve quarter ahead in the forecast horizon, respectively. The contribution of exchange rate in the variation of CPI is very low compared to its contribution in the variation of MPI which is consistent with the impulse response result. Money supply contributes only 1.31 percent to the variation in CPI four quarters ahead in the forecast horizon. This slightly increases to 1.9 percent after 12 quarters. Output gap contributed 3.9 percent of the variation in CPI in the first quarter while its contribution increases to 12.9 percent after 12 quarters (3 years). The significant contribution of output gap to variation in inflation indicates that domestic structural factors have significant effect on consumer price inflation than movements in exchange rate.

We also found that WCPI have a significant contribution to the variation of CPI inflation. It explains 9.9 percent of the variation in CPI in the first quarter and increases to 19.5 percent four quarters ahead. This shows the existence of significant imported inflation to consumer prices. Lastly, inflation explains 85.52 percent of its own variation at the first quarter, 60.72 percent after one year and 56.97 percent after 3 years. This indicates the increase in consumer prices is mainly attributed to its own variations, suggesting that the inflation process in Ethiopia has significant inertia.

5.2.3 Robustness Analysis

Results from SVAR models may highly depend on the specification of the underlying model. Therefore, the robustness of the estimated pass-through elasticities should be examined by subjecting the baseline model to various modifications. The subsequent section discusses the alternative model specifications and the respective impacts on estimated impulse responses.

Identification by means of the Choleski decomposition of the covariance matrix Σ is only unique up to the ordering of the variables in the system. Consequently, the same is true for the orthogonalized impulse responses (Stulz, 2006). In this section, two alternative identification strategies are applied to check the robustness of the base line model. The first option is giving different ordering to some variables included in the VAR while the second option is to apply different methodology in estimating the impulse responses. Concerning the first option we check whether the base line model is sensitive to the order of two variables. In the first alternative model we gave different ordering to the monetary variable (M2) thereby accounting for the fact that the appropriate position of the money supply is somewhat controversial in the context at issue (see the discussion in section 4.3.1). In the second alternative models we gave different VAR ordering to output gap.

In the base line model M2 was ordered at last assuming reactive nature of monetary policy. In the alternative model we change the order of this variable by placing it prior to exchange rate as Hanhn (2003) and Ito and Sato (2006) did, assuming forward looking nature of monetary policy.

$\Delta wcpi \rightarrow y^{Gap} \rightarrow \Delta m2 \rightarrow \Delta neer \rightarrow \Delta mpi \rightarrow \Delta cpi$ …….. Alternative Model 1

Identification is then achieved as described in section 4.3.1, i.e. by applying a Cholesky decomposition of the covariance matrix Σ. However, we do not find any significant changes in the estimated pass-though parameters due to a different ordering of M2. The results obtained from Alternative Model 1 are reported in appendix D. The estimated responses of import price to exchange rate marginally increases compared to the baseline model. In case of ERPT into consumer prices, the results are almost similar to those

obtained from the baseline model. Thus, the ordering of the M2 is of little importance for the pass-through estimates.

Second, following Ito and Sato (2006) we assume the lagged availability of information on the output gap, which results in no contemporaneous effect of output gap shocks on the central bank's monetary policy. It is also assumed that the NEER responds contemporaneously to world commodity price shocks and monetary policy shocks but not to output gap shocks. Accordingly, the "Alternative Model 2" is

$\Delta wcpi \rightarrow \Delta m2 \rightarrow \Delta neer \rightarrow y^{Gap} \rightarrow \Delta mpi \rightarrow \Delta cpi$ …….. Alternative Model 2

The estimated response of the MPI and CPI from the above alternative model is reported in appendix D. Again the result from this model shows no significant difference to those of the other models.

As a second alternative, generalized impulse responses are calculated instead of Cholesky orthogonalized impulse responses. As it is discussed in Stulz (2006) the concept of generalized impulse response was advanced in Koop et al. (1996) and applied to VAR models in Pesaran and Shin (1998). Unlike traditional impulse responses, this approach does not require orthogonalization of the shocks, and is invariant to the ordering of the variables. Thus generalized impulse response is estimated and the results are reported in appendix D. The results obtained from this method are also virtually similar to those of the other models. Generalized responses of import prices to exchange rate shocks is similar to the baseline (orthogonalized) responses while that of consumer prices are somewhat stronger than in the baseline case though the difference is not that much significant.

5.3 ERPT to Import and Consumer Prices: CVAR Approach

Since the SVAR model is estimated in first difference of the variables, information concerning long run relationship among these variables is lost. Thus the long run relationship between exchange rate and import and consumer prices is investigated using cointegration approach. As it is shown in section 5.1 all the variables included in the model are stationary at first difference (I (1)) with the exception of output gap. Thus in order to estimate CVAR model the next step is to test for the existence of meaningful long run relationship among the variables, i.e. the variables are cointegrated.

While there are certain circumstances where a stationary variable can enter a system of otherwise I (1) variables in a CVAR model, the framework is more generally valid when each of the variables in the system is integrated of the same order. Therefore in our CVAR model output gap (which is I (0) by construction) is replaced by logarithm of real GDP (LRGDP) which is I (1) due to the fact that all the other variables included in the model are stationary at first difference.[32] Johansen (1988) test for cointegration is applied and the results of the trace and maximum likelihood statistics are reported in Table 5.6 below.

[32] The replacement will not distort the very reason output gap is included in the model, i.e. to capture domestic demand shocks; because GDP can also be used as proxy for demand shocks (though the former is better).

Table 5.4: Johansen cointegration test results

Hypothesized No. of CEs	Eigenvalue	Trace statistic		Max-Eigen statistic	
		Statistic	C.V	Statistic	C.V
None	0.600086	153.2232*	69.81889	75.15354*	33.87687
At most 1	0.421080	78.06965*	47.85613	44.82050*	27.58434
At most 2	0.223628	33.24914	36.79707	20.75612	21.13162
At most 3	0.126289	12.49302	15.49471	11.07041	14.26460
At most 4	0.017199	1.422603	3.841466	1.422603	3.841466

Both Trace and Max-eigenvalue test statistic indicates 2 cointegrating equn(s) at the 0.05 level of significance. *denotes rejection of the hypothesis at the 0.05 level.
C.V: Critical Value

As we can see from the above table, both the trace statistic and maximum eigenvalue suggest the existence of two cointegrating vectors. Since the objective of this paper is to estimate the degree of ERPT to import and consumer prices, we estimate the unrestricted cointegrating vectors with ad-hoc normalization on MPI and CPI. In order to determine the pass-through effect to consumer prices, the results are normalized on consumer prices. To assess the pass-through to consumer prices, the system (i.e. the unrestricted cointegrating vector) is normalized on consumer prices. The coefficients on the exchange rate variables indicate the degree of pass-through.

The results in Table 5.4 and, 5.5 and 5.6 are based on the estimation of the CVAR with lag two selected by FPE, AIC, and HQ information criteria. Regarding the diagnostic tests, there is no problem of VAR stability, auto correlation and heteroscedasticity, but there is a vector normality problem. The results of the unrestricted estimates of the cointegrating relationship and the adjustment coefficients normalized on MPI are given in the table below.

Table 5.5: long-run relation of variables with respect to MPI

Variable	LMPI	LNEER	LCPI	LRGDP	LM2	Constant	LWCPI (exog)
β	1	0.286 (2.629)	-0.300 (-1.543)	-0.937 (-5.502)	-0.054 (-0.391)	7.780	-0.555 (-4.081)
α	-0.989 (-4.708)	0.062 (0.667)	0.074 (2.238)	0.136 (1.103)	-0.001 (-0.067)		
S.corr		J-Bera		Het			
25.1 [0.4593]		2463.714[0.0000]		567.325[0.5214]			

The parentheses ( ) are used to denote t- values, while [ ] represent p-values

For easier interpretation we can rewrite the long run equilibrium relationship normalized on MPI as;

$$LMPI = -7.780 - 0.286\,LNEER + 0.300LCPI + 0.937LRGDP + 0.054LM2$$

The estimated relation suggests that in the long run, a 1 percent increase (appreciation) in the NEER decreases MPI by a 0.29 percent. This implies that if NEER changes by 100 percent only 29 percent of it will pass into import prices. Thus, in the long run ERPT to import price is incomplete in the case of Ethiopia. Based on this we can argue that pass-through to import prices is far from complete both in the short run and in the long run in the case of Ethiopia.

Concerning the effect of other variables on MPI, LRGDP is found to be significant and correctly signed while those of LCPI and LM2 are found to be insignificant. In Table 5.5 'α' shows how different variables adjust to the long run equilibrium. As shown the adjustment coefficient of MPI is correctly signed and highly significant. The adjustment coefficient for MPI is 0.98 implying that if MPI exceeds its long run equilibrium by 1

percentage point, for example because of a temporary exchange rate shock, 98 percent of this deviation is adjusted within one quarter which thus takes maximum of four months only for MPI to adjust to its long-run equilibrium. This shows MPI quickly adjusts to its long run equilibrium following shocks in the endogenous variables.

Subsequently we analyze ERPT to consumer prices by normalizing the unrestricted cointegrating vector on CPI and the results are reported in Table 5.6 below.

Table 5.6: long-run relation of variables with respect to CPI

Variable	LCPI	LNEER	LMPI	LRGDP	LM2	Constant	LWCPI (exog)
β	1	-0.125 (-0.370)	-3.331 (-5.176)	3.122 (5.099)	0.179 (0.462)	-25.914	0.065 (3.258)
α	-0.022 (-2.238)	-0.01853 (-0.667)	0.315 (4.708)	-0.041 (-1.103)	0.001 (0.067)		
S.corr		J-Bera		Het			
25.1 [0.4593]		2468.521[0.0000]		567.325[0.5214]			

The parentheses ( ) are used to denote t- values, while [ ] represent p-values

Once more for easier interpretation we can rewrite the long run equilibrium relationship normalized on CPI as follows:

$$\text{LCPI} = 25.914 + 0.125\,LNEER + 3.331LMPI - 3.122LRGDP - 0.179LM2$$

As we can see, the coefficient of the exchange rate which could be interpreted as the long-run pass-through coefficient is insignificant, indicating absence of ERPT to consumer prices in the long run. This supports the result obtained from the structural VAR where ERPT to consumer prices is found to be low in the short run and becomes almost zero after one year. Once again we can argue that consumer price inflation is most

likely affected by other factors than exchange rate in the case of Ethiopia. If we consider the other variables included in the model, in the long run import price has significant positive impact on consumer prices. One percent increase in MPI increases domestic prices by about 3.3 percent implying that domestic importers overreact to changes in the price of imported goods[33]. This is an interesting finding because apart from the effect of the change in the exchange rate; a change in the price of imported goods that arises due to factors such as change in exporters cost of production, change in demand structure (either in the exporting firms market or in the market of the importing country) and other exogenous factors that affect the price of imported goods denominated in the exporters currency have large effect on consumer prices.

Concerning other variables, LRGDP is found to be highly significant, which however suggest that in the long run real GDP affects CPI negatively. Money supply (M2) is found to be wrongly singed and insignificant. The short-run dynamics suggest that the speed of adjustment of CPI to its long-run equilibrium is very slow. The adjustment coefficient for consumer price inflation is -0.022. This means, if inflation exceeds its long run equilibrium by 1 percentage point, 2.2 percent of this deviation is adjusted for every quarter, so it takes about 45 quarters for inflation to adjust to its long-run equilibrium.

[33] The overreaction of domestic importers to change in the price of imported commodities can be taken as one indicator of lack of competition and close substitutes to imported goods in the domestic market; which gives domestic importers enough market power to increase consumer prices more than increase in the price of imported good measured in import price index.

5.4 ERPT Asymmetry

In this section the existence of asymmetric ERPT will be examined. Accordingly Section 5.4.1 and 5.4.2 presents the analysis of pass-through asymmetry (in the case of MPI) with respect to direction and size of change in exchange rate respectively. In section 5.4.3 pass-through asymmetry with respect to change in inflation environment will be analyzed in the cases of consumer prices (CPI). For the former ones the analysis follows the approach used by Webber (2000) and Wickremasinghe and Silvapulle (2004), as mentioned in Chapter 4. The asymmetric model will be estimated using the CVAR approach.

Before estimating the pass-through asymmetry model, unit root tests on the constructed asymmetry series which are given in Chapter 4, namely E_t^A, E_t^D, E_t^L *and* E_t^S is conducted. The graphs of the series are shown in Appendix A.2, while the results of the ADF, Phillips-Perron and KPSS tests are shown in Table 5.7. Based on the preliminary visual inspection of the graphs of all the series, which all seem to be trending, the trend and intercept are included in the test equations of all unit root tests.

Table 5.7: Unit root results for asymmetry series

Variable	ADF		Phillips-Perron		KPSS		I(d)
	Level	Differenced	Level	Differenced	Level	Differenced	
E_t^A	-2.1048	-6.4404	-1.5533	-5.6418	0.1969	0.1049	I(1)
E_t^D	-2.6821	-8.8496	-2.5031	-8.84958	0.1644	0.1006	I(1)
E_t^L	-1.8684	-5.8024	-1.6844	-5.8024	0.1701	0.1027	I(1)
E_t^S	-2.1855	-6.5329	-2.2767	-6.6777	0.1508	0.0612	I(1)

Note: ADF and PP critical values are -3.4566 and -3.1593 at 5% and 10% level of significance respectively. The KPSS critical values are 0.146 and 0.119 at 5% and 10% level of significance respectively

The results obtained from the three tests suggest that all series are non-stationary in level but stationary at first difference (i.e. I (1)). Since the asymmetric model is estimated using the cointegrating approach, the next step should be to investigate the existence of cointegration by including the asymmetry variables into the base line model. In each case (i.e. direction and size asymmetry) Johansen test for cointegration (both trace and maximal eigenvalue) is conducted to determine the existence of cointegrating vector(s).

5.4.1 ERPT Asymmetry: Direction of Change in Exchange Rate

In this section, the pass-through asymmetry issue under investigation is whether the direction of change in the exchange rate (appreciation or depreciation) has any effect on the pass-through of exchange rate changes to import prices. To do so out of the VAR system our main focus is on equation 5.1.

$$\text{LMPI} = \beta_1 + + \beta_2\, LCPI + \beta_3 LRGDP + \beta_4 LM2 + \beta_5 E_t^A + \beta_6 E_t^D + U_t \quad \ldots\ldots\ldots\ldots \quad (5.1)$$

Where $E_t^A \; and \; E_t^D$ are accumulated sum of appreciation and deprecation episode

Given that all the variables in the model are I(1), the first step in the estimation methodology (CVAR) requires us to determine if equilibrium relationships exist between our variables. Based on Johansen's test for cointegration, both trace and maximal eigenvalue tests indicate the existence of two cointegrating vectors when the new series which shows appreciation and deprecation episode are included in the model. The lag length chosen for this model is two. The estimates of the parameters in a long run cointegrating vector normalised on MPI are given in Table 5.8.

Table 5.8: Pass-through asymmetry with respect to direction of change in exchange rate

Variable	LMPI	LCPI	LRGDP	LM2	E_t^A	E_t^D	Const.	LWCPI (exog)
β	1	0.193 (1.040)	-0.383 (-2.989)	-0.974 (-3.709)	0.227 (2.662)	-0.502 (-2.578)	9.001	-0.905 (-6.686)
α	-0.972 (-7.303)	0.059 (1.440)	-0.078 (-0.562)	0.005 (0.192)	-0.033 (-1.081)	0.192 (1.845)		
	S.corr			J-Bera		Het		
	36.1 [0.4683]			4608.801[0.0000]		688.905[0.1012]		

The parentheses ( ) are used to denote t- values, while [ ] represent p-values

In Equation (5.1) the long-run pass-through coefficients corresponding to appreciation and depreciation are β_5 and β_6, respectively. The results show that the appreciation ERPT coefficient is approximately 0.5 while the depreciation coefficient is approximately 0.22. This imply that a one percent appreciation of NEER results 0.22 percent decline in import price while a one percent deprecation of NEER will result 0.5 percent increase in import price. In other words, if exchange rate changes by 100 percent, 22 percent of it pass-through into import prices in the case of appreciation and 50 percent of it pass-through in to import price in the case of depreciation. Thus, the pass-through to import prices is greater when the change is in exchange rate is depreciation than when it is an appreciation.

The error correction coefficient for import prices is significant and correctly signed, implying that import prices adjust to equilibrium following shocks in the explanatory variables. The error correction coefficients of the other variables are found to be insignificant. The likelihood ratio (LR) test is performed to confirm whether the appreciation and depreciation coefficients are statistically significantly different. A

restriction that the long-run appreciation pass-through coefficient is equal to the depreciation coefficient (i.e. $\beta_5 = \beta_6$) is placed to test against the long-run asymmetry of import prices to exchange rate movements. The results show that the null hypothesis ($\beta_5 = \beta_6$) is rejected[34], suggesting that there is long-run asymmetry in the adjustment of import prices to direction of change in the exchange rate.

Hence, in the long-run, pass-through is significantly greater when the NEER depreciates than when it appreciates. In imperfectly competitive markets foreign firms face low domestic competition, which allow them to pass the cost of Birr depreciation to local importers without losing their market share, either invoices are denominated in local currency (Birr) or currency of the exporter firm. In other words, when Birr depreciates, exporting firms will not adjust their markups to maintain the same Birr price prior to the Birr depreciation. Rather the foreign exporters would choose to gain from the Birr depreciation and increase their profits. This is due to the fact that low domestic competition and lack of close substitutes in the country reduces the threat of losing their market if they (either exporting firms or domestic importers) let the domestic price of imported goods to increase when exchange rate depreciates. Thus, of the asymmetric pass-through theories, the binding quantity constraints model discussed in Chapter 2 best explains the phenomenon of greater pass-through during episodes of depreciation than appreciation in the case of Ethiopia.

[34] The likelihood ratio test statistic for $\beta_5 = \beta_6$, distributed as χ^2 (1), is 8.108798 [0.004405].

5.4.2 ERPT Asymmetry: Size of Change in Exchange Rate

This section will examine whether the size of change in the exchange rate (large or small) has any effect on the pass-through of exchange rate changes to import prices. In this case, out of the VAR system our main focus is on equation 5.2 below.

LMPI = $\beta_7 + + \beta_8\, LCPI + \beta_9 LRGDP + \beta_{10} LM2 + \beta_{11} E_t^L + \beta_{12} E_t^S + U_t$ …… (5.2)

Where E_t^L and E_t^S are accumulated sum of large and small change in exchange rate

Concerning cointegration in this case both trace and maximal eigenvalue test indicates the existence of three cointegrating vectors when the new series which shows large and small changes in exchange rates are included in the model. Again the lag length chosen for this model is two. The estimates of the parameters in a long run cointegrating vector normalised on MPI are given in table below.

Table 5.9:Pass-through asymmetry with respect to size of change in exchange rate

Variable	LMPI	LCPI	LRGDP	LM2	E_t^L	E_t^S	Const.	LWCPI (exog)
β	1	0.248 (0.962)	-1.117 (-6.435)	-0.924 (-2.136)	0.201 (2.572)	0.263 (3.214)	15.024	-0.324 (-3.023)
α	-0.931 (-4.549)	0.058 (1.918)	0.252 (2.347)	-0.016 (-0.802)	-2.574 (-0.756)	-0.311 (-0.467)		
	S.corr			J-Bera		Het.		
	32.3 [0.6448]			459.468[0.0000]		660.992[0.059]		

The parentheses ( ) are used to denote t- values, while [ ] represent p-values

In Equation (5.2) the long-run pass-through coefficients corresponding to large and small change in exchange rate are β_{11} and β_{12} respectively. The results show that the large

change ERPT coefficient is approximately 20.1 percent while the small ERPT coefficient is approximately 26.63 percent. Thus, the pass-through to import prices is greater when the change in exchange rate is small than when it is large. Also, the error correction coefficient for import prices is significant and correctly signed, implying that import prices adjust to equilibrium following shocks in the explanatory variables. Subsequently, likelihood ratio (LR) test was performed to confirm whether the coefficients of large and small change in exchange rate are statistically different from one another. A restriction that the long-run large change pass-through coefficient is equal to the small change coefficient (i.e. $\beta_{11} = \beta_{12}$) is placed to test against the long-run asymmetry of import prices to movement in exchange rate. The results show that the null hypothesis ($\beta_{11} = \beta_{12}$) is rejected.[35]

The result suggests that there is a long-run asymmetry in the adjustment of import prices with respect to the size of change in exchange rate. The finding that pass-through is greater during episodes of small change in the exchange rate than during episodes of large changes can be explained by the menu cost theory of asymmetric pass-through when imports are invoiced in the exporting firm's currency. As discussed in Chapter 2, the theory suggests that if imports are invoiced in the exporting firm's currency, then a small change in the exchange rate will have no effect on its invoice price, but the change in the exchange rate will be fully reflected in the price charged in the importing country, implying complete ERPT. However, if the exchange rate change is large, the exporting firm will adjust its invoice price, thus reducing the amount of pass-through. In this case pass-through is greater when exchange rate changes are small.

[35] The likelihood ratio test statistic for $\beta_{11} = \beta_{12}$, distributed as χ^2 (1), is 6.424019 [0.011259].

5.4.3 ERPT Asymmetry: Size of Inflation

A formal investigation of Taylor's hypothesis requires a comparison of pass-through estimates under alternative inflation environments. To identify the effect of change in inflation environment on the degree of ERPT to consumer prices (CPI) a dummy variable is introduced in the system. We constructed a dummy variable described in section 4.2.2; which captures a shift in the inflation environment staring from 2003/04. Then this dummy variable is interacted with the exchange rate term, and included in the specification, as depicted in equation (5.3) which of our interest out of the VAR system.

$$\text{LCPI} = \beta_{13} + \beta_{14} LMPI + \beta_{15} LRGDP + \beta_{16} LM2 + \beta_{17} LNEER + \beta_{18} D_t(E_t) + U_t \quad \ldots. (5.3)$$

Where D_t a dummy variable which takes the value one starting from the period in which the Ethiopia experienced high level of inflation, 2003/04Q1 and zero otherwise.

Regarding cointegration, both trace and maximal eigenvalue test indicates the existence of two cointegrating vectors when we include the interaction dummy in the model. Once more, the lag length chosen for this model is two. The estimates of the parameters in a long run cointegrating vector normalised on CPI are given in Table 5.10.

Table 5.10: Pass-through asymmetry with respect to inflationary environment

Variable	LCPI	$LNEER$	LMPI	LRGDP	LM2	$D_t(E_t)$	Const.	LWCPI (exog)
β	1	0.322 (-1.425)	0.650 (1.541)	-2.018 (5.071)	-1.223 (-4.631)	0.079 (1.444)	-12.619	
α	-0.047 (-3.405)	0.027 (0.665)	-0.101 (-0.898)	-0.185 (-3.688)	0.004 (0.463)	0.043 (0.220)		
	S.corr		J-Bera		Het.			
	39.9 [0.3012]		14780.75[0.0000]		520.0694[0.0502]			

The parentheses ( ) are used to denote t- values, while [ ] represent p-values

The coefficient on the interaction term is statistically insignificant which implies that the transition to high inflation environment did not result any change in the degree of ERPT to consumer prices. Thus, we found no evidence which supports Taylor's hypothesis. However we should note that tests for structural break are known to have very low power, especially in short samples like the recent inflationary environment in Ethiopia. A wider increase in pass-through may be taking place as a result of the high inflation that the country is facing recently, but it is too early to ascertain whether this change is taking place and too early to determine the structural explanations for such change.

6. CONCLUSION AND POLICY IMPLICATIONS

6.1 Conclusion

It was recognized in the literature that the degree of ERPT is a very important issue in designing trade and monetary policies. Regarding exchange rate policies, the pass-through relationship between exchange rate changes and prices of imported and consumer goods determine the degree of current account adjustment and international competitiveness achieved from variations in the exchange rate. Specifically, the effectiveness of the exchange rate as a policy tool in attempt for import reduction or export promotion depends on the degree of pass-through to import and consumer prices, regardless of several other factors. Concerning monetary policy, the exchange rate is considered as one of the major transmission channels of monetary policy. Theoretical and empirical literature suggests that in an open economy, fluctuations in the exchange rate affect inflation through direct changes in import prices as well as through aggregate demand, which is subject to changes in the relative price between foreign and domestic commodities.

The paper situates the need for an empirical study in the area given that the Ethiopian economy in general and the exchange rate management in particular, has since, 1992 been reformed. Following the introduction of managed floating exchange rate regime the value of Birr is continuing to decline either due to market forces or policy interventions taken in different time. In addition, the opening up of the economy through trade sector reforms tremendously boosts the flow of foreign trade. Undoubtedly, these developments

have considerable implications on the link between exchange rate and general price level of the economy.

In sight of this the study examined the degree of ERPT to import and consumer prices in Ethiopia during the period 1991/92 and 2010/11. It also investigated pass through asymmetry to import prices with respect to direction and size of changes in the exchange rate. In addition, the study tries to test Taylor's hypothesis by investigating whether degree of pass-through is different with respect to inflation environment. In order to achieve these objectives, related theoretical and empirical literatures were reviewed; Ethiopia's macroeconomic environment was briefly discussed giving more emphasis to inflation trends, exchange rate and trade policies and structure of trade.

The study estimates the pass-through coefficients using two different methods. The first method is SVAR where pass-through coefficients are estimated based on impulse response function obtained from the VAR models. The second one is CVAR model where the long run pass-through coefficient is measured by the coefficient of exchange rate term in the cointegrating vector normalized either on import or consumer prices. Based on the SVAR model, using the impulse response function, we establish that the degree of ERPT to import and consumer prices to be incomplete, persistent (in the case of import price) and significant in the short run. Pass-through to import prices was found to be significantly higher (also quick) than that of CPI and this suggests that pass-through declines along the pricing chain in Ethiopia.

On the other hand, the estimated pass-through coefficient for import price based on CVAR model is found to be around 0.29 showing that the degree of pass-through to MPI

is incomplete in the long run. However the estimated coefficient obtained from the same model indicated that exchange rate has insignificant effect on CPI implying absence of ERPT to consumer prices in the long run. Regarding the speed of adjustment, import prices were found to adjust by about 98 percent in one quarter for any disequilibrium in the long run relationship. The adjustment coefficient for CPI is estimated around -0.022 which suggest that about 2.2 percent of the disequilibrium in CPI will adjust towards long run equilibrium each quarter. Hence, we conclude that import price adjust quickly to its long run equilibrium following any disequilibrium in the system, while that of CPI adjust very slowly to its long run equilibrium.

The result obtained from the asymmetric model suggests that ERPT to import prices is higher in periods of Birr depreciation than appreciation which supports the binding quantity constraint theory. In addition, pass-through to import prices is found to be higher in periods of small changes than large changes in the exchange rate, which supports the menu cost theory when invoices are denominated in the exporters' currency. The study also tries to estimate the degree of pass-through in different inflation environment in order to test Taylor's hypothesis. However, no evidence is found which supports the hypothesis in the case of Ethiopia. This could be due to the fact that the change in inflation environment (from low to high) is a more recent occurrence in Ethiopia and hence it could be too early to determine the effect of such change on the degree of pass-through.

6.2 Policy Implications

Based on the fact that the concept of ERPT has important implication for exchange rate and monetary policy, the following policy implications are drawn based on our findings.

The finding that ERPT to import prices is incomplete in Ethiopia has important implication about the effectiveness of exchange rate measures which are intended to improve the country's trade balance. Specifically, devaluation measures which are taken to correct trade balance might not be effective to the extent they are expected due incomplete response of import price (and the resulting change in domestic demand) to exchange rate movements.[36] This means if import prices are less responsive to movements in the exchange rate, the "expenditure-switching" effects might be dampened. For instance, a depreciation of the Birr would increase the price of imported goods relative to domestic goods, which should—all else being equal—reduce the domestic demand for imported goods. But, since pass-through to import prices is found to be incomplete in Ethiopia, the change in the price of imported goods will be small and hence the incentive for consumers to switch expenditures from imported to domestic goods will be reduced. Thus policy makers should take into account the incomplete response of import prices when they decide to devalue the currency so as to improve trade balance.

Our finding of incomplete ERPT also has important implication for monetary policy. As it is shown by Adolfson (2001) and Smets and Wouters (2002) incomplete pass through

[36] irrespective of several other factors which might determine the effectiveness of exchange rate policy (such as supply factors, elasticity of foreign and domestic demand, availability of substitutes etc)

makes the exchange rate channel less effective. In addition, a low ERPT also implies that larger exchange rate movements are necessary for relative price adjustments.

A low degree of ERPT to consumer prices indicates that nominal exchange rate appreciations might not be an effective mechanism to lower inflationary pressures in Ethiopia. However, since the pass-through of exchange rate change to import prices is moderate, it is recommended that a more flexible exchange rate regime with a larger band of fluctuation[37] can allow the national bank to promptly respond to both domestic shocks and foreign shocks, while bearing less risk of the impact of exchange rate change on inflation. In addition, low ERPT provides greater freedom for pursuing independent monetary policy and makes the adoption of inflation targeting regime relatively easy.

Another implication is that fluctuations in exchange rates and import prices will have modest effects on domestic inflation in Ethiopia unless domestic policy mistakes are made. Therefore, even in a more integrated world economy, appropriate domestic policies still have a significant role in controlling inflation.

Finally, our results of high pass-through in the case of devaluation than appreciation shows that devaluation of the Birr increases inflation (by increasing MPI) in Ethiopia more than an appreciation reduces it, which in turn deteriorates the countries competitiveness in international market. Falling to account for this asymmetry pass-through can have important consequences in the sense that not taking into account the different effects of appreciations and depreciations, the real pass-through is not revealed.

[37] given our finding that pass through is high in the case of small change in exchange rate that large change

The estimated importance of the asymmetric effect exerted by the nominal exchange rate may pose important dilemmas for policy-makers wishing to achieve both price stability and export competitiveness. Indeed, an important policy implication of these findings is that the different response of import prices to the direction and size of change in exchange rate should be taken into account in deciding monetary policy rules.

Lastly, even if the study addresses its objectives there are still different areas for further research concerning ERPT. To mention some, in this study the analysis is conducted based on aggregate price indices (at macro level). In order to investigate which sector or items in the consumption basket are more affected by exchange rate shock, analysis is required at a more disaggregated level (if industry or sector-specific data is available in the future). Undertaking the study at disaggregated level also allows one to study the determinants of ERPT in Ethiopia. In addition the analysis regarding ERPT asymmetry can be executed with a different methodology instead of CVAR model. Standard non-linear models such as - threshold VAR- would enable one to get better result concerning the asymmetric response of price indices to exchange rate shocks.

REFERENCES

Adolfson, M. (2001). Monetary Policy with Incomplete Exchange Rate Pass-Through. SverigesRiks Bank Working Paper Series, No. 127.

Alemayehu Geda and Kibrom Tafere (2008), The Galloping Inflation in Ethiopia: A Cautionary Tale for Aspiring 'Developmental States' in Africa, Department of Economics, AAU.

Aliyu, S.U.R., Yakub, M.U., Sanni, G.K. and Duke O.O. (2010). Exchange Rate Pass-through in Nigeria: Evidence from a Vector Error Correction Model. Central Bank of Nigeria.

An, L. (2006). Exchange Rate Pass-Through: Evidence Based on Vector Autoregression with Sign Restrictions. Department of Economics, University of Kentucky.

Aziz, N. (2009). Exchange Rate Pass-Through to Import, Export and Domestic Prices: Evidence from a Developing Country. Department of Economics, University of Birmingham, UK.

Bacchetta, P. and Van Wincoop, E. (2002). A Theory of the Currency Denomination of International Trade. European Central Bank Working Paper No. 177.

Bacchetta, P. and Van Wincoop, E. (2002), "Why do Consumer Prices React Less than Import Prices to Exchange Rates?" *Journal of European Economic Association*, 1, 662-670.

Bailliu, J. and Fujii E. (2004). Exchange Rate Pass-Through in Industrialized Countries: An Empirical Investigation. Bank of Canada Working Paper, 2004-21.

Barhoumi, K. (2006). Differences in Long Run Exchange Rate Pass-Through into Import Prices in Developing Countries: An Empirical Investigation. *Economic Modelling*, 23: 926–951.

Bhattacharya, R., Patnaik, I. and Shah, A. (2011). Monetary Policy Transmission in an Emerging Market Setting. IMF Working Paper No. 5.

Bouakez, H. and Rebei, N. (2006). Has Exchange Rate Pass-Through Really Declined? Evidence from Canada. Bank of Canada Working Paper (2).

Brooks, C. (2002). *Introductory Econometrics for Finance*. Cambridge: Cambridge University Press.

Bussière, M. (2007). Exchange Rate Pass-through to Trade Prices: The Role of Non-Linearities and Asymmetries. European Central Bank, Working Paper Series No. 822.

Campa, J. and Goldberg L. (2002). Exchange Rate Pass-Through into Import Prices: a Macro or Micro Phenomenon? NBER Working Paper No. 8934.

Campa, J., Goldberg, L. and González-Mínguez, J. (2005). Exchange Rate Pass-Through into Imports Prices Euro area. Federal Reserve Bank of New York Staff Reports No. 219.

Canetti, E. and Greene, J. (1992). Monetary Growth and Exchange Rate Depreciation as Causes of Inflation in African Countries: An Empirical Analysis. *Journal of African Finance and Economic Development*, 1:37-62.

Chew, J., Oularis, S. and Meng, T. (2009). An Empirical Analysis of Exchange Rate Pass- Through in Singapore. Monetary Authority of Singapore Staff Paper No. 50.

Choudhri, E. and Hakura, D. (2001). Exchange Rate Pass-Through to Domestic Prices: Does the Inflationary Environment Matter? IMF Working Paper No.194.

Corsetti, G. and P. Pesenti. (2001). "International Dimensions of Optimal Monetary Policy." NBER Working Papers No. 8230.

Daniel K. (2007). An Analysis of Exchange rate Pass-through to Prices in South Africa. Department of Economics and Economic History, Rhodes University, Grahamstown.

Delatte, A. and López-Villavicencio, A. (2010). Asymmetric Responses of Prices to Exchange Rate Variations. Evidence from the G7 countries" *Journal of Macroeconomics*, Forthcoming.

Devereux, M. and Yetman, J. (2002). Price-Setting and Exchange Rate Pass-Through: Theory and Evidence. In Price Adjustment and Monetary Policy, Proceedings of a conference held at the Bank of Canada, Ottawa: Bank of Canada. PP. 347-71.

Devereux, M. (2001). Monetary Policy, Exchange Rate Flexibility and Exchange Rate Pass-through. University of British Columbia.

Devereux, M. and Yetman, J. (2008). Price Adjustment and Exchange Rate Pass-through. Bank for International Settlements, University of Hong Kong, Institute for Monetary Research.

Diago, W. (2011). Exchange Rate Pass-through and Inflation Targeting in Peru. Central Reserve Bank of Peru.

Dornbusch, R. (1987). Exchange Rates and Prices. *American Economic Review*, 77 (3): 93-106.

Enders, W. (1995). *Applied Econometric Time Series*. Iowa State University, John Wiley and Sons, Inc.

Ethiopian Economic Association. (2011). Report on the Ethiopian Economy. Addis Ababa, Ethiopia.

Frimpong, S. and Adam, A. M. (2010). Exchange rate pass-through in Ghana. *Journal of International Business Research* 3 (2): 186-192.

Gagnon, J. and Ihrig, J. (2004). Monetary policy and exchange rate pass-through. *International Journal of Finance and Economics* 9: 315-338.

Ghatak, S. (1995). *Monetary Economics in Developing Countries*. Second edition, ST. Martin's Press, Inc.

Gaulier, G., Lahrèche-Révil, A. and Méjean, I. (2006). Structural Determinants of the Exchange Rate Pass-Through. CEPII Research Centre Working Papers 2006-03.

Ghosh, A. and Rajan, R.S. (2006). Exchange Rate Pass-through in Asia: What does the Literature Tell us? George Mason University and Claremont Graduate University.

Goldberg, P. K. and Knetter M. M. (1997). Goods Prices and Exchange Rates: What Have We Learned? *Journal of Economic Literature*, 35 (3): 1243-1272.

Goldberg, P.K. (1995). Product Differentiation and Oligopoly in International Markets: The Case of the U.S. Automobile Industry. *Econometrica*, 63 (4): 891-951.

Garcia, C. J. and Restrepo, J. E. (2001). Price Inflation and Exchange Rate Pass-Through in Chile. Central Bank of Chile Working Paper No 128.

Gujarati, D. (2004). *Basic Econometrics*. Fourth Edition. McGraw-Hill Companies.

Hahn, E. (2003). Pass-Through of External Shocks to Euro Area Inflation. European Central Bank Working Paper No. 243.

Haile Kibret (2001), Monetary Policy and Monetary Approach to the Balance of Payments: the case of Ethiopia, M.S.C thesis, AAU.

Harris R. (1995). *Using Cointegration Analysis in Econometric Modeling*. London, New York, Prentice Hall /Harvastor Wheat Sheaf.

Hooper, P. and Mann, C. (1989). Exchange Rate Pass-Through in the 1980s: the Case of US Imports of Manufactures. Brookings Papers of Economic Activity, 1(3):297-337.

Hyder, Z. and Shah, S. (2004). Exchange Rate Pass-Through to Domestic Prices in Pakistan. State of Bank of Pakistan Working Paper No.5.

Ito, T. and Sato, K. (2006). Exchange Rate Changes and Inflation in Post-Crisis Asian Economies: VAR Analysis of the Exchange Rate Pass-Through. Research Institute of Economy, Trade and Industry Discussion Paper Series No. 018.

Kilian, L. (2011). Structural Vector Autoregressions. University of Michigan.

Kiptui, M., Ndolo, D. and Kaminchia, S. (2005). Exchange Rate Pass-Through: To What Extent Do Exchange Rate Fluctuations Affect Import Prices and Inflation in Kenya? Central Bank of Kenya Policy Discussion Paper No. 1.

Knetter, M. (1994). Is Export Price Adjustment Asymmetric? Evaluating the Market Share and Marketing Bottlenecks Hypotheses. *Journal of International Money and Finance*, 13 (1): 55-70.

Knetter, M. (1993). International Comparisons of Pricing-to Market Behavior. *American Economic Review*, 83, 473-486.

Krugman, P. and Obstfeld, M. (2003). *International Economics: Theory and Policy*. Sixth edition, Pearson Education, Inc.

Kumar, J. K. (2007). Economic Reforms and Exchange Rate Pass-through to Domestic Prices in India. Bank of International Settlement Working Paper No. 225.

Leigh, D. and Rossi, M. (2002). Exchange Rate Pass-Through in Turkey. IMF Working Paper No. 204.

Lonening, J., Durveall, D. and Yohannes, A. (2009). Inflation Dynamics and Food Prices in an Agricultural Economy: The Case of Ethiopia. Götenborgs University, Working Paper in Economics No. 347.

Loening, J. and Higashi, M. (2010). Decomposing Terms of Trade Fluctuations in Ethiopia. America Institute for Economic Research, Discussion Paper No. 205.

Lutkepohl, H. (1991). *Introduction to Multiple Time Series Analysis*. Berlin: Springer-Verlag.

Mann, C. L. (1986). Prices, Profit Margins, and Exchange Rates. Federal Reserve Bulletin 72(6), 366-379.

Marazzi, M. Sheets, N. and Vigfusson, R. (2005). Exchange Rate Pass-through to U.S. Import Prices: Some New Evidence. Board of Governors of the Federal Reserve System, International Finance Discussion Papers No. 833.

Marston, C. (1990). Pricing to Market in Japanese Manufacturing. *Journal of International Economics*, 29 (3-4): 217-236.

Masten, I. (2004). Identification of Exchange Rate Pass-Through Effect in Cointegrated VAR: an Application to New EU Member Countries. European University Institute and University of Ljubljana.

McCarthy, J. (1999). Pass-Through of Exchange Rates and Import Prices to Domestic Inflation in Some Industrialized Economies. Bank for International Settlements Working Paper No. 79.

McCarthy, J. (2000). Pass-Through of Exchange Rates and Import Prices to Domestic Inflation in Some Industrialized Economies. Federal Reserve Bank of New York Staff reports No.11.

Menon, J. (1993). Exchange Rate Pass-Through: Australian Imports of Motor vehicles. *International Economic Journal*, 7: 1-17.

Menon, J. (1995). Exchange Rate Pass-Through. *Journal of Economic Surveys*, 9:197-231.

Minh, V. (2009). Exchange Rate Pass-Through and its Implication for Inflation in Vietnam. Vietnam Development Forum Working Paper No. 0902.

Ministry of Agriculture and Rural Development (2010), Ethiopia's Agriculture Sector Policy and Investment Framework: Ten year road map (2010–2020). Draft.

Monacelli, T. (2005). Monetary Policy in a Low Pass-Through Environment. *Journal of Money, Credit, and Banking*. 37(6):1047-1066

Mwase, N. (2006). An Empirical Investigation of the Exchange Rate Pass-Through to Inflation in Tanzania. IMF Working paper No. 150.

National Bank of Ethiopia. (2004/05). Annual Report, Various Issues.

National Bank of Ethiopia. (2009). NBE's Monetary Policy Framework. Economic Research and Monetary Policy Process.

Obstfeld, M. and K. Rogoff. (1995). Exchange rate dynamics redux. *Journal of Political Economy* 103(3): 624-660.

Ohno, K. (1989). Export Pricing Behavior of Manufacturing: A U.S. – Japan Comparison. IMF Staff Papers 36(3), 550-579.

Peltzman, S. (2000). Prices Rise Faster than They Fall. *Journal of Political Economy*, 108 (3): 466-502.

Pilbeam, K. (1998). *International Finance*. Second Edition, London: Macmillan.

Pollard P. S. and Coughlin, C. C. (2003). Size Matters: Asymmetric Exchange Rate Pass-Through at the Industry Level. Working Paper 2003-029C.

Przystupa, J. and Wróbel, E. (2009). Asymmetry of the Exchange Rate Pass-Through: An Exercise on the Polish Data. MPRA working paper No. 17660.

Reginaldo N. and Leòn-Ledesma M. (2010). Is Low Inflation Really Causing the Decline in Exchange Rate Pass-Through? Department of Economics, University of Kent.

Romer, D. (1993). Openness and Inflation: Theory and Evidence. *Quarterly Journal of Economics*, 4, 869-903.

Rowland, P. (2003). Exchange Rate Pass-Through to Domestic Prices: The Case of Colombia. Banco de la República (Central Bank of Colombia).

Shewangizaw Sileshi (2003), The Role of Diversification in Reducing Impact of Export Instability on Ethiopian Economic Growth: An Empirical Investigation, M.S.C thesis, AAU

Smets, F. and Wouters, R. (2002). Openness, Imperfect Exchange Rate Pass-Through and Monetary Policy. European Central Bank Working Paper No. 128.

Stock, J. (1993). Unit roots, Structural Breaks and Trends. In Robert Engel and Daniel Mcfadden (Eds), *Hand book of Economics* Vol. 4. Amsterdam North-Holland.

Stock, J. and Watson, M. (2001). Vector Autoregressions. *Journal of Economic Perspectives*, 15 (4):101–115.

Stulz, J. (2006). Exchange Rate Pass-Through in Switzerland: Evidence from Vector Autoregressions. Swiss National Bank.

Taylor, J. (2000). Low Inflation, Pass-Through, and the Pricing Power of Firms. *European Economic Review* 44 (7): 1389-1408.

Ware, R. and Winter, R. (1988). Forward Markets, Currency Options and the Hedging of Foreign Exchange Risks. *Journal of International Economics* 25: 291-302.

Webber, A. (1999). Newton's Gravity Law and Import Prices in the Asia Pacific. Department of Economics, University of Wollongong, Working Paper, 99-12.

Wickremasinghe, G. and Silvapullle, P. (2004). Exchange Rate Pass through to Manufactured Import Prices: the Case of Japan. Mimeo: Monash University.

Wooldridge, J.M. (2003). *Introductory Economics*: A Modern Approach. Second Edition.

World Bank (2010), Ethiopian Agricultural Growth Project, Project Appraisal Document, Addis Ababa, Ethiopia.

World Bank's World Development Report, Gross National Income Per Capita 2010, Atlas method and PPP, July, 2011.

Yang, J. (1997). Exchange Rate Pass-Through into U.S. Manufacturing Industries. *Review of Economics and Statistics*, 79: 95-104.

Yelena, T. (2008). Understanding Changes in Exchange Rate Pass-Through. Federal Reserve Bank of San Francisco Working Paper No. 13.

Yimeserach Aklilu (2005), The Behavior of Money supply in Ethiopia, MSC thesis, AAU.

Yüncüler, Ç. (2009). Import Price Pass-through in to Inflation Indicators in Turkey. MSC thesis, Department of Economics, Middle East Technical University.

Zewdie Adane (2009), The Behavior and Determinants of Real Effective Exchange Rate in Ethiopia. MSC thesis, AAU.

Zorzi M., Hahn, E. and Sánchez, M. (2007). Exchange Rate Pass-through in Emerging Markets. European Central Bank Working Paper No. 739

APPENDICES

Appendix A.1: Construction of Import Price Index (Taken from Loening and Higashi, 2010)

The import unit value index of the component *i* is:

$$P^*_{mi,t} = \frac{P_{mi,t} q_{m,it}}{q_{mi,t}}$$

Where $P_{mi,t}$ and $q_{mi,t}$ represent the import unit value and the quantity of the component *i* at time *t.* The overall import price index ($P_{m,t}$) is a weighted average of all components:

$$P_{m,t} = \sum_{i=1}^{n} W_{xi,t} P^*_{mi,t}$$

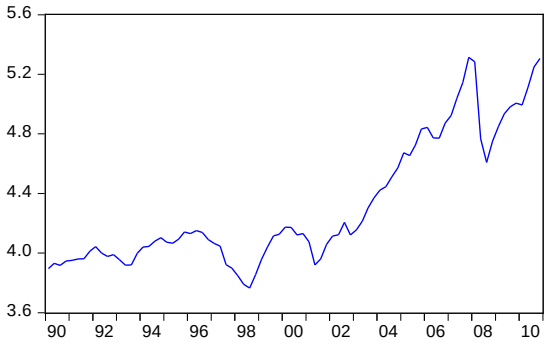
Where $W_{xi,t} = \frac{P_{mi,t} q_{mi,t}}{\sum_{i=1}^{n} P_{mi,t} q_{mi,t}}$

Note: To construct the index the unit value of major imports items from the class of semi-finished goods, capital goods and consumer goods including petroleum products are considered.

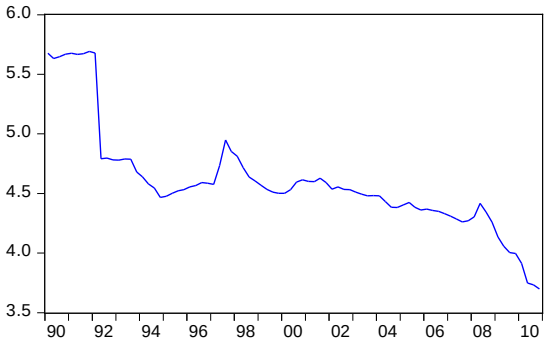
Appendix A.2: Time Series Plots

i) Variables Used in the Empirical Analysis at Level

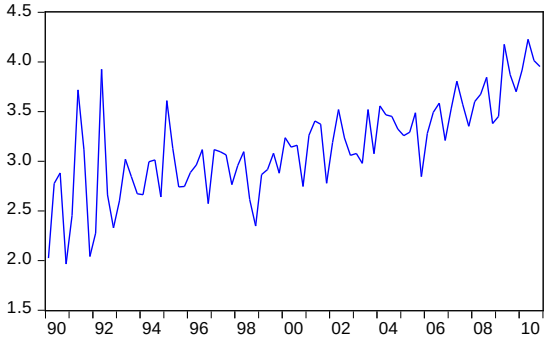
LWCPI



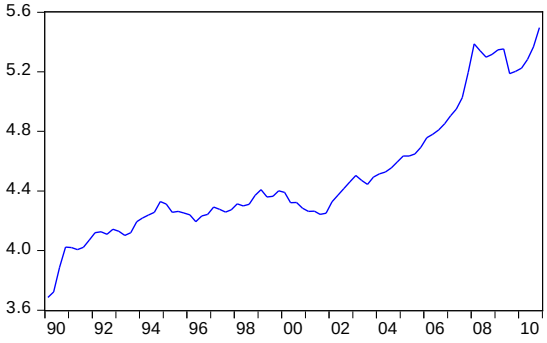
LNEER



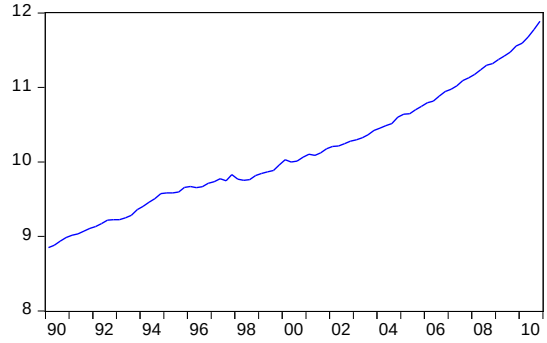
LMPI



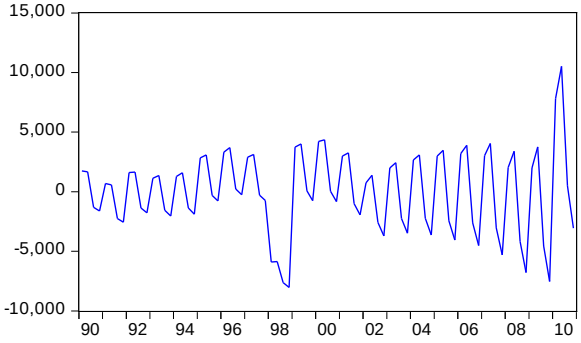
LCPI



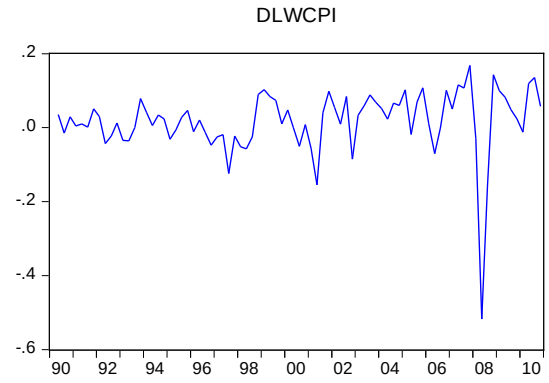
LM2

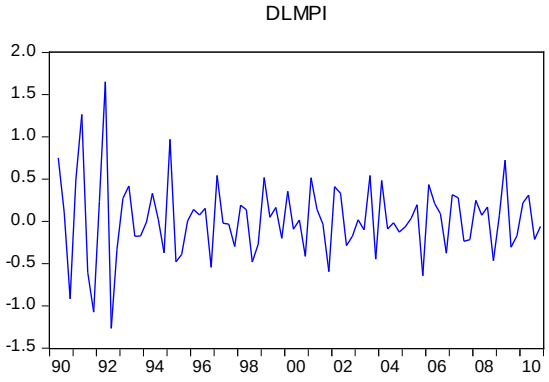


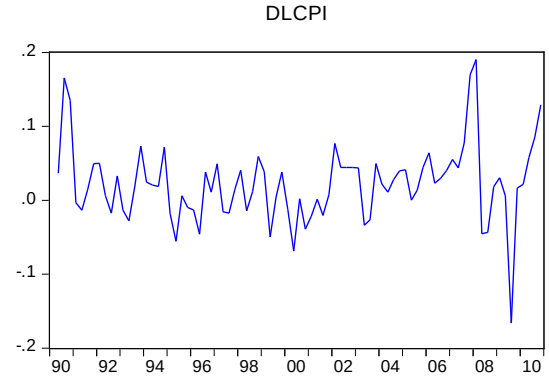
YGap

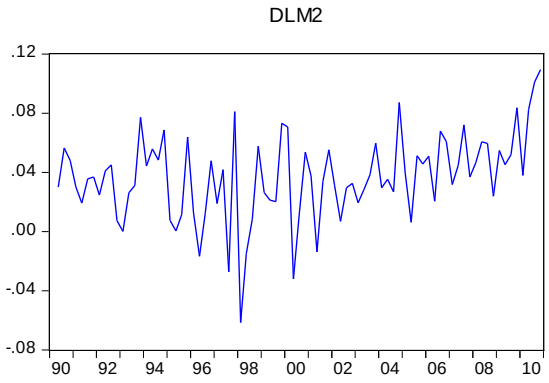


ii) Variables Used in Empirical Analysis at First Differences

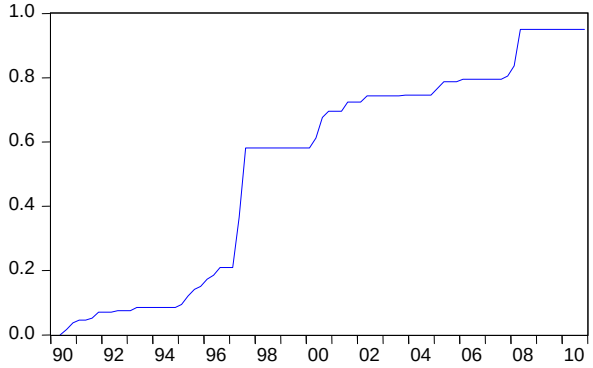




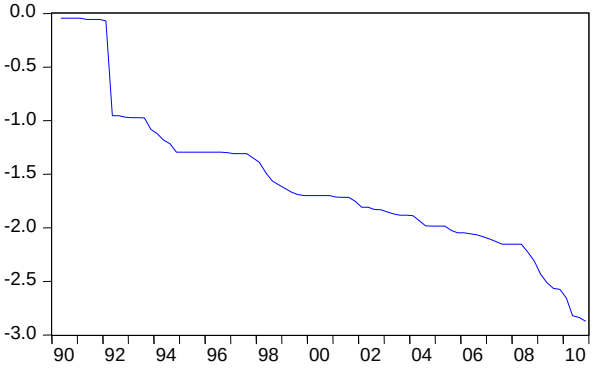




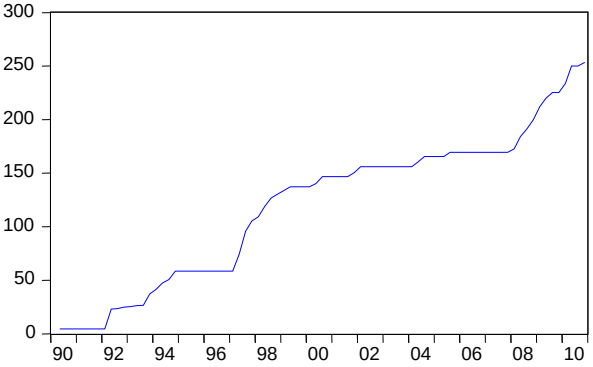
iii) Plots of Asymmetry Series



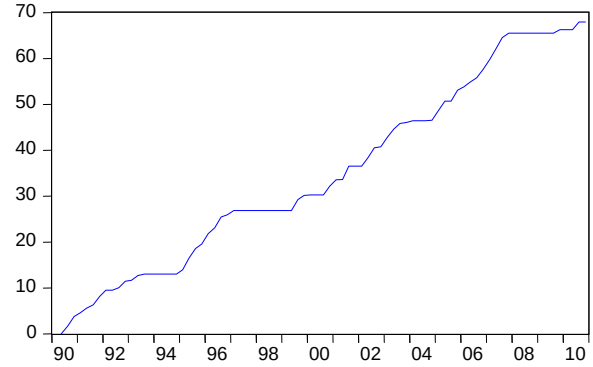
E_t^A



E_t^D



E_t^L



E_t^s

Appendix B.1: VAR Lag order Selection Results

i) VAR Lag Order selection Criteria

Endogenous variables: DLWCPI YGap DLNEER DLMPI DLCPI DLM2

Lag	LogL	LR	FPE	AIC	SC	HQ
0	433.6927	NA	7.99e-13	-10.82766	-10.64770*	-10.75557
1	487.4866	98.05473	5.11e-13	-11.27814	-10.01843	-10.77346
2	**544.1673**	**94.70706***	**3.07e-13***	**-11.80170***	**-9.462250**	**-10.86445***
3	572.9020	43.64767	3.84e-13	-11.61777	-8.198570	-10.24794
4	607.0141	46.63415	4.36e-13	-11.56998	-7.071025	-9.767558

*** indicates lag order selected by the criterion**

ii) VAR Lag Exclusion Wald Tests

Chi-squared test statistics for lag exclusion:
Numbers in [ ] are p-values

	DLWCPI	Y^{Gap}	DLNEER	DLMPI	DLCPI	DLM2	Joint
Lag 1	17.40069	47.00177	0.908023	42.73635	40.26389	8.183881	158.9562
	[0.007918]	[1.87e-08]	[0.988860]	[1.32e-07]	[4.04e-07]	[0.224939]	[0.000000]
Lag 2	7.665978	44.09297	6.794962	77.42173	15.34229	11.19456	153.2235
	[0.263610]	[7.08e-08]	[0.340226]	[1.22e-14]	[0.017755]	[0.082546]	[2.22e-16]
df	6	6	6	6	6	6	36

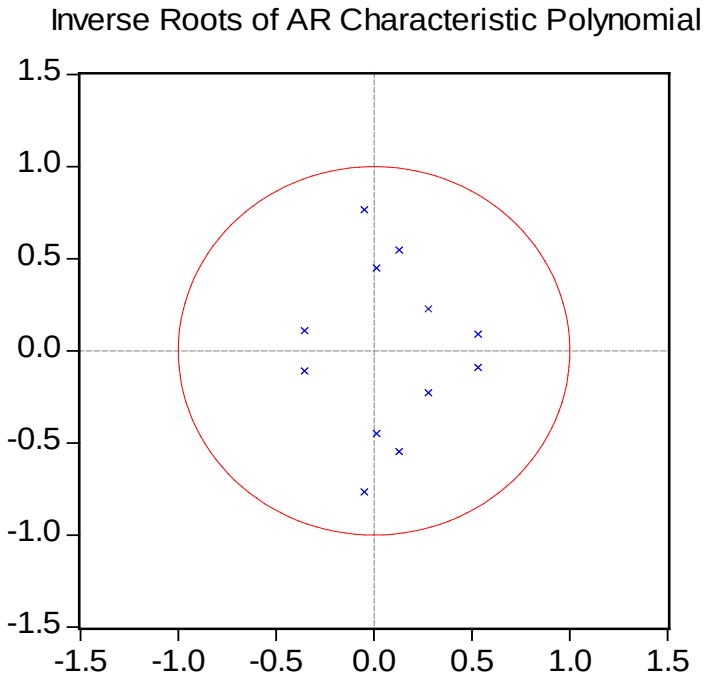
Appendix B.2: VAR Diagnostic Tests

i) Stability Test

Roots of Characteristic Polynomial
Endogenous variables: DLWCPI YGap DLNEER DLMPI DLCPI DLM2

Root	Modulus
-0.050152 - 0.765496i	0.767138
-0.050152 + 0.765496i	0.767138
0.127994 - 0.546686i	0.561469
0.127994 + 0.546686i	0.561469
0.531278 - 0.090283i	0.538895
0.531278 + 0.090283i	0.538895
0.012561 - 0.449274i	0.449450
0.012561 + 0.449274i	0.449450
-0.355277 - 0.109002i	0.371623
-0.355277 + 0.109002i	0.371623
0.277633 - 0.227543i	0.358965
0.277633 + 0.227543i	0.358965

No root lies outside the unit circle.
VAR satisfies the stability condition.



ii) Test for Residual Autocorrelation

VAR Residual Serial Correlation LM Tests
H0: no serial correlation at lag order h

Lags	LM-Stat	Prob
1	42.29716	0.2176
2	45.92372	0.1243

Probs from chi-square with 36 df.

iii) Test for Residual Normality

Component	Jarque-Bera	df	Prob.
1	104.6114	2	0.0000
2	16.88396	2	0.0002
3	2883.356	2	0.0000
4	2.144029	2	0.3423
5	113.9991	2	0.0000
6	2.896483	2	0.2350
Joint	3123.891	12	0.0000

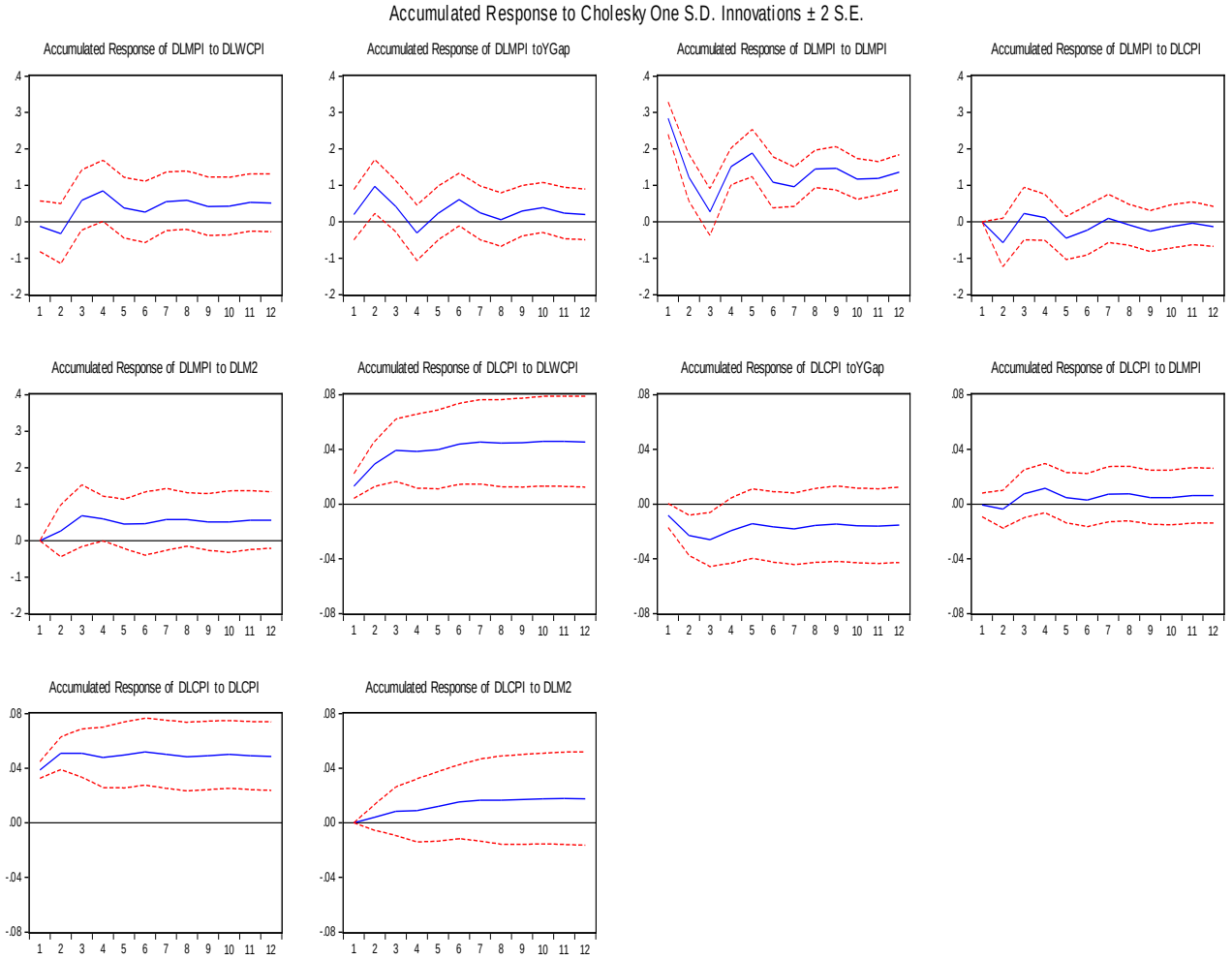
iv) Test for Residual Heteroskedasticity

VAR Residual Heteroskedasticity Tests:
No Cross Terms (only levels and squares)

Joint test:

Chi-sq	df	Prob.
578.9345	504	0.5432

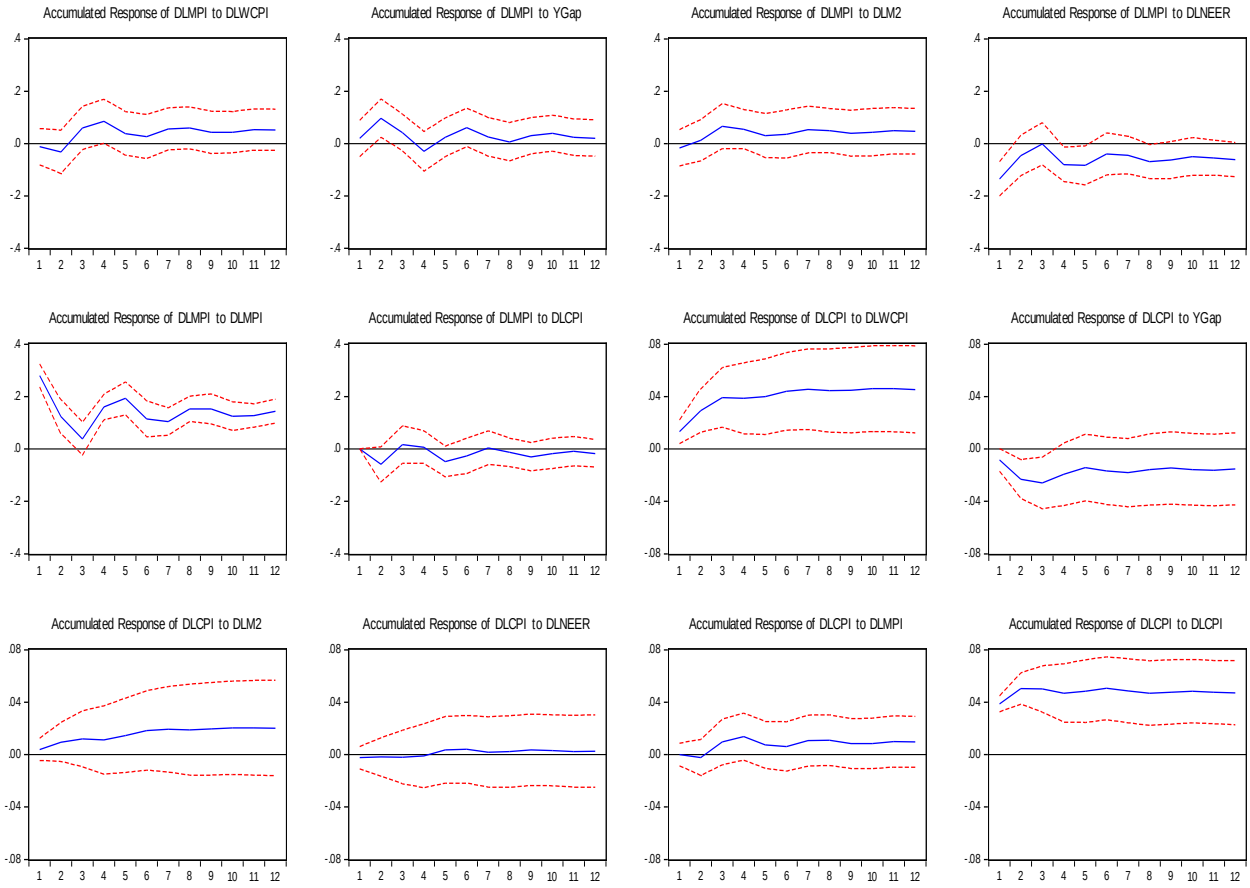
Appendix C: Impulse Response Results of MPI and CPI to Shocks in Other Variables (base line model)



Appendix D: Results of Alternative Models

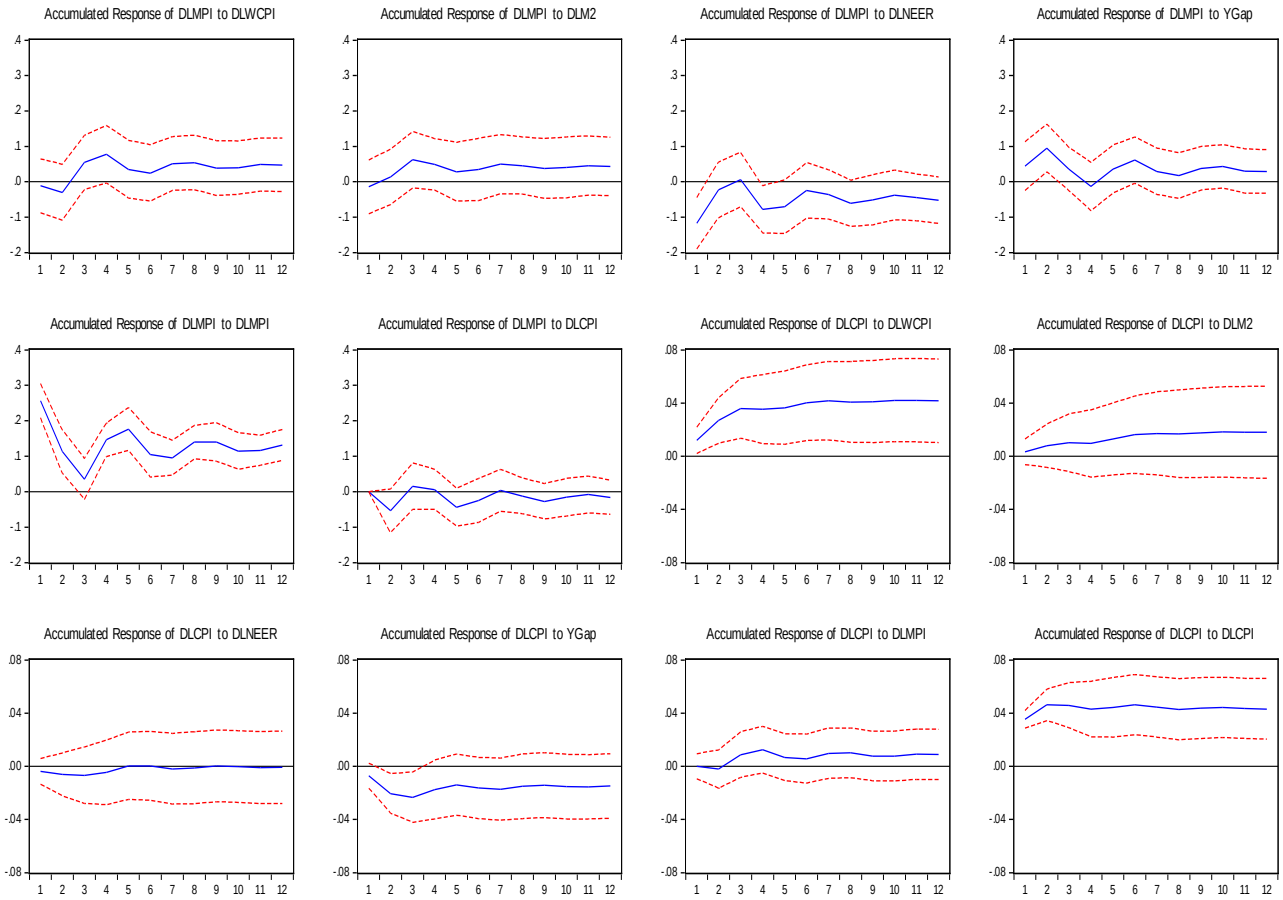
i) Alternative Model 1: $\Delta wcpi \rightarrow y^{Gap} \rightarrow \Delta m2 \rightarrow \Delta neer \rightarrow \Delta mpi \rightarrow \Delta cpi$

Response of MPI and CPI to various shocks in the system



ii) Alternative Model 2: $\Delta wcpi \rightarrow \Delta m2 \rightarrow \Delta neer \rightarrow y^{Gap} \rightarrow \Delta mpi \rightarrow \Delta cpi$

Response of MPI and CPI to various shocks in the system



iii) Generalized Impulse Response Results

Response of MPI and CPI to various shocks in the system