ADDIS ABABA UNIVERSITY
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MACROECONOMETRIC MODELLING OF ETHIOPIAN ECONOMY AND ITS POLICY IMPLICATION: AN ECLECTIC APPROACH

BY
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November, 2011
Addis Ababa

Acknowledgment

I would like to forward my appreciation and gratitude to my advisor Tadele Ferede(PhD) for his unreserved constructive comments throughout the development of this paper. This study has also benefited a lot from discussion with many people and I would like to pass my gratitude to Daniel Zerfu (PhD) , Eyasu Tsehayeye , Meseret Molla and other individuals working in different offices.

It is also my pleasure to express my gratitude to Ethiopian Development Research Institute (EDRI) which sponsored my school fee at the time of my study and professors of School of Economics, which equipped me with knowledge and shared their experience.

I am also grateful to my brothers: Deginet Tebekew (*Dagma*), for all his unreserved love and covering all my living and educational material expenses at the time of my study; Wondwosen Tebekew(*wonde*), the *kitchen beach* ;and Bizuhan Tebekew(*FasilFeker*), friend of the night. For every one of you who had given me your support at the time of my study *Thank you all!*

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Abstract

The paper presents a small macroeconometric model by categorizing the working of the economy in to aggregate demand, aggregate supply, monetary sector, and price sector. The model is estimated using data from 1970/71 to 2008/09 employing an eclectic approach, the Engle-Grager two step procedure and Autoregressive Dynamic lag Model (ARDL) approach of Pesearan et al (2001) to obtain the cointegrating relations and short run dynamic model. The construction of the model follows the lines of aggregate supply - aggregate demand framework. The adequacy of the model and its forecasting accuracy is checked using MAE, MAPE, RMSPE and Theil's inequality coefficients. And the model is found to track endogenous variables well for the given sample period. Policy simulation using the dynamic simulation method compares the dynamic responses to the fiscal policy in the form of expansionary government has an expansionary effect on domestic output, however followed by inflation and crowding out of private investment. The other simulation is a monetary restraint policy in the form of reducing domestic credit is effective to alleviate inflation and improve the trade balance though it is less effective to increase domestic output. Ethiopian economy is found to be highly susceptible to external shock and an increase in imported price level results a contraction in domestic output and creates inflation in domestic economy and a reduction in both export and import level of the country.

1 INTRODUCTION

1.1 Background

Macroeconomic adjustment policies have been adapted in Ethiopia since late 1950s hitherto. Main objectives of these macroeconomic policies had been to bring a long term change in the structure of the economy and a rapid economic growth. Ethiopia has aspired to bring structural change starting from the time where the first development plan has been designed however, from 1950s up until now the country is under the vicious circle of subsistence farming characterized by holding more than eighty percent of the population main source of livelihood.

Ethiopia has implemented different development plans. In the imperial era there had been three plans ranging from 1958-62, 1963-67 and 1969-74 and each of them having five years duration under free market ideology. In Derg era the first development campaign plan was with the intention of creating socialist Ethiopia which was commenced from 1978 up to 1984, and the second plan was a long term plan designed to have ten years epoch launched in 1984/85 and supposed to end in 1993/94 (see Alemayehu (1999), Ayele(2003)). In the ruling government of Ethiopia, Ethiopian Peoples Revolutionary Democratic Front (EPRDF), different development plans had been exercised unlike ex-governments from the point of implementing development plans. In the early 1990s least developing Countries (LDCs) had been levied a program by the Briton woods Institutions (World Bank and IMF) tagged by the structural adjustment program (SAP) and Ethiopia has been one of those countries selected for the prescription to swallow the medicine. And other programs implemented were own demand driven with the intention to achieve the millennium development goals (MDGs) set by the United Nations. These development plans are Sustainable Development and poverty Reduction program (SDPRP) extending from 2000-2005 and Plan for Accelerated and Sustained Development to End Poverty (PASDEP I) extending from 2005 to 2010. And recently Ethiopian government has announced a development plan named Growth and Transformation Plan (GTP) (see MOFED 2000, 2005, 2010).

Though Ethiopia has long period in exercising development plans in the standard of other African countries (Ayele,2003), but still now there is no macroeconomic models that had been attempted at an institution or government level to make policy analysis except at individual level mainly in the context of some partial academic research (EEA, 2008).

Models are used to organize and describe our understanding of the workings of national and global economies, provide a common framework for communication, predict future economic developments under alternative scenarios, and to evaluate potential outcomes of policies and external events (Garratt *et al*, 2006). Macro-econometric model that really mimics the working of the economy allows policy makers and other stakeholders to make policy exercises and understand how the economy functions.

Sound economic policy analysis and forecast relay on the quality of the data. Like other developing countries in Ethiopia there is absence of data for some economic variables like capital stock, amount of labor and also poor quality of data are part of the problems that exists. But this does not prohibit us from building the macro models, but these limitations have to be considered in the modelling exercise.

Having this as a background, the main objective of the paper is to build a macro-econometric model that represents systematic interaction of the economy and to characterize Ethiopian economy based on a model and to undertake a counterfactual analysis from the side of fiscal, monetary and external sector of the economy and forward policy implication.

1.2 Statement of the problem

In order to implement effective and sustainable economic policy appropriate economic guide line, development plan, is very decisive. But to monitor and evaluate this guideline appropriate tool is very mandatory. One of these tools is macroeconomic model. Macroeconomic models are laboratories to test ideas and policy proposals of policy makers and analysts by subjecting their anatomy i.e. economic structures of the sectors. Hazel and Norton (1986) and Roberta (2005) explain models are a distillation of economic theory and the use of models ensures policy-making is guided by a correct understanding of how economies function, and hence they help us to confirm and strengthen existing insights.

Constructing macro model particularly to the case of developing countries is often a difficult task due to insufficient and scattered data sources. In addition, macro-economic modelling is not an end by itself rather a dynamic process which needs continuous updating to capture the current economic conditions of the country. Hence to apply valuable and better economic policy, to make a counterfactual macroeconomic policy exercises macroeconomic model is a vital tool.

One of the techniques that help to construct macroeconomic models is macro-econometrics approach. Though after 1970s macro-econometric modelling was censured by Lucas(1976) critique which argued macro-econometric models are designed to perform former task only, and applying these models for simulation provides no useful information as to the actual consequences of alternative economic policies even features of the model which lead to success in short-term forecasting are unrelated to quantitative policy evaluation. Explicitly, the critique squabbles there is no reason to believe that the 'structure' of the decision rules (or economic relations) would remain invariant under a policy intervention, i.e. policy evaluation should be based on a simple principle of rational expectations theory.

As a response to Lucas (1976) critique there has been different approaches and tests forwarded by Hendry (1980) and Fair (2004). Hendry(1980) brought a methodology known as "general to specific approach" or commonly known as the London School of Economics(LSE) methodology where models are postulated in terms of Economic theory and structure(Static and dynamic nature of relations) to be determined by the data. Fair (2008) has also tested the rational expectation hypothesis and forwarded in most cases the theory is rejected by using the relationship between unemployment and inflation of US's data.

In principle forward looking and rational expectation are theoretically very interesting but application of these models to developing countries, especially where there is sluggish flow of information to the actors of the economy and where infinitesimal modern sectors is main manifestation of the economy the relevance of Lucas critique is not worth mentioning (Pauly, 2000).

Once a macroeconomic model is well developed it can be used for the analysis of policy reforms such as stabilization polices to reduce inflation, balance of current deficit, and

government budget deficit; liberalization of trade, exchange rate; tax reforms, and other relevant policies too.

To sum up, macroeconomic model like macro-econometrics models have to be built for a country in order to assess economic situation and its functioning.

1.3 Objective of the study

The main objective of this study is to construct a small macro-econometrics model for Ethiopia and evaluate different policy interventions. The specific objectives are to:

- Develop a macro-econometrics model by giving emphasis on the macroeconomic context of Ethiopia for basic elements of the economy;
- Characterize the macroeconomic structure of the economy based on the model developed; and
- Have a counterfactual simulation exercise from the fiscal, monetary and external sector of the economy.

1.4 Significance of the study

Though Ethiopia has exercised different development plans still the country does not have a macroeconometric model that is institutionalized by government or concerned body which is used as a framework to make policy analysis. Macro-econometric model that satisfies the very nature of a country's economic situation has paramount importance compared to that of main stream economic theories especially in the case developing countries like Ethiopia. This thesis is believed to fill this gap by developing a macroeconometric model taking key macroeconomic features of the country.

The thesis has two main significances. First, it gives what the long run and short run determinants of different components of the economy are. Second, it helps policy makers to undertake different policy exercises and it also contributes to further studies related to this thin area of research focus to the case of Ethiopia.

1.5 Organization of the study

The thesis is organized into seven chapters. The second chapter following the introduction focuses on the basic macroeconomic performance of the country for the study period(1970/71 up to 2008/09). Literature review is done from two sides one purely from theoretical aspect for different sectors and the other on empirical literature which is discussed in chapter three. Chapter four explains model specification and estimation technique applied. Chapter five gives empirical analysis to the model developed and gives interpretations of each of the equation for both long run and short run dynamics. The penultimate chapter deals on how the model tracks actual data and dynamic counter factual analysis. Finally, conclusion and policy implication will be discussed.

2 REVIEW OF ETHIOPIAN ECONOMY

The basic aim of this chapter is to give highlight on overall performance of Ethiopian economy for the study period that ranges from 1970/71-2008/09. An overview of the economy is given in relation to demand side, supply side, price, monetary and external sector developments.

2.1 Supply Side of the Economy

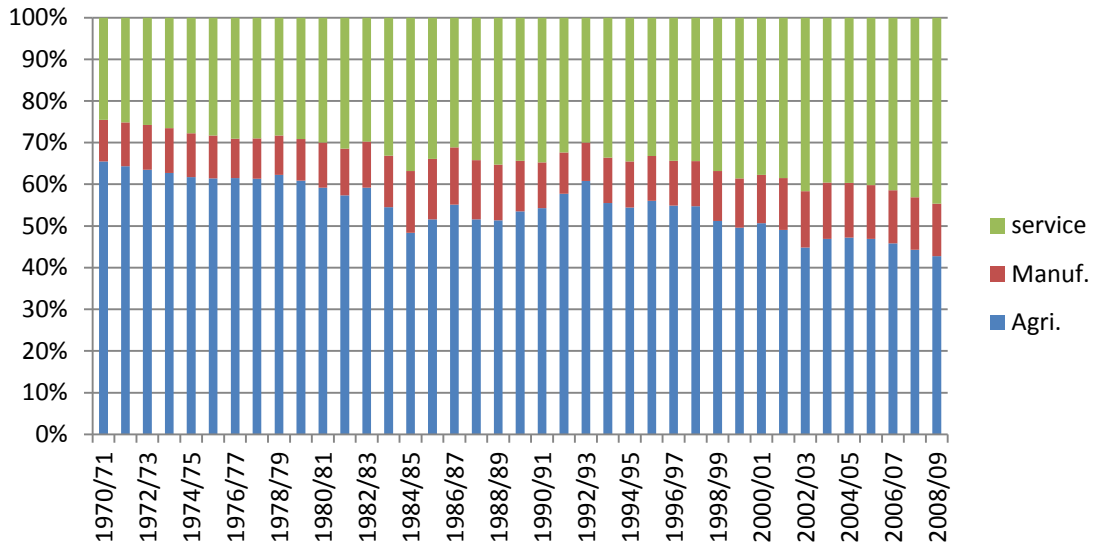
The real sector of the economy comprises agriculture, secondary (manufacturing, construction and electricity and water production) and service sector. Agriculture sector has played a central role in the economy of Ethiopia for the last four decades (1970/71- 2008/09) by having average share of about 55 percent and this sector is characterized to depend on the nature of motherland's good weather condition i.e. on the availability of amount of rainfall. MOFED (2009) documents agriculture sector contributes 45.9% on average at the period the economy has shown an imperative economic growth from 2003/04 up to 2008/09 with an average of 11.5 percent. Due to its role to the subsistence economy and the labor force it absorbs agriculture has been the central focus by all governments so as to build their mass basis by having different economic development plans. When we see the development trend in agriculture sector its share has declined from 65 percent in 1970/01 to 42 percent in 2008/09.

Industry sector has more or less a constant share to the economy for the last four decades which has contributed as low as 9.2 percent in 1992/93 and as high as 14.8 in 1984/85. The higher contribution of industry was in 1984/85 which is not because of the good performance of industry rather due to the drought that has happen in the country which resulted in a relative decrease for share of agriculture value added. Thus we can say the sector has on average a share of 13 percent of the total economy even in the period when the country is experiencing a continuous double digit growth.

Service sector's share has increased from 24.5 in 1970/71 to 44.7 percent in 2008/09. The increase in the share of service sector is more ascribed to the increase of wholesale and retail

trade, real estate, renting and business activities. The contribution of each of the sectors from total GDP for the last four decades is given in figure 2.1.

Figure 2.1: Share of Agriculture, secondary and Service Sector



Source: Own computation based on MoFED (2009/10) and EEA (2009) data.

The average economic growth rate for last four decades has been 3.82 percent and taking only the period for existing ruling government (1992/93 - 2008/09) economic growth has recorded an average of 5.51 percent , however and average of 11.6 percent is achieved for the period between 2003/04 - 2008/09. The economic growth of pre-1991 is significantly less than that of the post period but still the structure of the current economy is as where it has been in the early 1970s and even the contribution of sectors to economic growth is more or less with similar pattern. The contribution of different sectors to economic growth is given in table 2.1.

Regarding contribution to economic growth, service sector has contributed 50 percent of the growth to the total economy and agriculture has contributed around 36 percent and the rest 14 percent is from industry sector on average for the period between 1970/71- 2008/09.When we compare the sectors contribution of to the overall economic growth, in the pre-1991 period the contribution of agriculture to the total economic growth has been around 39 percent on average and in the existing regime the average contribution is still 36.6 percent. Industry contributes 11.1 percent in the pre-1991 period and in the EPRDF regime it contributes about

14 percent and in the case of service sector it is 49.7 percent in the pre-1991 and similarly it remains 49.36 in the post period. In general, even in the recent period (2003/4 - 2008/9) the contribution of different sectors to economic growth and the structure of the economy is fairly similar to pre-1991 period.

Table 2.1: Average Growth Rate and Contribution to Economic Growth of Sectors

Period	**Agriculture**		**Industry**		**Service**		**Total Economic Growth (%)**
	Average growth rate(%)	**Contribution to Growth(%)**	**Average growth rate (%)**	**Contribution to Growth (%)**	**Average growth rate (%)**	**Contribution to Growth (%)**	
1970/71-1991/92	1.32	**0.66**	1.78	**0.19**	**3.07**	0.85	**1.71**
1992/93 - 2008	4.25	**2.02**	6.43	**0.77**	7.13	**2.72**	**5.51**
2003/4 - 2008/9	10.79	**4.97**	10.3	**1.35**	12.95	**5.30**	**11.61**

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Source: Own computation based on MoFED data.

2.2 Demand Side of the Economy

Demand side of GDP is dominated by consumption with a share of about 90 percent before EPRDF regime and 92 percent after that, on average. Real gross capital formation as a share of real GDP has increased from 13.8 to 21.1 percent; resource balance has gone up from 3.5 to 13 percent post-1991. The share of demand component for different period is depicted in Table 2.2 below.

Table 2.2: Share of Demand Components

Demand Component	**1970/71 to 1991/1992**	**1992/93 to 2008/09**	**2003/04 to 2008/09**
Real Final Consumption	**89.7**	**91.8**	**95.1**
Real Private Final consumption	79.7	80.4	83.8
Real Government Final consumption	9.9	11.4	11.3
Real Gross capital formation	**13.8**	**21.2**	**24.3**
Real Private capital formation	7.77	9.98	9.93
Real Government capital formation	6.07	11.62	14.39
Resource Balance	**3.5**	**13.0**	**19.5**

Source: Own computation based on MoFED and EEA data base.

The average growth rate of demand components for pre-1992 is minimal as compared to post-1992. Final consumption has registered 1.97 percent average annual growth rate for pre-1991 period and 6.45 percent for the post-period and a momentum growth of 11 percent between 2003/04 to 2008/09, on average. The annual growth rates for gross capital formation, export and import growth rate for post -1992 is more than 5 times as compared to the pre-period. Table 2.3 below gives the average growth rates of demand components.

Table 2.3: Average Growth Rate of Demand Components

Demand Component	1970/71 **to** 1991/1992	1992/93 **to** 2008/09	2003/04 **to** 2008/09
Final Consumption	**1.97**	**6.45**	**10.94**
Private Final Cons.	1.92	6.42	12.06
Government Final cons.	3.70	8.21	2.83
Gross capital formation	**1.90**	**12.98**	**12.34**
Export	0.26	10.69	7.40
Import	2.67	12.38	12.79
National saving	3.19	9.56	16.77

Source: Own computation based on MoFED data

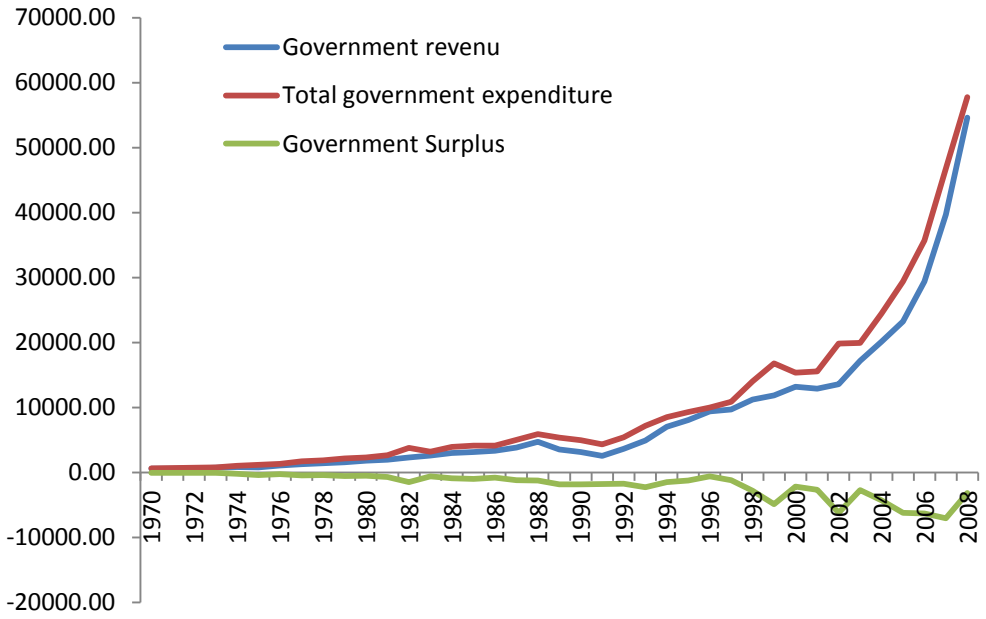
The growth in gross capital formation has been very sluggish in the pre- existing regime which has recorded an average growth rate of 2 percent annually but 13 percent for post period which is credited to the investment atmosphere created for the private investment and government investment for post 1992 period. In the period between1992/93 to 2008/09 the real private investment has been growing on average at 8.3 percent annually.

2.3 Fiscal Development

One of the economic instruments used to guide the economy is by implementing a fiscal policy through revenue collection and proper allocation of resources. General government pulls receipts from tax revenue, non tax revenue and grants. Tax revenue has a share of 60 percent, and non tax revenue and grant have a share of 21 and 19 percent from the total receipt on average for the last four decades. Of the total expenditure 63.9 percent is covered from revenue, 15 percent from the grant and the rest 21 percent is covered from domestic and foreign borrowing. After economic liberalization i.e. over the period 1991/92 to 2008/9, the

share of import duties and taxes cover 40 percent the total tax revenue due to the increase in custom revenues tax gained from the increase in import. Government revenue, expenditure and surplus starting from 1970/71 to 2008/09 is presented in figure 2.2.

Figure 2.2: Trend of Government Revenue, Expenditure and Surplus



Source: Own computation based on MoFED data

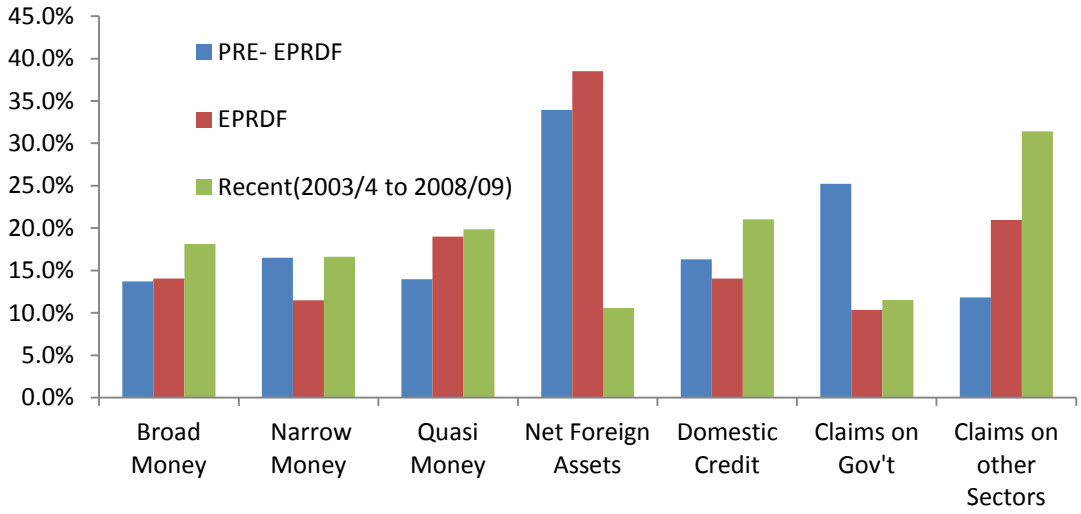
From Government expenditure side, budget is allocated for current and capital expenditure. Current expenditure includes general services consisting of general government service expenditures, national defense, internal order and justices, economic services and social services. Capital expenditure includes expenditures on economic and social developments. The proportion allocated for current expenditure is on average 69 percent and the remaining 31 percent for capital expenditure for the last four decade. In the EPRDF regime there is a slight improvement in the allocation of resource to speed up economic development yet the share of recurrent budget takes 62 percent and the rest 38 percent is allocated to capital expenditure on average. However, for recent period (2003/04 – 2008/09) the budget allocation is fairly equally shared between the two categories of expenditure.

2.4 Monetary Developments

The annual growth rate of domestic liquidity is measured by the broad money supply across a period of time. The expansion of broad money has reached its climax in the last six years of the study period, however, annual average growth had been similar for both pre and post-1991 periods that has registered 13.7 and 14 percent respectively. For the last six years (2003/04-2009/10) average annual growth rate of domestic liquidity has been 18.1 percent with maximum of 21.2 percent for the year 2006/07.

Narrow money, which includes currency outside of banks and net demand deposits, has grown by 16.5 percent and 11.5 percent for pre and post-1991 period respectively; but for recent period (2003/04- 2008/9) annual percentage growth is equivalent to the pre-1991 period. Main factors influencing the growth of broad money are net foreign asset and domestic credit. The annual growth rate of net foreign asset is higher for post-1991 period and domestic credit has reduced on average especially due to the decrease in government claims though there is an increase for the non governmental institutions, on average. The growth rate of broad money and its determinants is shown in figure 2.3 below.

Figure 2.3: Growth rate of Broad Money and its determinants



Source: Own computation based on NBE data

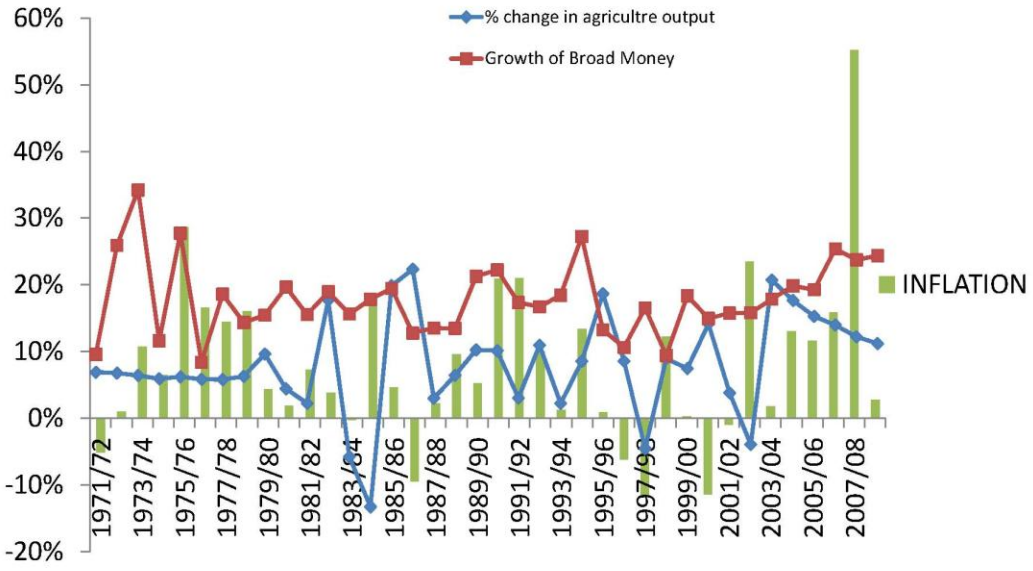
In the recent period (2003/04 – 2008/09) the growth rate domestic credit is 21 percent on average. Claims by non-governmental sectors have been growing with an average of 31.4 percent and for government it has been growing with an average of 11.5 percent.

2.5 Price Developments

Price level is affected with many factors in the case of Ethiopia. In periods when there is drought, historical data attests the presence of price hike due to the decrease in agriculture output. For instance in drought year 1984/85, 1991/92, 2002/03 agriculture output has declined by 20, 3, 11 percent respectively and this has caused inflation rate up to 19, 21, and 23.5 percent respectively.

Also following monetarist's argument, inflation is a monetary phenomenon that results from monetary growth. For the period starting from 2003/04 – 2008/09 inflation has been growing with 16.7 percent and money supply has also been growing by 18 percent on average that shows a strong co-movement between the two variables.

Fig 2.4: Inflation, percentage change in agriculture output and growth rate of broad mone



Source: Own computation based on MoFED ,NBE and EEA(2009) data

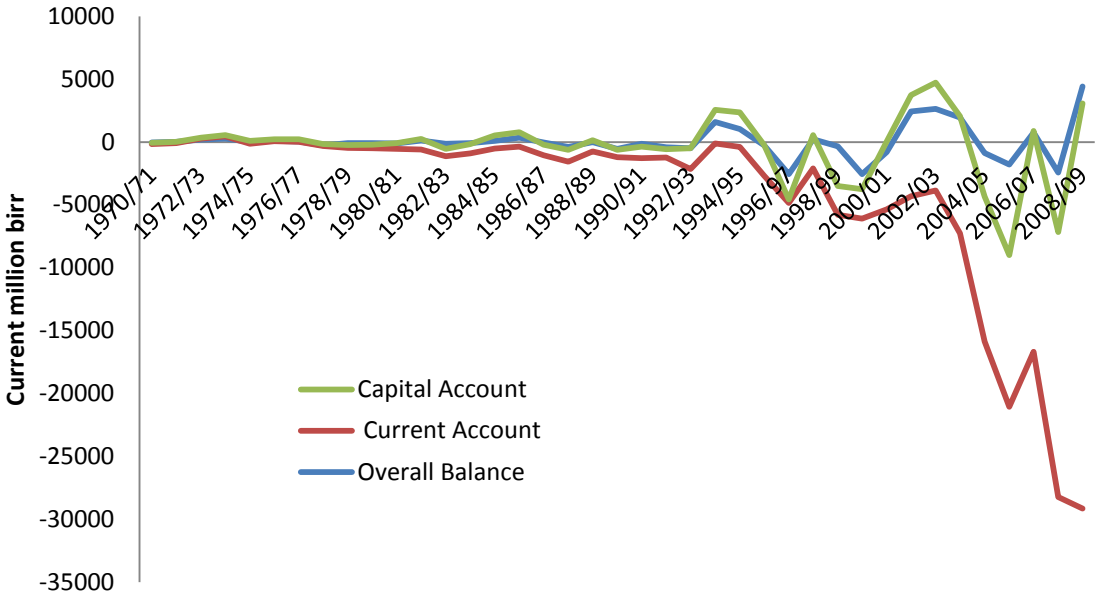
In the period (2005/6-2009/10) which is known as PASDEP period, the country has faced a peak to peak growth of 64.1% CPI for the first time in its entire economic history. This inflationary period (2005/6 up to 2008/9) has created high macroeconomic instability and erodes the wealth of households. The main reasons for the periods inflation had been

imported inflation (such as the increase in the price of fuel, steel, fertilizer), money supply growth, inefficient market structures and inflationary expectations by the market participants (seeMOFED(2009);Andnet and Abebe(2006); Alemayehu and Kibrom(2008)).

2.6 External Sector Development

External position of a given economy can be traced using balance of payment as a mirror. Balance of payment summarizes the economic transactions of a given economy with the rest of the world. In the case of Ethiopia overall balance of payment has a swinging pattern and at times when it is in surplus capital account surpasses current account. In the last four decades except 1972/73 and 1973/74 current account balance has been below zero which shows the country's high dependence on imported commodities. The development in the overall balance of payment, current account and capital account is presented in figure 2.5 below.

Figure 2.5: Trends on overall balance of payment, current account and capital account



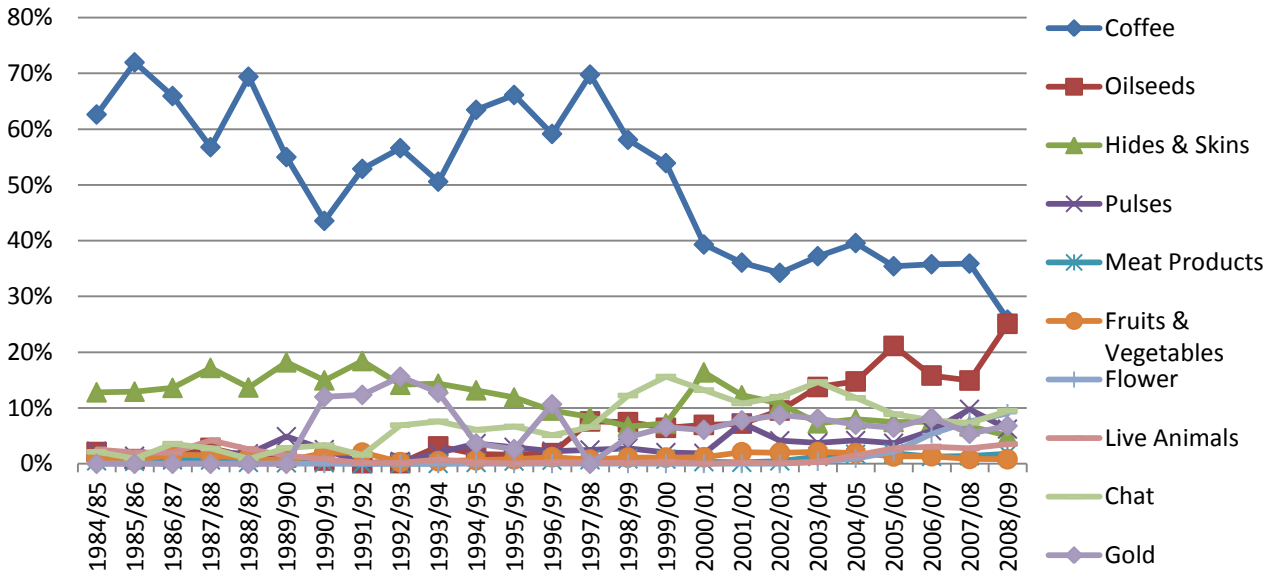
Source: Own computation based on NBE.

Ethiopian export sector is highly dominated by export of primary commodities namely coffee, oilseeds, pulses, chat, flower, animal and animal's primary products like leather and leather products and gold. From the total merchandise export coffee contributes about 52 percent on average for the period 1970/1 – 2008/09, and around 47 percent post-1991 and 35 percent for

recent period 2003/04 – 2008/09. The recent decline in share of coffee export earning is due to the increase in export of oilseeds, pulses, flowers and *chat*. Items listed above have a share of 85 percent on average from the total merchandise export earnings. The trend on the share of export for each of the commodities is given in figure 2.6.

Export of commodities has grown by 6 percent on average for pre-1991 period and 13 percent for post-1991 period and recently by 24 percent for the period 2003/04-2008/09. (MOFED, 2010) has argued the increase in recent performance of export is ascribed to the favorable exchange rate polices and improved infrastructure but without standing this fact till now the country is exporting similar commodities for the last four decade without any structural change.

Figure 2.6: Trend on Export of Commodities



Source: Own computation based on NBE**.**

Ethiopian import is characterized mainly by import of raw materials, semi finished commodities, petroleum and petroleum products, capital goods like import of tyres of heavy vehicles, aircraft and consumer goods. Of the total imported commodities consumer goods have a share of 33 percent and the rest took 67 percent, on average. From consumer goods about 67 percent is on non durable commodities which include cereals, other food items, medical and pharmaceutical and textile fabrics; the rest on durables like radio and television, tyres, cars and other vehicles. The amount of merchandise import annual growth rate has risen

from 9 percent of pre-1991 period to 22 percent for the post period and by 35 percent when we take out the period 2003/04 - 2008/09.

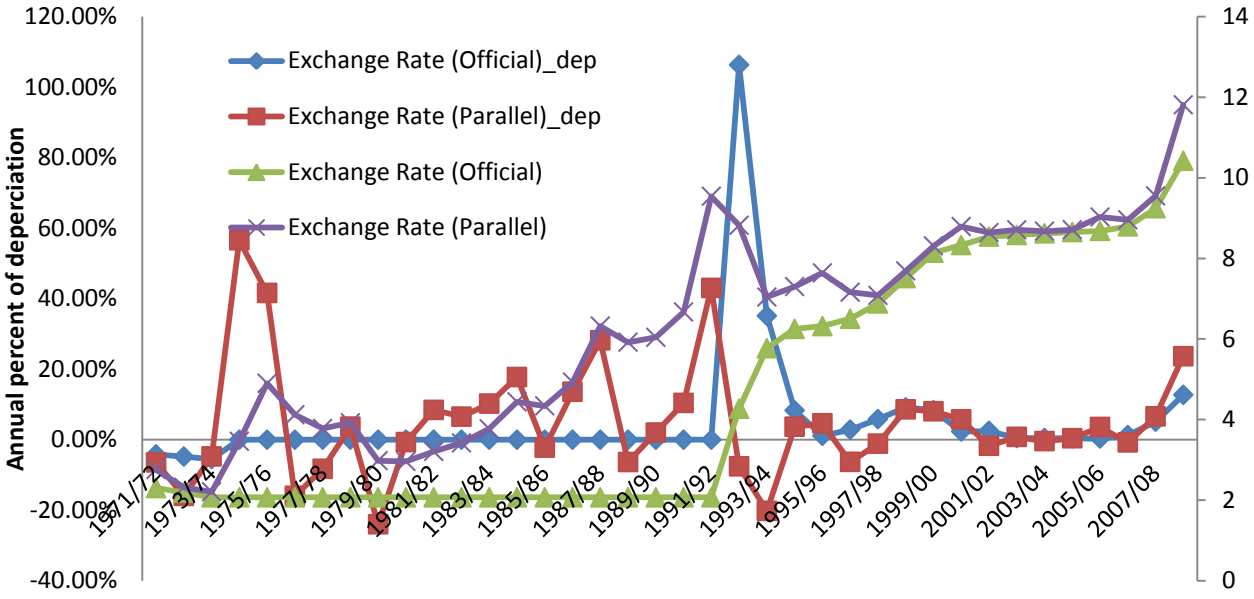
Trade deficit widened on average by 25 percent for post-1991 and 34 percent for 2003/04-2008/09. This is due to the fact that export earning covers about 60 percent of the imported merchandise in pre-1991 period on average and a quarter of the total import for post-1991 period due to the trade liberalization. And strikingly merchandise export can only finances about 21 percent of merchandise import for the period the country has experienced continuous growth. This widening gap between import and export is financed through external source either transfers or debt.

2.7 Development in Foreign Exchange Market

Before the fell of Bretton Woods system one of the main feature regarding international monetary system were the relatively fixed exchange rates of individual currencies to US dollar and the convertibility of the dollar into gold for foreign official institutions. However, staring from 1971 it was replaced by the present regime of rapidly fluctuating exchange rates.

In the case of Ethiopia starting from 1970/71 the official exchange rate of birr against dollar has been two birr and forty cents in the official market and 2 birr and ninety five cents for the parallel foreign exchange rate market. In the pre-1974 period birr has been depreciating by 5 percent on average but during Derg regime (1974/75 – 1990/91) the exchange rate has been fixed at a value of 2.07 birr. However, after 1992/93 exchange rate has been liberalized and the rate is devalued by 106 percent once to get its market price. In the Derg regime before the official devaluation was made the parallel market of dollar was the one that represents the true value Ethiopian currency (birr). The official and parallel exchange rate values and amount of depreciation in percentage change is given in figure 2.7 below.

Figure 2.7: Annual depreciation and exchange rate of birr against dollar



Source: Own computation based on NBE and EEA (2009) data

In the period 1974/75 – 1991/92 parallel exchange market premium is on average 127 percent greater but post-1992/93 period the average parallel exchange rate premium has deteriorated to 12.7 percent and if we exclude 1992/93 the premium goes down to 6.8 percent on average.

3 LITERATURE REVIEW

3.1 INTRODUCTION

This chapter reviews theoretical and empirical literatures at sectoral level to light how behavioral equations are specified that are going to be used in the development of the macro-econometrics model. The theoretical literature focuses on standard theories for different sectors, and theories related to developing economies. The empirical literature gives an explanation on models constructed for developing countries. And the final section briefly summarizes macro-econometric models developed to Ethiopia.

The formulation of a complete macroeconomic framework suitable for policy analysis requires not only a description of the basic accounting identities or equilibrium conditions that must hold at aggregate level, but also the specification of private agents' behavioral functions (Agenor and Montel,2008, p.62). Since behaviors of agents vary across economic status, pragmatic behavioral equations should be identified consistent to the case of developing countries. To enrich this issue and build a good representative model of the whole system to give literature review at sectoral level is found to be relevant.

3.2 THEORETICAL LITERATURE

3.2.1 Theoretical Model of Aggregate Demand

Aggregate demand of a given economy comprises domestic absorption and trade balance. Domestic absorption equates the sum of private consumption, investment and government consumption.

3.2.1.1 Consumption Behavior

Consumption expenditure takes the lion share among aggregate demand components; and marginal propensity to consume gives a lot of implication on the long run growth policies. Since higher MPC implies lesser saving this in turn leads to lesser investment and growth rates. Literature on consumption behavior can be viewed as Keynesian and post-Keynesian theory. Following Keynes which gave the first hypothesis of consumption behavior in 1936, absolute income hypothesis (AIH), other theories had been developed following this theory were: Post-Keynesian theories including Duesenberry's (1949) relative income hypothesis

(RIH), Modigliania and Blumberg's (1954) life cycle hypothesis (LCH) and Friedman's (1957) permanent income hypothesis (PIH). The other recent hypothesis that considers forward looking behavior of consumers was developed as response [1] to Lucas (1976) critique is the random walk hypothesis of Robert Hall (1978). Both Keynesian and post-Keynesian explain the aggregate consumption level by focusing on the micro foundation of economic theory (Campbell and Mankiw, 1989).

Absolute income hypothesis (AIH) takes for granted that the amount of aggregate consumption mainly depends on the amount of aggregate income (both measured in terms of wage-units), this is because of psychological characteristic of the community, and i.e. the portmanteau function 'propensity to consume' is a stable function.[2] Also the average propensity to consume (APC) given as the ratio of consumption to income decrease as income rises (Keynes, 1936, p.70).

But after World War II Keynes's conjunctures failed to manifest the existing reality, i.e. income has raised but saving did not. This experience dramatically underlined the inadequacy of consumption function that relates consumption or savings solely to current income. And another anomaly for AIH arises from Simon Kuznet(1942) time series analysis on average propensity to consume, which resulted APC is more or less constant for the sample period considered for the study (1879 up to 1938 of US's data). Though, Keynesian conjunctures fail to hold for long series still that holds for short time period household consumption data. This controversy has created *consumption puzzle* as many literatures described it (see Friedman, 1957, P. 4, Mankiw, 2009, p.435, Campbell and Mankiw, 1989).

[1] Following Lucas's critique, Robert Hall (1978) proposed a new approach to studying consumption that was firmly founded on the postulate of rational expectations and that was immune to the problems Lucas pointed out (see Campbell and Mankiw,1989, p. 1).

[2] " *The fundamental psychological law, upon which we are entitled to depend with great confidence both a priori from our knowledge of human nature and from the detailed facts of experience, is that men are disposed, as a rule and on the average, to increase their consumption as their income increases, but not by as much as the increase in their income…. we take it as a fundamental psychological rule of any modern community that, when its real income is increased, it will not increase its consumption by an equal absolute amount, so that a greater absolute amount must be saved, unless a large and unusual change is occurring at the same time in other factor*" (Keynes,1936, p.70)

To solve consumption puzzle, i.e.to bring reconciliation for the cyclical or short run achievements of the Keynesian consumption hypothesis and failure in the long run resulted in other three fundamental theories RIH, LIH, and PIH. The main goals of these hypotheses were to solve the two anomalies raised. These are: average propensity to consume should decline as income increases for cyclical fluctuations (short run) and APC should remain constant for permanent life time income in the long run (Campbell and Mankiw, 1989).

Duesenberry(1949) hypothesis of relative income hypothesis has both social and economic components. His hypothesis appeared by criticizing assumptions about consumption choices. He argued AIH is badly flawed and simplistic, because it failed, inter alia, to recognize the central importance of habit formation and took no account of how levels of expenditures could be increased not by changes in income or prices, but by contact with "superior" goods generated by the consumption expenditures of others with whom the individual or family came into frequent contact. Duesenberry called this largely social influence on consumption as "demonstration effect," and this is the mechanism that tended to force up consumption expenditures independently of price and income considerations. Given the importance of social considerations in determining expenditures, RIH argued it is relative rather than absolute levels of income that determines the nature and direction of individual's consumption and saving. Also it adds if theory is inline with this argument, theory of consumer demand will be a more plausible economic theory (Manson, 2000).

Modiglani *et al* (1957) emphasized income varies systematically over people's lives and saving allows consumers move income from those times in life when income is high to those times of low. This interpretation of consumer behavior formed the basis for life cycle hypothesis. In LCH consumption depends on both income and wealth. They noticed that wealth does not vary proportionately with income; higher income corresponds to low average propensity to consume in short periods. But over long periods, both wealth and income grow together and hence it fulfills Kuznets finding of constant APC and the long run constraint of the consumption puzzle (Mankiw, 2009, p 447 - 451).

Permanent income hypothesis (PIH) emphasizes income of an individual is subject to a random and temporary shock. Hence, current income of an individual equates the sum of

permanent component and transitory component.[3] PIH formally hypothesizes the relation between permanent income and permanent consumption as permanent consumption is the product of permanent income and other variables.

It should be noted that the ratio between permanent Consumption and permanent income is independent of the size of permanent income but does depend on other variables, in particular:

(1) the rate of interest (i) or sets of rates of interest at which the consumer unit can borrow or lend; (2) the relative importance of property and non property income given by the ratio of nonhuman wealth to income (w); and (3) the portmanteau factor determining the consumer, unit's tastes and preferences for consumption versus additions to wealth. This hypothesis also solves the consumption puzzle like LCH (Friedman, 1957, p.21).

Robert Hall (1978) showed, if lifecycle permanent income hypothesis is correct and if the consumers have rational expectations, then changes in consumption over time should be unpredictable and the variable is said to follow a random walk. This implies consumption lagged more than one period has no predictive power for current consumption[4] ; and a more stringent testable implication of random-walk hypothesis holds consumption is unrelated to *any* economic variable that is observed in earlier periods even lagged income. Hence forecasts of future changes in income are irrelevant, since information used in preparing them is already incorporated in today's consumption (Hall, 1978).[5]

However, Campbell and Mankiw (1989) found expected changes in income are associated with expected changes in consumption. In other words, Hall's hypothesis of consumption as a random walk does not hold. They found when income is expected to rise by 1 percent consumption should be expected to rise by 0.5 percent. This strong connection between

[3] "The *permanent component* is to be interpreted as reflecting the effect of those factors that the unit regards as determining its capital value or wealth: the nonhuman wealth it owns; the personal attributes of the earners in the unit, such as their training, ability, personality; the attributes of the economic activity of, the earners, such as the occupation followed, the location of the economic activity, and so on. It is analogous to the "expected" value of a probability distribution. The *transitory component* is to be interpreted as reflecting all "other" factors, factors that are likely to be treated by the unit affected as accidental" or "chance" occurrences, though they may, from another point of view, be the predictable effect of specifiable forces, for example, cyclical fluctuations in economic activity " (Friedman M., 1957, P. 21-22) .

[4] The implication is tested with time series data for the post war United States (see Hall, 1978).

[5] (Mankiw, 2009:456) documents the idea as this hypothesis can be said differently as consumption reflects "surprises" about the life time income.

current income and consumption provides at least circumstantial evidence for 'rule of-thumb'[6] behavior on the part of some consumers. This implies predictable changes in income lead to a predictable changes in consumption.

The basic difference between Keynesian and post-Keynesian theory is the issue of sensitivity and smoothing. In Keynesian consumption function, current consumption is sensitive to change in current income; whereas in post-Keynesians, Euler consumption functions is implemented to smooth entire life time consumption assuming available liquidity. In other words, AIH does not take expectation into consideration thus no more inter-temporal decision by households; whereas post-Keynesian theories do. When inter-temporal decision is considered in the short run MPC is less than what Keynes has suggested and near unity in the long run. Consequently if the short run MPC is low, then multiplier effect of changes in government expenditure will be small (Agenor and Montel, 2008, p. 62-64). Bayer & MC Morrow explained this consequence as–in the context of the overall macroeconomic debate and Friedman's PIH can be interpreted as a direct assault on the efficacy of Keynesian short term demand management policies (Bayer & MC Morrow ,1999).

Agenor and Montel (2008) surveyed literatures on theory of consumption behavior related to developing counties. In their study, income decomposition (as permanent and transitory) matters, that is propensity to consume out of permanent income is greater than propensity to consume out of current income which is consistent with theory of consumption smoothing. However, neither elasticity of consumption with respect to permanent income found to be unity, nor elasticity of consumption with respect to transitory income equals zero. This evidence supports strict PIH is not supported by the data of developing countries. If household's behavior is consistent with consumption smoothing, the application of this theory to developing countries raises four major issues. These are: (1) Can households effectively smooth there consumption? (2) If households are able to smooth consumption over time, can they choose effective length of planning horizons? (3) What is the effect of interest rates on the *level* of current consumption, and *growth* of consumption since theory makes no prediction? (4) What is the effect of fiscal policy on private consumption? (*Ibid* p.66 - 74).

In particular, if current income plays a central role in consumption - in case of rule-of-thumb consumer's analysis based on PIH for policy analysis is less reliable than AIH. Thus old-

[6] Consumers consuming their current income.

fashioned Keynesian consumption function may therefore provide a better benchmark for analyzing fiscal policy than does the model with infinitely-lived consumers (Campbell and Mankiw, 1989).

3.2.1.2 Investment Behavior

Investment, a determinant factor for the rate of physical capital accumulation which in turn affects the growth of productive capacity, is a forward looking activity with irreversible aspect and tend to be a volatile component of aggregate demand (Agenor and Montel, 2008, p.74). The major reason behind volatility of investment is arguably the uncertainty that surrounds its expected profitability. Investment relates goods market with the money market via interest rate, which is an instrument of monetary policy and it is also used a bridge to link impact of fiscal policy such as capital tax, tax breaks, and depreciation allowances on output (see Branson, 1989, p.316-332; Mankiw 2009, p.467-468).

The first investment theory is explained by neoclassicals. This theory is derived using microeconomic foundation concept where a firm can maximize its market value by adjusting its capital stock to a point where marginal value product of capital equals the user cost of capital (market interest rate). But it lacks to explain what determines marginal value product of capital (Mankiw 2009, p.467-468, Romer, 1996).

The other theory is Keynesian theory of investment explained by Keynes (1936) marginal efficiency of capital. In words of Keynes marginal efficiency of capital is defined as:

> *"More precisely, I define the marginal efficiency of capital as being equal to that rate of discount which would make the present value of the series of annuities given by the returns expected from the capital-asset during its life just equal to its supply price[7]" (Keynes 1936, p:91).*

Simply it is interpreted as the rate of interest which will discount the present value of the project to zero.

The accelerator model is identified as a Keynesian construct which is primarily owing to its widespread use in econometrically estimated macroeconomic models. In this model the firm is assumed to keep a stable relationship between capital stock it desires to maintain the level

[7] "Supply price is defined as a price which would just induce a manufacturer newly to produce an additional unit of such assets, i.e. what is sometimes called its *replacement cost* " Keynes(1936), p. 91

of output. A key implication of this model is that investment (change in capital stock) is driven by change in aggregate demand (Bennett, 1987).

The standard model of business fixed investment model is neoclassical model of Jorgenson (1967) which is advanced from previous neoclassical model, also named as flexible accelerator model (Mankiw,2009,p.462). This model examines the benefits and costs to firms owning capital goods; and how the level of investment, i.e. additional stock of capital is related with marginal product of capital, interest rate and tax rules affecting investment i.e. the real cost of capital depend on the relative price of capital goods, the real interest rate, and the depreciation rate. According to this model firm's decision to invest depends on whether marginal product of capital exceeds the cost of capital. The model also assumes that if a firm is willing to pay the cost of capital, the financial market will make the funds available (see Mankiw, 2009, p.462-471; Romer, 1996,p. 345-347).

This model has at least two major failings as a description of actual behavior. First the model concerns firms' demand for capital and it implies that firms desired capital stocks are smooth functions of exogenous variables (Jergonson, 1971)[8]. As a result, a discrete change in one of the exogenous variables leads to a discrete change in the desired capital stock. The problem with this implication is that, since the rate of change of the capital stock equals investment minus depreciation, a discrete change in the capital stock requires an infinite rate of investment. For the economy as a whole, however, investment is limited by the economy's output; thus aggregate investment cannot be infinite. The second problem with the model is that it does not identify any mechanism through which expectations affect investment demand. But in practical terms, expectations about demand and costs are key to investment decisions. Firms expand their capital stocks when they expect their sales to grow and the cost of capital is low, and they shrink when they expect their sales fall and the cost of capital to be high (Romer,1996, p.347-348). Also in the contemporary situation of developing countries where their financial market is characterized as highly "repressed" makes the assumption of absence of liquidity constraint elusive.

[8] The determinants of the desired level of capital may be divided into three groups: 1)capacity utilization, represented by the ratio of output to capacity, the difference between output and capacity, change in output, sales less previous peak of sales, and so on; 2) internal finance, represented by the flow of internal funds, the stock of liquid assets, debt capacity, and accrued tax liability; 3) external finance, represented by interest rates, rates of return, stock prices, the market value of the firm (Jorgenson, 1971, p.1130).

Both Keynesian and the neo-classical accelerator models did not consider adjustment cost[9] and the effect of expectation. However, there existed an investment theory that overcomes these drawbacks namely, *q* theory model of investment. Tobin (1969) proposed that firm's base their investment based on the ratio of market value installed capital to replacement cost of installed capital, which is called *Tobin's q*. Thus a firm increases its capital stock if the market value of capital exceeds what it costs to acquire it, and it decreases its capital stock if the market value of the capital is less than replacement cost (See Branson, 1989; Romer, 1996; Mankiw, 2009).

In practical terms, marginal q-the ratio of the market value of a marginal unit of capital to its replacement cost gives relevant information to characterize investment behavior than average q. Marginal q is likely to be harder to measure than average q-the ratio of the total value of the firm to the replacement cost of its total capital stock. If the firm is a price-taker with constant returns to scale in both production and installation, then marginal *q* is equal to average *q*. If a firm is a price-maker then average *q* is higher than marginal *q* by what is legitimately called the monopoly rent. Thus it is important to know how marginal q and average q are related (Hayashi, 1982).

However, Blejer and Khan (1984) argue there is big gap in standard investment theories of developed nations so as to directly apply for developing countries. The main ones are institutional and structural factors that are present in most developing countries-such as the absence of well-functioning financial markets, the relatively larger role of the government in capital formation, distortions created by foreign exchange constraints and other market imperfections. Thus, the assumptions underlying in the standard optimizing investment models typically are not satisfied in developing countries; secondly even if the standard models could be directly adapted to developing countries, severe data constraints arise when attempts are made to implement them empirically. For example, data on variables such as the stock of capital, the labor force, and wages simply do not exist for most developing countries

[9] Romer (1996) citing Mussa(1977),the adjustment costs come in two forms, internal and external. Internal adjustment costs arise when firms face direct costs of changing their capital stocks. Examples of such costs are the costs of installing the new capital and training workers to operate the new machines. External adjustment costs arise when each firm, as in our baseline model, faces a perfectly elastic supply of capital, but where the price of capital goods relative to other goods adjusts so that firms do not wish to invest or disinvest at infinite rates (Romer 1996,p. 348).

and in the absence of information on real financing rates (debt and equity), it is not possible to calculate easily the service price or user cost of capital (Blejer and Khan, 1984).

3.2.1.3 Government Sector

One of the key dividing issues between Keynesians and Classical economists is their attitude on the ability and necessity of role of government in the operation of the economic process. Classical economists strongly believe that government has the ability to influence the outcome of the economy but should not intervene the economic process; whereas Keynesian's strongly urge government has both capacity and commitment to reconcile the economic process using countercyclical policy (Heijdra and van der Ploeg , 2002, p.18-26).

Keynesians argued federal budget should be allocated to increase aggregate demand consistent with the full-employment rate of output. But the new classical economists believe there are strong forces pushing a market economy towards full-employment equilibrium and applying macroeconomic policy has nothing to add for stabilizing the economy. In short, macroeconomic policies are ineffective (*Ibid*).

In the case of developing countries, the role of government is very high compared to developed economies. What interests in government modelling is its budget deficit status and how it finances. To model government sector, we need the government budget constraint. Consideration of the macroeconomics of government budget constraint points to the dangers that arise from excessive budget deficits: inflation, exchange crises, external debt crises, and high real interest rates, with implications for real exchange rate, external trade account and investment (Fischer and Easterly, 1990).

These different consequences in the macro economy result from the way how government finances the budget deficits. If the option of financing is through printing money it is associated with inflation; by running down the foreign exchange leads to the exchange rate crisis; by borrowing from abroad brings exchange rate crises; and borrowing domestically creates a "credit squeeze" through higher interest rates that resulted from competition with private sector which passes to each component of the aggregate demand (see Fischer and Easterly,1990 ; Easterly and Schmidt-Hebbel,1994).

In relation to consumption expenditure, Fischer and Easterly (1990) and Easterly and Schmidt-Hebbel (1994) citing the work of Baro (1974) on Ricardian equivalence result,

which states the effect of deficits and taxes are equivalent on consumption was argued by citing (Haque and Montiel ,1989; Corbo and Schmidt-Hebbel,1991) that the hypothesis does not hold for the case of developing countries(*Ibid*).

The relationship between Public investment and private investment still remain an empirical question. In order to see how government affects different actors of the market and even the markets themselves, government expenditure and revenue have to be checked very closely.

3.2.1.4 External Sector

International trade is the bridge that links the domestic economy with the rest of the world. And this can be easily traced using relationships established using the balance of payment. The well established theoretical models related to the balance of payment include elasticity, absorption, Mundell- Flemming and monetary approach.

Elasticity approach is concerned to answer when will devaluation (in the case of fixed exchange rate) or depreciation (in the case of floating exchange rate) compensate for price distortion in international trade, which are assumed to be the major cause of the value of import exceeding export. Marshall-Learner condition (or Marshal-Learner-Robinson) is the main theory of elasticity approach to the balance of payment where level of analysis is given using partial equilibrium frame work of export and import markets. This theory states that real devaluation (or real depreciation) of currency improves trade balance if the sum of elasticities (in absolute value) of demand for import and export with respect to real exchange rate is greater than one. If the sum of these elasticicites is less than one, then devaluation is followed by current account deterioration (Johnson, 1977).

In empirical analysis, the distinction between the long and the short run analysis is decisive which leads to a J-curve effect, i.e. real devaluation (depreciation) will worsen the current account balance in the short run, but will improve in the long run given Marshall-Learner condition is satisfied. However the model has been criticized since it lacks the general equilibrium foundation; and it ignores the effect of devaluation may have on the domestic price level and domestic nominal wage formation (see Johnson, 1977; Dhliwayo, 1996).

Absorption approach of balance of payment has come as a theory by criticizing the drawback of elasticity approach. The absorption approach views the balance of trade from the point of

national income accounting, i.e. current account balance is the difference between national income to absorption. The main argument suggested is favorable configuration of price elasticities may not be sufficient to produce a positive balance of payments effect resulting from devaluation, if devaluation does not succeed in reducing domestic absorption. Dhliwayo(1996) citing the original papers on absorption approach to BOP by Machlup (1943) and Alexander (1952), has explained the main argument of the theory. Devaluation increases the domestic income relative to domestic absorption and hence current account balance improve given the marginal propensity to absorb is less than unity; otherwise foreign balance is not improving except through the direct effects. But when marginal propensity to absorption is greater than one, which implies the economy is at full employment; devaluation will improve the balance of payments through the direct effect on absorption - the expenditure reducing effect of devaluation. This expenditure reducing effect occurs through three channels, namely, the real cash balance, income redistribution and money illusion effects[10] (*Ibid*).

Mundell – Flemming model is the most widely used Keynesians Model. It got its Keynesian nature from the early works of Mundel (1960, 1961a and b, 1963) and Flemming (1962) (Boughton, 2003; Snowdon and Vane, 2005[11]). These models were developed in an open market context. Mundell's paper had introduced "principle of effective market classification"- which explains that a policy instrument should be assigned to the target over which it has the strongest (relative) influence. To answer this question, he has developed a model that consists of goods and services and foreign exchange market; also using the model he has developed the dynamic adjustment of internal and external balance in response to monetary shocks. Whether monetary (that is, interest rate) policy should be directed towards internal or external balance was shown to depend on whether the exchange rate is floating or fixed. And he suggested monetary and fiscal policies are both more effective for restoring internal balance under flexible than fixed exchange rates, but the advantage for monetary policies is greater; and in an extreme case with perfect capital mobility, fiscal policy will be ineffective for restoring internal balance(Boughton, 2003).

[10] Details on how the three channels reduce expenditure is explained in detail in Dhliwayo, 1996, P. 5 and 6

[11] In their reference they have considered 1963 article of Mundell see p. 123-134.

Fleming (1962) focused on examining the consequences of a country's choice of exchange regime on the effectiveness of fiscal and monetary policies for regulating domestic output. He argued that monetary policy is more effective under floating exchange rates, both in absolute terms and relative to a fiscal policy action of a given size. He also showed the effect of floating on the effectiveness of fiscal policy measured as an autonomous change in domestic spending with a fixed stock of money was ambiguous (*Ibid*).

By joining these two independent models's which emphasize on external and domestic markets brings the full Mundell– Flemming model.

The monetary approach to the balance of payment is influenced by Johnson (1972a) and Frenkel and Johnson (1976)(Snowdon andVane,2005 p.188). This approach argues balance of payments is a monetary not a real phenomena i.e. balance of payment is the change in the monetary base less the change in the domestic component (Johnson, 1977, Ardalan, 2004, Snowdon and Vane (2005), p.187-192). Following the work of Jonson (1972) as a monetary to balance of payment approach the model developed assumes real income is fixed at its full employment or natural level, the law of one price holds in both commodity and financial markets, and both the domestic price level and interest rate are pegged to world levels (*Ibid*).

Ardalan (2004) explains Johnson (1972) and Hume (1752) monetary approach is similar except their departure on absolute, rather than relative price level consideration of Johnson (1972). In Hume (1752), the domestic price level can vary from purchasing power parity due to stock disequilibrium in the domestic money market. Such a variation in relative price levels gives rise to changes in trade flows which affect the balance of payments, and hence the domestic money stock in the long run. The monetary approach, on the other hand, often relies on the excess demand for money to *directly affect the overall balance* rather than via a change in relative price levels. It should be pointed out that both the Humean adjustment process and the monetary approach have the same implications with respect to the price level in the long run (Ardalan, 2004).

The policy implications of the monetary approach under fixed exchange rates includes first there is an automatic adjustment i.e. monetary approach predicts there is automatic adjustment mechanism that operates, without discretionary government policy, to correct balance of payments disequilibria and following this the power of expenditure switching policies will only temporarily improve the balance of payments if they induce an increase in the demand

for money by raising domestic prices. Secondly, in the case of a small country maintaining a fixed exchange rate with the rest of the world, the country's money supply becomes an endogenous variable hence the power of monetary policy will be completely impotent to influence any variable, other than foreign exchange reserves, in the long run. Thirdly, inflation is viewed as an international monetary phenomenon which can be explained by an excess-demand expectations model because excess demand depends on world, rather than domestic monetary expansion (Johnson, 1977; Snowdon and Vane, 2005, p.189-192).

3.2.2 Theoretical model of Monetary Sector

"Money is just one of many commodities" (McCallum, 1989, p.3), having three main functions: medium of exchange, unit of account and store of value (McCallum, 1989, p.16-18).[12]This shows the relationship between money and economic activity is closely related[13]. Like other sectors of the economy there are different arguments among different schools of thought concerning theory of money demand. In this section emphasis is given only to major theories of money demand that include: quantity theory of money, Liquidity Preference, and modern quantity theory of money in relation to functions of money.

Using quantity theory of money we get two versions of thought: Classical's Fisher (1911) and neoclassical's Pigou (1917) approach. According to Fisher (1911) commonly named as "equation of exchange" relates the quantity of money in circulation (M_s) to the volume of transactions (T) and the price level of articles traded in a given period (P_T) through a proportionality factor called the "transactions velocity of circulation" (V_T), which measures the average number of times a unit of money is employed in carrying out transactions in the given period which can be mathematically given as: $M_sV_T = P_TT$. This theory implies money is held simply to facilitate transactions and it does not have any intrinsic utility. In classical model velocity of money and volume of transaction are assumed to be constant and hence the equilibrium price level moves in strict proportion to the quantity of money, that is, money is "neutral"(Sriram, 1999c).

[12] There are some literatures that add Source of *deferred payment* as a fourth functions (see Sriram, 1999c)

[13] "… money is the drink which stimulates the system to activity" Keynes(1936), p.112

The other approach, Cambridge approach or cash balance approach is primarily associated with the neoclassical Pigou (1917). This approach has similarities with that of Fisher (1911) but there are three basic differences. First emphasis is made on individual's choice rather than on market equilibria. Second, money is held not only as a medium of exchange as in Fisher's case, but also as a store of value that provides satisfaction to its holder by adding convenience and security. And third, it pointed out the role of wealth and the interest rate in determining the demand for money. Unlike Fisher's formulation, the velocity is termed as the "income velocity of circulation" determined by technological and institutional factors and is assumed to be stable (*Ibid*).

The second theory, Liquidity preference, discusses the three motives for money demand. With the words of Keynes these are:

> *(i) the transactions-motive, i.e. the need of cash for the current transaction of personal and business exchanges; (ii) the precautionary-motive, i.e. the desire for security as to the future cash equivalent of a certain proportion of total resources; and (iii) the speculative-motive, i.e. the object of securing profit from knowing better than the market what the future will bring forth (Keynes, 1936,* p.*111).*

In other words, transaction and precautionary motives of money demand are for medium of exchange though the latter is for caution against unexpected needs. And the speculative motive for holding money is related to store of wealth, and the amount of money holding is sensitive for future levels of interest rate, to be specific the future yield on bonds. Hence Keynes's money demand theory incorporates interest rate *formally* as determinant for money demand compared to his predecessors. He has also theorized money demand depends positively on the level of income and negatively with interest rate. The major implication of the Keynesian analysis is that when interest rate is very low, everyone in the economy expects it will increase in the future. And hence they prefer to hold money whatever is supplied. At this stage, aggregate demand for money becomes perfectly elastic with respect to the interest rate. The economy gets into a situation called "*liquidity trap*" that is interest elasticity of money demand can be infinite at low levels of interest rate (Keynes,1936; Sriram,1999c).

Other approaches of money demand had evolved relaying on different characteristics of money after Keynes's work. The motive for holding money has lead to the formulation of different theories, for instance the *medium of exchange* function leads to transactions models

of which inventory models assume level of transactions to be known and certain; the *precautionary demand* models treat net inflows as uncertain; and store-of-value function gives rise to asset or portfolio models where money is held as part of the portfolio of assets of the individuals (*Ibid*).

Another approach which differs from the previous theories is the consumer demand theory approach or the modern quantity theory of money. This theory is developed following Freidman's (1956) argument on demand for assets should be based on axioms of consumer choice, and by treating money like any other asset yielding a flow of services and using a broad measure of wealth (human and non-human) as the appropriate budget constraint.

Freidman's theory differs from Keynes in three main aspects. First he suggested a broad range of opportunity cost variables thus changes in interest rates should have little effect on the demand for money as the differentials of expected returns between alternative assets and money remain relatively stable. Second money is considered like an asset and the opportunity cost of holding money is expected rate of inflation, which is a proxy for yield on real goods. Third permanent income is the key determinant of money demand as money demand is not very sensitive to the changes in differentials of expected rates of alternative assets and money (*Ibid*).

As a summary, though there are diverse theories that differ in assigning the role of money by emphasizing on transactions, speculative, precautionary or utility, all of them share common important elements (variables) among almost all approaches. A general specification for money demand function in the long term demand for money expressed by demand for real balances(the ratio of *selected* nominal monetary aggregate to price level) is a function of the chosen scale variable i.e. to represent the economic activity and the opportunity cost of holding money (Sriram , 2001).

3.2.3 Theoretical model of Aggregate Supply

Theoretical underpinnings on determinants and functional form explaining aggregate supply needs special care due to its contentious nature. By definition aggregate supply is explained by production function that maps aggregate inputs into aggregate output. But what matters is what does "mapping aggregate inputs into aggregate output" exactly means (Felipe and Fisher, 2003). Aggregate supply is derived by relying on microeconomic foundation of firm

level aggregate production function. However, some literatures like (Felipe and Fisher, 2003) and (Felipe and McCombie, 2010) argue there is a serious problem to use aggregate supply at macro level due to aggregation problem and concluded aggregate production functions do not exist at macro level except in unlikely special cases, and inferred any economic theory that makes use of this concept and applying econometric estimation has no scientific value. But, Romer (1987) argued though production function is theoretically microeconomics concept empirical evidence provided to have a tendency of macro. Also, Temple (2006) has shown the existence of production function using value added approach as an outset[14]; and pointed what arguments to use as inputs. He also added identifying functional form should be the focus on empirical estimation.

To truck different objectives the main criteria to choose functional forms depends on the different criteria. To elicit some of them, first the functional form should be parsimony in parameter, i.e. excess parameter exacerbates problems of multicollinearity so the functional form should contain no more parameters than that are necessary.[15] Secondly, ease of interpretation, i.e. excessively complex or parameter reach functional forms may contain implausible implication, thus the functional form chosen should have to contain parameters that are important and does have intuitive economic interpretation. Thirdly, it should be computational ease; i.e. the functional form can have linear or non linear forms but this is directly related to the tradeoff between the computational requirement and of the form to be applied. The other two criteria are related to the model developed - the interpolative and extrapolative robustness. The interpolative robustness checks whether the production function is consistent with in the range of observed data; and the extrapolative robustness checks the compatibility outside of the range of observed data. This behavior is very important in case of forecasting (Fuss *et al* 2005, p.219-268).

To explain behavior of production function there are several types of functional forms that are proposed but the commonest are Cobb-Douglas and constant elasticity of substitution (CES)

[14] For the proof see(Temple,2005)

[15]The objective of most production studies is to analyze the income shares of factors of production especially on the aggregate shares of capital and labour; to check whether the existence of constant returns to scale or the presence of decreasing or increasing scale of returns; the degree of substitutability of factors of production; the decomposition of production relationships into nested or additive components, i.e. issues of separability ; and the modification of the technological structure over time- technical progress**(**Fuss et al, 2005**).**

production functions. Cobb-Douglas type of production function is chosen from others types because of its simplicity for estimation relative to others; and the parameters estimated (factor shares) are constant. This functional form restricts the elasticity of substitutions among factors of production (capital and labour) is always unity; and technical development is Hicks-Neutral and the returns to scale are constant. To improve the restriction of elasticity of substitution, constant elasticity of substitution is introduced (Fuss *et al*, 2005).[16]

In macroeconomic models, aggregate demand and aggregate supply interact to determine the short-run performance of the economy, but when it comes to the long-run analysis of economic growth, aggregate demand usually makes its exit and aggregate supply rules the roost (Dutt, 2006). So the model that is going to be developed will treat the two sides of the economy.

3.2.4 Theoretical model of Labor Market, Wage and Price

This sector has a strong link with other sectors of the economy. If we take labor market, it is related to supply side; price sector affects goods market i.e. demand side of the economy directly, and in relation to external sector via the price of import and export of commodities and it also interacts to the monetary sector too.

The common traditional theories related to modelling this framework are of two types. The monetarist inflation theory and wage price mechanism or the Phillips curve. The monetarist inflation theory emphasizes monetary variables are the causes for the swinging of price i.e. an increase in money supply transmits to the real sector via a change in price level. In Phillips curve the transmission mechanism is through excess demand in labor market which determines the unemployment rate and finally affecting price. Another one is a structural model of inflation which stresses the source of price instability is due to market mechanism. A number of theories postulated to explain determinants of inflation are discussed in detail with their strength and weakness in (Frisch, 1990, for a survey).

The development of contemporary inflation theory was greatly influenced by the development of the Phillips (1958) model, formalized by Lipsey (1960), who derived the Phillips curve from a supply and demand system of a single labor market with theoretical explanation unlike Phillips's empirical basis. The main idea of Phillips-Lipsey model is that wage inflation is

[16] See Fuss *et al*(2005) "A Survey of Functional forms In the Economic Analysis of Production" p.219-268

explained by excess demand in the labor market, whereby the rate of unemployment is interpreted as an indicator of the level of excess demand. Phillips-Lipsey model beliefs a stable relationship Phillips curve exists (Frisch, 1990).

However, empirical refutation on the shape of Phillips curve has brought Friedman(1968) and Phelps (1967) *natural rate of hypothesis* which makes a distinction between the short-run and long-run Phillips curves based on the 'natural rate' of unemployment. According to Friedman and Phelps, short-run Phillips curve has a negative sloped relationship between the rate of inflation and the rate of unemployment, with inflationary expectations being constant; but the long-run Phillips curve is a vertical line at some unemployment rate called the "natural" rate of unemployment. Also this rate is consistent with any rate of inflation provided that it is fully anticipated. In their hypothesis an adaptive expectations adjustment mechanism leads to a gradual revision of inflationary expectations. The increase in the expected rate of inflation leads to an upward shift of the short run Phillips curve. This hypothesis restricts the scope of monetary and fiscal policy considerably, but a systematic exploitation of the short-run Phillips curve by economic policy remains possible (Frisch, 1990).

Natural rate hypothesis was later challenged by Lucas (1973) and Sargent and Wallace (1975),who argued that natural rate is inconsistent with the concept of adaptive expectations since economic agents usually have biased expectations, but rational expectations are more representative of agents behavior than the adaptive expectations embodied in the natural rate model (Frisch, 1990).

Blanchard and Summers (1988) postulated hysteresis hypothesis which argues non-accelerating inflation rate of unemployment (NAIRU) is a function of actual employment. However, the expectations-augmented Phillips curve remains a dominant theory in mainstream macroeconomic analysis (Blanchard and Summers, 1988).

The second theory of inflation, monetarist theory of inflation, argues inflation is solely a monetary phenomenon. This theory is based on four propositions. First the economic system is inherently stable and hence it returns automatically to full-employment equilibrium after a disturbance. Secondly, any rate of growth of money supply is compatible with full-employment equilibrium. Although different rates of inflation result, which means the quantity theory of money holds true by considering output and velocity of money is given, money supply adjusts the level of price. Thirdly, a change in the rate of growth of the money

supply has a transitory effect on the level of output in short run dynamics but a permanent increase in the *trend* rate of inflation. And at last, activist demand management and compensatory countercyclical policy are considered as a source of instability (Frisch, 1990).

But within monetarist's closed economy inflation model, there is no consensus on the third proposition explained above. Because of this there are two main classes as Monetarism I and Monetarism II. Monetarism I rests on the distinction between the short-run and the long-run Phillips curves; for monetarism II not even a short-run Phillips curve exists. So the main difference between the two schools is that monetarism I allows for short-run adjustment processes in which the commodity and labor markets may not be in equilibrium, whereas monetarism II assumes that there is not just a tendency toward long-run equilibrium but a continuous sequence of equilibria. According to monetarism I, as long as the expectations adjustment process is not terminated, the rate of unemployment and output deviate from their "natural" levels but to monetarism II systematic monetary policy does not matter[17]; i.e. it does not affect real variables such as the rate of unemployment or output. But to the rational expectations approach, monetary policy has real effects caused by the unpredictable component of the money supply hence they will be in congruent with that of Monetarism II (Frisch, 1990).

Another approach of monetarist theory is the open economy version. This approach has been developed following the balance-of payments theory, which was principally developed by Mundell (1971) and Johnson (1972b). Their study focuses on the model of a small, open economy that is linked to the world economy through the balance of payments. In contrast to the monetarist theory of the closed economy, this model stresses that an increase in the domestic money supply does not raise the domestic rate of inflation but leads to deterioration in the balance of payments (current account balance). However, the monetary approach supersedes the model of the single economy and sketches a theory of world inflation, according to which changes in the world price level depend on changes in the world money supply (Frisch, 1990).

[17] A change in the rate of growth of the money supply can be divided into a systematic part (correctly anticipated by the agents) and an unexpected "surprise" part. A change in the systematic part increases the expected rate of inflation and simultaneously the actual rate of inflation.

Structural model of inflation, unlike Phillips curve model and the monetarist theory of inflation attempts to explain the long-run trend of rising price levels. Structural models propose the long-run inflationary tendency is traced to the interaction of four factors, which are partly technological and partly behavioral that constrict the operation of the market mechanism. These factors are differences in productivity in the industrial and service sectors, a uniform rate of growth of money wages in sectors, different price and income elasticities for the output of the industrial and service sectors, limited flexibility of prices and wages; that is, wages and prices are rigid in a downward direction.

"Structural" models are characterized by the assumption that economic activity can be aggregated into two sectors; a "progressive" (industrial) sector and a "conservative" (service) sector. Given different rates of productivity growth in the industrial and service sectors, a uniform rate of growth of money wages throughout the economy must lead to permanent cost pressures in the service sector, which is assumed to have the lower productivity growth. Because firms in this sector use the markup pricing rule (a fixed profit margin imposed on rising unit labor costs), this cost pressure creates cost-push inflation for the economy as a whole. Structural inflation, therefore, implies a change in the relative supply prices of the two sectors. The supply price of the service sector rises relative to the supply price of the industrial sector. Finally, in simple terms, this type of inflation assumes small price elasticity but a large income elasticity of demand for the output of the service sector (Frisch, 1990).

The Scandinavian model of inflation is constructed from Aukrust (1977) and the team of Edgren, Faxen, and Odhner (EFO) (1973), formulated an inflation model for a small, open economy, in which they linked the fundamental principles of the structural model with the small-country assumption. The model is aggregated as export and import goods into an "exposed" sector and nontraded goods into a "sheltered" sector that operates under fixed exchange rate regime.[18] More precisely, the “exposed” sector includes all those goods (and services) subject to international competition, whereas the sheltered sector represents those goods and services completely protected from international competition.

[18] The division is following Bela Balassa (1964) model of an open economy with two sectors: the progressive sector, which produces traded goods, and the static sector, which makes non-traded goods. (See Frisch, 1990, p. 163)

In the Scandinavian model the exposed and sheltered sectors differ through specific assumptions about technical progress and the price behavior of suppliers. First, it is assumed that technical progress is biased toward the exposed sector, where labor productivity expands at a faster rate than in the sheltered sector. Thus the rate of change in labor productivity in the exposed sector exceeds sheltered sector. The differences in the degree of market competition lead to different pricing strategies by firms in each of the two sectors. In the exposed sector firms are pure price takers in accordance with the model of pure competition; they adjust the quantities they produce to the given, fixed world market price. Whereas world market conditions determine product prices in the exposed sector (or the rate of increases in prices in the exposed sector), firms in the sheltered sector form prices on the basis of total costs. Specifically, we assume that prices in the sheltered sector reflect unit labor costs and a fixed profit margin or markup. In contrast to the exposed sector, prices in the sheltered sector change when unit labor costs change. Therefore, prices in the exposed sector are determined in the world market, whereas prices in the sheltered sector are determined through the development of domestic costs (Frisch, 1990).

3.3 EMPERICAL LITERATURE OF DEVELOPING COUNTRIES

So as to develop a macro-econometrics model that does reflect the working of a developing country's economy a related empirical literature survey has paramount importance, à la with such idea models for developing countries are summarized. Models of recent period are investigated and block by block summary is given for models done in the case of Africa. In addition to this some developing countries other than Africa are also summarized specially those peculiar characteristics. And finally, models constructed to the case of Ethiopia will be discussed.

3.3.1 Macroeconometrics Modelling In Africa

Musila and Rao (2002) developed a macroeconometrics model for Kenyan economy. Their main objective is to make decision by testing sensitivity of different macroeconomic variables for different policies including fiscal, monetary and exchange rate policy. The model contains four blocks: production, expenditure, monetary and price blocks. The model contains thirty

two equations of which 20 are stochastic equations and the remaining 12 equations are accounting identities which close the model.

Production block is further disaggregated into five sectors: resource sector (comprising of agriculture, forestry, fishing, mining and quarrying), manufacturing, construction, government services and other sector. To model each of these sectors input-output formulation which gives a relationship between the value added and final demand consumers is used. To specify each of the sectors their main role is identified using the input-output table. Resource sector is identified so as to satisfy the domestic demand and export demand; thus value added is specified as a function of real consumption and export of goods. All but construction, which is specified by investment expenditure in construction and land improvement, are specified like the resource sector.

The expenditure sector consists of consumption, investment, government and net export. Real consumption is specified as a function of real disposable income, interest rate and expected inflation which is in line with the Keynesian AIH, but with some adjustment of habit persistence so as to have a good approximation. Government sector is further disaggregated into government expenditure and revenue. Current expenditure of government is treated as exogenous; whereas revenue from direct tax is assumed to vary directly with nominal GDP, i.e. in line with the *automatic stabilizer hypothesis*[19]. The net export block includes export and import of goods and services sector. In this block both export and import sectors are further disaggregated into goods and services. Export is determined by real world income and the ratio of export price to the price of foreign substitutes. Demand for imports depends on country's real GDP and on the ratio of import price index to price of domestic substitutes.

Money supply is modeled as exogenous; specifically it is determined when monetary authority sets the interest rates. The money demand is split into two components as narrow money and time and saving deposits. The two spitted components are specified as a function of real GDP and nominal interest rate.

Price block has included GDP deflator, consumer price index, export price index and import price index as a subset. Consumer price index is considered as a function importe price, GDP deflator and real money balance. GDP deflator is determined by import price and exogenous

[19] In an economic boom tax revenue is higher and in a recession tax revenue is lower; not only in absolute terms but as a proportion of national income

variable factor cost which is a proxy for wage. This implies both GDP deflator and consumers price determination follow a mark up over cost approach. The export and import price indices are assumed to be determined on the world market and changes in domestic exchange rate.

Data spanning from 1970-1995 is used for constructing the macroeconometric model. The parameters for short run and long run dynamics were estimated using ordinary least square estimator (OLS) which is consistent for cointegration analysis.

Ameyaw(2004)has constructed a small macro-econometric model for Ghanaian economy to make analysis on inflation and BOP issues. To make such analysis the model includes price, monetary, and external sector block. In the price block commodities are classified as tradable and non-tradable commodities. The tradable commodities are expalined as a function of official exchange rate, parallel exchange and world price of tradable goods. Price for non tradable is determined by domestic money market equilibrium condition. Demand for narrow money (M1) is specified by the income level, inflation and rate of depreciation of the domestic currency in the parallel market.[20] And money demand equation for the time and savings deposits is assumed to be a function of real GDP, interest rate, and the rate of inflation. In external sector, export is disaggregated following the Ghana's export tradition. The export sector is subdivided into export of cocoa, gold, and other exports. The specification for export is similar to Musila (2002) but there is additional determinant parallel exchange rate. The import equation is formulated as a function of real domestic income, relative price of imports, capital availability variable (a proxy for FDI or foreign capital inflows) and essential imports (food and drinks, medicine, and crude oil). Finally the model closes with balance of Payment and money supply identity, and trade balance definition.

Matlanyane (2005) modeled Lesotho's economy by disaggregating the economy into four blocks as real, external, government and monetary sectors where each of these blocks are further disaggregated into different sectors.

The real sector consists of supply side, demand side and price blocks. The supply block consists of domestic output, demand for private investment, labour demand and real wage. Domestic output is determined using Cobb-Douglas type of production function taking

[20] This way of modeling is also applied in the case of Ethiopia by Dick, Durevall , Josef, L. Loening, Yohannes, A. Biruu **"**Inflation Dynamics and Food Prices in Ethiopia," where parallel exchange is used to represent currency substitution in the country.

labour, capital as factor inputs and technical progress. Labour demand and capital are specified stochastically; nevertheless technical progress a measure of technical advancement is estimated by a time trend exogenously. Private investment is specified as a combination of simple accelerators principle and Jargonson's neoclassical flexible accelerator approach. It is specified as a function of real output and user cost of capital which is determined endogenously. Labour demand is specified using micro foundation concept of profit maximizing behavior of a firm, and is determined by real GDP and real wage.

The demand side of the real sector holds private consumption only. Its specification follows permanent income and life cycle hypothesis. This is based on the notion that consumer's access to liquidity. If consumers are liquidity constrained, consumption choices is based on disposable income and their rate of time preference and rate of return are identical; but for unconstrained consumers decision is based on total life time resources with marginal propensity to consume fluctuating over time to account for consumption smoothing. In the long run private consumption is specified as a function of real disposable income, real broad money to proxy money supply (M3)[21] to proxy real wealth, and the real Treasury bill rate.

The external sector estimates real export and import of goods and services and identities describing major accounts in the balance of payment which includes the capital and financial balance, current account balance, and overall balance of the balance of payment. Both export and import functions are specified like Musila and Rao (2002) and Ameyaw (2004) in the previous models reviewed above. Exchange rate is given exogenously as the country's economy is working under a fixed exchange rate regime.

The government sector is modeled in order to describe its expenditure, revenue, budget financing and debt accumulation. Government expenditure is treated as exogenous variable. And government revenue is disaggregated into five kinds of taxes: individual income tax, company tax, other income tax, goods and services tax and other taxes stochastically; and other sources of revenue custom revenue and non tax revenue determined exogenously. Using government revenue and expenditure as argument the difference from previous to the latter is assigned to the budget balance. Government debt is disaggregated into five types: total government debt, external debt, domestic debt, short term domestic debt and long term domestic debt. The first four are determined endogenously and the last one is determined

[21] It is defined as the sum of real nominal M2 and government deposit.

exogenously. Domestic debt is specified as a function of government budget balance and bond interest rate, and external debt is related to the current nominal current account balance. Total government debt is equated as the sum of internal and external debt. And deducting the long term debt from the total government debt gives the short term debt.

Monetary sector is disaggregated to estimate demand for three monetary aggregates, viz, currency in circulation, demand deposit and time and saving deposits; and nominal Treasury bill rate. Money supply is determined exogenously and adjusts to money demand. Money demand equation of currency in circulation is specified following the theory of transaction balance approach to money demand by which public holding of currency represents the money held for the purpose of effecting transactions; demand deposit is specified as a function of real national output and the interest rate[22] and time and saving deposit rate is specified as a function of real national output and real treasury rate. Interest rate (nominal Treasury bill rate) is specified stochastically as a function of real national output, government budget deficit and consumers price inflation rate. Monetary sector closes by equating money multiplier as the ratio of nominal broad money to reserve money as an identity.

The price block comprised four types of prices: producer price, consumer price, export price, and import prices like Musila and Rao (2002) but equations are specified differently. The consumer price is modeled as a function of producer price, excess demand and import prices, while producers price as a function of capacity of utilization[23], and the ratio of real wage to user cost of capital. Both export and import prices are specified as a function of world price and nominal exchange rate but producer price is added as an argument in the specification of export equation.

In general, the model has characterized the economy cavernously, and interaction among different sector is well managed. However, some of the assumptions are difficult to reflect the characteristics of a developing country's economy such as the assumption of investment as a function of real GDP and user cost of capital alone might create omitted variable bias which may have a potential to distort results. For example other factors like government investment, availability of credit, and availability of foreign reserve to import capital goods which are

[22] which is the treasury bill rate is taken for estimating interest rate

[23] Capacity utilization is defined as the ratio of actual real GDP at factor cost to the potential GDP at factor cost, where the potential real GDP at factor cost is derived by fitting a trend on actual real GDP using the Hodric-Prescott filter.

thought to determine private investment in the case of developing countries had been included in the model. Aggregate Supply equation's assumption of technical progress using time trend as a proxy is possible, but if it had been specified with factors that determine the technical advancement would have been very plausible. In the modeling of export and import equations, assumption of one commodity has been considered. But it would have better of imported commodities were disaggregated further. Since most of developing countries imported commodities belong to capital goods, intermediate goods or final consumption goods and this would add more value to the model.

The modeling technique applies cointegration analysis using Eangle – Granger procedure. However due to small sample period employed for modeling (1980-2000) the author has used dummy variables liberally which is not recommended in macro-econometrics modelling. As the number of dummy variables increases it minimizes forecasting power of the model.

Akanbi and Du Toit (2010) constructed macro-econometric model for Nigerian economy having real, external, government, and monetary blocks. The main objective of the model is to explain and give suggestion for the persistent growth–poverty divergence experienced by the country. To track this objective they come up with two models by changing the economic environment using closures (identities and bridge equations) from the single frame work. The first model is identified as a supply side oriented i.e. when demand side is marginalized and making the supply side of the economy very active. On the supply side, the presence of structural constraint, total output (GDP) is specified as a function of its determinants. The second model is demand side oriented (supply side marginalized). It is generated following the Keynesian demand identity which makes the demand side to play active role in the economy, i.e. assuming limited or no supply constraint in the economy and demand management persuades.

The real sector specification is characterized in a similar fashion like that of Matlyana (2005), but the arguments considered differ. Output specification of Akanbi and Du Toit (2010) deemed technological progress is determined stochastically like other factor inputs of output - capital and labour. Technological progress is explained as a function of macroeconomic stability, openness of economy, human resource development and financial sector development. Two output functions for oil and non oil are specified using Cobb-Douglas

production function.[24] Capacity utilization, level of political stability are among others to affect private investment in addition to the usual total output and user cost of capital in the model.

Exchange rate is specified assuming prices are sticky in the short run and explain the prolonged departure of the exchange rate from long-run Purchasing Power Parity (PPP) as a function of relative income (ratio of domestic GDP to foreign GDP), relative money supply (ratio of domestic money supply to foreign money supply) and relative price (ratio of domestic price to foreign price) with their major trading partners.

Monetary sector is included to elicit information on how monetary variables feed into the economy. Money supply is assumed to be exogenous whereas money demand is out off modelling and viewed only through the inverted demand function, i.e. the nominal interest rate equation.

In government sector, government expenditure is determined exogenously, and the revenue side is not modeled. Akanbi and Du Toit (2010) argued since more than 90 percent of government revenue is generated for the production of oil only and also tax revenue plays insignificant role in the economy, tax revenue is not modlled in their study.[25]

The price block which serves as a major linkage between the supply-side and aggregate demand-side through capacity utilization and excess demand is represented in the model through producer price and consumer price. Consumers and producer price are specified in similar fashion with that of Matlyana (2005); but consumer price specification added exchange rate as additional argument.

The modeling technique of Akanbi and Du Toit (2010) and Matlyana (2005) is similar in terms estimation technique and even in most of the structures of the equations; though certain differences in equations specifications are included so as to reflect the working of their respective country's economy.

[24] In Soludo (1995) modelling the same economy, aggregate supply equation is estimated by a Cobb-Douglas production function using gross private capital stock, public capital stock, labour force and time trend that captures the effects of technical change as argument.

[25] In Soludo (1995), he rather explained government revenue from oil sector is about 75%, and government revenue is modelled by identifying income from oil source and non oil. He represented the government revenue behavior using 7 equations; where 5 of them are behavioral (2 for oil and other for non oil) and the rest are identities. (consider the time where the models are developed to evaluate the share of oil)

Haque et al (1990) developed "a framework for macroeconomic analysis of developing countries" using pooled data of 31 countries. They have pointed out that modeling of developing countries is unlike that of developed nations since there is no consensus on the frame work to study the macroeconomic issue. The prototype model has made two strong assumptions, at least to the case of Ethiopia[26]. The first assumption, expectations are formed rationally by forward looking economic agents, and the second one is concerning capital mobility.

Haque et al (1990) framework of modeling is a variety of Mundell-Fleming, i.e. having one domestically produced good consumed both domestically and abroad and one imported good. The model constructed consists of four blocks: aggregate demand, aggregate supply, monetary sector and government sector.

Aggregate demand is defined like national accounting identity. Consumption is specified as a function of interest rate and current disposable income. Disposable income is defined as GDP plus earnings in net asset held abroad minus the interest paid on domestic debt and taxes is linked to the net changes in consumer wealth as an identity for private sector budget constraint. This constraint implies consumption equation is identified following the life cycle hypothesis with real money balance as a proxy for wealth. Investment is determined simply as a function of real interest rate, total output and initial capital stock; nevertheless other factors believed to affect private investment of developing countries are not taken into consideration.

In external sector, import and export behaviors are determined stochastically. Export is specified as a function real exchange rate and income of the importing country of the domestic supply. Import behavior is modelled to reflect the shortage of foreign exchange availability that leads to the imposition of import controls and foreign exchange rationing, and specified as a function of real exchange rate, real domestic output, and reserve-import ratio (reserve divided by import in domestic currency) lagged one period variable.

Aggregate supply determines output using Cobb- Douglas production function taking labour and capital as inputs. The production function assumes constant returns to scale; and it also adds ratio of output to labour one period lagged for lagged adjustment, and time trend for technical progress over time as additional explanatory variables. To model supply function

[26] In their modeling Ethiopia is a subset from the 31 countries considered in the study(see p, 547)

assumption of complete wage-price flexibility holds true is a strong assumption to be real in case of developing countries specifically to country like Ethiopia which is include the modelling exercise.

In the money market, supply of money is determined endogenously following the monetary approach to the balance of payment; and money demand as a function of income positively and nominal rate of interest negatively in the usual manner. Also interest rate is determined stochastically assuming agents do have forward looking behavior (this is also subject to critiques to developing countries where information asymmetry is the very nature of the economies). It is specified by the interest party condition that equates the domestic nominal interest rate to the sum of the nominal rate prevailing abroad and the expected change in value of the domestic currency (uncovered interest party). This way of specification has allowed them to test for the degree of capital mobility in the economy. Government sector of Haques *et al* (1990) model specifies government budget constraint dynamically as a function of expenditure and revenue ,where expenditure is exogenously determined..

In their estimation, they have assumed slope parameters do not change across countries so that it can be interpreted as a "typical" developing country model[27]. In their estimation technique they have checked the error components structure and have shown the procedure they followed allows efficient estimation in models with panel data. But recent literatures on panel data analysis explain estimation techniques including two-stage least squares (EC2SLS) and three stage (EC3LS) applied in Haque et al (1990) lead to spurious result.

Bodart and Le Dem (1996) constructed a model that describes a dynamic model of a small, open developing country with a pegged exchange rate regime and perfect capital mobility, which is applied for the case of Côte d'Ivoire. The paper's objective is how to represent labour market into the macroeconomic models of developing countries. Thus, detail disaggregation of labor market vis-a- vis value added is done. The supply side of the model is disaggregated into three sub sectors: agricultural sector, urban formal sector, and the urban informal sector. The agricultural sector is further disaggregated as one that produces agricultural exports and that produce agricultural food crops. Production in the urban formal sector consists of manufactured goods, which are sold to both the international and domestic markets. Output of

[27] But,there is heterogeneity among the countries that are considered in their study(see p.547 which countries are included)

urban informal sector consists of non-traded goods. In the specification of production function, agriculture sector value added is determined by the labour engaged in the activities and technical progress.[28] Labour is allocated in the two sectors based on the amount that maximizes revenue gained in either of the two sectors.[29]The formal urban sector Production is specified by combining: capital, labor, and intermediate inputs. Technology is described by CES production function in capital and labor.[30] For informal sectors output it is specified as a function of technical progress and labour engaged in the activity, though labour is determined as total labour force in the urban sector less the labour force engaged in the formal and public sectors.

The demand side contains private consumption (disaggregated as food and manufactured commodities), investment (both government and private) and external sector. And most equations are specified in the usual pattern. Finally the model closes by sectoral identities and budget balancing equations for the public, private, and external sectors.

The model does have many strong features especially in terms of labour disaggregation and specification as it largely reflects the working of developing countries; but assumption on the rural labour force in agricultural sector as unemployment is non-exsistant and labour force of informal sector as a residual are subject to criticism. The other assumption (like Haque *et al*(1990)) on capital mobility is also another strong assumption which has to be seen with precaution.

3.3.2 Other Countries Macro-econometrics Models

Maroney et al (2004) constructed a macro-econometric model for Bangladesh economy using data from 1974 to 2000. The primary objective of this paper was to analyze the empirical strength of short-run and long run impact of monetary policies, fiscal policies, external resources, and remittance shocks (or innovations) on Bangladesh's macro-economy. The methodology implemented is a vector error correction model. This is presided by unit roots and Johanson's cointegration test to check necessary conditions fulfillment. The economy is modelled using nine key macroeconomic variables including real gross domestic product,

[28] Modelling is based on the assumption that land is essentially fixed and the stock of capital is minimal and the possibilities for its extension are rather limited. However, in recent period to the case of Ethiopia expansion in cultivated area is responsible for recent improvements in agricultural output.(see Seyoum,2008 ; Hill *et al*,2009)

[29] For mathematical derivation see Bodrat and Le Dem (1996), p.425-426

[30] This method isapplied in Alemayehu and Huizinga (2006)

consumer price index, terms of trade between agriculture and manufacturing sectors, real investment, real value of remittances, real net exports, real external resources (international reserve), money stock(M1), and real government expenditure.

Nadim et al (2008) developed a small macro-econometric model for Pakistan's economy. The model is constructed based on data ranging from 1973-2006. The model contains 11 endogenous and 30 exogenous variables. The model focuses on the demand side of the economy thus labour supply and production functions are marginalized. The behavioral equations in the model include: consumption, private investment, exports of goods & services, imports of goods & services, money demand, money multiplier, overnight call money rate, weighted average lending rate, food and non-food consumer prices and GDP deflator.

The model is closed by four identities and two definitional equations. The first identity is for total investment, which is the sum of government investment and private investment, where the former is treated as an exogenous variable. The second identity represents the trade balance which is measured as exports minus import of goods and services (both are endogenous in the model). Third identity is national income accounting identity (nominal GDP), which is the sum of consumption (private and government), investment and the trade balance. Fourth identity is about consumer price index which is the weighted average of food and non-food consumer price index. The two definitional equations are narrow money supply (M1) which equated as the product of money supply one period lagged times money multiplier; and real GDP as a ratio of nominal GDP to GDP deflator.

Singh (2005) developed a small macro-econometrics model for Fiji's economy having AD-AS framework. In the model there are 9 behavioral equations and two identities that close the model. The behavioral equations specified are private consumption, private investment, export and import from the aggregate demand side of the economy; supply side is specified by a single equation as a function of capital, labour and technical progress estimated by time trend. Monetary sector of the model includes money demand as a function of real income and interest rate, and money supply is considered as exogenous. The price block consists of three types of price: producers price GDP deflator as a proxy (which is also practiced in Matlyana(2005), Musila and Rao (2002)), consumers price index and wage. The two identities that close the model are the national accounting identity that equates GDP and the

other identity equates amount of output as the weighted average output supplied and output demanded.

The model developed has a sample period from 1970 to 2002; the technique for estimating each of the equations is following General To Specific method (GETS) also named as London school of Economics (LSE) Technique and Johanson's Maximum Likelihood (JML) method. Each equation is estimated using both techniques and an equation that tracks behavior of the data is included to the final macro-econometrics model.

Ra and Rhee (2005) developed a medium sized Keynesian macro-econometric model for Nepal- i.e. demand driven. This model contains five building blocks: final demand, prices, credit and money, government, and the balance of payment. The model is developed to analyze policy simulation, economic planning and debt sustainability. The model simulates a policy analysis using scenarios that are congruent to the national plan of the country.

In modeling consumption behavior, variables expected to affect consumption including disposable income, real interest rate and money supply were used as an argument. Real interest rate is found to be insignificant (i.e. real interest rate has no role for inter temporal decision) and also the real money balance (the ratio of M2 to consumer price index) is taken as a proxy for wealth is found to be insignificant which leads us to conclude Nepalese consumers are à la with the rule–of - thumb consumers. Hence, consumption is affected only by real disposable income and its lags. Private investment behavior also deviates from the usual convention since output is found to be insignificant. Government development expenditure affects positively and significantly, and interest rate negatively and significantly. In monetary sector modelling is done for credit (both private and government) and net foreign asset endogenously. Private credit is only significantly affected by real income; government credit explained by the overall government budget deficit and net foreign asset as a function of overall balance of payment. Balance of payment which contains foreign loans and official capital grants as a subset is related with government block using two bridge equations to link foreign government borrowing and foreign grants which are elements to government sector.

This model is used so as to judge the achievability of the national plan by taking different simulation scenarios (low and high case scenarios). By comparing scenario results with the national plan recommendations were given so that the optimistic national plan to be attained.

3.3.3 Macroeconometric Modelling In Ethiopia

Kidane and Kockläuner (1985) has brought macro-econometrics modeling exercise in the history of Ethiopia for the first time. The model developed is a supply driven model having 27 equations out of which 19 are behavioral equations, 7 of them are identity equations, and the remaining 1 equation is a bridging equation.

The supply driven model consists of four sectors: production, expenditure, external trade, and saving and trade gap. Production sector is disaggregated among agriculture, non agriculture, construction and other services. Expenditure block contains private consumption, government consumption and investment. Investment is further disaggregated into agriculture, other commodities, construction and other services investment. External trade consisting of export and import is disaggregated as export of coffee and other commodities for export sector; and imports of capital goods, intermediate goods, consumption goods, fuel and services for import. Saving is disaggregated into private and government; and the only bridging equation relates saving gap with trade gap so as to close the model.

The model is peculiar in terms of not including monetary sector and price. Some equations face serious specification problem to serve as behavioral estimation equations. Also the macro model lacks inter sectoral linkage which makes forecasting and impulse response analysis difficult and deliver a plausible result. In terms of model estimation technique, since adequate statistical tests are not scrutinized estimations might not escape their spurious nature which generally invalidate the macro model.

Lemma (1993)[31] constructed a macro-econometric model for Ethiopia which inclined more to the supply side of the economy – it is a supply driven model. The model has four blocks: production sector and investment, foreign trade, public finance and price blocks explained by 53 equations of which 14 are behavioral and the rest are identities. The model is constructed to be in harmony with the structural and institutional peculiarities to the socialist era (1974/75-1991) of Ethiopian economy. In modeling supply side, agriculture and non-agriculture sector are specified independently. The aggregate level of investment is a function of major source of funding such as government savings, credit from banking system and foreign capital inflow. Foreign trade block contains three export behavioral supply functions:

[31] This paper's review is based on the literature review done by Alemayehu and Daniel (2004) ," A Review of Macro Modelling in Ethiopia", p. 16-17

private export for pulses and hide; and public coffee export function. Import demand contains capital and raw material goods, and consumer good import which is assumed to be exogenous. The government current expenditure and export tax rates are treated as policy instruments. Finally, the price block identifies two price equations based on consumer price index (CPI) and industrial sector price deflator.

Daniel (2001) has built a small macro-econometrics model having AD-AS framework for Ethiopian economy. The model disaggregates the economy into four blocks: aggregate supply, aggregate demand, monetary and price blocks. Aggregate supply is further disaggregated into agriculture and non agriculture sector; and aggregate demand into private consumption, private investment, government consumption and external trade sectors.

Supply side of the economy is specified using two behavioral equations. The first, agricultural supply function is specified as function of labour engaged in agricultural sector, amount of rainfall, relative price of agricultural sector to non agriculture, time trend, and partial adjustment of one lagged period agricultural output. Non agricultural sector, it is specified as a function labour force in the activity, gross investment, intermediate imports, and capacity utilization rate. In turn capacity utilization rate is specified stochastically taking amount of rain fall and import of capital goods as explanatory factor.

In demand side, consumption is specified following Keynesian AIH theory with persistent habit formation. Private investment is modeled following accelerators principle but extended to capture the constraints that reflect developing countries case and it is specified by real output, government investment determined exogenously, total import, capital flight[32] and public borrowing[33]. Government expenditure is determined endogenously by foreign capital inflow[34], import price level and total revenue. Government revenue is explained as a function of real output, level of foreign trade, and foreign capital inflow. In the side of external sector, export is specified as a function of terms of trade, real exchange rate, capacity utilization rate and level of domestic output. Import behavior is specified by classifying imports into two classes: import of consumer goods and intermediate goods. Both of them are specified as a

[32] The paper considers this variable as controversial and it does not have any importance to the case of Ethiopia and hence it is left out in the modeling exercise, whereas Haque et al(1990) and Bodrat and Le Dem(1996) had assumed in the reverse order .

[33] Alemayehu and Huizinga (2006) also used this approach.

[34] This factor is added following the fiscal response to foreign financial flow.

function of real income, real exchange rate and one lagged period of foreign exchange reserve.

In monetary block, money supply is considered as partly endogenous from the behavior it inherits from the side of balance of payment and fiscal deficit. Money supply is included in the model as an identity equated as the sum of budget deficit, domestic credit to the private sector, and change in foreign exchange reserve. Money demand is modeled as a function of scale variable i.e. real income and the opportunity cost of holding money interest rate and inflation rate. Exchange rate is specified stochastically; and modeling is done on real exchange rate determined by terms of trade, openness, foreign financial flows and excess money supply.

The price level is represented by a single equation. It is determined as a function of excess demand over supply in domestic economy, excess money supply over money demand, import prices, and capacity utilization rate.

Daniel (2001) macro-econometric model comprises 12 behavioral equations and 13 identity and bridge equations. The way how equations are cross linked gives the model a good feature on tracking impulses and implied responses in a nice manner. When we see the model developed in general, it is modeled in static manner; i.e. short run dynamics of the economy is not measured and some behavioral equations are misspecified. For instance, if we take private investment equation total import is considered as determinant for private investment; but had been capital or intermediate imports; on the specification of the supply side of the agricultural sector the inclusion of relative price of agriculture to non agriculture[35]; and in the non agriculture behavioral equation non agricultural output determinants like gross investment and capacity utilization rate had suffered the model a lot. Since there is high multicollinearity between investment, imports and also between capacity utilization and investment. Capacity utilization rate, that is included so as to reflect supply constrained nature of the economy, is not specified properly and this has decreased the power of the full model because of its linkage with other equations.[36]

[35]This style of modelling is used by Bodrat and Ledem(1996); but they have applied it for the same sector (agriculure sector producing two types of commodities) to maximize revenue earned by allocating the initial endowment of labour, not across different sectors. (for derivation and argument see p.425-426)

[36] See the definition of capacity utilization according to Jorgnson (1971) of literature part.

From empirical results, residuals of private investment and supply equations (for both agriculture and non agriculture) had shown non-normality behavior which is one sign of misspecification.[37] Since some of the relevant test statistics (used as a battery of test) like Durbin Watson test statistics, unit root test, integration levels are not reported; so it is not possible to say on hetroskedasticity, serial correlation, and spurious nature of the equations included in the model.

Alemayehu and Huizinga (2006) also constructed a macro model for Ethiopia.[38] The model is based on the aggregate demand – aggregate supply (AD-AS) framework. The supply side contains three main components: formal sector, informal sector and agricultural sector.[39] Formal sector's output is assumed to be demand driven in the short run, but supply driven in the long run.[40] The supply is formulated as a function of labour, capital and intermediate imports. Agricultural sector is modelled as supply driven which is specified by exogenous factors that includes land, fertilizer, quality of seeds, labour and rain fall. The output of non informal sector is measured residually by subtracting agricultural and formal sectors output from GDP; and it is specified as a function of labour engaged in the sector. Demand for factor input, labour, for urban sectors is a function of formal sectors output, wage and price level; but for the other two sectors labour is calculated residually and assumed to grow with growth of economically active population to be engaged in productive work and this is a Similar assumption that is used by Bodrat and Le Dem(1996).

Investment is specified following neoclassical investment theory, and other factors to the context of developing country. It is explained as a function of output, real interest rate, public investment, capacity utilization, relative price of capital, and depreciation costs.

The level of import depends on the percentage change in import due to output effect and relative prices, where import price is formulated as a function of exogenous price of imports in foreign currency, exchange rate and import tariff.

[37] The paper passes this result by stating as in Johanson's procedure the problem of non normal vector residuals is not a problem.

[38] Though the model developed is using reduced form of behavioral equations, I summarize only the theoretical model to be consistent with the objective of the paper.

[39] This way of classification is also applied by Bodrat and Le Dem(1996)

[40] It is justified as supply components like investment to increase capacity are outside of the firm's control, such as the quality of infrastructure, and an overall stable economic and political climate.

Final demand for goods, consumption is modelled as a function of current income and interest rate.[41] Consumption is disaggregated into consumption of food and non food sectors.

The modeling of export assumes Ethiopia as a small and open economy i.e. the country is a price taker in the world market, and the law of one price holds for the major long existing export, coffee. Hence export of coffee is supply driven based on profit motive; and the behavioral equation is specified as the difference between exogenous world price and domestic cost. But for non coffee export it is modelled as demand driven. Hence export other than coffee is specified as a function of the income of the level of trading partners, real exchange rate and capital stock which is estimated by investment as a ratio of to value added.

For government sector, government expenditure and revenue are formulated using semi-behavioral equations. Price equations were specified for agriculture sector, formal sector and non formal sectors. To specify the determinants of price level neoclassical assumptions of microeconomics were in action. In the case of agriculture sector price of agriculture commodity is formulated as a function of domestic supply of agricultural output, imported food item, price of imports, nominal exchange rate, and autonomous consumption level. For the formal sector price is determined by wage, labor productivity, user cost of capital, price of import, capacity utilization, indirect taxes, and subsidy. For informal sector price is formulated as a mark up over the informal sectors wage. And finally, the general price

level is calculated as a weighted average of the price of each of the sectors.[42]

In monetary block, demand for money is defined as a function of real GDP, the price level and the nominal interest. Interest rate, interest on bonds , is specified as a function of total output, price level and money supply. Exchange rate is considered as floating, and it is specified as a function of level of import, export earning, aid and external finance.

In the macro model, Alemayehu and Huizinga (2006) have used a reduced input output matrix that gives a link between the components of aggregate demand and sectoral value-added.

[41] Consumption behavior's equation is formulated following permanent income hypothesis but due to absence of reliable data the researchers ignored the wealth variable from the equation.(see p.15).Though, they specify following the permanent income hypothesis they did not justify whether the behavior of Ethiopian households is consistent with the hypothesis.

[42] Details on the mathematical derivation are available at Alemayehu and Huizinga (2006), also similar kind of analysis is given in Bodrat and Le Dem(1996).

Ethiopian Economic Association(2008) constructed a macro model for Ethiopian economy with a frame work of AD-AS but more inclined to the supply side so to elucidate the supply constrained nature of the economy. The model can be categorized to a class of medium-large kind of macro-econometrics model as it consists 44 behavioral equations, 38 identities and bridge equations, and 61 exogenous variables. The EEA model contains 7 blocks: production, aggregate demand, labor market, prices, fiscal sector, monetary sector, and external sector block.

Each block is subdivided into different major sectors. The production block contains agriculture, industry and services sectors. Demand block consists of consumption and investment of private and government, export and import sectors. This block identifies behavioral equations for consumption and investment; other sectors are treated in the external sector account. These sectors are included in demand block for the sake of creating identity only. Price block has specified two behavioral equation namely, general consumer price index and food prices. The Fiscal Sector is sub divided into revenue and expenditure. The monetary sector is classified into two categories; the assets side and the liabilities side. Behavioral equations are specified for the asset side of the economy especially, for domestic credit. The external sector classification is based on the balance of payments and behavioral equations are identified for the trade account only. Also the real exchange rate categorized in this block is determined using behavioral equation. The equations of the model are developed using Dynamic OLS (DOLS) Method[43]. The model is tested using a battery of tests.

The brief review of the models done above gives valuable contribution to modelling the macroeconomic behavior of their respective economy. However, each model has its own limitations. The construction of macro-econometric model of an economy is an evolving process and a given model cannot consider all aspects of the economy. The model presented in this paper is built on the accumulated knowledge of past models and makes an attempt to provide improved specifications for endogenous variables and estimation techniques applied.

[43] Detail on this technique can be referred from Stock-Watson (1993)

4 MODEL SPECIFICATION AND ESTIMATION

4.1 Introduction

Macro-econometrics model can be crudely defined as the set of behavioral equations, institutional and definitional relationships that represents the structure and operations of an economy. Behavioral equations are constructed based on the individual behavior of the economic agents (Valadkhani, 2004). The earliest models of 1970 were developed by focusing only on the demand side of the economy by marginalizing the supply side of the economy since the period had been "golden age of Keynesianism". Thus the model does not give sufficient attention to the role of the money market, relative prices and expectations. To fill this gap different alternative modelling approaches were developed. As cited in Soludo (2002) and Valadkhani (2004**),** Challen and Hagger (1983) had classified macroeconometric models into five catagories as Keynes–Klein (KK) model, the Phillips–Bergstrom (PB) model, the Walras–Johansen (WJ) model, the Walras–Leontief (WL) model, and Muth–Sargent (MS) model.

The KK models are demand oriented models that deals with the problems of short-run instability of output and employment using mainly stabilization policies. The PB model is also a demand-oriented model and modelling is done based on differential or difference equations to estimate the structural parameters of a stochastic model. The WJ model is mainly a multi-sector model which is developed based on Walras's postulates that the economy consists of various inter-dependent markets, which reach an equilibrium state by the profit maximizing behavior of producers and utility maximizing behavior of consumers in competitive markets. The various sectors in the WJ model are linked together via their purchases and sales among economic agents. The WJ model is highly non-linear and uses logarithmic differentiation. The WL is a general equilibrium system which incorporates the input output (IO) table into the Walrasian general equilibrium. The MS model is based on the evolution of the theory of rational expectations. The MS model has similarity with KK regarding its dynamic property and non-linear, stochastic and incorporating the use of discrete time (see Soludo (2002); Valadkhani (2004**)**).

From 1970s onwards the acceptance of macro-econometric modelling for the purpose of policy analysis and forecasting has been in question[44]. This is because of several reasons such as: forecasting inadequacy, theoretical contrasts with rational expectations theory, structural instability (Lucas critique), the endogenous–exogenous division of the model variables in order to pass the identification conditions, the existence of the problem of unit roots and" ignorance" of cointegration and the time-series properties of the data(*Ibid*).

Lucas (1976) critique argues macro-econometric models are designed to perform the former task only and applying these models for simulation provides no useful information as to the actual consequences of alternative economic policies - even features of the model which lead to success in short-term forecasting are unrelated to quantitative policy evaluation. Explicitly, the critique squabbles there is no reason to believe that the "structure" of the decision rules (or economic relations) would remain invariant under a policy intervention; hence policy evaluation should be based on a simple principle of rational expectations theory (Lucas, 1976).

To rectify the drawback of earlier modelling approach at least three methodological alternatives of modelling have emerged in the literature, these are Sims (1980, 1982), Leamer (1983), and Hendry (1980). The first one is Sims's atheoretical VAR, which underscores the role of data with no theoretical foundation. In this approach there is no differentiation between exogenous and endogenous variables in the system. The second is Leamer's methodology which starts by defining the concept of exogeneity as the conditional distribution of the endogenous variable given the exogenous variable remains stable to any changes in the exogenous variable. The third approach is the Hendry's methodology which is known as the "general to specific modelling approach" or the London School of Economics (LSE) methodology in the literature. This methodology accepts structural models as the starting point but goes one step further to adopt a totally different and rigorous technique for model specification, estimation, hypothesis testing and simulation. This approach begins with a general dynamic autoregressive distributed lag (ADL) model which is postulated in terms of economic theory. Then, by performing a number of likelihood ratio restriction tests on this

[44] Modelling approaches of the early 1950s and 1960s are known as the Cowles Commission approach which is based on the structural multi equation modelling

model, a specific model can be obtained, so that it is congruent with the data generation process (DGP). In other words, theory determines the explanatory variables, whereas the static or dynamic nature of the relationship will be defined by the data. The model evaluation in this methodology is extensively examined by a battery of diagnostic tests and forecasting performance. Passing different types of diagnostic tests is a necessary but not sufficient condition. In addition, Hendry's approach expects too much from the data (Pagan, 1987).

Regarding Lucas's critique, Klien (1989) has argued there is more persistence in the structure of economic relationships. Though there is change in the economy of the world this does not mean that the parametric structure is changing; he also suggested that random errors and exogenous variables may be the main source of changes. Also, Fair(2004, 2008) argues expectations of the future affect current decisions, agents are assumed to form these expectations on the basis of past values, where the parameters multiplying these values are constant which means expectations are backward looking . He also added "parameters in the expectation equations are assumed not to depend on the parameters in the model: expectations are not model consistent (rational)" (Fair (2004); Fair (2008)).

For macro-econometric model to be applicable different researches (Hendry and Richard (1983), Pesaran and Smith (1985), Intriligator *et al.* (1996), Jansen (2004)) had suggested more or less similar criterions. The first issue is on data admissibility, that is economic variables should be placed in an acceptable range. Second, there should be consistency between economic theory and interpretation of parameters of the model, i.e., an appropriate theory should support the signs of the estimated parameters. Third, estimated parameters should remain stable over the period under study. Fourth, residuals should be random, i.e. they should be stochastic and stationary. Fifth, an exogeneity test should be undertaken to ensure that the explanatory variables are at least weakly exogenous. Finally an encompassing test is also suggested to be undertaken to test whether or not the estimated model is superior to all the alternative rival models.

In this study, the full system is comprised from different subsystems the economy. Jansen (2004) has noted modelling macro-econometric models using a single framework is becoming difficult due to the complex nature of the economy. Jansen (2004, p.17) has explained it as:

> "*Users of macroeconomic models often demand a detailed description of the economy, and in order to accommodate that demand, realistic macroeconomic models invariably become too large to be specified simultaneously. The suggested methodology therefore relies on valid conditioning and marginalisation of this function in order to arrive at tractable subsystems, which can be analyzed with statistical methods. The objective is to obtain data congruent sub-models that represents partial structure, which can be combined into a model for the entire economy."*

The modelling technique for this study is based on first selecting relevant variable that represent subsectors of the economy using economic theory. Then we construct the relevant subsector models. This is done by using the theoretical long run equilibrium relationships among variables of interest. Finally, by combining these subsystems model of the entire economy is constructed.

The full structure of the model constructed in this thesis consists of four blocks aggregate demand, aggregate supply, price, and monetary block. Aggregate demand block is comprised from private consumption, private investment, government expenditure and external sector of the economy. Aggregate supply deals with the production of agriculture and non agricultural goods and services. Price block consists of producers and consumer price equation. These price equations are affected by monetary sector, aggregate demand and aggregate supply. Monetary block is comprised of money demand and money supply that interacts with different blocks of the economy. The next section deals with specification of each block in detail.

4.2 Model specification

This section presents the behavioral equations, identities, and bridge equations of the model. The specification is done using general to specific approach (LSE) approach for specifying each of the equations considered in the model.

4.2.1 Aggregate Demand Block

4.2.1.1 Private Consumption

The specification of private consumption follows permanent income and lifecycle hypothesis. Hence in the long run, private consumption is specified as a function of real disposable income, real wealth, real interest rate and level of inflation. This means the behavior of households is by assuming they save for future consumption. For consumers having lack of liquidity constraint consumption is based on disposable income whereas for unconstrained consumers the rate of time preference and rate of return (consumption smoothing) is done based on marginal propensity to consume and the amount of resource endowed.[45] Following this argument, in the long run consumption behavior is specified as:

$$\log RCp_t = \beta_{co} + \beta_{c1} \log RY_t^d + \beta_{c2} \log RM2_t + \beta_{c3} R_t + \beta_{c4} \log CPI \qquad (4.1)$$

Where RCp_t is real private consumption; RY^d is real disposable income; $RM2$ is real broad money which is a proxy to wealth, R is the real discount interest rate; CPI is consumers price index which measures the price level. The nominal discount interest rate is converted into real discount interest rate using:

$$R_t = \left(\frac{i_t - \pi_t}{1 + \pi_t} \right) \qquad (4.2)$$

Where, i is the nominal discount interest rate. Disposable income and a gain in wealth is expected to affect private consumption positively and the effect of interest rate and price level is not known *a priori.*

[45] "If the PIH model is true, consumption is proportional to permanent income; it thus tends to be above current income when current income is relatively low and expected to rise, and below current income when current income is expected to fall. To put it in another way, dissaving anticipates rising income and saving anticipates falling income" (see Campbell(1986), p. 2).

4.2.1.2 Private Investment

Investment demand in the economy is divided into private and public investment demand. Public investment is considered as a policy variable in this study, hence it is determined exogenously. Private investment behavior is specified based on flexible accelerators approach like Blejer and Khan (1984). The standard model is extended to include factors that are supposed to expound private investment behavior by incorporating institutional and structural characteristics. The model done by Blejer and Khan (1984) allows us to be applicable for developing countries like Ethiopia since it modifies the limitations found in the standard model. Accelerators model establishes a stable relationship between the stock of capital that a firm desires and the level of output (Y_t). This suggests desired level of capital (Kp^*_t) is given by:

$$Kp^*_t = \alpha Y_t \qquad (4.3)$$

If firms invest without delay, the actual level of capital stock equals the desired level of capital. But in reality, lags in adjustment of actual investment arise due to time spent to construct the new factory, installation of capital, to train workers on how to operate the new facilities. Thus actual stock of capital is assumed to adjust to the difference between desired stock in period *t* and actual stock in previous period which is given as:

$$\Delta Kp_t = \beta(Kp^*_t - Kp_{t-1}) \qquad (4.4)$$

or

$$Kp_t = \beta Kp^*_t + (1-\beta)Kp_{t-1} \qquad (4.5)$$

Where Kp is actual private capital stock, ΔKp is net private investment, and β is coefficient of adjustment, $0 \le \beta \le 1$. Gross private investment (Ip_t) is equated as net investment plus depreciation of the previous period's capital, i.e.

$$Ip_t = \Delta Kp_t + \delta Kp_{t-1} \qquad (4.6)$$

Where, δ is the rate of depreciation.

The gradual adjustment of desired level of capital stock to that of actual capital stock is influenced by many economic factors. These factors include capacity utilization, availability

of finance, and level of public sector, uncertainty, and cost of capital. Thus, we can express the coefficient of adjustment as a function as:

$$B_t = f(cu_t, \Delta DCp_t, Ig_t, \pi_t, i_t) \qquad (4.7)$$

Where cu is the capacity utilization rate that is measured as the ratio actual output to potential output[46]; Dcp is the change in real bank credit to the private sector plus real net private capital flows; Ig is the real public sector investment; π_t is inflation rate that measures the degree of uncertainty; i_t is the interest rate. By rearranging equations (4.3) to (4.6) and substituting into (4.7) gives private investment function:

$$\log RIp_t = \beta_{I0} + \beta_{I1} \log RY_t + \beta_{I2} \log cu_t + \beta_{I3} \log \Delta Dcp_t + \beta_{I4} \log Ig_t + \beta_{I5} \log cpi + \beta_{I6} r_t \qquad (4.8)$$

The inclusion of change of domestic credit as an explanatory variable is to incorporate the effect of access to finance. The total capital formation is given by:

$$I = Ip + Ig \qquad (4.9)$$

Where, I is gross capital formation. The expected signs for the coefficients of income, domestic credit, and capacity utilization are positive whereas for government investment, inflation and interest rate it is not known *a priori.*

4.2.1.3 Government Sector

Government sector considers both revenue and expenditure side. In most studies expenditure is treated as exogenous. However, in this study both sides are specified stochastically though expenditure side is partly exogenous. Government generates its revenue from taxes, non tax revenues and external grants. Tax revenue consists of direct tax and indirect taxes. Government expenditure is disaggregated into current expenditure and capital expenditure. Current expenditure consists of wages and salaries, expenditure on goods and services, interest payments (both domestic and foreign), and subsides and transfers. In the revenue side tax revenue is specified stochastically whereas nontax revenue and external grant are determined exogenously. From expenditure side, current expenditure is specified stochastically whereas capital expenditure is determined exogenously.

[46] The "potential" output is estimated first by regressing GDP on time and adding the highest positive residual on the fitted values. This approach of approximation is used in the case of Ethiopia by Yohannes (2000) and Seid (2000).

4.2.1.3.1 Government Revenue

Government revenue is influenced by level of economic activity, degree of trade, foreign aid, and overall debt. A proxy for the degree of economic activity is output (GDP) which measures the tax base and it is expected to increase tax revenue. The revenue performance also depends on the degree of trade especially from import side of the economy after the trade liberalization at least to the case of Ethiopia. There is also an argument on the fiscal response as government gets a receipt from aid (grants and loan), government's behavior on revenue collection and expenditure is subjected to change. Additionally, to generate foreign exchange and to service its debt government chooses to reduce import by increasing import tariff or other taxes which is supposed to close the trade deficit and service the debt (see Tanzi (1992), Gupta (2007)).[47] Following these arguments tax revenue function is specified as a function of GDP, import, foreign aid and concessional loan. The government revenue is given as:

$$\log TR_t = \beta_{T0} + \beta_{T1}\log Y_t + \beta_{T2}\log IM_t + \beta_{T3}\log FA_t + \beta_{T4}\log consloan \qquad (4.10)$$

Where TR is total tax revenue; Y is nominal GDP; IM is total import; FA is foreign aid; *consloan* is concessional loan. Total government revenue identity is given as:

$$TGR_t = TR_t + \overline{NTR}_t + \overline{Grant}_t \qquad (4.11)$$

Where *TGR* is total government revenue; *NTR* is non tax revenue, and *Grant* is foreign grant and aid.

4.2.1.3.2 Government Expenditure

Government current expenditure (GE) is financed either from tax revenue or by borrowing from international or domestic sources. Thus, current expenditure can be specified as a function of tax revenue, foreign aid, concessional loan and price level. Thus, government expenditure is specified as[48]:

$$\log GE_t = \beta_{G0} + \beta_{G1}\log TR_t + \beta_{G2}\log FA_t + \beta_{G3}\log cpi + \beta_{G4}\log consloan \qquad (4.12)$$

and total government expenditure identity is given by:

$$TGExp_t = GE_t + \overline{GCE}_t \qquad (4.13)$$

Where, *TGEXP* is total government expenditure and *GCE* is government capital expenditure.

[48] for Similar specifications see Heller (1975), Mosley et al (1987), Gang and Khan (1991), Khan and Hoshino (1992), Otim (1996), McGillivray (2000), Dawit and Abera (2006)

The sector closes by public deficit (*pubDef*) which is given the difference between government revenue and expenditure which is given mathematically as:

$$PubDef_t = TGR_t - TGExp_t \qquad (4.14)$$

4.2.1.4 External Sector

External sector comprises export, import and real exchange rate behavioral equations. The export sector is represented by a single equation since exported commodities are mainly primary commodities. The import sector consists of two equations: import of consumer goods, import of intermediate and capital goods. Though the exchange rate behavioral equation is impacted by parallel market, modelling is done using the official exchange rate's real effective exchange rate assuming the significance of the parallel market is negligible at least in the long run.

4.2.1.4.1 Export Sector

Export behavior is specified following the assumption that Ethiopia is a small country. Factors that determine export demand for Ethiopian goods and services are influenced by real income of trade partners and country's competitiveness which is measured by using real effective exchange rate and the capacity to supply. Since most developing countries are supply constrained, capacity to supply depends on capital accumulation. In this thesis we have assumed the ratio of investment to value added is used as a proxy for the measure of capital accumulation.[49]

Following this argument, export behavior is specified as:

$$\log X_t = \beta_{x0} + \beta_{x1} \log RY_t^{row} + \beta_{x2} \log REER_t + \beta_{x3} \left(\frac{ITOT_t}{RY_t} \right) \qquad (4.15)$$

Where X is export; RY^{row} income of the trade partners of Ethiopia; REER is the real exchange rate; $\left(\frac{ITOT_t}{RY_t} \right)$ the ratio of total investment to total income.

[49] This approach is applied by Alemayehu and Huzinga (2006)

4.2.1.4.2 Import Sector

Import demand behavioral equation is adopted from Khan and Knight (1988). Demand for import is determined by domestic demand which is proxied by gross domestic income, real exchange rate, and foreign exchange reserve to reflect import constraint that results from availability of foreign reserve. Import is disaggregated into two parts as consumer goods and intermediate and capital goods (see Soludo(1995),Taye(1999), Daniel(2001)).This classification is done so as to reflect Ethiopian domestic firms are heavily dependent on imported intermediate and capital goods. The availability of intermediate and capital goods in turn is expected to influence the utilization of non agricultural sector of the economy. Both classifications of import follow similar specification; but their interaction to other sectors differs thus each of the equations is specified by its own as follows.

Import of Consumer goods

$$\log Mcn_t = \beta_{Mc0} + \beta_{Mc1} \log RY_t + \beta_{Mc2} \log RESV_t + \beta_{Mc3} \log REER_t \qquad (4.16)$$

Where , *Mcn* is import of consumer goods, *RESV* is available foreign exchange reserve.

Import of Intermediate and capital goods

$$\log Mcp_t = \beta_{Mcp0} + \beta_{Mcp1} \log RY_t + \beta_{Mcp2} \log RESV_t + \beta_{Mcp3} \log REER_t \qquad (4.17)$$

And as an identity we have total import given by:

$$Mt = Mcn_t + Mcp_t + Mo_t \qquad (4.18)$$

Where, M is total import and Mo is import of other commodities.

Exchange Rate

To model real exchange rate, we follow Edwards (1989) approach.[50] For specifying real exchange rate factors that are expected to determine the long run behavior, *"real exchange rate fundamentals"* to the context of Ethiopia are considered while the external REER fundamentals included are international prices (terms of trade), international transfers including foreign aid flows. Domestic REER fundamentals included are openness and government consumption as a ratio of GDP which are policy related factors. In developing countries fiscal deficits are mostly financed by seigniorage (printing money) which results in

[50] This method is also adopted by Mungule (2004) for Zambia, Taye (1999) for Ethiopia, and Ghura and Grennes (1993)for Sub-Saharan Africa.

excess domestic credit which has a role to create macroeconomic instability. Thus, real exchange rate is specified as a function of terms of trade, foreign capital inflow, openness, and excess domestic credit. This is given by:

$$\log REER_t = \beta_{RR0} + \beta_{RR1} \log Tot_t + \beta_{RR2} \log F_t + \beta_{RR3} \log Open_t + \beta_{RR4} \log ExDC_t + \beta_{RR5} Dummy \quad (4.19)$$

Where *Tot*, represents terms of trade given as the ratio of export price to import price; *F* is net capital inflow; *Open* stands for openness of the economy measured by the ratio of sum of export and import value to total GDP; *ExDC* for excess credit measured by the change in domestic credit[51], *Dummy* represents period where there is exchange rate liberalization.

4.2.2 Monetary sector

The modelling of monetary sector is done to examine how monetary variables are related to other sectors of the economy. In modelling monetary sector, only money demand is determined stochastically. The formal financial sector in the case of Ethiopia is characterized as 'repressed' like other developing countries. Since national bank of Ethiopia controls interest rate this variable is considered as exogenous. This implies interaction of money demand and volume of money supply does not clear in the conventional way. Since aggregate output and demand are not linked via interest rate to the monetary sector, excess demand is incorporated in the price equation to reflect demand pressure.

4.2.2.1 Money Demand

Money demand equation is specified using two behavioral equations as narrow money and Quasi-money (which includes saving and time deposit)[52]. We can explain demand for narrow money using a scale variable that represents the transactions demand for real money given by real income (RY) a measure of expected opportunity cost of holding money rather than goods, inflation rate (P) ; the marginal opportunity cost of holding money which is proxied by interest rate of treasury bill of 3 months(*rtbill*) and parallel market exchange rate (BEX_t) that measures the expected cost of holding domestic currency instead of foreign currency which

[51] Excess domestic credit is measured following Edward (1989) definition. i.e. the difference between the ratio of change in domestic credit to broad money and the rate of economic growth.

[52] The selection of appropriate money stock is generally based on either transaction theory or asset theory. Transaction theory emphasizes money's role as a means of payment, and hence it deals with narrow money. Asset theory concentrates on money's function as a store of value and focuses on broad money.

represents currency substitution in the country (see Dureva et al (2010) for the case of Ethiopia; Ameyaw(2004) for Ghana; Adam et al (2004) for the case of Vietnam, Bahmani-Oskooee and Chi Wing Ng (2002) for Hong Kong). Demand for Narrow money (M1) is given as:

$$\log RM1_t = \beta_{M10} + \beta_{M11}\log RY_t + \beta_{M12}\log P_t + \beta_{M13} rtbill_t + \beta_{M13}\log BEX_t \quad (4.24)$$

Where RM1 is real narrow money given as a ratio of nominal M1 to price level, in this case consumer price index. The expected coefficients for real income is positive and for inflation and interest rate it is expected to be negative but for the case of parallel exchange rate the sign of the coefficient is ambiguous to be determined *a prior.*

Money demand equation for Quasi-money (*MQ*) is assumed to be a function of real GDP, real interest rate (rr), and the rate of inflation. And the equation is specified as:

$$\log RMQ_t = \beta_{Mq0} + \beta_{Mq1}\log RY_t + \beta_{Mq2}\log P_t + \beta_{Mq3}\log rr_t \quad (4.25)$$

The sum of narrow money and Quasi-money gives broad money demand (Mt) which is given by:

$$M2 = M1 + MQ \quad (4.26)$$

4.2.2.2 Money Supply

Money supply is influenced by domestic credit, net foreign asset, and others net assets[53] Domestic credit comprised claims by government and claims by other sectors. The relationship between supply and demand for money (M2) is determined via money multiplier so that both sides equilibrate and monetary sector closes.[54] It is expressed as:

$$M_t^s = \mu M2 = \mu(NFA + NDA) \quad (4.27)$$

Where, *NFA* is net foreign asset and *NDA* is net domestic asset, and μ is money multiplier, which is calculated as the ratio of *M2* to reserve money (Currency in circulation and banks deposits at the National bank of Ethiopia)

$$NDA = GC + NGC + ONA \quad (4.28)$$
$$DC = GC + NGC \quad (4.29)$$

[53] Other net assets are comprised from cumulated retained profits plus the initial investment in the bank made by its owners (McCallum 1989).

[54] Closure of money supply is adopted from McCallum (1989) considering the money demand equation. (see p. 56-62 for the mathematical derivation.)

Where, *GC* is credit claimed by government; *NGC* is claims by other non-governmental sectors and *ONA* is others net assets.

4.2.3 Aggregate Supply

To model supply side of the real economy, production sectors are classified as agriculture and non agriculture sectors. Each of them is specified using the Cobb-Douglass production function with constant returns to scale (CRS) technology. The supply side of the model is specified by taking the country's economic structure. This type of classification is applied in Taye (1999), Seid(2000), Daniel (2001) and Alemayehu and Huziga(2006).

4.2.3.1 Agricultural Production Function

The agriculture production function specifies agricultural output as a function of capital implemented in agriculture (like ox and physical instruments for agricultural activity), labour force in agriculture, amount of rainfall and technical change. Thus the agricultural output is specified as:

$$\log Ya_t = \beta_{Ya0} + \beta_{Ya1} \log Ka_t + \beta_{Ya2} \log La_t + \beta_{Ya4} \log RF_{t-1} + \beta_{Ya5} T \qquad (4.31)$$

Where, Ya is agricultural output; Ka is capital in agriculture; *La* is labour force in agriculture sector; RF is the amount of rain fall; and is *T* technological change.

4.2.3.2 Non-Agricultural Production Function

Non agriculture side of the economy comprises manufacturing and service sector. The supply of this sector is influenced by labour force, capital stock, availability of imported raw materials and intermediate goods, domestic output of agricultural raw materials(Ya), and technical change(A). Agricultural output is considered as one determinant to manufacturing output since most manufacturing industries are of agro industries that take agricultural commodities as intermediate and also service sector like hotels and trade activities use domestic agricultural raw materials for their business activities. In this thesis agriculture's level of output is considered as one source to measure the supply of domestic raw materials. Taking all these factors into consideration the non agricultural production is specified as:

$$\log Yn_t = \beta_{Yn0} + \beta_{Yn1} \log Kn_t + \beta_{Yn2} \log Ln_t + \beta_{Yn3} \log Ya + \beta_{Yn4} \log Mcp_t + \beta_{Yn4} A_t \qquad (4.32)$$

Where, *Yn* is non agricultural output*; Kn* is capital in non-agriculture*; Ln is* labour force, Mcp is import of intermediate and capital goods.

Total output of the economy(Y) is given as the sum of agricultural output and non agriculture.

$$Y = Ya + Yn \qquad (4.33)$$

4.2.4 Price Sector

Price sector allows different sectors of the system to communicate and enforce systems to reach into equilibra. Through price sector producers and consumers interact to keep the economy in balance. The price sector contains two behavioral equations: producer price and consumer price. GDP deflator is taken as a proxy for producer price due to data limitation (See Musila (2000), Mataliyana(2005) and Akibani and Du Toti(2010) for similar treatment).

4.2.4.1 Producer Price

Producer price is expected to be determined as a mark up over unit costs in the long run; i.e. as mark up over all inputs used for production. The costs incurred are for labour, capital cost, imported raw material costs. Labour cost is measured by wage rate and that of imports is measured by the import price in local currency. Profit margins are assumed to depend positively on the capacity utilization (cu) rate. The producer price is specified as:

$$\log p_t = \beta_{p0} + \beta_{p1} \log imp_t + \beta_{p2} \log wage_t + \beta_{p3} \log cu_t \qquad (4.34)$$

Where *P* is the GDP deflator; *imp* is import unit price which is given exogenously; *wage* is the wage rate.

4.2.4.2 Consumers Price

Consumer price is directly influenced by producer price and other additional factors import price, excess demand, exchange rate, and real money balance. Using these arguments consumer price is specified as:

$$\log cpi_t = \beta_{cp0} + \beta_{cp1} \log imp_t + \beta_{cp2} \log p_t + \beta_{cp3} \log ED_t + \beta_{cp4} REER_t + \beta_{cp5} \log \frac{M2}{P} \qquad (4.35)$$

Where, *ED* is excess demand.

> *…whatever 'explanations' we prefer, it is not to be forgotten that theoretical models are all our own artificial inventions in a search for an understanding of real life; they are not hidden truths to be 'discovered'."* (Havelmo 1944, p. 3)

4.3 Estimation Technique

4.3.1 Introduction

Time series data is implemented to formulate the macro-econometrics model developed in this study. Recent macro-econometrics models explain the working of the economy by utilizing time series property of macro variables. Some of the properties are stationarity, order of integration, and cointegration among variables are among other properties of dynamic time series analysis. To apply the standard test statistics (t- test statistics, F- test statistics, chi-square statistics) for dynamic time series models and give the right inference stationarity of variables is a prerequisite criterion. Otherwise, analysis made among non stationary variables may lead to *spurious regression* which shows contemporaneous correlations rather than meaningful causal relations that end up with misleading estimators and test statistics.

Following Nelson and Plosser (1982), non-stationarity of a series is defined whether a given series is *mean reverting*[55] or not; and they have identified two fundamental classes of non-stationary process namely trend stationary and difference stationary processes. Trend stationary (TS) processes consists data generating process which can be explained by a "deterministic function of time called trend, plus a stationary stochastic process with mean zero". The other classes are difference stationary (DS) processes where "first or higher order difference is stationary and invertible ARMA process". In other words DS processes exhibit stochastic nature which results in unbounded variance over time; but TS are deterministic processes which does have a constant variance across time. And the other difference is on the unit root each of the processes contains. TS process contains a unit root in the moving average

[55] A series is said to be mean reverting if there is a tendency in the long run to return to its mean

(MA) part of the ARMA process whereas DS has in AR part. Because of this, precaution has to be taken while testing the presence of unit root in the series and on identifying whether the series is TS or DS. In the data[56] they considered, they had concluded "economic time series do not contain deterministic trend but stochastic trends characteristics of the DS class of processes" (Nelson and Plosser, 1982, p. 152). Since the two processes need different techniques to transform into a stationarity series the unit root test for the variables of interest has to be done with precaution. Recent techniques for analyzing dynamic time series like cointegration and error correction models are developed considering such properties of data generating process; and give a representation that considers the long run and short run behavior of a macroeconomic relationship that exists among variables.

4.3.2 Tests for order of Integration

Engle and Granger (1987) define "a series (X_t) with no deterministic component which has a stationary invertible, ARMA representation after *differencing d* times is, is said to be *integrated of order d*, denoted $X_t \sim I(d)$." and remains to have a stochastic trend after *d-1* times differenced (Lutkepohl,2007).This means the stochastic component of a series is removed by differencing *d* times till stationary series is achieved. If we have a series having order of integration zero it means a series is stationary at level and integrated of order one implies the series is stationary after the first difference.

From economic point of view when order of integration is one it creates an interesting question since models with unit roots shocks have persistent effect that last forever, while for the case of stationary models shocks does have a temporary effect (Verbic, 2004) . To investigate the presence of unit roots in the error terms there are several tests such as Dickey–Fuller (1979) test, Kwiatkowski, Phillips, Schmidt and Shin (1992) (KPSS test)[57], Augmented Dickey Fuller(ADF),and Phillips–Perron (PP) test. In this paper Augmented Dickey Fuller and Phillips–Perron (PP) test are implemented. To discuss test on unit root take a data generating process given by:

[56] US data set (see list of variables on Nelson and Plosser(1982), p.151)

[57] It takes the null the hypothesis that a series is stationary, against the alternative of non-stationarity. Since KPSS test have different data generating process from ADF test the two strictly not comparable. (see Harris and Sollis (2003), p. 42)

$$y_t = \rho y_{t-1} + u_t \qquad u_t \sim IID(0, \sigma^2)$$
$$y_0 = 0 \qquad (4.36)$$

If one were testing the true hypothesis $H_o : \rho = \rho_0$ for $|\rho_0| < 1$, the test would be easily performed. Running the regression (4.36), the *t-stat*istic $\frac{\rho - \rho_0}{se(\rho)}$ has asymptotically a standard normal distribution and can be compared with tables of significance points for $N(0,1)$. In small samples the statistic is approximately *t*- distributed, although the coefficient estimate ρ is biased downward slightly. But in the cases where $|\rho_0| \geq 1$ which implies non-stationarity and a situation when at least there is one unit root, test statistics no longer holds as the distribution of the test statistic given is not asymptotically normal. In such a case critical values developed by Dickey (1976) will be implemented. The critical values in Fuller's tables are related to three different cases. The first case when equation (4.36) is used as it is; secondly when there is a constant term; and thirdly when there is a constant term and time trend in the equation.

Mathematically it is given as:

$$Y_t = \mu_b + \rho_b Y_{t-1} + u_t \qquad (4.36a)$$
$$Y_t = \mu_c + \gamma_c t + \rho_c Y_{t-1} + u_t \qquad (4.36b)$$

The null hypothesis is that $\rho_i = 1$ for $i = b, c$. The applicability of each model depends on what is known about the DGP. If a test is not similar (that is, tests for which the distribution of the test statistic under the null hypothesis is independent of nuisance parameters in the DGP), then the appropriate critical values may depend upon unknown nuisance parameters (constant and trend terms), which will invalidate standard inferences (Banerjee *et al*, 1993).

Harris and Sollis (2003) also suggested it is necessary to have a regression model that has more deterministic component for testing purpose than the hypothesized DGP; otherwise the test cannot nest both the null and alternative hypothesis(see, Harris and Sollis (2003), P.47). For such a reason a DGP having both constant and deterministic term is suggested to be more reliable. Mathematically this is given by:

$$Y_t = \phi + \gamma t + u_t \qquad where \qquad u_t = \rho u_{t-1} + \varepsilon_t \qquad (4.37)$$

Reparametrizing equation (4.37) gives:

$$\Delta Y_t = (\phi(1-\rho)+\rho\gamma)+\gamma(1-\rho)t+(\rho-1)Y_{t-1}+\varepsilon_t$$

So our null hypothesis will be $\rho=1$, if it holds we have $\Delta Yt=\gamma+\varepsilon_t$.This implies we have a trend at a rate of $\gamma(1-\rho)$ in the alternative hypothesis and a drift at a rate γ in the null.[58]

The Dickey-Fuller test discussed so far above is based on the DGP is AR (1), but a process might have AR(p) thus the error terms in DF test of AR(1) will be auto correlated in order to compensate the misspecification of the dynamic structure of Y.Thus the presence of autocorrelation in the error terms will invalidate the applicability of DF distribution which assumes error terms are white noise. Thus assuming Y_t follows P[th] order AR process:

$$Y_t = \psi_1 Y_{t-1}+\psi_2 Y_{t-2}+...+\psi_p Y_{t-p}+u_t \qquad (4.38) \quad ;$$

and after reparameterizaion we have :

$$\Delta Y_t = \psi^* Y_{t-1}+\psi_1\Delta Y_{t-1}+\psi_2\Delta Y_{t-2}+...+\psi_{p-1}\Delta Y_{t-p+1}+u_t$$
$$u_t \sim IID(0,\sigma^2) \qquad (4.38a)$$

Where, $\psi^* = \psi_1+\psi_2+...+\psi_p-1$

In this case the presence of unit root us done by hypothesizing the null ψ^* = 0 against the alternative ψ^* < 0. This process of testing a unit root is known to be Augmented Dickey-Fuller test. In similar fashion with that of DF, a test is undertaken by adding constant and deterministic trend term; and the model for undertaking this test is given by:

$$\Delta Y_t = \psi^* Y_{t-1}+\sum_{i=1}^{p-1}\psi_i\Delta Y_{t-i}+\mu+\gamma t+u_t \quad where \quad u_t \sim IID(0,\sigma^2) \qquad (4.39)$$

Where, p is the lag length of DGP (Harris and Sollis, 2003). In order to determine the lag length Akaike information criterion is used.

Another approach of testing unit root is Phillips and Perron (1988) approach. This approach is non parametric and gives an alternative test for the presence of unit root. The test sticks to the DF test rather than adding lagged first differences so as to capture the presence of autocorrelation like ADF. Phillips and Perron suggest by adjusting DF-statistics considering the autocorrelation in the error terms is possible to conduct asymptotic inference with the same distribution applied for DF-test (See Banerjee *et al* (1993), Harris and Sollis (2003),

[58] "In practice, unfortunately, the powers of available unit-root tests are low for alternatives different from, but close to, the null of unity" (see Banerjee *et al* (1993), p.101)

Verbic (2004)). The data generating processes implemented are based up on three different regression models like Dickey-Fuller tests. For DGP with no constant and a constant term the DGP does have similarity though the error terms are not assumed to be white noise, while the DGP having a constant and deterministic term is given by:

$$Y_t = \mu_c + \gamma_c (t - T/2) + \rho_c Y_{t-1} + u_{ct} \qquad (4.40)$$

,and adjustments are done in similar way as Newey and West (1987) work (see Banerjee *et al* (1993)[59],p. 108-113).

4.3.3 Cointegration and Error correction Mechanisms

Cointegration analysis is made based on the equilibrium or long run relationship that exists among variables. 'Classical' econometric theory generally assumed stationary data especially considering constant mean and variance across time periods. Nevertheless, relaying on stationarity assumption and making inference induces a serious consequence where data are empirically proved to be non-stationary. To make a proper inference we should have a stationary data. This can be done either by differencing a given series or creating a linear combination among the variables that do not have a unit root i.e. what is known as cointegration transformation (Hendry and Juselius, 2000, p. 25).

Engle and Granger (1987) has set two main criteria for components of vectors (series) to be cointegrated. The first criterion is all variables should have the same level of integration. Secondly, the linear combination of the vectors which is a vector by itself (say Z_t) must be integrated of a lower order than the original variables.

Since most economic series are integrated of order one, Engle and Granger concentrate on series' having order of integration one; and cointegration would mean if components of a series were all I(1),then the equilibrium error would be I(0) and the linear combination will rarely far from zero. If it has zero mean and the linear combination will often cross the zero line. Whereas, if series are not cointegarated then the linear combination of the components can wander widely and zero- crossing would be very rare which suggests equilibrium concept

[59] " PP tests may fail to be consistent against some stationary alternative hypotheses (Stock and Watson I988b)" (see Banerjee *et al* (1993), p.119)

has no practical implication (Engle and Granger, 1987). The techniques suggested to estimate the long run relationship among variables in a given economic relationship for this study are of two types: Engle-Granger method, and the Autoregressive Distributed Lag (ARDL) Bounds Tests Approach.

4.3.3.1 The Engle-Granger (EG) Approach

Cointegration analysis according to Engle-Granger (EG) is a two step procedures which is in line with the definition of cointegration. In the first procedure the order of integeration of the variables is determined. Secondly assuming there is some dynamic relationship that links the $I(1)$ series $\{X_t\}$ and $\{Y_t\}$ static cointegration regression is estimated using OLS[60] given by:

$$Y_t = \beta X_t + \varepsilon_t \qquad (4.41)$$

If Y_t and X_t are cointegrated the error term is $I(0)$; otherwise ε_t will be $I(1)$. Thus the presence of cointegartion can be tested by making a unit root test on the OLS residuals ξt found in (*4.41*). To perform this test, run a regression of:

$$\Delta\xi_t = \varphi\xi_{t-1} + \zeta_t \qquad (4.42)$$

and then test a null hypothesis of $\varphi = 0$ (unit root) or no cointegration using MacKinnon (1991) critical values as a test statistic.[61] And another alternative tests for cointegration is the cointegration regression Durbin-Watson test (CRDW) proposed by Sargan and Bhargava (1983) which is based on the standard Durbin—Watson (DW) statistic obtained from a regression involving (4.41), known to be "the uniformly most powerful invariant test " because the test is not affected by a trend entering in (4.41). This test's critical value is found to be applicable when ξt follows a first-order process (i.e., there is no higher-order residual autocorrelation) and thus CRDW test is generally not a suitable test statistic (see Verbic (2004); Banerjee *et al* (1993); Harris and Sollis(2003))[62].

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[60] This is because of superconsistency property i.e. as the sample size increases the estimate value of non stationary series converges to the true parameter much faster rate than from the conventional asymptotic property.

[61] The critical values or upper quintiles of the distributions can be calculated using $C(p) = \Phi_\infty + \Phi_1 T^{-1} + \Phi_2 T^{-2}$ where T is the number of sample observations taken and other parameters are calculated based on the number of variables considered and computed from simulation results.

[62] seven test statistics is proposed for testing the null of non-co-integration against the alternative of co-integration in Engle and Granger (1987)(see p.265-270)

Engle and Granger (1987) has shown that co-integrated series can be represented by error correction models using the Granger representation theorem. And also the converse holds; if an $I(1)$ series are generated by the error correction model, then the series is necessarily cointegrated. In other words, (Hendry and Juselius, 2000) explain this relationship as "ECMs and cointegration were actually two names for the same thing: cointegration entails a feedback involving the lagged levels of the variables, and a lagged feedback entails cointegration."[63]

Once a cointegrating relationship exists among series of variables a typical error correction model (ECM) representation can be given. To formulate the ECM, following simple dynamic model of short-run adjustment autoregressive dynamic lag model given by ADL (1,1):

$$Y_t = \vartheta_0 + \vartheta_1 X_t + \vartheta_1 X_{t-1} + \varphi_1 Y_{t-1} + \zeta_t \qquad (4.43)$$

We can derive the ECM by reparametrizing equation (4.43) .First by subtracting Y_{t-1} in (4.43) in both sides and then add and subtract on $\vartheta_0 X_{t-1}$ on the right-hand sides we get:

$$\Delta Y_t = \varphi_0 + (\varphi_1 - 1)Y_{t-1} + \vartheta_0 \Delta X_t + (\vartheta_1 + \vartheta_0) X_{t-1} + \zeta_t \qquad (4.43a)$$

And finally if we add and subtract $(\vartheta_1 - 1)X_{t-1}$ on both sides we have

$$\Delta Y_t = \varphi_0 + (\varphi_1 - 1)(Y_{t-1} - X_{t-1}) + \vartheta_0 \Delta X_t + (\vartheta_1 + \vartheta_0 + \varphi_1 - 1) X_{t-1} + \zeta_t \qquad (4.43b)$$

or as an alternative if we add and subtracted $\kappa_1 = (\vartheta_1 + \vartheta_0) X_{t-1}$ on both sides of the equation

$$\Delta Y_t = \varphi_0 + (\varphi_1 - 1)(Y_{t-1} - \kappa_1 X_{t-1}) + \vartheta_0 \Delta X_t + \zeta_t \qquad (4.43c)$$

All equations included starting from (4.43) up to (4.43c) tell same relationship where one is derived from the other. The terms $(Y_{t-1} - X_{t-1})$ or $(Y_{t-1} - \kappa_1 X_{t-1})$ in (4.43b) and (4.44c)[64] respectively represent the discrepancy and the coefficient $(\varphi_1 - 1)$ on these terms can be taken as a measure of *the speed of adjustment* (short-run adjustment) of Y to a discrepancy between Y and X in the previous period and the coefficient ϑ_0 measures the short run adjustment.

[63] Banerjee et al (1993) has also shown if two series are cointegrated by the Granger Representation Theorem the series must have *vector autoregressive, error-correction, and moving-average representations* (p.153-157).

[64] The term acts as "attractor" towards which the system converges when there is a divergence from it due to non-stationarity (due to stochastic trends)

And we call equations given by (4.43a, 4.43b, 4.43c) as *error correction models* (see Banerjee *et al* (1993), Harris and Sollis(2003)).

For the error correction model (4.43c) or (4.43d), we have $\Delta Y_t, \Delta X_t, \zeta_t$ are $I(0)$, so far the model remains stationary there are two possible options. The first is $(\varphi_1 - 1) = 0$ and $(Y_{t-1} - \kappa_1 X_{t-1}) \sim I(1)$, and the second option is $(\varphi_1 - 1) \neq 0$ and $(Y_{t-1} - \kappa_1 X_{t-1}) \sim I(0)$. If $(\varphi_1 - 1) = 0$, it implies there is no adjustment and Y_t does not return to equilibrium, rather it drifts as non stationary variable. But if $(\varphi_1 - 1) \neq 0$ then the "equilibrium error" given by $(Y_{t-1} - \kappa_1 X_{t-1})$ is a stationary auto regressive process (Hendry and Juselius, 2000). Hence, once we have known cointegating vectors $(1, -\kappa_1)'$ and all terms in (3.43d) are $I(0)$, then we can estimate the equation using standard OLS technique. And the long run relationship is given using equation (4.41) and short run dynamics can be given either by (4.43b) or (4.43c). And we can derive a generalized error-correction model (ECM) for higher number of variables and it can be given as:

$$\Delta Y_t = \varphi_0 + (\varphi_1 - 1)(Y_{t-1} - \kappa_1 Z_{t-1}) + \sum_{i=1}^{m} \vartheta_{Yi} \Delta Y_{t-i} + \sum_{i=1}^{n} \vartheta_{Zi} \Delta Z_{t-i} + \zeta_t \qquad (4.44)$$

Where, Z refers to the set of exogenous variables that are included in the equation.

Although EG procedure is used extensively in empirical applications[65] it has criticism due to the assumption of existence of a unique cointegrating vector. When there exsists more than one explanatory variable the most recommended procedure is that of Johanson (1988) which is based on VAR analysis.

4.3.3.2 Autoregressive Distributed Lag Bounds Tests Approach

This approach is pioneered by Pesaran and Shin (1999). This study uses Autoregressive Distributed Lag (ARDL) Bounds Tests Approach for some of the estimable equations. The approach considers both the dependent and independent variables and their lags in the estimable equation. The term "autoregressive" refers to lags of the dependent variable and "distributed lag" to the lag of regressors.

[65] Most of the models reviewed in the empirical section have applied EG procedure.

ARDL method is considered for this study because of its advantage over the other methods. It gives us consistent estimate for long run coefficients that are asymptotically normal irrespective of whether the underlying regressors are I(1) or I(0) or mutually cointegrated. This means it helps us to make inference in the absence of same level of integration for the series that are considered in the model but the variables considered should be integrated of I(1) or I(0)(Pesaran *et al*, 2001).

ARDL approach can be illustrated using an example for basic equilibrium specification for real effective exchange rate equation specified in this thesis. The long run equation used to estimate the real effective exchange rate given in equation (4.19) is:

$$\log REER_t = \beta_{RR0} + \beta_{RR1}\log Tot_t + \beta_{RR2}\log F_t + \beta_{RR3}\log Open_t + \beta_{RR4}\log ExDC_t + \beta_{RR5} Dummy$$

Following *Pesaran et al*(2001)the ARDL representation of this model is given by :

$$\begin{aligned}\Delta\log REER_t = {} & \beta_{RRc0} + \sum_{i=1}^{m}\beta_{RRc1}\Delta\log REER_{t-i} + \sum_{i=0}^{m}\beta_{RRc2}\Delta\log Tot_{t-i} + \sum_{i=0}^{m}\beta_{RRc3}\Delta\log F_{t-i} + \\ & \sum_{i=0}^{m}\beta_{RRc4}\Delta\log Open_{t-i} + \sum_{i=0}^{m}\beta_{RRc5}\Delta\log ExDC_{t-i} + \beta_{RR0}\log REER_{t-i} + \beta_{RR1}\log Tot_{t-1} + \\ & \beta_{RR2}\log F_{t-1} + \beta_{RR3}\log Open_{t-1} + \beta_{RR4}\log ExDC_{t-1} + \beta_{RR5} Dummy \qquad (4.45)\end{aligned}$$

The presence of long run relationship among the variables under investigation is tested by means of bound testing procedure designed by Pesaran *et al* (2001). To undertake this test ARDL model which is sometimes called conditional error correction model is estimated and a test using the non standard F statistics prepared by Pesaran *et al* (2001) will be made. To test the presence of cointegration among the variables a joint significance test on the null hypothesis ($H_0 : \beta_{RR0} = \beta_{RR1} = \beta_{RR2} = \beta_{RR3} = \beta_{RR4} = 0$) which implies no cointegartion is done as a first step. The non standard F statistics has calculated two sets of critical values for a given significance level by assuming if all sets are I (0) and the other one if all sets are (1). This bound test hence gives us three possibilities. These are: first if the F-statistic fall below a lower critical value then the null hypothesis cannot be rejected; second if the F-statistic fall between the two bounds then the result will be inconclusive; and third if the F-statistic is above the upper bound it implies the presence of long-run relationship.

Once the existence of long run relationship is confirmed, the long run equation and the short-run dynamics or error correction models can are estimated from the ARDL model selected. The long run relationships are estimated by taking the ARDL model chosen and the residual

found from the long run equation will be the equilibrium correction term. In similar fashion to the Engle- Granger two step procedure, the short run dynamic or error correction model will be estimated.

5 Empirical Analysis

This chapter first discusses statistical property of variables considered for the estimable equations regarding the presence of unit root. Next, we estimate the structural equations discussed in the previous chapter, conduct diagnostic checks and provide economic interpretation; the third section focuses on the tracking performance of model and the final section deals on counterfactual simulations.

The estimation technique implemented for the study is based on Engle-Granger two-step procedure and ARDL technique. Analysis is given for both long-run and short run adjustment processes that exist among variables.

5.1 Statistical properties of Individual Series

To uncover the problem that resulted from the non-stationarity property of time series, making an exploration on the behavior of individual time series data is very useful. In doing so, two ways of testing presence for a unit root, ADF and PP test, are implemented. Most of the variables under investigation are found to be integrated of order one and capital stock used for both agriculture and non agriculture are found to be the only I(2) variables. Table (5.1) and (5.2) give tests for the order of integration results for level and first difference of the variables which are considered to model the subsystem models that will deliver the full model by solving simultaneously.

Table 5.1: Order of integration for variables at level

Series	Model	Lags for ADF	ADF	PP
LINT	Intercept and Trend	0	-2.3841	-2.46
	Intercept	0	-2.0093	-2.0356
	None	0	-0.1882	-0.143
LOG_CONSLOAN	Intercept and Trend	0	-0.7277	-0.833
	Intercept	0	-1.8722	-1.8652
	None	0	2.1613	1.9250
LOG_DC	Intercept and Trend	4	-3.3176*	-2.0928
	Intercept	0	-0.2935	6.7786
	None	0	6.4691	6.7786
LOG_DCP	Intercept and Trend	1	-2.8626	-2.0031

Series	Model	Lags for ADF	ADF	PP
LOG_DCP	Intercept	0	-2.8626*	0.7972
	None	0	4.2497	4.2497
LOG_EXCESSDD	Intercept and Trend	0	-2.4981	-2.5378
	Intercept	0	-0.6259	-0.4198
	None	0	1.2665	1.6662
LOG_FRAID	Intercept and Trend	0	-2.4689	-2.4121
	Intercept	0	0.2967	0.6846
	None	0	2.0631	-2.6272***
LOG_GDPN	Intercept and Trend	0	2.067803	1.0639
	Intercept	0	3.9901	2.6935
	None	2	1.5957	4.6676
LOG_GOVTEXPC	Intercept and Trend	0	-2.5907	-0.1867
	Intercept	0	-0.2975	-0.1866
	None	0	4.4869	4.9934
LOG_IMPT	Intercept and Trend	0	-0.6806	-0.73334
	Intercept	0	1.74022	1.74022
	None	0	5.7346	5.6329
LOG_LAGAF	Intercept and Trend	1	-3.2416*	-4.2075**
	Intercept	0	2.3518	2.3518
	None	0	36.8132	32.4643
LOG_LNAGG	Intercept and Trend	0	-2.0057	-1.8918
	Intercept	0	3.3478	2.5148
	None	0	29.4837	19.8296
LOG_NFCI	Intercept and Trend	0	-5.2129***	-5.2100***
	Intercept	0	-1.7619	-1.4326
	None	1	0.9389	1.8159
LOG_OPEN	Intercept and Trend	0	-1.6593*	-1.749
	Intercept	0	-0.9149	-0.99866
	None	0	1.2317	1.1705
LOG_P	Intercept and Trend	0	-0.8906	-1.2964
	Intercept	0	1.8288	1.6877
	None	0	4.9335	4.5752
LOG_RAIN	Intercept and Trend	0	-3.9902**	-3.9262**
	Intercept	0	-4.0890***	-4.0299***
	None	2	0.3026	0.2473
LOG_RCP	Intercept and Trend	0	0.2566	0.5727
	Intercept	0	2.153	2.8179
	None	0	3.2915	3.0934
LOG_REERIINV	Intercept and Trend	1	-1.9632**	-1.6235

	Intercept	0	-0.9833	-1.1234
Series	**Model**	**Lags for ADF**	**ADF**	**PP**
	None	0	0.4334	0.3445
LOG_RGDP	Intercept and Trend	2	0.9476	0.3808
	Intercept	2	2.6777	3.468
	None	0	3.1989	3.1781
LOG_RIG	Intercept and Trend	0	-2.5029	-2.6267
	Intercept	0	-1.1598	-1.1041
	None	0	2.144234	2.9225
LOG_RIP	Intercept and Trend	0	-4.0448**	-3.8765**
	Intercept	0	-0.8491	-2.418
	None	1	0.494677	0.7166
LOG_RM1CPI	Intercept and Trend	0	-4.4463***	-4.5886***
	Intercept	0	-1.2076	-1.1798
	None	0	1.8839	2.7892
LOG_RM2CPI	Intercept and Trend	0	-2.1155**	-2.2536
	Intercept	0	-0.657	-0.6586
	None	0	3.2759	3.2759
LOG_RMCN	Intercept and Trend	0	-2.2931	-2.2093
	Intercept	0	-0.4527	-0.1846
	None	0	1.7152	2.5998
LOG_RMCP	Intercept and Trend	0	-4.2191**	-2.1319
	Intercept	0	-3.6155**	0.4773
	None	0	-2.6272***	3.2616
LOG_RQM1CPI	Intercept and Trend	0	-2.0138**	-1.9578
	Intercept	0	-0.4619	-0.3458
	None	0	1.8719	2.1272
LOG_RX	Intercept and Trend	0	-1.7642*	-1.8647
	Intercept	0	-0.5316	-0.5134
	None	0	1.5331	1.9607
LOG_RYAGG	Intercept and Trend	0	-1.359	-1.0213
	Intercept	2	2.1115	2.2982
	None	0	1.8384	-2.6272***
LOG_RYDN	Intercept and Trend	2	0.9662	0.378
	Intercept	2	2.8682	4.4949
	None	0	3.5476	3.2332
LOG_RYNAG	Intercept and Trend	0	0.4886	0.4886
	Intercept	0	2.7246	2.4204
	None	1	2.7482	4.2324
LOG_RYROW	Intercept and Trend	0	-1.7178	-1.5348
	Intercept	0	-2.7079*	-4.8122***

	None	0	10.913	9.7191
Series	**Model**	**Lags for ADF**	**ADF**	**PP**
LOG_TOT	Intercept and Trend	3	-2.8825	-3.3322*
	Intercept	0	-1.0475	-0.8563
	None	0	-0.9983	-0.9983
LOG_TR	Intercept and Trend	1	-1.673	-1.3497
	Intercept	0	1.0872	1.0435
	None	0	6.3034	6.1212
LOG_TSDEPR	Intercept and Trend	0	-2.3618	-2.4289
	Intercept	0	-2.5906	-2.6451*
	None	0	-0.5517	-0.5283
LOG_WAGE	Intercept and Trend	0	-2.8407	-2.8415
	Intercept	0	-0.0148	-0.1683
	None	0	1.1295	1.0063
LOGBEX	Intercept and Trend	0	-2.7368	-2.8408
	Intercept	0	-0.7635	-0.3253
	None	0	1.2316	2.2337
LOGCPI_CSAAD	Intercept and Trend	0	-1.5356	-1.9644
	Intercept	0	0.0059	-0.1456
	None	0	4.0114	3.3587
LOGCU	Intercept and Trend	2	1.1625	0.6931
	Intercept	2	2.2758	2.0095
	None	0	1.4881	1.4881
LOGINVTOGDP	Intercept and Trend	0	-3.5044*	-3.4358*
	Intercept	1	-1.0238	-1.5557
	None	1	-0.5893	-0.8739
LOGMUVITT	Intercept and Trend	0	-3.0204	-2.9865
	Intercept	0	-1.2769	-1.3862
	None	0	2.3667	2.7906
EXCREDITF	Intercept and Trend	0	7.2415***	-7.12473***
	Intercept	0	-7.35149***	-7.2263***
	None	1	-2.11135**	-5.0824***
INFL	Intercept and Trend	0	-4.9913***	-4.9772***
	Intercept	0	-5.07895***	-5.0651***
	None	1	-3.78224***	-3.8304***
LOG_KAGG	Intercept and Trend	1	4.6146	4.6146
	Intercept	1	2.6618	4.0749
	None	1	1.5862	11.8177
LOG_KNAGG	Intercept and Trend	0	4.6146	4.6146
	Intercept	0	2.6617	4.0749
	None	1	1.5684	11.7209

The (*), (**) and (***) shows the test is significant at 10, 5 and 1 percent level.

For ADF and PP test when both Constant and Trend terms are included the Mackinnon critical values are -3.1983, -3.5330 and -4.2192 for 10, 5 and 1 percent significance level respectively. The critical values are -2.6091, -2.9411 1nd -4.2191 for 10, 5, and 1 percent significance level when a constant term is included. If neither a constant nor a trend is included Mackinnon critical values are -1.6115,-1.9499,-2.6272 at 10, 5 and 1 percent significance level respectively.

Table 5.2: Order of integration for Differenced variable

Series	Model	Lags for ADF	ADF	PP
ΔLINT	Intercept and Trend	0	-6.54561***	-6.5456***
	Intercept	0	-6.6425***	-6.6425***
	None	0	-6.7224***	-6.7224***
ΔLOG_CONSLOAN	Intercept and Trend	0	-5.7352***	-5.7224***
	Intercept	0	-5.3600***	-5.3600***
	None	0	-4.6307***	-4.6812***
ΔLOG_DC	Intercept and Trend	0	-7.0504***	-6.9336***
	Intercept	0	-7.1233***	-7.0054***
	None	1	-1.5565	-4.1785**
ΔLOG_DCP	Intercept and Trend	0	-5.7201***	-5.7369***
	Intercept	0	-5.3997***	-5.4423***
	None	1	-4.2313***	-4.3953***
ΔLOG_EXCESSDD	Intercept and Trend	1	-6.8425***	-7.40189***
	Intercept	2	-3.1183**	-7.4315***
	None	2	-3.1183	-6.8824***
ΔLOG_FRAID	Intercept and Trend	0	-8.1339***	-8.1339***
	Intercept	0	-7.91103	-7.9105***
	None	0	-6.9898***	-6.9309***
ΔLOG_GDPN	Intercept and Trend	0	-3.8452**	-3.9708**
	Intercept	1	-1.0463	-3.09886**
	None	1	0.1067	-1.0895
ΔLOG_GOVTEXPC	Intercept and Trend	0	-6.1478***	-6.2063***
	Intercept	0	-6.2367***	-6.3055***
	None	0	-4.1858**	-4.3254***
ΔLOG_IMPT	Intercept and Trend	0	-5.7359***	-5.7359***
	Intercept	0	-5.3342****	-5.3805***
	None	1	-1.4761	-3.4398***
ΔLOG_LAGAF	Intercept and Trend	0	-4.6746***	-4.5911***
	Intercept	0	-4.3444***	-4.3387***
	None	2	-0.1021	-0.20612
ΔLOG_LNAGG	Intercept and Trend	0	-4.4439***	-4.6418***
	Intercept	0	-3.4475**	-3.56275**
	None	1	-0.303	-0.6617
ΔLOG_NFCI	Intercept and Trend	0	-9.4575***	-18.861***
	Intercept	0	-9.5688***	-17.159***
	None	0	-9.4255***	-10.523***
ΔLOG_OPEN	Intercept and Trend	0	-5.4499***	-5.4505***
	Intercept	0	-5.5335***	-5.5335***

Series	Model	Lags for ADF	ADF	PP
	None	0	-5.3676***	-5.4008***
ΔLOG_P	Intercept and Trend	0	-5.1081***	-5.1070***
	Intercept	0	-4.7918***	-4.7819***
	None	0	-3.2078*	-3.3794*
ΔLOG_RAIN	Intercept and Trend	1	-7.7399***	-9.2697***
	Intercept	1	-7.8389***	-9.2919***
	None	1	-7.9451***	-9.4903***
ΔLOG_RCP	Intercept and Trend	0	-5.5228***	-5.4975***
	Intercept	0	-4.9656***	-4.9757***
	None	0	-4.0977**	-4.0996***
ΔLOG_REERIINV	Intercept and Trend	0	-4.3209***	-4.2019**
	Intercept	0	-4.3873***	-4.2752***
	None	0	-4.4330***	-4.3399***
ΔLOG_RGDP	Intercept and Trend	1	-6.1258***	-5.3985***
	Intercept	1	-5.2252***	-4.8113***
	None	2	-1.7065*	-4.0284***
ΔLOG_RIG	Intercept and Trend	0	-5.3595***	-5.4889***
	Intercept	0	-5.4339***	-5.5993***
	None	0	-4.9895***	-5.0032***
ΔLOG_RIP	Intercept and Trend	0	-12.3818***	-37.9839***
	Intercept	0	-12.1969***	-14.1734***
	None	0	-12.3051***	-14.1481***
ΔLOG_RM1CPI	Intercept and Trend	0	-10.8555***	-11.7375***
	Intercept	0	-10.7762***	-11.5543***
	None	0	-9.1082***	-8.5343***
ΔLOG_RM2CPI	Intercept and Trend	0	-5.6786***	-5.6786***
	Intercept	0	-5.7746***	-5.7746***
	None	0	-4.6570***	-4.6851****
ΔLOG_RMCN	Intercept and Trend	0	-7.4583***	-7.6217***
	Intercept	0	-7.5206***	-7.6107***
	None	0	-6.8766***	-6.8482***
ΔLOG_RMCP	Intercept and Trend	0	-4.2268***	-6.9267***
	Intercept	0	-3.6210***	-6.5431***
	None	0	-2.6289***	-5.6259***
ΔLOG_RQM1CPI	Intercept and Trend	0	-7.2984***	-6.7053***
	Intercept	0	-7.3518***	-7.3607***
	None	0	-6.7402***	-6.7053***
ΔLOG_RX	Intercept and Trend	0	-5.4418***	-5.5309***
	Intercept	0	-5.4839***	-5.2211***

	None	0	-5.2601***	-5.5309***
Series	Model	Lags for ADF	ADF	PP
ΔLOG_RYAGG	Intercept and Trend	1	-7.1827***	-8.9176***
	Intercept	1	-6.3289***	-5.6849***
	None	1	-5.5012***	-5.3167***
ΔLOG_RYDN	Intercept and Trend	1	-6.1653***	-5.4265***
	Intercept	1	-5.1170***	-4.6301***
	None	2	-1.6018	-3.9251***
ΔLOG_RYNAG	Intercept and Trend	1	-4.5815***	-4.5816***
	Intercept	1	-3.9139***	-3.8711***
	None	1	-2.6904***	-2.6149**
ΔLOG_RYROW	Intercept and Trend	0	-4.5972***	-5.3958***
	Intercept	0	-4.0604***	-3.7391***
	None	0	-1.9344***	-1.6618*
ΔLOG_TOT	Intercept and Trend	0	-6.8536***	-6.85361***
	Intercept	0	-6.9563***	-6.9563***
	None	0	-6.8089***	-6.8898***
ΔLOG_TR	Intercept and Trend	0	-4.6665***	-4.4915***
	Intercept	0	-4.5893***	-4.4425***
	None	0	-2.7754***	-2.7754***
ΔLOG_TSDEPR	Intercept and Trend	0	-6.8396***	-6.88747***
	Intercept	0	-6.7995***	-6.8410***
	None	0	-6.8813***	-6.9272***
ΔLOG_WAGE	Intercept and Trend	0	-5.4860***	-5.4844***
	Intercept	0	-5.3256***	-5.3154***
	None	0	-5.2166***	-5.2554***
ΔLOGBEX	Intercept and Trend	0	-6.3920***	-5.3358***
	Intercept	1	-6.4579***	-5.5404***
	None	1	-4.6873***	-4.4851***
ΔLOGCPI_CSAAD	Intercept and Trend	0	-4.8446***	-4.8212***
	Intercept	0	-4.9373***	-4.9168***
	None	0	-3.6679***	-3.7052***
ΔLOGCU	Intercept and Trend	0	-6.1748***	-5.4901***
	Intercept	1	-4.9920***	-4.6908**
	None	1	-4.6219***	-4.6219***
ΔLOGINVTOGDP	Intercept and Trend	0	-9.2245***	-9.6724***
	Intercept	0	-9.2455***	-9.2991***
	None	0	-9.3399***	-9.1648***
ΔLOGMUVITT	Intercept and Trend	0	-6.7753***	-7.0269***
	Intercept	0	-6.7809***	-6.9103***
	None	0	-5.6870***	-5.6847***

ΔLOG_KAGG	Intercept and Trend	0	-2.6946	-2.5778
Series	Model	Lags for ADF	ADF	PP
	Intercept	0	1.2952	-1.1786
	None	0	-0.6139	-0.8236
ΔLOG_KNAGG	Intercept and Trend	0	-2.6946	-2.5778
	Intercept	0	1.2952	-1.1786
	None	0	0.6139	0.8236

(*), (**) and (***) shows the test is significant at 10, 5 and 1 percent level.

For ADF and PP test when both Constant and Trend terms are included the Mackinnon critical values are -3.2003, -3.5366 and -4.2268 for 10, 5 and 1 percent significance level respectively. The critical values are -2.6102, -2.9434 and -4.2268 for 10, 5, and 1 percent significance level when a constant term is included. If neither a constant nor a trend is included Mackinnon critical values are -1.6113,-1.9501,-2.6289 at 10, 5 and 1 percent significance level respectively.

5.2 Estimation Result of Structural Equations

5.2.1 Aggregate Demand

5.2.1.1 Real Private consumption

The long run relationship of private consumption is determined by the level of real disposable income, real wealth (RM2), interest rate, and inflation which is given by the consumer price index (CPI). The estimable equation reveals that all the variables considered except interest rate are found to be statistically significant in affecting the real private consumption in the long run. And the long run equation is given by:

$$\log RCp = 0.11 + \underset{(26.9)\ ***}{1.04}\ \log RY^{d} - \underset{(-5.46)\ ***}{0.106}\ \log RM2 + \underset{(1.89)\ *}{0.03}\log cpi + \underset{(2.82)\ ***}{0.088}\ \text{D91-}\ \underset{(-2.18)**}{0.06}\ D99$$

$$\bar{R}^{2} = 0.99 \quad S.E = 0.03 \ \text{ DW= 1.71} \quad \text{T= 39 (1970 - 2008)}$$

From the long run relationship, real disposable income and inflation affect the real private consumption positively; whereas real wealth has a negative effect. The other two impulse dummies D91 for regime shift between the present and pre-1991 regime has a positive influence . D99 dummy captures the effect of the brunt of Ethio-Ereteria war on the real private consumption and it negatively affected real private consumption. The long run relationship shows a 1 percent increase in the real disposable income and inflation leads an equivalent increase of about 1.04 and 0.03 percent increase in the real private consumption, respectively, other things remaining equal. The result of long run consumption equation shows households consume their current income. And also, for households to increase their wealth by 1 percent they have to scarify 0.11 percent of their consumption. That means there is crowding out effect between consumption and wealth accumulation.

After estimating the estimable long run equation the residual is checked whether or not the linear combination among variables is stationary or not. The ADF statistics for the residual found from the long run relationship is found to be -5.215 and the Mackinnon critical statistics[66] is compared with the Mackinnon response surface value -4.38 for five percent

[66] Calculated by inserting to the Mackinnon reponse surface value formula and taking only with constant gives (-4.1+ -10.745/40+ -21.57/$(40)^2$ = -4.38). The Mackinnon surface values are taken from Harris(1995) Table A.6

level of significance and this leads us to reject the null hypothesis of no cointegration. Once the long run relationship is attested, the short run dynamics is shown by the Error Correction Model (ECM). After the ECM is estimated residuals found are checked for the relevant diagnostic test. The error correction model and the diagnostic test for the real private consumption is given as:

$$\Delta \log RCp = \underset{(58.56)\,***}{0.86}\ \Delta \log RY^{d} - \underset{(-9.37)\,***}{0.09}\ \Delta \log RM2 + \underset{(11.79)\,***}{0.11}\ \Delta \log cpi + \underset{(8.95)***}{0.057}\ D91 + \underset{(11)\,***}{0.068}\ D00 - \underset{(-21.52)\,***}{0.80}\ \varepsilon_{-1}$$

$$\bar{R}^{2} = 0.99 \qquad S.E = 0.005 \quad DW = 1.62 \qquad T = 38\ (1971 - 2008)$$

$$\chi^{2}_{n}(2) = 1.34[0.51] \quad \chi^{2}_{sc}(1) = 0.04[0.85] \quad \chi^{2}_{sc}(2) = 0.15[0.93]$$

$$\chi^{2}_{hsw} = 11.6[0.47] \qquad ARCH(1) = 2.47[0.12] \quad \chi^{2}_{ff}(1) = 1.73[0.19]$$

Real disposable income, inflation and real wealth affect private consumption in the short run adjustment process in similar fashion to that of long run. The coefficient of the lagged residual shows the dynamic adjustment of the long run equilibrium path and it is found to be significant with expected sign. The coefficient of the lagged residual tells us any disequilibrium created in the real private consumption is reverted back to the long run equilibrium with less than one and half year or within a given year about 80 percent of the disequilibrium that occurs in the previous year clears.

All relevant diagnostic tests have been conducted. In all equations constructed t- ratio are reported in parenthesis, adjusted R-squared by $\bar{R}^{2}$, Standard error of regression by $S.E$, Durbin-Watson statistics by DW and period of observations included after adjustment by T is also reported.

For the error correction model, the residuals are checked for the following diagnostic tests: (1) normality is checked using Jareque-Bera(χ^{2}_{n}) ; serial correlation (χ^{2}_{sc}) using Lijung Box Q ; heteroskedasticity test using white test (χ^{2}_{hsw}) and Lagrangian multiplier(LM) test ; Autoregressive conditional heteroskedasticity (ARCH); Misspecification test using r*egression specification error test(RESET) (* χ^{2}_{ff}) ; and stability of the parameters is checked using the cumulative sum of the recursive residuals (CUSUM) and cumulative sum of squares of the recursive residuals (CUSUM squares).

The diagnostic test shows that the model has passed all the tests. The parameters are found to be stable for the period of the sample study and it is tested using the recursive sum and sum squares and it is found that the test statistics lay within the 5 percent critical lines suggesting that the parameters are stable as shown in figure 5.1 below.

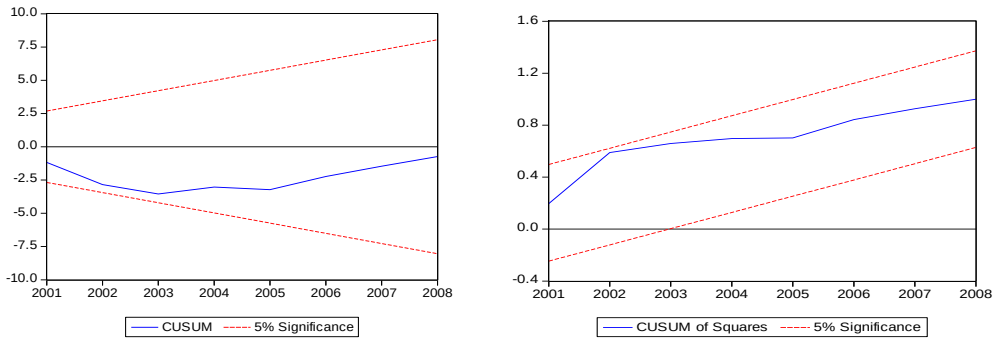


Figure 5.1: Parameter stability test for private consumption

Interest rate which has been included in the model specification is found to be insignificant both in the long run and error correction model hence it is removed from the real private consumption behavioral equation. That means interest rate does not have significant effect on private consumption at least in sample period considered for the study.

5.2.1.2 Real Private Investment

Demand factors that affect private investment include real GDP and capacity utilization and both have a positive and significant impact on private investment. Supply side factors include availability and costs of financing measured by credit and lending interest rate, respectively, and have positive and significant effect. This result supports Macknnion and Shaw (1973) hypothesis which argue cost of credit is not what matters rather its availability especially in developing countries such as Ethiopia. Strikingly, investment undertaken by the public investment has negatively affect private investment, suggests crowding out effect and inflation, measure of uncertainty, has a negative effect on the development of private investment.

$$\log RIp = \underset{(2.460\ ***)}{0.458}\ \log RY + \underset{(1.964\ *)}{0.875}\log cu + \underset{(5.394\ ***)}{0.634}\ \log Dcp - \underset{(-1.754\ *)}{0.263}\log Ig$$

$$+ \underset{(3.518***)}{0.064}\ i - \underset{(-4.579\ ***)}{0.898}\ \log cpi - \underset{(-4.140\ ***)}{1.016}\ D82 - \underset{(-4.333\ ***)}{1.017}\ D84 + \underset{(3.172\ ***)}{0.828}\ D92$$

$$\bar{R}^2 = 0.87 \quad S.E = 0.22 \quad DW = 2.01 \qquad T = 39\ (1970 - 2008)$$

The impulse dummy D82 reflects the negative effect of the nationalization policy which was undertaken by the military regime; dummy D84 indicates the period where the lowest capacity utilization rate the country has ever faced due to drought within the sample period. Dummy D92 having a positive effect ,a reflection of the privatization and other reforms programs commenced by the existing regime.

Before producing the ECM, the residuals found in the long run relationship have an ADF value of -6.05 to test whether there is no cointegration among the variables considered and the test confirms to reject the null hypothesis of no integration.[67] The error correction model is presented as :

$$\Delta \log RIp = \underset{(-4.502\ ***)}{-0.566}\ \Delta \log RIp(-1) + \underset{(1.529)}{1.595}\Delta \log RY(-1) + \underset{(1.840\ *)}{1.497}\ \Delta \log cu + \underset{(1.836\ *)}{0.555}\Delta \log Dcp - \underset{(-0.112)}{0.036}\Delta \log Ig(-1)$$

$$- \underset{(-1.231)}{0.042}\Delta i - \underset{(-3.111\ ***)}{1.330}\ \Delta\pi - \underset{(-3.920\ ***)}{1.223}\ D82 + \underset{(2.412\ **)}{0.809}\ D92 - \underset{(-2.296\ **)}{0.663}\ \varepsilon(-1)$$

$\bar{R}^2 = 0.71$ $S.E = 0.29$ DW= 1.74 T= 37 (1972 - 2008)

$\chi^2_n(2) = 5.09[0.08]$ $\chi^2_{sc}(1) = 0.66[0.42]$ $\chi^2_{sc}(2) = 4.75[0.093]$

$\chi^2_{BGhst^1} = 9.75[0.46]$ ARCH(1)=5.69[0.058] $\chi^2_{ff}(1) = 4.04[0.04]$

$F_{RESET}(1,26) = 3.00[0.10]$

Where , χ^2_{BGsw} stands for Breush- Pagan- Godfrey hetrosckedasticity test[68].

In the short run, the level of income, capacity utilization, domestic credit and inflation have similar effects like that of the long run. However, public investment and interest rate are found to be insignificant in affecting private investment in the short run. The coefficient of lagged residual term is -0.66 suggests 66 percent of the disequilibria that resulted in the previous year's shock will be adjusted by the current year.

The error correction estimation for the real private consumption has passed all tests and stability of parameters is checked using CUSUM and CUSUM squares and both tests confirm the parameters are stable for the sample period considered at 5 percent significance. Figure 5.2 shows the CUSUM and CUSUMQ tests for private investment's short run dynamic estimable equation.

[67] The Mackinnon response surface critical value is computed up to six variables but since the ADF value is high negative it atleast will be significant at 10 percent

[68] Due to insufficient number of observation the test cannot be done using white test.

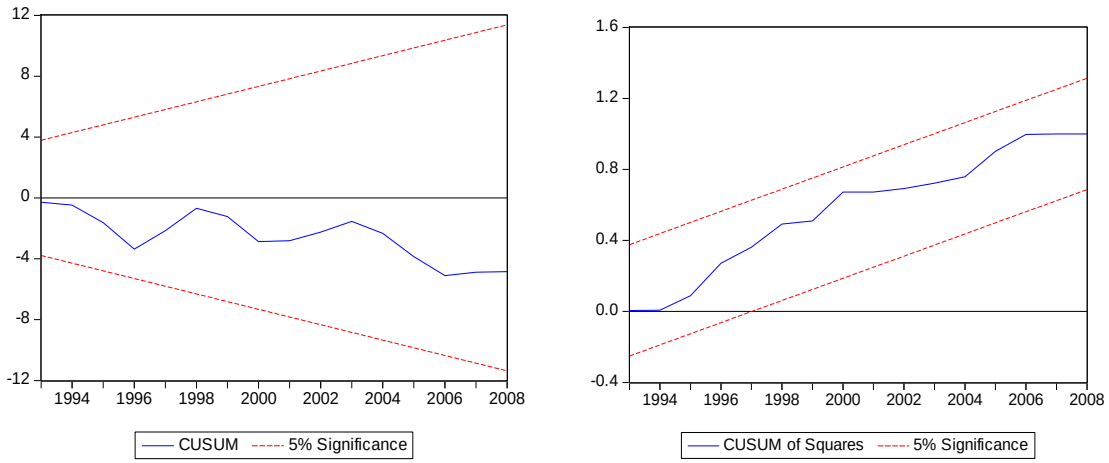


Figure 5.2: Parameter stability test for private Investment

5.2.1.3 Government Sector

5.2.1.3.1 Government Revenue

The long run estimable equation of total tax revenue is estimated as a function of nominal income, import, foreign aid which constitutes grant and concessional loan and inflation. The equation is given by:

$$\log TR_t = \underset{(8.99)***}{0.29}\log NY + \underset{(3.7)***}{0.27}\log IM + \underset{(3.31)***}{0.19}\log Gr + \underset{(2.90)***}{0.08}\log ConL + \underset{(1.83)*}{0.17}\log cpi$$

$$\bar{R}^2 = 0.99 \qquad S.E = 0.12 \quad \text{DW= 1.59} \qquad \text{T= 39 (1970 - 2008)}$$

The long run tax revenue equation shows tax revenue is positively affected by all variables considered. The long run relationship indicates as nominal income increases by 1 percent tax revenue is expected to increase by 0.23 percent, and as openness of the country increases from import side by 1 percent, tax revenue is expected to increase by 0.36 percent keeping other factors constant. Foreign aid which is hypothesized to have a negative influence on the tax collection activity of government is not supported to the case of Ethiopia.Rather a 1 percent increase in grant and concessional loan is followed by 0.19 and 0.08 percent increment, respectively. Inflation which is considered as a threat to the private institution is found to have a positive effect on government's tax revenue as it takes 0.17 percent of the additional 1 percent increase in CPI keeping other factors constant. This means inflation is a hidden tax where government uses as an opportunity to gather more revenu.

To have the ECM, the residual of the long run equation is checked for stationary and it found to be stationary which assures the presence of long run relationship among variables considered in the estimable equation.[69] And the error correction model is presented as:

$$\Delta \log TR_t = \underset{(2.63)^{**}}{0.25}\,\Delta \log TR(-1) + \underset{(1.59)}{0.32}\,\Delta \log NY + \underset{(2.15)^{**}}{0.23}\,\Delta \log IM + \underset{(3.15)^{***}}{0.123}\,\Delta \log Gr + \underset{(1.19)}{0.05}\,\Delta \log ConL - \underset{(-0.20)}{0.03}\,\Delta \log cpi - \underset{(-2.40)^{**}}{0.29}\,\varepsilon(-1)$$

$\bar{R}^2 = 0.62$ $S.E = 0.07$ DW= 1.84 T= 37 (1972 - 2008)

$\chi^2_n(2) = 2.32[0.31]$ $\chi^2_{sc}(1) = 0.06[0.80]$ $\chi^2_{sc}(2) = 0.13[0.94]$

$\chi^2_{hsw} = 27.96[0.47]$ ARCH(1)=0.22[0.63] $\chi^2_{ff}(1) = 0.93[0.33]$

In the short run adjustment process, good tax revenue collection of previous period has a positive persuasion on the current year's revenue performance. The nominal income is significant marginally at 10 percent and a 1 percent change will have a 0.32 percent change on tax revenue; and a 1 percent change in import has a 0.23 percent change in tax revenue. Grant component of foreign aid is found to be significant at 1 percent and positively related to government revenue whereas concessional loan is not found to affect the short run behavior of tax collection significantly.

To use tax revenue's error correction model, diagnostic tests are undertaken under different tests and it has successfully passed all the tests. Concerning stability of parameters, the two recursive estimates, CUSUM and CUSUNSQ, were undertaken and parameters were found to be stable for the sample period considered. The stability test is given figure 5.3.

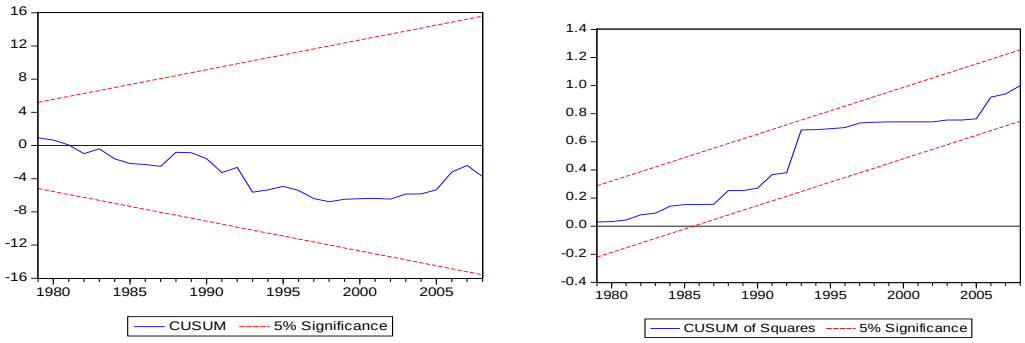


Figure 5.3: Parameter stability test for government revenue

[69] The ADF statistics compared with Mackinnon's critical value is found to significant at 10 percent.

5.2.1.3.2 Government Expenditure

The long run current government expenditure is specified as a function of foreign aid, total tax revenue and inflation. However, for both long run and short run adjustment processes grant component of foreign aid is found to be insignificant whereas concessional loan does have long run impact though in the short run it is found to be insignificant. In the long run, tax revenue, inflation, concessional loan and other two dummies, *Ddrt and Dwar,* for drought and war period, respectively, affect current government expenditure positively. The long run estimable equation is presented as*:*

$$\log GE = \underset{(7.90)***}{1.40} + \underset{(10.81)***}{0.68}\log TR + \underset{(2.75)***}{0.08}\log ConL + \underset{(2.06)**}{0.20}\log cpi + \underset{(3.67)***}{0.16}\,Ddrt + \underset{(3.16)***}{0.14}\,Dwar$$

$$\bar{R}^2 = 0.99 \qquad S.E = 0.12 \quad \text{DW= 1.58} \qquad \text{T= 39 (1970 - 2008)}$$

As governments tax revenue increases by 1 percent it is expected to have a 0.68 percent increase in government's current expenditure and for a 1 percent increase in long term borrowing expenditure changes by 0.08 percent and also for a one percent increase in CPI is expected to shoot up current government expenditure by 0.20 percent, at *cetris paribus* condition. At the time of drought and war there is an increase in current expenditure and thus we have a positive coefficient of elasticity. The error correction model for government expenditure is given by:

$$\Delta\log GE = \underset{(2.74)***}{0.41}\,\Delta\log TR + \underset{(2.68)**}{0.50}\,\Delta\log cpi - \underset{(-1.79)*}{0.36}\,\varepsilon(-1)$$

$$\bar{R}^2 = 0.08 \qquad S.E = 0.13 \quad \text{DW= 1.94} \quad \text{T= 38 (1971 - 2008)}$$

$$\chi^2_{n}(2) = 1.63[0.44] \quad \chi^2_{sc}(1) = 0.00[0.99] \quad \chi^2_{sc}(2) = 0.91[0.63]$$

$$\chi^2_{hst} = 6.49[0.37] \quad \text{ARCH(1)=3.80[0.051]} \quad \chi^2_{ff}(1) = 2.74[0.10]$$

In the short run adjustment process, government expenditure is significantly affected by tax revenue and price surge. The error correction term suggests about 36 percent of the disequilibria is adjusted on a yearly basis. The ECM has passed all diagnostic tests with the exception of ARCH test which is marginally significant at 5 percent level of significance. Finally, stability of the parameters is guaranteed in the sample period by the test of CUSUM and CUSUMSQ. See parameter stability test in figure 5.4.

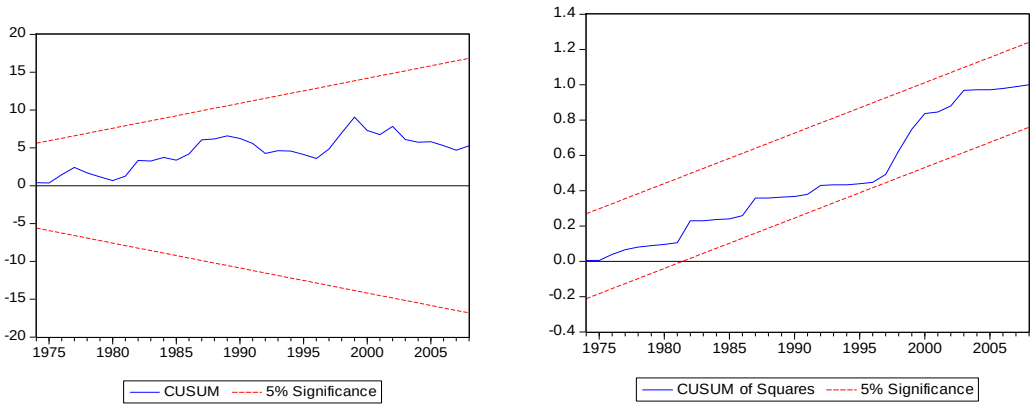


Figure 5.4: Parameter stability test for government expenditure

5.2.1.4 External Sector

5.2.1.4.1 Export Sector

The coefficients that explain the export sector have expected signs and all of them are found to be positive and significant. The long run estimable equation is presented as:

$$\log X = \underset{(1.53)}{-3.15} + \underset{(4.69)***}{0.57}\log RY^{row} + \underset{(7.17)***}{0.72}\log REERI + \underset{(1.70)*}{0.32}\left(\frac{ITOT_t}{RY_t}\right) - \underset{(-2.08)**}{0.13}\,Ddrt + \underset{(4.34)***}{0.40}\,D03$$

$$\bar{R}^2 = 0.95 \quad S.E = 0.15 \quad \text{DW= } 0.99 \qquad \text{T= 39 (1970 - 2008)}$$

In the long run, as income of trading partners to Ethiopia increases the country's export of goods and services increase. Depreciation of the Ethiopian currency (Birr) is associated with an increase in the export which suggests that supply of Ethiopian export is price responsive. The increase in investment to GDP ratio has a significant impact and this might be due to increase in government's huge investment on infrastructure and an increase in the private investment. The other two dummy variables included Ddrt and D03, are drought period and dummy after 2003, respectively. Since Ethiopian exports highly rely on primary commodities, bad weather condition affects the level of export negatively. Dummy, D03, is incorporated in the long run model to reflect the recent expansion in export gained from the expoer diversification of primary crops.

The Error correction Model is estimated after checking the presence of cointegrating relationship among the variables and the variables are found to be cointegrated at 5 percent level of significance, and the error correction model for export equation is estimated as:

$$\Delta \log X = \underset{(3.34)***}{2.20}\ \Delta \log RY^{row} + \underset{(2.89)***}{0.47}\ \Delta \log REERI + \underset{(3.51)***}{0.44}\ \Delta\left(\frac{ITOT_t}{RY_t}\right) - \underset{(-2.80)***}{0.13}\ Ddrt - \underset{(-3.36)***}{0.49}\ \varepsilon(-1)$$

$\bar{R}^2 = 0.64$ $S.E = 0.12$ DW= 1.87 T= 38 (1971 - 2008)

$\chi^2_n(2) = 2.33[0.31]$ $\chi^2_{sc}(1) = 0.001[0.97]$ $\chi^2_{sc}(2) = 1.37[0.50]$

$\chi^2_{hsw} = 12.85[0.61]$ ARCH(1)=0.24[0.62] $\chi^2_{ff}(1) = 1.88[0.17]$

Elasticity between the short run and long run coefficients for income of trade partners and ratio of investment to GDP is higher for the short run adjustment process which suggests demand by the trade partners and investment have greater effect in the short run as compared the long run. Depreciation has greater effect in the long run than a short run adjustment process.

The ECM has passed all diagnostic tests as reported above. The error term found from the long run equation is with the expected negative sign and is also statistically significant at 1 percent level of significance and indicating the speed of adjustment for the disequilibrium in export sector takes almost two years to revert to its long run equilibrium. Stability of parameters is supported in the CUSUM and CUSUMSQ for the entire sample period. The parameter stability test is given in figure 5.5.

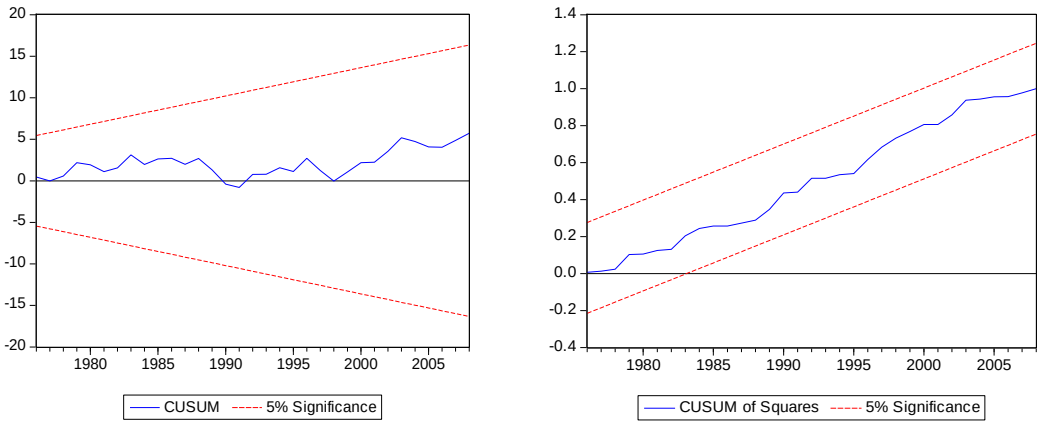


Figure 5.5: Parameter stability test for export

5.2.1.4.2 **Import Sector**

5.2.1.4.2.1 Import of Consumer Goods

Import behavior is modelled by disaggregating into import of consumer goods, and capital and intermediate goods. Import of consumer goods depends on the country's real domestic

income and the capacity to import which is explained by the availability of foreign reserve financed by either from export earning or amount net foreign capital inflow. According to economic theory, real income, foreign exchange gained from foreign earning i.e. from export and net foreign capital inflow has a positive and significant effect on the level of import. The long run equation for import of consumer goods is given by:

$$\log Mcp = \underset{(-3.01)^{***}}{-7.35} + \underset{(2.99)^{***}}{0.88}\log RY + \underset{(4.65)^{***}}{0.57}\log RX + \underset{(1.86)^{*}}{0.06}\log Nfci$$

$\bar{R}^2 = 0.93 \quad S.E = 0.21$ DW= 1.62 T= 39 (1970 - 2008)

A 1 percent increase in the domestic income increases import of consumer goods by 0.88 percent. And as export increases by 1 percent, import of consumer goods increases by 0.57 percent and by 0.06 percent for a 1 percent increase in net foreign capital inflow. A test of cointegration among the variables rejects suggests the presence of long run relationship and the short run adjustment equation is given by:

$$\Delta\log Mcp = \underset{(2.32)^{**}}{1.17}\Delta\log RY + \underset{(2.01)^{*}}{0.34}\Delta\log RX + \underset{(0.27)}{0.006}\Delta\log Nfci - \underset{(-3.44)^{***}}{0.54}\varepsilon(-1)$$

$\bar{R}^2 = 0.30$ $S.E = 0.18$ DW= 1.68 T= 38 (1971 - 2008)

$\chi^2_{n}(2) = 0.21[0.90]$ $\chi^2_{sc}(1) = 0.80[0.37]$ $\chi^2_{sc}(2) = 2.25[0.32]$

$\chi^2_{hsw} = 3.32[0.97]$ ARCH(1)=0.38[0.53] $\chi^2_{ff}(1) = 3.25[0.07]$

In the short run adjustment process, import of consumer goods is more elastic to real income, but factors which determine capacity to import have inelastic elasticity with their expected sign. The responsiveness of import of consumer goods in response to net foreign capital inflow is very inelastic and insignificant in the short run. Real effective exchange rate which has been included in the model identification is found to be statistically insignificant for both long run and short run process and because of this the variable is not include in the final equation of the model. This suggests any devaluation on Ethiopian currency (birr) has no significant effect to this category of import in the sample period considered. This implies this class of commodities do not have domestically produced substitutes which creates the country to be unresponsive to price changes The short-run dynamics of import of consumer goods equation represented by the lagged residual from the long run equation is found to be negative and significant. The error correcting term suggests any disequilibrium that occurs in the import of consumer goods takes roughly almost two years to revert to the equilibrium condition.

The error correction model has passed all the desired diagnostic tests which assure the model is well specified with the correct functional form.

In the long run relationship specification a dummy variable has been included to see whether trade liberalization has an effect on import of consumers assuming behavioral changes on import has changed but this dummy impulse is found to be insignificant and it is excluded from the estimable equation. The stability of the parameters included in the ECM regression is checked using recursive error sum and sum of squares and results are found to be within the 5 percent significance level which attests parameters are stable within the sample period. The test result for stability of parameters is given in figure 5.6 below.

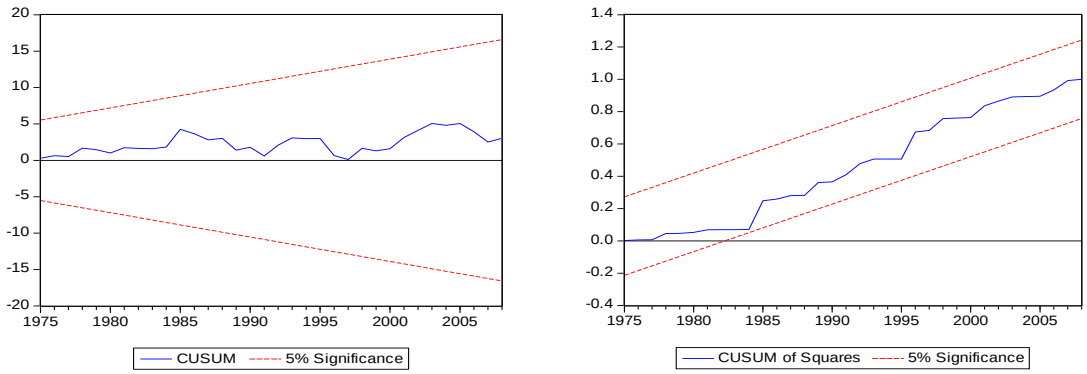


Figure 5.6: Parameter stability test for consumer goods

5.2.1.4.2.2 Import of Capital and Intermediate goods

The long run import intermediate and capital goods estimable equation is specified as a function of income, foreign reserve and price of import and it is given as:

$$\log Mcn = \underset{(-2.52)^{**}}{-6.09} + \underset{(2.06)^{**}}{0.66}\log RY + \underset{(4.54)^{***}}{1.01}\log RX - \underset{(-1.94)^{*}}{0.39}\log REERI + \underset{(1.65)^{*}}{0.05}\log Nfci$$

$$\bar{R}^2 = 0.95 \quad S.E = 0.18 \quad \text{DW= 1.00} \qquad \text{T= 39 (1970 - 2008)}$$

All variables included in the estimable equation are found to be significant **and** with their expected sign. Import of capital and intermediate goods is significantly influenced by availability of foreign exchange or capacity to import and real income of the country. In the long run, a 1 percent increase in real income, foreign earning through export and net capital inflow leads a 0.66, 1.01, and 0.05 percent increase in import of capital and intermediate goods, respectively. The depreciation of the real effective exchange rate by 1 percent

decreases import of capital and intermediate goods by 0.39 for these categories of goods by making import more expensive.

To formulate the error correction model, a linear combination of the variables considered in the long run equation is checked whether they generated stationary series or not. And the residual's ADF test result -5.17 compared to the MacKinnon's critical value (-4.77) shows the rejection of the null hypothesis that no cointegration is found to be significant at 5 percent level of significance and this assures us the presence of long run relationship among the variables investigated. The short run dynamic model is presented as:

$$\Delta \log Mcn = \underset{(2.07)^{**}}{0.76}\ \Delta \log RY + \underset{(1.91)^{*}}{0.74}\Delta \log RY(-1) - \underset{(-1.74)^{*}}{0.67}\ \Delta \log RY(-2) + \underset{(4.29)^{***}}{0.70}\ \Delta \log RX$$
$$- \underset{(1.94)^{*}}{0.29}\Delta \log RX(-1) + \underset{(3.03)^{***}}{0.46}\ \Delta \log RX(-2) \quad + \underset{(1.71)^{*}}{0.41}\quad \Delta \log REERI$$
$$- \underset{(-2.29)^{**}}{0.43}\Delta \log REERI(-2) + \underset{(0.69)}{0.01}\Delta \log Nfci - \underset{(-2.23)^{**}}{0.30}\ \varepsilon(-1)$$

$\bar{R}^2 = 0.78$ $\quad S.E = 0.12$ $\quad$ DW= 1.73 $\quad$ T= 36 (1973 - 2008)

$\chi^2_{n}(2) = 0.56[0.75]$ $\quad \chi^2_{sc}(1) = 0.35[0.55]$ $\quad \chi^2_{sc}(2) = 0.61[0.74]$

$\chi^2_{BGhst} = 7.02[0.53]$ $\quad$ ARCH(1)=0.09[0.76] $\quad \chi^2_{ff}(1) = 0.23[0.63]$

In the short run adjustment equation, contemporaneous change and once lagged real income have positive influence whereas the twice lagged has a perverse impact in the long run. The short run adjustment of export of current and twice lagged export has positive and significant effect, however once lagged export has negative effect on the import of capital and intermediate import goods and services. In the short run net foreign capital inflow has the expected sign but it is insignificant.

The residuals of the error correction model have passed different diagnostic tests as shown in the equation below ECM. From the ECM the error term attests any disequilibria that occur in the import of intermediate and capital goods takes roughly four years to converge to its equilibrium level. The stability of import of intermediate and capital goods is tested using cumulative sum and cumulative sum of squares and figure 5.7 suggests parameters are stable for the sample period considered.

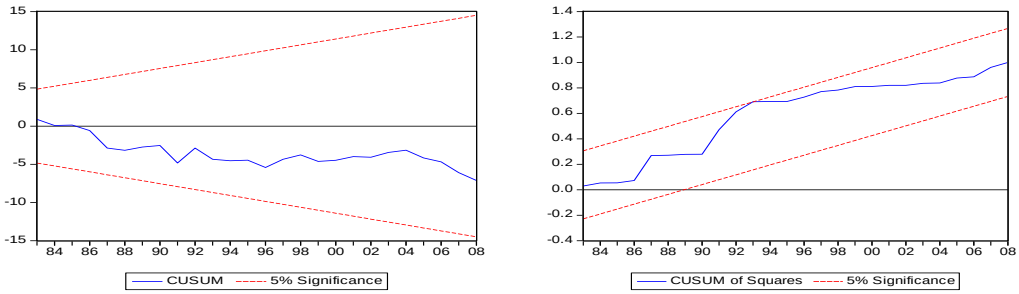


Figure 5.7: Parameter stability test for import of capital and intermediate goods

5.2.1.4.3 Real Effective Exchange Rate

In the identification of Real Effective Exchange Rate Index (REERI) estimable equation we have variables with mixed level of integration hence using Engle-Granger two step is not feasible since the approaches relies on variables having the same level of integration in particular integrated of level one. Thus we have used a method that got currency when the level of integration is mixed, i.e. having integrated level of order one and stationary at level. As shown in table 5.1, the variable EXCREDITF is stationary at level and other variables considered in this estimable equation are of integrated order one. To get the appropriate estimable equation, first the conditional error correction model based on AIC or BIC is estimated so as to test the presence of long run relationship among variables considered and to select the appropriate lag length following the technique recommended by Pesaran *et al*(1999,2001).

The selected unconditional error correction model is ARDL (1,2,0,2)[70], with variables in the sequence of logarithmic form of real effective exchange rate, terms of trade ,degree of openness and excess credit. The unconditional error correction is given in annex 3 and the lagged level variables are used to check the presence of long run relation using Wald statistics. It can be tested by hypothesizing that the coefficient of the lag variables is equal to zero. Using the F statistics found from Wald test and a non standard F bound statistics generated by Pesaran *et al* (2001), we infer presence of long run relationship among the variables considered. The F- statistics found from the Wald statistics is 8.52 and F statistics of Pesaran *et al* (2001) table at 1 percent level of significance has a bound value of [4.29, 5.61].

[70] Models estimated using ARDL are done using Microfit version 4

Since calculated Wald F statistics is greater than higher bound of Pesaran *et al* (2001) tabulated value we infer there is long run relationship among variables considered. The long run estimable equation is given by:

$$\log REERI = \underset{(-1.72)^{*}}{-1.84} + \underset{(3.96)^{***}}{0.74}\log Tot + \underset{(5.06)^{***}}{0.65}\log Open - \underset{(-1.72)^{*}}{0.77}\log ExDC + \underset{(4.46)^{***}}{0.63}\, Ddv$$

Equilibrium real exchange rate model shows real effective exchange rate deprecates due to increase in terms of trade and degree of openness. However, excess domestic credit leads to appreciation in real effective exchange rate in the long run. The reason attached to this argument is as there is excess domesic credit, it will be followed by inflation and this results in appreciation of domestic currency. And dummy variable, *Ddv*, is for the period where the nominal exchange rate is determined through floating exchange rate regime (managed float) i.e. since 1992.

The short run adjustment error correction model is given by:

$$\Delta\log REERI = \underset{(2.62)^{**}}{-0.22}\Delta\log Tot + \underset{(4.40)^{***}}{0.44}\Delta\log Open + \underset{(2.85)^{***}}{0.16}\Delta\log ExDC(-1) + \underset{(4.51)^{***}}{0.35}\, Dddv - \underset{(-3.65)^{***}}{0.24}\, D96 - \underset{(-8.27)^{***}}{0.49}\,\varepsilon(-1)$$

$\bar{R}^2 = 0.84$ $\quad S.E = 0.06$ $\quad$ DW= 1.40 $\quad$ T= 36 (1973 - 2008)

$\chi^2_{n}(2) = 2.63[0.27]$ $\quad \chi^2_{sc}(1) = 3.11[0.08]$ $\quad \chi^2_{sc}(2) = 3.24[0.20]$

$\chi^2_{hst} = 12.95[0.37]$ $\quad$ ARCH(1)=2.96[0.09] $\quad \chi^2_{ff}(1) = 0.66[0.42]$

In the short run dynamics model, improvement in terms of trade leads to the appreciation of Ethiopian currency. This suggests in the short run, income effect dominates the substitution effect whereas in equilibrium the reverse holds, and hence a rise in terms of trade appreciates real effective exchange rate. A change in excess domestic credit with lag of one period has depreciation impact on real exchange rate. And another dummy impulse is included by watching the recursive errors generated for the year 1996. Disequilibrium from the long run real effective exchange rate of the local currency explained by the lagged residual, $\varepsilon(-1)$, suggesting that any deviation that happened in any given year roughly takes two years to revert to equilibrium position. The residual found from the short run dynamic model are evaluated using different tests and they have passed all diagnostic tests. And stability of parameters is tested using CUSUM and CUSUMSQ and it is shown in figure 5.8.

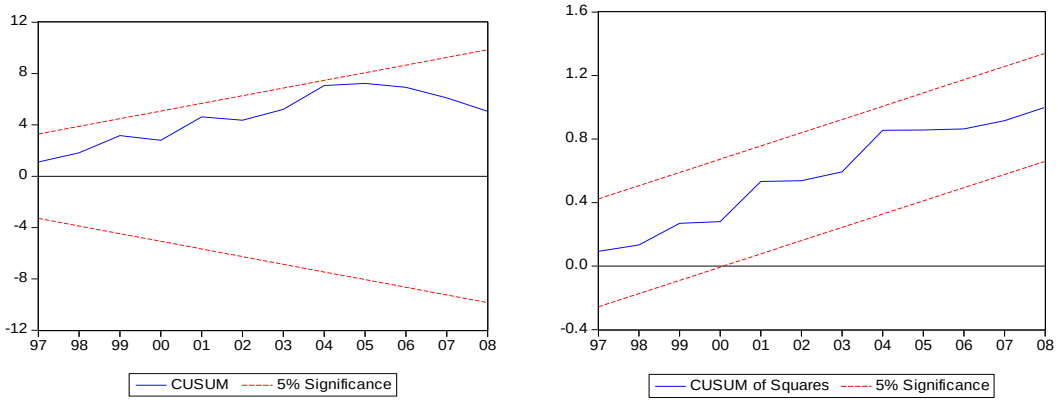


Figure 5.8: Parameter stability test for government expenditure

In the specification of real effective exchange rate, net foreign capital inflow has been included in the model identification but it is found to be insignificant both in the short run and long run thus it is not included in the model.

5.2.2 Monetary Sector

5.2.2.1 Narrow Money Demand

Monetary sector is modeled using equations for narrow money and quasi money (time and saving deposit). In the modelling, we used the Pesaran *et a*l (2001) ARDL method since we have mixed level of integration for the variables hypothesized to affect narrow and quasi money demand in the long run. The variables included are national economic activity proxied by GDP, inflation rate, parallel market exchange rate and the interest rate of treasury bill of 3 months. But interest rate is found to be insignificant to influence narrow money balance in equilibrium. The other variables are found to be significant and the long run narrow money balance is estimated to using ARDL approach and the selected model is ARDL (2, 0, 1, 0) in the order of narrow money, GDP, inflation and parallel exchange rate. And the long run estimable equation is given by:

$$\log RM1 = -1.82 + \underset{(2.90)^{***}}{0.94}\log RY - \underset{(-2.22)^{**}}{0.04}\pi + \underset{(2.40)^{***}}{0.59}\log BEX$$

The equilibrium model shows demand for narrow money is positively related to real income and parallel market exchange rate, but negatively to inflation rate. The main determinant for the demand for narrow money is real income followed by depreciation of parallel market foreign exchange and inflation.

The short run dynamic model shows similar kind of relationship like that of the long run relationship. The included dummy variable, *Dum74*, shows the political instability the country has faced and this has lessened demand for narrow money. The one lagged residual found from the long run relationship shows any disequilibrium that occurred in the demand to narrow money clears only 29 percent of the disequilibrium in a yearly basis. The short run dynamic model for narrow money is given by:

$$\Delta \log RM1 = \underset{(-4.82)^{***}}{-0.42}\ \Delta \log RM1(-1) + \underset{(1.63)}{0.28}\Delta \log RY - \underset{(-5.40)^{***}}{0.005}\ \Delta\pi + \underset{(3.44)^{***}}{0.33}\ \Delta \log BEX - \underset{(-4.87)^{***}}{0.44}\ Dum74 - \underset{(-8.80)^{***}}{0.29}\ \varepsilon(-1)$$

$\bar{R}^2 = 0.86$ $S.E = 0.05$ DW= 1.50 T= 34 (1975 - 2008)

$\chi^2_{n}(2)$ = 1.42[0.49] $\chi^2_{sc}(1)$ = 1.18[0.28] $\chi^2_{sc}(2)$ =3.34[0.18]

χ^2_{BGhst} = 14.94[0.19] ARCH(1)=0.33[0.57] $\chi^2_{ff}(1)$=13.15[0.003]

The error correction model has passed all adequacy tests except RESET tests. The failure to this might be due incorrect functional form. And finally, stability of parameters is checked through CUSUM and CUSUMSQ and shown in figure 5.9.

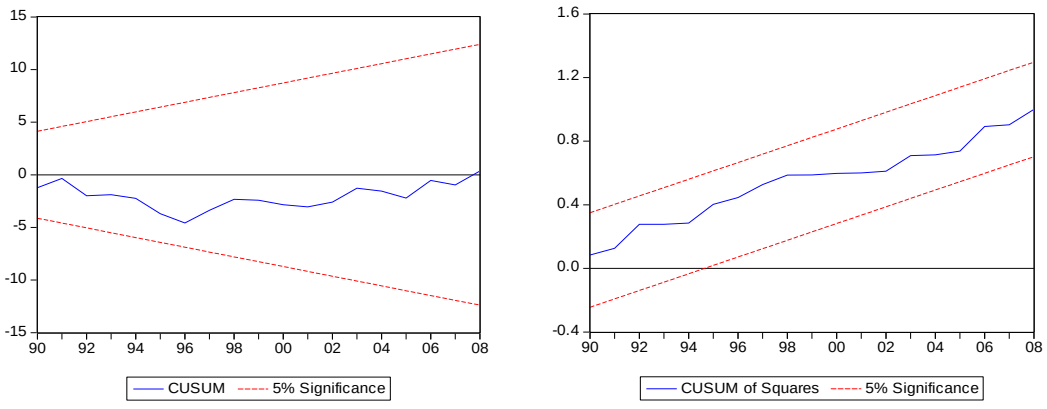


Figure 5.9: Parameter stability test for narrow money demand

5.2.2.2 Quasi Money demand

The long run equation is identified following ARDL technique and the model is selected from $4^4 = 256$ equations by giving lags from 0 to 3 for all variables considered in the quasi money equation. And the model selected that minimizes the Schwartz criterion is ARDL(3 , 2, 1, 2)

for variables in the order of RMQ, RY, time and saving deposit rate and inflation rate. The long run equation is given by:

$$\log RMQ = \underset{(9.41)^{***}}{4.12}\log RY + \underset{(3.01)^{**}}{1.32}\log rtsd - \underset{(-4.57)^{***}}{0.09}\pi - \underset{(-7.68)^{***}}{37.85}$$

The existence of long run relationship is checked using the unrestricted error correction model following the steps recommended by Pesaran *et al* (2001). And short run dynamic model is given by:

$$\Delta\log RMQ = \underset{(-1.76)^{*}}{-0.26}\Delta\log RMQ(-1) + \underset{(0.47)}{0.17}\Delta\log RY - \underset{(-5.31)^{***}}{0.01}\Delta\pi - \underset{(-4.77)^{***}}{0.12}\varepsilon(-1)$$

$\bar{R}^2 = 0.47$ $S.E = 0.16$ DW= 1.92 T= 37 (1972 - 2008)

$\chi^2_n(2) = 46[0.00]$ $\chi^2_{sc}(1) = 0.02[0.89]$ $\chi^2_{sc}(2) = 0.15[0.93]$

$\chi^2_{hst} = 23.18[0.19]$ ARCH(1)=15.17[0.57] $\chi^2_{ff}(1) = 9.33[0.00]$

In the short run dynamics time and saving deposit rate does not have a significant effect. And the change in contemporaneous quasi money is affected by the previous year change of its own lag positively and a one percent change in inflation is followed by about a 0.01 percent change of quasi money. And the error correction term tells once a shock has happened in the quasi money, only 12 percent of the disequilibria is reverted to its long run level. The short run dynamic model for quasi money only passes a test related to serial correlation otherwise there is problem on the normality and heteroskedasticity test of the residuals found from the error correction model.

5.2.3 Aggregate Supply

5.2.3.1 Agriculture Production Function

Agriculture production function is estimated using ARDL model since mixed level of integration are found for variables that are hypothesized to affect the agriculture value added in the long run. The model is chosen based on the AIC, and the selected model is ARDL (2, 1, 1, 0) in the order of agricultural output, change in capital stock, agricultural labour force, and amount of rainfall. The presence of long run relationship is tested by producing unrestricted error correction model and testing lagged values of the variables considered in the functional form of agricultural output. The Wald F-statisics is found to be 4.11 and at 10 percent significance level which has the minimum bound for I(0) , 2.72 and the higher bound I (1)

3.77. From the result, we have an F-value greater than the higher bound which leads us to reject the null hypothesis of no cointegartion among the variables.

Agriculture output is affected significantly by labour force engaged in agriculture sector and availability of rainfall. However, the impact of change in capital stock is not significant[71]. The equilibrium agricultural output is given by:

$$\log Yagg = \underset{(1.43)}{4.83}\Delta\log Kagg + \underset{(8.22)***}{0.88}\log Lagg + \underset{(1.94)*}{0.26}\log rain - \underset{(-1.92)}{0.13}$$

The short run dynamic model is presented as:

$$\Delta\log Yagg = \underset{(0.51)}{0.87}\Delta^2\log Kagg - \underset{(-3.37)***}{3.40}\Delta\log Lagg + \underset{(2.10)**}{0.16}\Delta\log rain - \underset{(-4.89)***}{0.20}Dout - \underset{(-4.80)*}{0.38}\varepsilon(-1)$$

$$\bar{R}^2 = 0.58 \qquad S.E = 0.06 \qquad \text{DW= 1.52} \qquad \text{T= 37 (1972 - 2008)}$$

$$\chi^2_{n}(2) = 2.21[0.33] \qquad \chi^2_{sc}(1) = 1.88[0.17] \qquad \chi^2_{sc}(2) = 1.92[0.38]$$

$$\chi^2_{hst} = 9.03[0.70] \qquad \text{ARCH(1)=0.195[0.66]} \qquad \chi^2_{ff}(1) = 0.001[0.97]$$

In the short run, the rate of change in capital stock is insignificant and the change in agricultural labour force has an elastic coefficient that affects agricultural output negatively and significantly. Which implies the change in the amount of capital stock, in this case the amount of land, ox, and other machines, do not have significant effect to add agriculture value added in the short run. For the labour force employed in agriculture sector, there is diminishing return to total value added. Rainfall has a positive and significant impact in the short run dynamics too. The impulse dummy represents periods with high drought, these were 1984 and 2002.

The short run dynamic equation is tested for model adequacy and stability of parameters. The model has passed all tests and the results are given below the ECM, and the stability of parameters is done using CUSUM and CUSUMSQ, and they are shown in figure 5.10.

[71] It is significant at higher level of significance level (i.e. with p- value of 0.163)

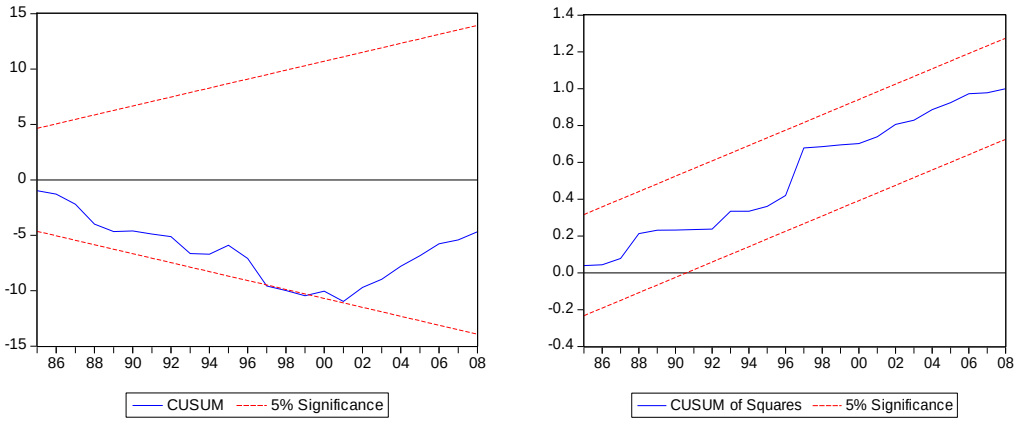


Figure 5.10: Parameter stability test for agriculture production

5.2.3.2 Non-Agricultural production Function

The long run non agriculture production function is estimated using the Engle- Granger two step method since all the variables included are of I(1). To check the presence of long run relationship among variables the residual found from the long run estimable equation is tested for presence of unit root and an ADF statistics -4.43 is compared with Mackinnon's 10 percent respose surface values of -4.40 and hence we reject null hypothesis of no long run relationship among the variables at 10 percent level of significance. The equilibrium non agricultural output is significantly and positively affected by the change in non agriculture capital stock, labour force, agricultural output and the import of intermediate and capital goods. However, the dummy variable which holds the change in government's policy is found to be negative which shows existing government has performed negatively in terms of increasing the performance of non agricultural output though the coefficient of the dummy variable is very minimal. The long run estimable equation is given by:

$$\log Yn = \underset{(5.54)^{***}}{9.97}\ \Delta\log Kn + \underset{(7.79)^{***}}{0.65}\ \log Ln + \underset{(9.21)^{***}}{0.34}\ \log Ya + \underset{(4.32)^{***}}{0.12}\ \log Mcn - \underset{(-2.79)^{***}}{0.06}\ Dg$$

$$\bar{R}^2 = 0.98 \quad S.E = 0.07 \qquad \text{DW= 1.24} \qquad \text{T= 38 (1971 - 2008)}$$

In the short run dynamics, the change in non agricultural output is significantly affected by nonagricultural capital stock to a higher extent followed by change in non agriculture labour force and value added of agriculture and finally by import of intermediate and capital goods. The error correction term is found to be significant 5 percent level of significance and it

suggests 28 percent of the disequilibrium that resulted from any shock clears in a year. And the short run dynamic model is given by:

$$\Delta \log Yn = \underset{(3.37)^{***}}{4.72}\ \Delta^2 \log Kn + \underset{(2.09)^{**}}{3.51}\ 71\Delta^2 \log Kn(-1) + \underset{(2.93)^{***}}{0.79}\ \Delta \log Ln + \underset{(2.56)^{**}}{0.17}\ \Delta \log Ya + \underset{(3.03)^{***}}{0.11}\ \Delta \log Mcn - \underset{(-2.77)^{***}}{0.28}\ \varepsilon(-1)$$

$\bar{R}^2 = 0.36$ $S.E = 0.05$ DW= 1.64 T= 36 (1973 - 2008)

$\chi^2_n(2) = 0.96[0.61]$ $\chi^2_{sc}(1) = 0.54[0.46]$ $\chi^2_{sc}(2) = 0.63[0.72]$

$\chi^2_{hsw} = 27.37[0.16]$ ARCH(1)=0.78[0.38] $\chi^2_{ff}(1) = 0.21[0.64]$

The model has passed all adequacy test and the parameters are found to be stable in the sample period considered for the study. And the test for the stability of parameters is given figure 5.11.

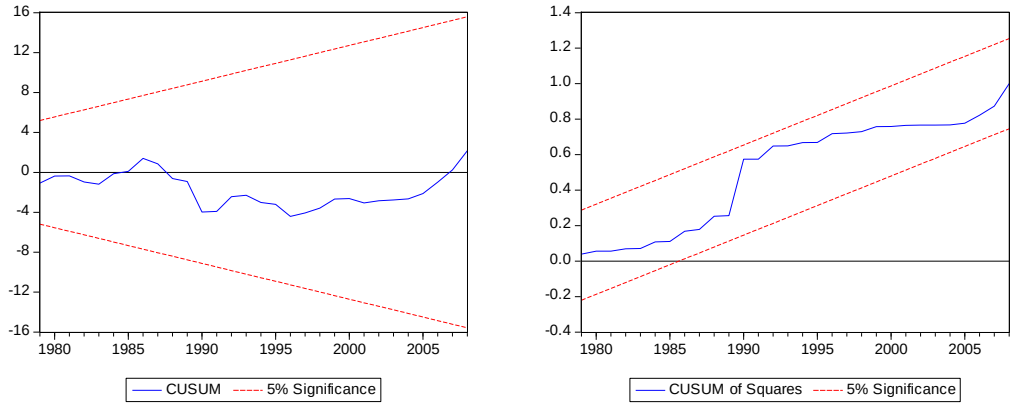


Figure 5.11: Parameter stability test for non agriculture production

5.2.4 Price Sector

5.2.4.1 Producers Price

In the estimable equation of producer price the linear combination of variables considered generate a stationary process which assures presence of long run relationship among variables considered. The ADF statics, -5.02, found from the unit root test having a constant is used to test the presence of cointegration by comparing with Mackinnon's critical surface value of -4.38 and it is found to be significant at 5 percent level of significance and the result assures us the variables considered are found to be cointegrated. In the long run, producer price is

highly influenced in the order of capacity utilization, import price, wage and drought, *Dpout.* All variables considered contribute to hike producer price and they are found to be significant at 1 percent level of significance. The long run estimable equation is given by

$$\log p = \underset{(-4.61)***}{-2.26} + \underset{(13.99)***}{0.53}\log imp + \underset{(4.84)***}{0.19}\log wage + \underset{(4.39)***}{0.64}\log cu + \underset{(3.93)***}{0.34}\, Dpout$$

$$\bar{R}^2 = 0.97 \quad S.E = 0.11 \qquad \text{DW= 1.67} \qquad \text{T= 39 (1970 - 2008)}$$

Producers price is expected to increase as economies capacity to utilization increases i.e.as there is a one percent change in capacity utilization then it is expected to increase the producers price by 0.64 percent. And also, since most of the intermediate commodities that are used for the production process are imported, a unit change in the price of imported commodities is expected to increase the level of producer's price by 0.53 percent while other things are remaining constant. When wage amount increases it expected to increase producer's price since producers price is a mark up over wage. Hence from our long run producers price equation a one percent change in wage is expected to increase producers price by 0.19 percent. The error correction model for producer price is given by:

$$\Delta\log p = \underset{(3.54)***}{0.35}\,\Delta\log p(-1) + \underset{(2.22)**}{0.28}\,\Delta\log p(-2) + \underset{(2.97)***}{0.15}\,\Delta\log imp + \underset{(1.44)}{0.08}\Delta\log wage - \underset{(-1.96)*}{0.28}\,\Delta\log cu + \underset{(5.51)***}{0.81}\,\Delta\log cu(-2) + \underset{(3.01)***}{0.45}\,\Delta\log cu(-4) + \underset{(5.19)***}{0.199}\, Dpout - \underset{(-2.79)***}{0.27}\,\varepsilon(-1)$$

$$\bar{R}^2 = 0.69 \qquad S.E = 0.05 \qquad \text{DW= 1.82} \qquad \text{T= 34 (1975 - 2008)}$$

$$\chi^2_{n}(2) = 2.36[0.31] \qquad \chi^2_{sc}(1) = 0.16[0.69] \qquad \chi^2_{sc}(2) = 0.37[0.83]$$

$$\chi^2_{BGhst} = 1.34[0.99] \qquad \text{ARCH(1)=0.27[0.61]} \qquad \chi^2_{ff}(1) = 4.33[0.04]$$

$$F_{ff}(1,24) = 3.26[0.08]$$

In the short run adjustment process, the change in current producer price got a feedback effect from the first and second period lag of its own. Short run elasticity's are found to be less than their long run values for import and the drought impulse dummy. The effect of wage on producer price is found to be insignificant in the short run adjustment process, this in line with Keynesians wage rigidity hypothesis. As observed from the ECM the effect of capacity utilization goes back up to the fourth lag and it affects producer price in its second and fourth lags but decreases with its contemporaneous change.

The ECM residuals had passed all diagnostic tests and they have pledged the model is correctly specified. The error correction term shows the speed of adjustment put forward that

once the producer price has shifted from the equilibrium and speed of adjustment is relatively slow to revert to its equilibrium. In other words, it suggests once a shock has happened in the producers price it takes about four years to clear the disequilibria. And finally, the stability of parameters is checked using the recursive error sum and sum squares using the CUMSUM and CUSUMSQ tests and the parameters are found to be stable for the period of study. The tests for these parameters are depicted in figure 5.12.

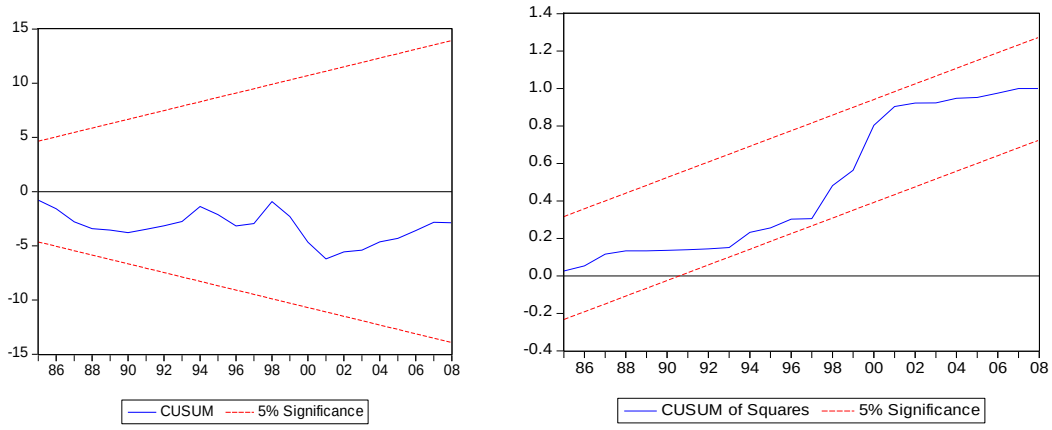


Figure 5.12: Parameter stability test for producer price

5.2.4.2 Consumer Price Function

The variables included in the specification of consumer estimable equation are integrated of order one and their linear combination gives a stationary relationship. The long run estimable equation is given by

$$\log cpi = \underset{(6.34)***}{0.36}\log imp + \underset{(4.81)***}{0.57}\log p + \underset{(4.70)***}{0.17}\log ED - \underset{(-8.49)***}{0.396}\log REERI + \underset{(2.26)**}{0.13}\log Dc$$

$$\bar{R}^2 = 0.99 \quad S.E = 0.08 \qquad \text{DW= 1.13} \qquad \text{T= 39 (1970 - 2008)}$$

In the long run, consumer price is expected to increase because of the hike in domestic producer price, import price, excess demand and domestic credit expansion. However, real effective exchange rate depreciation is found to have a negative effect on the development of consumer price which is unusual in many economies. However, this phenomenon is also reflected in transition and developing economies for instance in Croatia[72] due to "fear of floating". This means monetary policy reacts excessively to depreciation pressures thus

[72] (see Vizek, 2007)

causing price contractions. Generally, inflation that occurs in Ethiopia is affected by domestic and foreign factors and also by monetary factors.

In the short run adjustment process, elasticity to the case of domestic producers and import prices is less than the corresponding long run counterpart whereas for supply of domestic credit the elasticity is more than twice. This suggests expansion of domestic credit has higher influence to aggravate inflation in the short run. Excess demand is found to be significant after a lag of 2 years in the short run adjustment process. Also a change in consumer price after lag 3 has an effect on the current change in consumer price which tells inflation inertia that surges in the economy takes three years has to leave its place for current change in inflation. The error correction model for consumer price estimable equation is presented as:

$$\Delta \log cpi = \underset{(2.99)***}{0.275}\,\Delta \log cpi(-3) + \underset{(3.45)***}{0.135}\,\Delta \log imp + \underset{(4.04)***}{0.422}\,\Delta \log p + \underset{(2.28)**}{0.912}\,\Delta \log ED(-2)$$
$$- \underset{(-4.49)***}{0.283}\,\Delta \log REERI + \underset{(4.54)***}{0.281}\,\Delta \log Dc - \underset{(-3.092)***}{0.153}\,D97 - \underset{(-5.06)***}{0.77}\,\varepsilon(-1)$$

$\bar{R}^2 = 0.85$ $S.E = 0.04$ DW= 1.99 T= 35 (1974 - 2008)

$\chi^2_n(2) = 1.25[0.54]$ $\chi^2_{sc}(1) = 0.41[0.51]$ $\chi^2_{sc}(2) = 0.87[0.65]$

$\chi^2_{hst} = 6.25[0.62]$ ARCH(1)=2.29[0.13] $\chi^2_{ff}(1) = 2.17[0.14]$

The error correction term has got its correct sign and any disequilibrium that resulted from a shock clears 77% of the disequilibria in a single year. In the short run adjustment process, impulse dummy is included after watching the recursive sum of errors in 1997 which has a significant effect in lessening the change in consumer price. The ECM has passed all relevant diagnostic tests and stability of parameters checked using CUSUM and CUSUMQ test are depicted in figure 5.13.

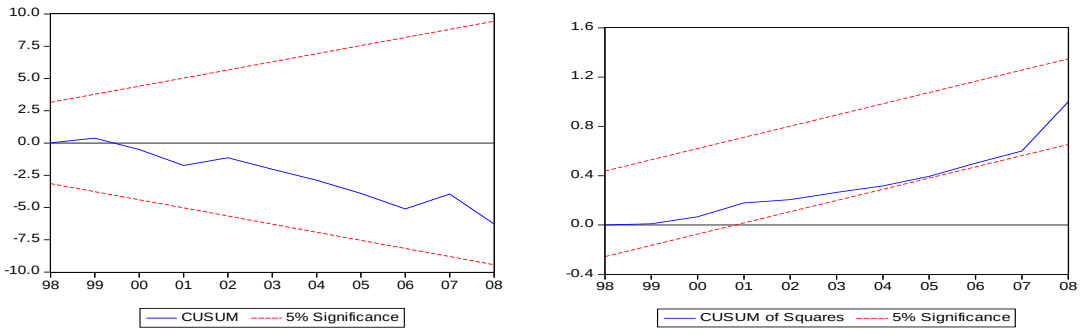


Figure 5.13: Parameter stability test for consumer price

6 MODEL EVALUATION AND COUNTER FACTUAL SIMULATION

6.1 Introduction

In the previous chapter, we have discussed subsystems of the model that give us the full system. In this chapter, we explain how the model as a full system performs and selected simulation experiments.

Following Challen and Hagger (1983) and Pindyck and Rubinfield (1991) suggestion, statistical and theoretical criteria satisfied by individual equation does not necessarily mean that solving all equations simultaneously represents a reliable full model. Thus testing the reliability of the model whether it tracks historical time path of endogenous variables generated and the ability to forecast should be evaluated.

Large econometric models of current days that are used in forecasting and simulation purposes are generally highly simultaneous and log-linear in their functional form. Though models are linear in logarithm, solutions are solved using non-linear solution techniques. Here, we have applied the same technique and functional form **àla with** other models. The algorithm used for solving simulation model is the class of Gauss-Sidel method. This algorithm is an iterative algorithm which solves each equation in the model for the values associated with endogenous variables, treating all other endogenous variables as fixed.[73]

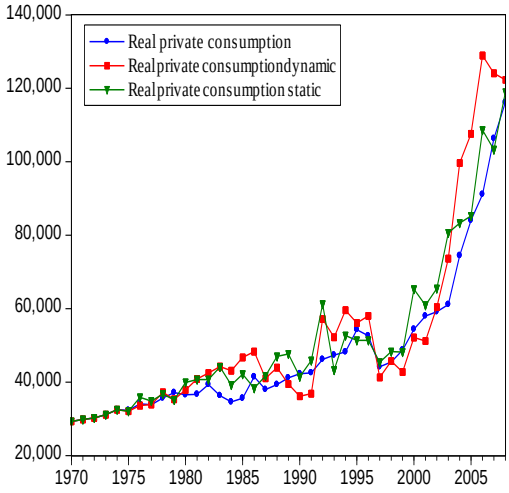
6.2 Tracking Performance of the Model

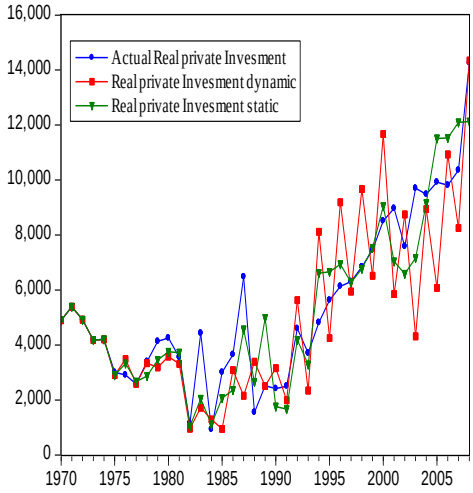
The model's performance in terms of tracking historical time paths of endogenous variables is done using with-in-sample tracking performance of the model. Graphical presentation is used to indicate the ability of the model to track historical data. The variables considered are real variables taking 1999/00 as a base year. Endogenous variables considered are private consumption, private investment, tax revenue, government recurrent expenditure, export of goods and services, import of intermediate and capital goods, import of consumer goods, real effective exchange rate, real demand for narrow money , real quasi money, agriculture value added, non agriculture value added, producers price, consumer price index and finally real gross domestic product. Figure 6.1 shows actual, static and dynamic solution for the variables

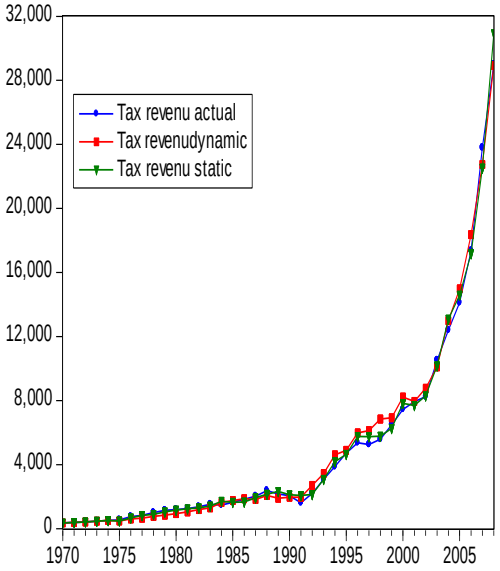
[73] (see Eviews user manual for version 6).

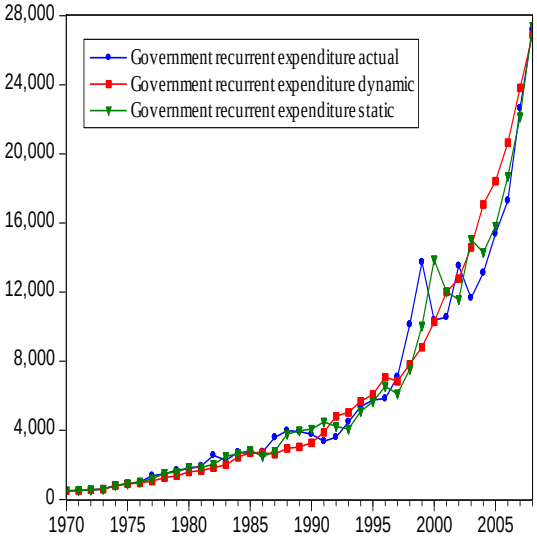
considered. The model is solved for the period starting from 1975 up to 2008 due to the lagged variables up to forth lag in the ECM constructed in the model.

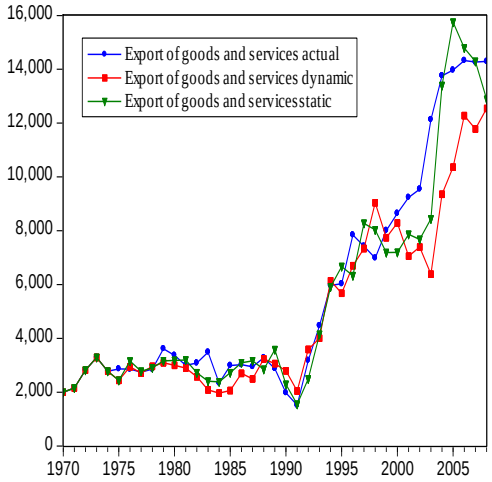
Figure 6.1: Actual, dynamic and static simulation of selected variables







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Export of goods and services dynamic
Export of goods and servicesstatic
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10,000
8,000
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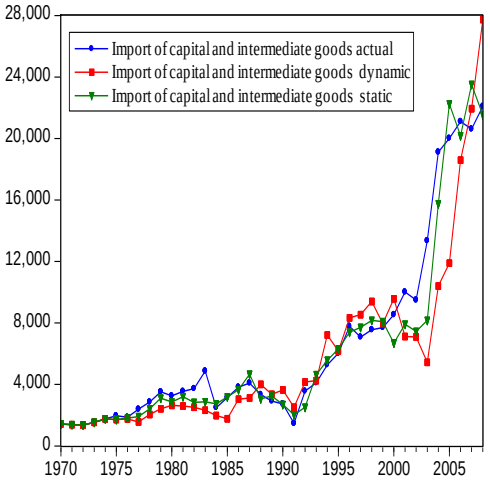
4,000
2,000
0
1970
1975
1980
1985
1990
1995
2000
2005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Import of capital and intermediate goods dynamic
Import of capital and intermediate goods static
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16,000
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4,000
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1970
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1985
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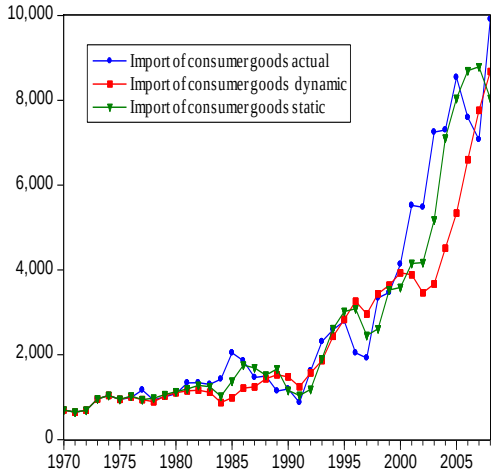
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Import of consumergoods dynamic
Import of consumergoods static
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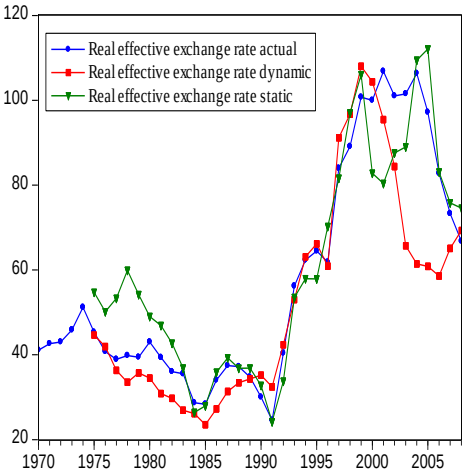
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Real effective exchange rate static
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1975
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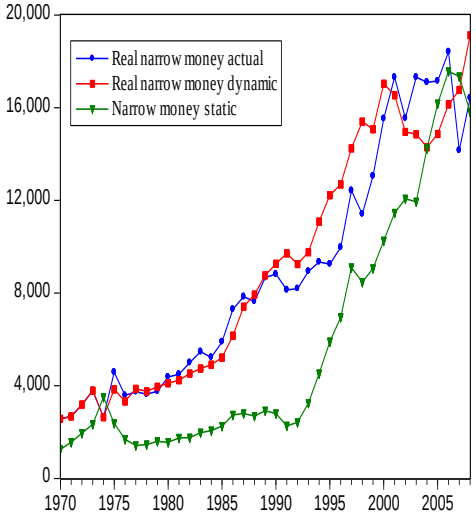
2000
2005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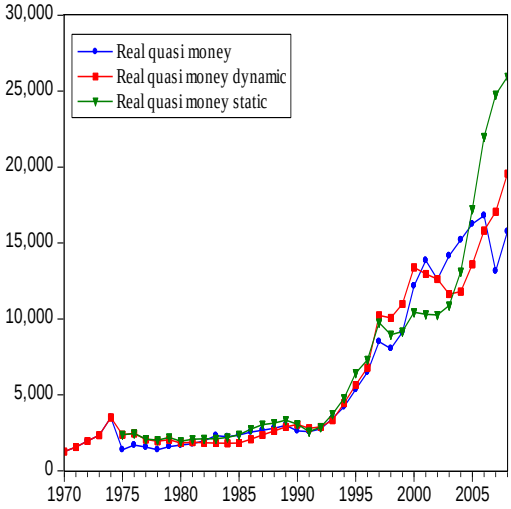
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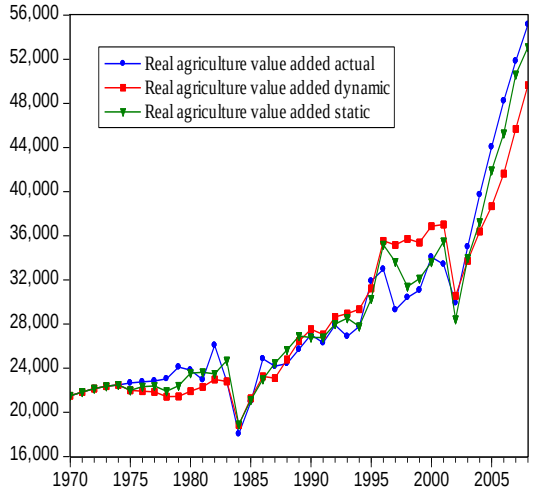
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Real agriculture value added dynamic
Real agriculture value added static
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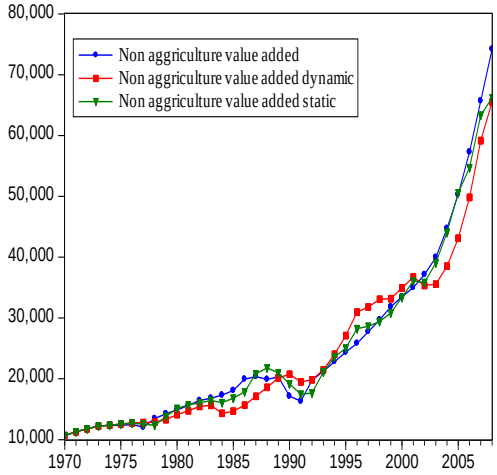
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Non aggriculture value added static
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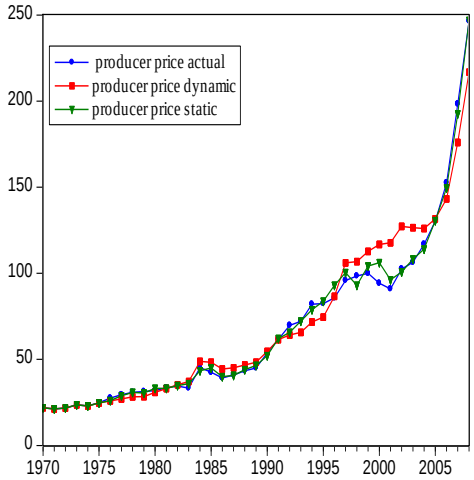
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producer price static
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1995
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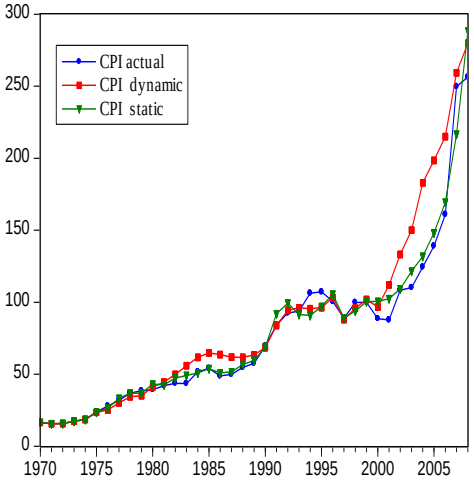
2005


CPI actual
CPI dynamic
CPI static
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100
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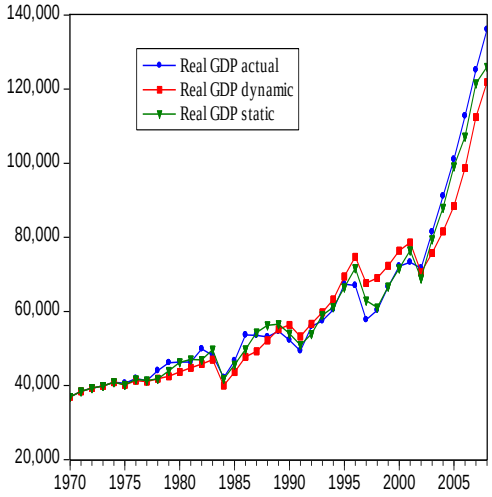
2000
2005



From the above figure we can infer both static and dynamic solutions are close to the historical data for most variables though high deviation is observed in the demand for narrow money equation between the static solution and actual value. But for other variables the model successfully tracks endogenous behavior of variables at a reasonable degree of accuracy.

The standard procedure for evaluating how well a model fits data is to solve the model by performing a dynamic, deterministic simulation[74] and making a comparison with the predicted values of the endogenous variables and actual values (Fair, 1994) . The criterion that are most frequently used to evaluate tracking performance of a given model are: Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Root Mean Square Percentage Error

[74] When the simulation is "deterministic" the expected values of the error terms are assumed to be zero, and in most cases the error terms are set to zero for a deterministic solution (Fair, 1994).

(RMSPE), and Theil's inequality coefficient (U).[75] Except the first statistic, which depends on scale of measurement, the rest are unit free. In most cases, unit free statics are preferable (see Pindyck and Rubinfield, 1991; Challen and Hagger,1983).

To compute these statistics, the model is first solved using dynamic system solutions starting from 1975 to 2008. The system is solved simultaneously period by period with the solution values found from the previous periods being used as lagged values to subsequent periods.[76] The summary statics for selected endogenous variables is reported in table 6.1.

The result from the table suggests maximum MAPE is around 7 percent for real GDP whereas for the rest it is less than 4 %; RMSPE for all variables is less than 1 percent. These results also suggest the model has traced endogenous variables adequately.

In addition, Theil's inequality coefficient is further decomposed into bias, variance and covariance proportions. According to Pindyck and Rubinfield (1991) the bias proportion informs how far the mean of the forecast is from the mean of the actual series. The variance proportion shows how far the variation of the forecast is from the variation of the actual series and the covariance proportion measures the remaining unsystematic forecasting errors. The main implication out of decomposition is if the forecast is "good" then the bias and variance proportion will be small and most of the bias would be unsystematic.[77] Table 6.2 gives bias, variance and covariance proportion of endogenous variables.

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[75]

$$MAE = \frac{1}{T}\sum_{t=1}^{T}|\hat{Y}_t - Y_t|$$

$$MAPE = \frac{1}{T}\sum_{t=1}^{T}\left|\frac{\hat{Y}_t - Y_t}{Y_t}\right|$$

$$RMSPE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\frac{(\hat{Y}_t - Y_t)^2}{Y_t^2}}$$

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(\hat{Y}_t - Y_t)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(\hat{Y}_t)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}Y_t^2}}$$

where $\hat{Y}_t$ is the simulated value at time t and T is the sample size.

[76] (for detail discussion see Fair, 1994).

[77] The informative decomposition of Theil's inequality coefficient is not accepted universally (see Watson and Teelucksingh (2002), P.138 - 140)

Table 6.1: Dynamic simulation accuracy of stochastic variables (1975 to 2008)

Variable Name	MAE	MAPE	RMSPE	U
Real Private Consumption	0.119	1.09%	0.02%	0.007
Real private Investment	0.321	3.83%	0.28%	0.026
Tax Revenue	0.121	1.60%	0.04%	0.009
Government Current Expenditure	0.155	1.84%	0.05%	0.011
Real export of goods and services	0.175	2.05%	0.07%	0.014
Real import of Consumer goods	0.284	3.32%	0.17%	0.021
Real import of capital goods	0.224	2.86%	0.15%	0.020
Real Effective Exchange Rate	0.154	3.87%	0.25%	0.026
Demand for Narrow Money	0.118	1.29%	0.02%	0.008
Demand Quasi Money	0.162	1.99%	0.06%	0.012
Agriculture Output	0.097	0.96%	0.01%	0.006
Non-Agriculture output	0.070	0.67%	0.01%	0.004
Producer price Index	0.091	2.16%	0.06%	0.013
Consumer price index	0.125	2.91%	0.14%	0.019
Real GDP	4730.12	6.68%	0.62 %	0.047

Though there is less number of literatures discussing on what should be the expected maximum U-statistics and proportion value of the decomposed values, in this model we have found a Theil's inequality coefficient that is less than 0.05.[78] And with regard to the decomposition, about 65% of endogenous variables have a bias less than 10 percent but for real private consumption, export of goods and services, real effective exchange rate and consumer price index the proportion of bias is found to be between 20 and 25 percent. The variance proportion is below ten percent for 80 percent of the cases and most of the variation has concentrated in the unsystematic component of the decomposition i.e. for about 85 percent of the cases more than 70 percent of the forecast error is found to be captured by covariance proportion and for the rest it is found to be above 60 percent.

[78] Oshikoya (1990) has suggested Theil's inequality coefficient less than 0.3 are not considered to be large values.

Table 6.2: Forecasting Evaluation using Theil's Inequlity coefficient decomposition

Variable Name	U	bias	variance	covariance
Real Private Consumption	0.007	0.24	0.15	0.61
Real private Investment	0.026	0.06	0.01	0.93
Tax Revenue	0.009	0.01	0.29	0.69
Government Current Expenditure	0.011	0.05	0.17	0.78
Real export of goods and services	0.014	0.21	0.07	0.72
Real import of Consumer goods	0.021	0.14	0.00	0.86
Real import of capital goods	0.020	0.13	0.04	0.83
Real Effective Exchange Rate	0.026	0.25	0.00	0.74
Demand for Narrow Money	0.008	0.02	0.08	0.91
Demand Quasi Money	0.012	0.05	0.01	0.94
Agriculture Output	0.006	0.05	0.01	0.94
Non-Agriculture output	0.004	0.01	0.01	0.99
Producer price Index	0.013	0.05	0.02	0.93
Consumer price index	0.019	0.29	0.09	0.61
Real GDP	0.047	0.04	0.24	0.72

6.2.1 Dynamic Counter Factual Simulation

Simulation exercises are undertaken for fiscal, monetary and external shocks. The experiments are taken by making a continuous change from 1992 to 2008 for shock variables. The impact changes of these variables are presented in the form of percentage deviation from the base run of the model.

6.2.1.1 Fiscal Policy Shock

Fiscal policy shock is done by changing government investment as a shock variable. In this scenario, simulation is done by increasing government by10 percent staring from 1992 to 2008. The results of this scenario are presented in the form of percentage deviation from the base run and the results is given in table 6.3.

As government expenditure increases by 10 percent the overall economic activity increase by 1.15 percent on average of for the period considered in the simulation. Since the increase in capital stock is a function of investment and increase in capital stock has a direct impact on

the supply side of the economy that has resulted an average increase on the value added of agriculture and non agriculture by an amount of roughly by 2.61 and 2.19 percent respectively. But as government investment increases it is followed by an increase in price level by an amount of 0.35 percent on average for both producers and consumer's price level. This increase in price level would have an effect on the real effective exchange rate to appreciate. The increase in government investment decreases the level of private investment by 2.2 percent which means government has a crowding out effect on private investment. Since the increase in investment has increased the overall level economic activity private consumption, tax revenue, export and import has got the positive flavor from the multiplier effect.

Table 6.3: Simulation result of an increase in government investment by 10%

Year	**Private cons**	**Private Invest**	**Tax**	**Gove. Expend**	**Export**	**Import of intermediate capital**	**Import cons**
1992	0.45	-3.34	0.42	0.17	0.49	0.66	1.64
1993	2.53	2.9	1.66	0.8	2.97	3.88	1.96
1994	1.53	-4.63	1.01	0.71	-0.75	0.24	2.53
1995	2.8	3.82	1.95	1.06	2.81	5.23	1.32
1996	1.89	-8.49	0.36	0.84	-1.79	-3.72	0.47
1997	2.12	3.03	1.38	0.94	1.13	4.54	2.48
1998	-0.08	-4.18	0.41	0.31	-0.78	1.6	1.75
1999	1.5	1.43	1	0.58	1.67	2.72	1.42
2000	0.27	-5.33	-0.06	0.21	-1.17	-2.04	0.87
2001	2.11	0.75	0.93	0.57	2.1	2.12	-0.13
2002	0.9	-8.34	0.03	0.51	-1.8	-2.91	0.88
2003	2.29	3.32	1.32	0.8	2.72	5.32	0.56
2004	1.39	-9.64	0.53	0.66	-1.26	-1.89	1.46
2005	2.35	5.17	1.73	0.96	2.63	6.31	1.87
2006	2.1	-8.88	1.12	0.84	-0.13	-0.5	1.56
2007	3.21	3.65	1.89	1.24	2.09	3.66	1.56
2008	2.1	-8.37	1.01	0.96	-0.99	-0.45	1.37
Average	**1.73**	**-2.19**	**0.98**	**0.71**	**0.58**	**1.46**	**1.39**

Year	**REERI**	**Demand RM1**	**Demand RQM**	**VA non agriculture**	**VA agriculture**	**CPI**	**Real GDP**
1992	0.13	0.47	0.81	3.49	-0.05	-0.06	1.22
1993	0.1	0.27	1.07	2.46	0.01	0.12	0.9
1994	-0.34	0.75	1.44	5.59	0.12	0.21	2.25
1995	0.17	0.47	2.1	1.06	0.42	0.13	0.61

1996	-1.63	0.38	1.34	1.59	0.38	0.77	0.84
1997	-0.52	0.69	2.26	3.64	0.64	0.47	2.07
1998	0.45	1.34	3.38	3.77	0.33	-0.07	2.01
1999	0.14	1.23	3.5	2.06	0.5	0.03	1.2
2000	-0.48	1.2	3.61	2.45	0.32	0.07	1.29
2001	-0.74	0.69	3.42	-1.16	0.44	0.16	-0.33
2002	-1.5	0.71	2.55	2.18	0.2	0.69	1.19
2003	-0.6	0.3	3.02	-0.37	0.37	0.49	-0.01
2004	-1.22	0.79	2.56	2.92	0.17	0.71	1.48
2005	-0.02	0.67	3.31	1.8	0.48	0.44	1.1
2006	-0.8	1.02	3.3	2.39	0.33	0.47	1.36
2007	-0.77	0.72	3.34	1.14	0.77	0.63	0.91
2008	-1.13	0.93	3.42	2.15	0.7	0.66	1.45
Average	**-0.52**	**0.74**	**2.61**	**2.19**	**0.36**	**0.35**	**1.15**

6.2.1.2 Monetary policy Shock

With regard to monetary policy exercise, domestic credit (using both government and private domestic credit) is used as a shocking variable. For this simulation we see the overall effect of a monetary restraint policy in the economy taking what would have been case if there was a sustainable 10 percent reduction of domestic credit starting from 1992 up 2008. The result of this simulation is given in table 6.4 below.

Table 6.4: Simulation result of a decrease in domestic credit by 10 percent

Year	Private cons	Private Invest	Tax	Gove. Expend	Export	Import of inter. capital	Import cons
1992	-3.60	-4.38	-0.88	-2.17	-0.84	0.36	1.17
1993	-4.21	3.86	-0.59	-2.03	3.64	6.72	1.89
1994	-5.07	-4.79	-1.37	-2.40	2.63	1.75	2.97
1995	-3.56	4.45	-0.97	-2.39	5.43	2.50	1.59
1996	-3.93	-10.27	-2.50	-1.96	0.66	-5.28	0.75
1997	-2.80	2.61	-1.10	-1.46	3.54	3.59	2.59
1998	-4.49	-6.70	-1.83	-1.81	0.97	0.46	1.71
1999	-2.72	0.09	-1.07	-1.24	3.18	2.41	1.54
2000	-3.62	-7.25	-1.86	-1.58	0.57	-2.07	0.96
2001	-2.03	-0.79	-1.04	-1.31	3.16	1.12	-0.25

2002	-2.99	-10.44	-1.90	-1.31	-0.75	-3.91	0.57
2003	-1.57	1.42	-0.72	-1.06	2.73	3.05	-0.15
2004	-2.22	-11.88	-1.42	-1.17	-1.00	-3.44	0.60
2005	-1.58	3.05	-0.41	-0.97	2.67	4.19	0.65
2006	-2.07	-11.34	-1.16	-1.25	0.25	-2.26	0.20
2007	-1.14	1.29	-0.56	-0.98	2.67	1.48	-0.10
2008	-1.87	-11.47	-1.42	-1.24	-0.19	-2.84	-0.34
Average	**-2.91**	**-3.68**	**-1.22**	**-1.55**	**1.72**	**0.46**	**0.96**

Year	**REERI**	**Demand RM1**	**Demand RQM**	**VA non agricult.**	**VA agric.ure**	**CPI**	**Real GDP**
1992	1.70	2.40	4.66	3.45	-0.05	-3.68	1.20
1993	6.55	3.14	4.61	2.13	0.01	-4.25	0.78
1994	7.41	3.03	5.37	4.27	-0.12	-4.94	1.60
1995	6.03	2.79	5.75	-0.95	-0.02	-5.59	-0.38
1996	3.35	1.50	3.09	-0.36	-0.20	-3.95	-0.25
1997	3.73	0.82	3.01	1.61	-0.02	-3.70	0.75
1998	4.17	0.98	3.11	1.91	-0.43	-3.79	0.70
1999	3.84	0.36	2.26	0.53	-0.18	-3.13	0.15
2000	3.34	0.21	2.19	0.90	-0.37	-3.09	0.23
2001	2.98	-0.24	1.68	-2.71	-0.21	-3.00	-1.35
2002	1.74	-0.36	0.41	0.56	-0.44	-2.31	0.09
2003	2.09	-0.82	0.61	-2.15	-0.26	-2.45	-1.12
2004	1.32	-0.38	-0.15	1.03	-0.47	-2.15	0.28
2005	2.77	-0.57	0.35	-0.46	-0.23	-2.41	-0.33
2006	2.31	-0.21	0.15	-0.17	-0.46	-2.52	-0.28
2007	2.49	-0.60	-0.17	-1.98	-0.15	-2.43	-1.09
2008	1.92	-0.56	-0.68	-1.13	-0.40	-2.34	-0.76
Average	**3.40**	**0.68**	**2.13**	**0.38**	**-0.24**	**-3.28**	**0.01**

As domestic credit shrinks by 10 percent, inflation has declined by 3.28 percent on average. Since domestic credit directly affects the capital formation on both private and public investment. Private investment has in turn a direct impact on the level of economic activity which in turn weakens the level of consumption and tax revenue collection by 2.9 and 1.22 percent on average for the period under consideration.

Excess domestic credit is one factor that causes appreciation of domestic currency, as this shock is a restraint monetary policy it is followed by a depreciation of 3.4 percent and that has put a strong positive effect on export sector that increases by 1.72 percent on average. Import declines but since most imports are not substitutable in the country, the effect of depreciation is compensated by foreign earning that increases the level of import directly. Real demand for narrow money and quasi money has increased by 0.68 and 2.13 percent on average due to the

decrease in inflation which is an opportunity cost of holding assets. However, the overall decrease in domestic credit negatively affects agriculture sector and positively the non agricultural sector.

6.2.1.3 External Shock

The effect of external shock is simulated by increasing 10 percent on import price only and the result is depicted in table 6.5. As import price changes keeping export price unchanged, terms of trade deteriorates and this has a direct influence on the real effective exchange rate that in turn has a close connection with the level of export and import related to the demand side of the economy. A rise in import price also directly affects producer and consumer price. These factors in turn affect revenue and expenditure of government, private investment and private consumption.

A 10 percent increase in import price leads to an appreciation of domestic effective exchange rate by 7.17 percent. This is followed by a decrease in the level of export as our exports are expensive to the ROW and since export earning is one factor to covers import; it is followed by a decrease in the level of import for intermediate and capital goods by 5.26 percent and 4.65 percent for consumer goods.

Since imported commodities price has a direct impact on the domestic price level, a 10 percent increase in imported price resulted in an average of 8.6 percent increase in the level of inflation and 5 percent to the case of producer price. As overall price increases it creates uncertainty to the private investment and together with other multiplier effects private investment declines by about 7.5 percent. Government expenditure and revenue increases but that of expenditure increases by higher percentage and this has a negative effect on the overall balance of government budget. Also with an inflationary environment created, demand for money decreases. On the supply side, as import of intermediate and capital good decreases and it affects the value added of non agriculture sector adversely by 1.5 percent and for agriculture sector by 0.7 percent on average. In combination, both supply and demand side effects have a detrimental impact on real GDP and has resulted a decline of 1.1 percent on average for the period of simulation.

Table 6.5: Simulation result of an increase of import price by 10 percent

Year	Private cons	Private Invest	Tax	Gove. Expend	Export	Import of Capital	Import of consumer
1992	-0.92	-5.72	0.15	0.96	-2.15	-1.23	0.65
1993	0.33	1.05	1.48	2.72	-1.31	0.35	-0.33
1994	-0.86	-9.9	1	3.48	-6.31	-7.64	-1.48
1995	0.38	-2.6	2.33	4.69	-5.34	-5.06	-4.43
1996	-1.63	-16.03	1.34	4.78	-10.14	-11.41	-6.22
1997	-1.97	-4.37	2.68	4.78	-7.47	-3.52	-5.09
1998	-5.13	-12.23	1.69	3.82	-9.21	-6.01	-5.85
1999	-4.11	-4.66	2.35	3.56	-6.51	-3.69	-5.55
2000	-5.41	-10.72	1.41	2.77	-8.24	-7.16	-5.58
2001	-3.59	-4.13	2.08	2.82	-5.63	-4.27	-6.48
2002	-4.46	-12.69	1.15	2.61	-8.92	-8.61	-5.3
2003	-3.18	-1.3	2.07	2.79	-5.64	-1.9	-5.77
2004	-3.79	-13.69	1.35	2.72	-8.92	-7.76	-4.78
2005	-3.04	0.48	2.28	2.97	-5.53	-1.01	-4.87
2006	-3.51	-13.73	1.52	2.81	-7.93	-7.43	-5.4
2007	-2.11	-1.81	2.31	3.3	-5.81	-4.26	-6.02
2008	-2.58	-14.79	1.58	3.24	-8.87	-8.8	-6.48
Average	**-2.68**	**-7.46**	**1.69**	**3.22**	**-6.7**	**-5.26**	**-4.65**

Year	REERI	Demd. RM1	Demd. RQM	VA non agg.	VA agg.	P	CPI	Real GDP
1992	0.15	-0.51	-1.11	3.28	-0.05	1.42	1.73	1.14
1993	-1.41	-2.49	-3.19	1.24	0.01	2.88	4.54	0.45
1994	-5.89	-3.51	-4.9	2.67	-0.19	4.37	7.04	0.94
1995	-8.11	-5.05	-6.53	-3.05	-0.19	5.48	9.41	-1.26
1996	-10.19	-5.63	-8.24	-2.92	-0.63	6.17	11.29	-1.49
1997	-9.39	-5.06	-7.74	-1.25	-0.61	6.42	11.39	-0.9
1998	-8	-3.86	-6.76	-0.92	-1.18	6.32	10.78	-1.05
1999	-7.66	-2.97	-6.01	-2.08	-0.95	6.01	10.12	-1.41
2000	-7.38	-2	-5.17	-1.4	-1.16	5.61	9.26	-1.19
2001	-7.6	-1.86	-5.02	-4.76	-0.91	5.22	8.8	-2.6
2002	-8.42	-1.46	-5.57	-1.24	-1.09	4.91	8.9	-1.09
2003	-7.81	-1.66	-5.12	-3.72	-0.82	4.72	8.56	-2.08
2004	-8.35	-1.17	-5.61	-0.41	-0.94	4.64	8.77	-0.61
2005	-7.11	-1.39	-5	-2.04	-0.66	4.66	8.55	-1.27
2006	-7.72	-1.18	-5.27	-1.84	-0.87	4.73	8.64	-1.28
2007	-8.03	-1.82	-5.79	-3.96	-0.6	4.84	9.02	-2.28
2008	-9.04	-2.02	-6.58	-3.25	-0.91	4.94	9.45	-2.08
Average	**-7.17**	**-2.57**	**-5.51**	**-1.51**	**-0.69**	**4.9**	**8.6**	**-1.06**

7 CONCLUSION AND POLICY IMPLICATION

7.1 Conclusion

This study has attempted to develop a small macro-econometric model for the Ethiopian economy and to conduct simulation experiments for different economic policy scenarios.

The model in this study is constructed by dividing the whole economic activity into four blocks: aggregate demand, monetary, aggregate supply, and price block. The model consists of from 14 behavioral equations. The model is constructed using time series data ranging from 1970/71 to 2008/09 using Engle-Granger two step procedure and Autoregressive Dynamic Lag (ARDL) approach developed by Pesearan *et al* (2001). The simulation process is done by solving both the long run and short run equations for the period 1975/76 to 2008/09. The performance of the model is checked using graphical method by comparing actual, statistic and dynamic solution of the model. Also, adequacy of the model for the dynamic solution is checked using forecasting accuracy statistics: MAE, MAPE, RMSPE and U-Theils statistics.

In modelling the economy, an attempt has been made to include both demand and supply sides. From the demand side, private consumption is positively affected by disposable income and inflation. Private investment is influenced by demand side factors i.e. gross domestic product and capacity utilization and from supply factors availability and cost of financing have positively impacted private investment. However, government investment crowds out private investment. In the government sector, government revenue increases as tax base expands which is proxied by level of nominal income and degree of openness, especially from the import side. An increase in price level also has an advantage to increase government revenue. Government expenditure boosts as tax revenue, concessional loan and price level increase. In external sector, since the economy is supply constrained, an increase in capital formation (gross investment) increases export, and income of the rest of the world has a positive effect. The degree of competitiveness, measured by real effective exchange rate, depreciation encourages the amount of export.

Import of consumer goods is determined by domestic income, and amount of foreign exchange notably but in the case import of intermediate and capital goods real effective

exchange rate also an additional determinant. Real effective exchange rate depreciates as terms of trade and degree of openness increases and appreciates due to excess domestic money supply.

In the monetary sector, demand for narrow money increases as economic activity and depreciation of parallel market for foreign exchange rate increases and negatively with price level.

In the supply side, value added of agriculture is positively affected by the amount of capital accumulation, agricultural labor force and harvest season proxied by the amount of rainfall. Non agriculture value added is mainly determined through non agriculture capital accumulation, non agriculture labour force, agriculture value added, and import of intermediate and capital goods.

In the price sector, producer price is found to be a markup over import price, wage and capacity utilization rate of the economy. Inflation aggravates due to increase of import price, domestic price, excess demand and excess domestic credit. However, consumer price level decreases due to depreciation of real effective exchange rate.

Policy simulations have been undertaken based on the structure of the economy. Three policy simulations which are related to fiscal policy, monetary policy, and external shocks have been conducted. An expansionary fiscal policy in the form of an increase in government investment expenditure resulted in an increase in output, but it generates inflationary effect and results in appreciation of domestic currency. Notwithstanding an increase in level of output it has a negative effect on private sector in the form of crowding out effect. Monetary policy which is in the form of decreasing domestic credit results in a significant decline in inflation and it also leads to depreciation of domestic currency. However, it is less effective in terms of stimulating domestic output. External shock tracked by an increase of import price results in a substantial contraction in the domestic output, and it also increases inflation and causing appreciation of domestic currency and has also detrimental effect on the level of export and import.

7.2 Implications

The conclusion policy implications can be made:

- Fiscal policy expansion in the form of government investment has expansionary effect on the level of output but it also generates inflation and negatively affects private investment. So government has to find optimal level of investment that results a reasonable degree of inflation and encourage private investment.
- Monetary policy in the form of decreasing domestic credit for both government and non government has the effect of minimizing inflation substantially. Thus a prudent monetary policy that considers investment and price level is required.
- Ethiopian economy is highly susceptible to the rest of the world for instance an increase in import price has a devastating effect on the domestic economy, so different policies which are consistent to one another has to be designed, especially that focus on encouraging export, import substitution and competitiveness of the country.

7.3 Areas for Future Study

It should be noted that macro-econometric modelling is a continuous exercise. The model has highlighted the structure of Ethiopian economy using a macro-econometric model. In general, the main problem faced has been absence and unavailability of quality data which has created a major impediment on the estimation process and this has created to minimize the scope of specification of certain equations that has to be included in the model. For instance, absence of quality data on labour force and wage rate, the model does not include labour market endogenously. For variables where there is no data, proxies have been used in terms of actual variables at the expense of economic theory.

Because of the above mentioned limitation and the very nature of macro-econometric modeling improvements can be made by adopting some of the speciation done in this study.

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Annex 1

Variables used in the Model

Variable Name	Type	Description	**Source of Data**
ABSORB	Endog	Absorption	MOFED
CP	Endog	private consumption	MOFED
CPI_CSAAD	Endog	Consumer price Index that is deflated taking 1999 as a base	CSA
DC	Endog	Total domestic credit	NBE
DCP	Exog	Domestic non government credit	NBE
DDUM	Exog	Dummy included for 1992	
DGC	Exog	Domestic government credit	NBE
DLOGKAGG	Endog	Change in agriculture capital stock	Own computation using Incremental capital output ratio estimation technique
DLOGKNAGG	Endog	Change in non agriculture capital stock	Own computation
DUM2000	Exog	Dummy included at 2000	
DUM74	Exog	Dummy included at1974	
DUM96	Exog	Dummy 1996	
DUM97	Exog	Dummy included at 1997	
DUM_EPRDF	Exog	Dummy included before and after EPRDF	
DUMMY82	Exog	Dummy included at 1982	
DUMMY84	Exog	Dummy included at1984	
DUMMY8402	Exog	Dummy for1984 and 2002	
DUMMY8499	Exog	Dummy included at1984 1nd 1999	
DUMMY91	Exog	Dummy included at 1991	
DUMMY92	Exog	Dummy included at 1992	
DUMMY99	Exog	Dummy for 1999 government expenditure	
DUMMY_2003	Exog	Dummy before and after 2003	
DUMMY_DROUGHT	Exog	Dummy to hold drought years	
DUMMY_GOVTSHIFT	Exog	Dummy for policy change(EPRDF and imperial era) with DERG	
DUMMY_WAR	Exog	Dummy to hold war period	

Variable Name	Type	Description	Source of Data
EXCESSDD	Endog	Excess demand	Own computation
EXCREDITF	Endog	Excess domestic credit finally considered	Own computation
FRAID	Exog	Grant	World Bank
G	Endog	government final consumption expenditure	MOFED
GCAPEXP	Exog	Government Capital expenditure	MOFED
GCF	Endog	Gross Capital Formation	MOFED
GDPN	Endog	GDP AT CURRENT PRICE	MOFED
GDPNRESID	Exog	Discrepancy found after accounting consumption, government expenditure, Investment,trade balance	
GNPN	Endog	Gross national income at current price	MOFED
GOVTEXPC	Endog	Government recurrent expenditure	MOFED
GOVTRESID	Exog	Difference between recurent expenditure and final government consumption	Own computation
GROWTH	Endog	Growth rate	Own computation
IG	Exog	nominal government investment	MOFED
IMPT	Endog	IMPORT OF GOODS AND SERVICES AT CURRENT PRICE	MOFED
M2	Endog	Broad Money	NBE
MUVITT	Exog	Import unit Value Index	Own computation
NFCI	Exog	Net foreign capital inflow	NBE
NFY	Exog	current transfers from ROW, net	MOFED
NMCN	Endog	import of capital goods	MOFED
NMCP	Endog	import of consumer goods	MOFED
NMOTSERV	Exog	import of other and services	MOFED
NTR	Exog	non tax revenu	MOFED
NTRS	Exog	Incomes from ROW net	MOFED
OPEN	Endog	openness of a given Economy	Own computation
P	Endog	Producer Price(GDP deflator)	MOFED
QM	Endog	Quasi Money	NBE
RCP	Endog	Real Private Consumption	
REERIINVA	Endog	Real effective exchange rate	NBE

Variable Name	Type	Description	Source of Data
RESID_CONS2	Endog	Residual from long run private Consumption equation	
RESID_CPI2	Endog	Residual from long run consumer price index equation	
RESID_EXPT	Endog	Residual from long run Export equation	
RESID_GOVTEXPCL	Endog	Residual from long run Government expenditure equation	
RESID_PINVT	Endog	Residual from long run private Investment equation	
RESID_PPI	Endog	Residual from long run producers price index equation	
RESID_QM1_NN	Endog	Residual from long run Quasi Money equation	
RESID_REERFCI3	Endog	Residual from long run Real effective Exchange Rate equation	
RESID_RM1ARDL	Endog	Residual from long run Narrow money equation	
RESID_RMCN_NFCI	Endog	Residual from long run import of capital and Intermediate goods and services equation	
RESID_RMCPNFCI	Endog	Residual from long run import of consumer goods and services equation	
RESID_YAGGAD	Endog	Residual from long run agriculture supply equation	
RESID_YNONAGAD	Endog	Residual from long run Non - agriculture supply equation	
RESIDTAX_MLOAN	Endog	Residual from long run tax revenue equation	
RG	Endog	Real government Expenditure	
RGCF	Endog	Real Gross Capital Formation	
RGDP	Endog	Real GDP	
RIG	Endog	Real Investment	
RIP	Endog	Real Private Investment	
RM1CPI	Endog	Real narrow money deflated with cpi	
RMBM2CPI	Endog	Real broad money deflated with cpi	
RMCN	Endog	Real import of consumer goods	

Variable Name	Type	Description	Source of Data
RMCP	Endog	Real import of capital and intermediate goods	
RMOTSERV	Endog	real import of other services	
RQMCPI	Endog	Real Quasi money deflated with CPI	
RX	Endog	Real Export	
RY	Endog	Real Income	
RYAGG	Endog	Real agricultural output supply side	
RYDN	Endog	Real disposable Income	
RYNAGG	Endog	Real Non agricultural output real value	
TAXPROD	Exog	Tax on product found residual	Own computation
TB	Endog	Trade balance	MOFED
TGEXP	Endog	Total government expenditure	MOFED
TGR	Endog	Total government revenue	MOFED
TOT	Endog	Terms of trade data	own computation
TR	Endog	Total revenu	MOFED
XGS	Endog	Export of goods and services nominal	MOFED
XUVITT	Exog	Export unit value calculated from TOT EEA	MOFED
YAGG	Endog	Nominal Agricultural output real value	MOFED
YD	Endog	Disposable income	MOFED
YNAGG	Endog	Nominal Non agricultural output real value	MOFED

Annex 2

Behavioral Equations, Identity and Bridge equations used for the Macro-Econometric Model

resid_cons2 = LOG_RCP - (0.111025679351 + 1.0422423279 * LOG_RYDN - 0.105668385777 * LOG_RM2CPI + 0.032212239261 * LOGCPI_CSAAD + 0.0886942683561 * DUMMY91 - 0.0662252001795 * DUMMY99)

log_rcp = 0.856234124347 * (log_rydn - log_rydn(-1)) - 0.0924376970011 * (log_rm2cpi - log_rm2cpi(-1)) + 0.105765676892 * (logcpi_csaad - logcpi_csaad(-1)) + 0.0569159319431 * DUMMY91 + 0.0681078840903 * DUM2000 - 0.797110808963 * RESID_CONS2(-1) + log_rcp(-1)

resid_pinvt = log_rip - (0.4583635136 * log_rgdp + 0.633534791522 * log_dcp - 0.262824729242 * log_rig + 0.0643941718478 * lint - 0.897549135723 * logcpi_csaad + 0.874687970607 * logcu - 1.01616965774 * dummy82 - 1.01704286821 * dummy84 + 0.828381396404 * dummy92)

log_rip = - 0.566444079157 * (log_rip(-1) - log_rip(-2)) + 1.59530313709 * (log_rgdp(-1) - log_rgdp(-2)) - 0.0364418261235 * (log_rig(-1) - log_rig(-2)) - 1.33049372238 * (logcpi_csaad - logcpi_csaad(-1)) + 0.555460651255 * (log_dcp - log_dcp(-1)) - 0.0421115776326 * (LINT - LINT(-1)) + 1.49730500245 * (logcu - logcu(-1)) - 1.22297972657 * DUMMY82 + 0.809307329393 * DUMMY92 - 0.663473849383 * RESID_PINVT(-1) + log_rip(-1)

RESIDTAX_MLOAN = LOG_TR - (0.286920574632 * LOG_GDPN + 0.269766556804 * LOG_IMPT + 0.186563293651 * LOG_FRAID + 0.17429943944 * LOGCPI_CSAAD + 0.0829771976306 * LOG_CONSLOAN)

log_tr = 0.247228317299 * (log_tr(-1) - log_tr(-2)) + 0.316360129421 * (log_gdpn - log_gdpn(-1)) + 0.234757094578 * (log_impt - log_impt(-1)) + 0.12281114038 * (log_fraid - log_fraid(-1)) - 0.0303007432369 * (logcpi_csaad - logcpi_csaad(-1)) + 0.0500221168278 * (log_consloan - log_consloan(-1)) - 0.293531715272 * RESIDTAX_MLOAN(-1) + log_tr(-1)

resid_govtexpcl = LOG_GOVTEXPC - (1.40875702034 + 0.679927453513 * LOG_TR + 0.198539559017 * LOGCPI_CSAAD + 0.0756083020882 * LOG_CONSLOAN + 0.138596499507 * DUMMY_WAR + 0.160227732063 * DUMMY_DROUGHT)

log_govtexpc = 0.406952894346 * (log_tr - log_tr(-1)) + 0.501302215026 * (LOGCPI_CSAAD - LOGCPI_CSAAD(-1)) - 0.366426235796 * RESID_GOVTEXPCL(-1) + log_govtexpc(-1)

resid_expt = log_rx - (- 3.14770737526 + 0.568670337204 * log_ryrow + 0.724154982779 * log_reeriinv + 0.316907470943 * loginvtogdp - 0.129771441309 * dummy_drought + 0.39985626439 * dummy_2003)

log_rx = 2.20516353475 * (log_ryrow - log_ryrow(-1)) + 0.468236006794 * (log_reeriinv - log_reeriinv(-1)) + 0.436814619762 * (loginvtogdp - loginvtogdp(-1)) - 0.132903838959 * DUMMY_DROUGHT - 0.486382190019 * RESID_EXPT(-1) + log_rx(-1)

resid_RMCPNFCI = LOG_RMCP - (- 7.34928111187 + 0.885671910092 * LOG_RGDP + 0.572416558996 * LOG_RX + 0.0584292375375 * LOG_NFCI)

LOG_RMCP = 1.17292419527 * (log_rgdp - log_rgdp(-1)) + 0.341536449163 * (log_rx - log_rx(-1)) + 0.00622894728823 * (LOG_NFCI - LOG_NFCI(-1)) - 0.537956825654 * RESID_RMCPNFCI(-1) + LOG_RMCP(-1)

RESID_RMCN_NFCI = LOG_RMCN - (- 6.09125851396 + 0.656520525564 * LOG_RGDP + 1.0147131673 * LOG_RX - 0.392646625249 * LOG_REERIINV + 0.0449227007763 * LOG_NFCI)

LOG_RMCN = 0.756120614161 * (log_rgdp - log_rgdp(-1)) + 0.73569321213 * (log_rgdp(-1) - log_rgdp(-2)) - 0.672377603795 * (log_rgdp(-2) - log_rgdp(-3)) + 0.696580282846 * (log_rx - log_rx(-1)) - 0.267254693753 * (log_rx(-1) - log_rx(-2)) + 0.464430298933 * (log_rx(-2) - log_rx(-3)) + 0.406802361742 * (log_reeriinv - log_reeriinv(-1)) - 0.433271229947 * (log_reeriinv(-2) - log_reeriinv(-3)) + 0.0123589174108 * (LOG_NFCI - LOG_NFCI(-1)) - 0.303124473605 * RESID_RMCN_NFCI(-1) + LOG_RMCN(-1)

resid_reerfci3 = log_reeriinv - (0.73547 * log_tot + 0.64994 * log_open - 0.77203 * excreditf + 0.63019 * dum_eprdf - 1.8382)

log_reeriinv = - 0.230355939716 * (log_tot(-1) - log_tot(-2)) + 0.435617535304 * (log_open - log_open(-1)) + 0.1568025921 * (excreditf(-1) - excreditf (-2)) + 0.359366526172 * DDUM - 0.241008007377 * DUM96 - 0.497483741242 * RESID_REERFCI3(-1) + log_reeriinv(-1)

RESID_QM1_NN = log_rqm1cpi - (4.1198 * log_rgdp + 1.3188 * LOG_TSDEPR - 0.094521 * infl - 37.8457)

log_rqm1cpi = - 0.262588441917 * (log_rqm1cpi(-1) - log_rqm1cpi(-2)) + 0.169201167591 * (log_rgdp - log_rgdp(-1)) - 0.0106454207072 * (infl - infl (-1)) - 0.124008870845 * RESID_QM1_NN(-1) + log_rqm1cpi(-1)

resid_rm1ardl = log_rm1cpi - (0.93492 * log_rgdp - 0.037221 * infl + 0.59843 * logbex - 1.8180)

LOG_RM1CPI = - 0.420827868601 * (log_rm1cpi(-1) - log_rm1cpi(-2)) + 0.282215660725 * (log_rgdp - log_rgdp(-1)) - 0.00533420729234 * (infl - infl(-1)) + 0.333163788479 * (logbex - logbex(-1)) - 0.447084404076 * DUM74 - 0.286626162191 * RESID_RM1ARDL(-1) + LOG_RM1CPI(-1)

resid_yaggad = log_ryagg - (4.8368 * dlogkagg + 0.87847 * log_lagaf + 0.25655 * log_rain - 0.13000)

log_ryagg = - 3.40293954591 * (log_lagaf - log_lagaf(-1)) + 0.1571039844720093 * (log_rain - log_rain(-1)) - 0.1988223500011885 * DUMMY8402 - 0.3779916858489141 * RESID_YAGGAD(-1) + log_ryagg(-1)

resid_ynonagad = LOG_RYNAG - (9.97424190006 * DLOGKNAGG + 0.652228285412 * LOG_LNAGG + 0.121145660882 * LOG_RMCN + 0.338123546386 * LOG_RYAGG - 0.0563232518809 * DUMMY_GOVTSHIFT)

log_rynag = 4.72306181147 * (dlogknagg - dlogknagg(-1)) + 3.70499961406 * (dlogknagg(-1) - dlogknagg(-2)) + 0.785646888465 * (log_lnagg - log_lnagg(-1)) + 0.111186976204 * (log_rmcn - log_rmcn(-1)) + 0.172380018533 * (log_ryagg - log_ryagg(-1)) - 0.282749258327 * RESID_YNONAGAD(-1) + log_rynag(-1)

resid_ppi = log_p - (- 2.27550569912 + 0.525556479309 * logmuvitt + 0.639572239515 * logcu + 0.191783910372 * log_wage + 0.340674715368 * dummy8499)

log_p = 0.353762271113 * (log_p(-1) - log_p(-2)) + 0.283259447676 * (log_p(-2) - log_p(-3)) - 0.282687064027 * (logcu - logcu(-1)) + 0.810559254608 * (logcu(-2) - logcu(-3)) + 0.456456499148 * (logcu(-4) - logcu(-5)) + 0.149178083608 * (logmuvitt - logmuvitt(-1)) + 0.0787290928181 * (log_wage - log_wage(-1)) + 0.19906694929 * DUMMY8499 - 0.266652036101 * RESID_PPI(-1) + log_p(-1)

resid_cpi2 = logcpi_csaad - (0.355447158632 * logmuvitt + 0.574767278425 * log_p - 0.396632592091 * log_reeriinv + 0.128015237143 * log_dc + 0.166429593763 * log_excessdd)

logcpi_csaad = 0.27460866135 * (logcpi_csaad(-3) - logcpi_csaad(-4)) + 0.135776971453 * (logmuvitt - logmuvitt(-1)) + 0.422130183785 * (log_p - log_p(-1)) - 0.283447317797 * (log_reeriinv - log_reeriinv(-1)) + 0.0535051608974 * (log_excessdd - log_excessdd(-1)) + 0.280485837366 * (log_dc - log_dc(-1)) - 0.15275888161 * DUM97 - 0.768729457309 * RESID_CPI2(-1) + logcpi_csaad(-1)

absorb = rgcf + rcp + rg

gdpn = cp + gcf + G + xgs - impt + GDPNRESID

rgdp = RY + taxprod

Log_gdpn = log(gdpn)

excessdd = absorb / rgdp * 100

log_excessdd = log(excessdd)

growth = (rgdp - rgdp(-1)) / (rgdp(-1)) * 100

infl = (LOGCPI_CSAAD - LOGCPI_CSAAD(-1)) * 100

dlogkagg = dlog(Kagg)

dlogknagg = dlog(knagg)

rcp = exp(log_rcp)

cp = rcp * (P / 100)

Log_rydn = log(rydn)

YD = GNPn + NTRS + FRAID

rydn = (YD / P) * 100

rip = exp(log_rip)

ip = (rip * p) / 100

log_rgdp = log(rgdp)

RGCF = RIP + RIG

LOG_RIG = log(RIG)

rig = (ig / p) * 100

GCF = (RGCF * P) / 100

log_dcp = log(dcp)

tr = exp(log_tr)

GNPn = gdpn + NFY

TGR = NTR + TR + FRAID

govtexpc = exp(log_govtexpc)

G = GOVTEXPC + GOVTRESID

TGEXP = GCAPEXP + GOVTEXPC

RG = (G / p) * 100

rx = exp(log_rx)

xgs = rx * (p / 100)

invtogdp = rgcf / rgdp

LOG_NFCI = log(NFCI)

rmcp = exp(log_rmcp)

nmcp = rmcp * (p / 100)

rmcn = exp(log_rmcn)

nmcn = rmcn * (p / 100)

rmotserv = (nmotserv / p) * 100

impt = nmcn + nmcp + NMOTSERV

open = ((impt + xgs) / gdpn) * 100

Loginvtogdp = log(invtogdp)

log_fraid = log(fraid)

tot = (XUVITT / MUVITT) * 100

log_tot = log(tot)

log_open = log(open)

log_impt = log(impt)

TB = XGS - impt

REERIINVA = exp(log_reeriinv)

EXCREDITF = ((DC - DC(-1)) / m2(-1)) - (LOG_RGDP - LOG_RGDP(-1))

rm1cpi = exp(LOG_RM1CPI)

rqmcpi = exp(log_rqm1cpi)

M1 = rm1cpi * (cpi_csaad / 100)

QM = rqmcpi * (cpi_csaad / 100)

M2 = M1 + QM

DC = DGC + dcp

log_dc = log(DC)

rmbm2cpi = (M2 / cpi_csaad) * 100

log_rm2cpi = log (rmbm2cpi)

ryagg = exp(log_ryagg)

yagg = ryagg * (p / 100)

rynagg = exp(log_rynag)

ynagg = rynagg * (p / 100)

RY = RYAGG + RYNAGG

kagg = 0.233376372 * Ktot

knagg = 0.766623628 * ktot

ktot = rgcf(-1) + ktot(-1)

cpi_csaad = exp(logcpi_csaad)

p = exp(log_p)

Annex 3

Unrestricted Error Correction Models for those estimated using ARDL approach

For Real Effective Exchange rate Equation

ARDL(1,2,0,2) selected based on Akaike Information Criterion

****

Dependent variable is LOG_REERI

36 observations used for estimation from 1973 to 2008

****

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LOG_TOT	.73547	.18586	3.9570[.001]
LOG_OPEN	.64994	.12835	5.0637[.000]
EXCREDITF	-.77203	.44835	-1.7219[.097]
DUM_EPRDF	.63019	.14134	4.4585[.000]
C	-1.8382	1.0692	-1.7193[.097]

Dependent Variable: DLOGREERINV
Method: Least Squares
Date: 09/05/11 Time: 16:46
Sample (adjusted): 1973 2008
Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.894066	0.543922	-1.643740	0.1127
DLOGTOT	0.043778	0.122953	0.356057	0.7248
DLOGTOT(-1)	-0.321482	0.122975	-2.614210	0.0149
DLOGOPEN	0.422457	0.139770	3.022523	0.0057
DEXCREDITF	0.060535	0.143335	0.422333	0.6764
DEXCREDITF(-1)	0.175118	0.109424	1.600353	0.1221
LOG_REERIINV(-1)	-0.469659	0.105835	-4.437643	0.0002
LOG_TOT(-1)	0.355048	0.093665	3.790618	0.0008
LOG_OPEN(-1)	0.297646	0.113012	2.633747	0.0143

EXCREDITF(-1)	-0.344711	0.251157	-1.372492	0.1821
DUM_EPRDF	0.304738	0.064126	4.752153	0.0001

R-squared	0.802685	Mean dependent var	0.012206
Adjusted R-squared	0.723759	S.D. dependent var	0.148107
S.E. of regression	0.077843	Akaike info criterion	-2.021774
Sum squared resid	0.151489	Schwarz criterion	-1.537921
Log likelihood	47.39192	Hannan-Quinn criter.	-1.852896
F-statistic	10.17008	Durbin-Watson stat	1.678407
Prob(F-statistic)	0.000001		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	8.520683	(4, 25)	0.90002
Chi-square	34.08273	4	0.0000

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(7)	-0.469659	0.105835
C(8)	0.355048	0.093665
C(9)	0.297646	0.113012
C(10)	-0.344711	0.251157

Restrictions are linear in coefficients.

Money Demand Equations

For narrow money Long run relationship

Estimated Long Run Coefficients using the ARDL Approach
ARDL(2,0,1,0) selected based on Schwarz Bayesian Criterion

****

Dependent variable is LRM1
36 observations used for estimation from 1973 to 2008

****

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LRGDP	.93492	.32212	2.9024[.007]
INFL	-.037221	.015995	-2.3270[.027]
LOGBEX	.59843	.24898	2.4035[.023]
C	-1.8180	3.2105	-.56627[.576]

The unrestricted Error Correction model

Dependent Variable: DLOGRM1
Method: Least Squares
Date: 09/08/11 Time: 17:38
Sample (adjusted): 1972 2008
Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.447926	1.074511	-0.416865	0.6800
DLOGRM1(-1)	-0.510023	0.152615	-3.341882	0.0024
DLOGRGDP	0.243627	0.309587	0.786941	0.4379
DINFL	-0.004516	0.001496	-3.017838	0.0054
DLOGBEX	0.103000	0.147464	0.698478	0.4906
LOG_RM1CPI(-1)	-0.327232	0.148629	-2.201668	0.0361
LOG_RGDP(-1)	0.286488	0.166581	1.719818	0.0965
INFL(-1)	-0.010618	0.002284	-4.649270	0.0001
LOGBEX(-1)	0.222980	0.135731	1.642812	0.1116

R-squared	0.631418	Mean dependent var	0.049081
Adjusted R-squared	0.526109	S.D. dependent var	0.154013
S.E. of regression	0.106022	Akaike info criterion	-1.442571
Sum squared resid	0.314737	Schwarz criterion	-1.050726
Log likelihood	35.68757	Hannan-Quinn criter.	-1.304428
F-statistic	5.995859	Durbin-Watson stat	2.566965
Prob(F-statistic)	0.000165		

Wald Test:
Equation: UECM_RM1

Test Statistic	Value	df	Probability
F-statistic	5.875946	(4, 28)	0.0015
Chi-square	23.50379	4	0.0001

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(6)	-0.327232	0.148629
C(7)	0.286488	0.166581
C(8)	-0.010618	0.002284
C(9)	0.222980	0.135731

Restrictions are linear in coefficients.

Quasi Money Demand Equation

Estimated Long Run Coefficients using the ARDL Approach

ARDL(3,2,1,2) selected based on Schwarz Bayesian Criterion

'***

'Dependent variable is LOG_RQM1

'34 observations used for estimation from 1975 to 2008

'***

'Regressor	Coefficient	Standard Error	T-Ratio[Prob]
'LOG_RGDP	4.1198	.43783	9.4097[.000]
'LOG_TSDEP	1.3188	.43847	3.0077[.006]
'INFL	-.094521	.020694	-4.5676[.000]
'C	-37.8457	4.9239	-7.6861[.000]

'***

Dependent Variable: DLOG_RQM
Method: Least Squares
Date: 09/11/11 Time: 16:31
Sample (adjusted): 1973 2008
Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.032345	2.411662	-1.672019	0.1075
DLOG_RQM(-1)	-0.373928	0.185564	-2.015087	0.0552
DLOG_RQM(-2)	-0.210070	0.189824	-1.106659	0.2794
DLOGRGDP	0.259274	0.481271	0.538728	0.5950
DLOGRGDP(-1)	0.004244	0.549881	0.007717	0.9939
DLOGTSDEPR	0.091140	0.145175	0.627794	0.5361
DINFL	-0.010311	0.002549	-4.045672	0.0005
DINFL(-1)	0.007270	0.004514	1.610753	0.1203
LOG_RQM1CPI(-1)	-0.150079	0.098518	-1.523375	0.1407
LOG_RGDP(-1)	0.463659	0.290286	1.597251	0.1233
LOG_TSDEPR(-1)	0.252097	0.136442	1.847652	0.0770
INFL(-1)	-0.018769	0.005286	-3.550451	0.0016

R-squared	0.626229	Mean dependent var	0.057941
Adjusted R-squared	0.454917	S.D. dependent var	0.214637
S.E. of regression	0.158466	Akaike info criterion	-0.585351
Sum squared resid	0.602676	Schwarz criterion	-0.057511
Log likelihood	22.53631	Hannan-Quinn criter.	-0.401120
F-statistic	3.655490	Durbin-Watson stat	2.042721
Prob(F-statistic)	0.003834		

Wald Test:
Equation: URECM_QMNN

Test Statistic	Value	df	Probability
F-statistic	4.471173	(4, 24)	0.0077
Chi-square	17.88469	4	0.0013

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(9)	-0.150079	0.098518
C(10)	0.463659	0.290286
C(11)	0.252097	0.136442
C(12)	-0.018769	0.005286

Restrictions are linear in coefficients.

Agricultures Unrestricted Error correction Model

Method: Least Squares
Date: 07/21/11 Time: 18:14
Sample (adjusted): 1972 2008
Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOGRYAGG(-1)	0.250644	0.170285	1.471909	0.1518
DDLOGKAGG	-3.023857	2.822841	-1.071210	0.2929
DLOGLAGAF	-7.806410	2.901726	-2.690265	0.0117
DLOGRAIN	0.192089	0.113757	1.688585	0.1020
LOG_RYAGG(-1)	-0.384150	0.136669	-2.810797	0.0088
DLOGKAGG(-1)	1.429576	2.339519	0.611056	0.5459
LOG_LAGAF(-1)	0.345145	0.094052	3.669721	0.0010
LOG_RAIN(-1)	0.097659	0.110141	0.886680	0.3825

R-squared	0.466451	Mean dependent var	0.025034
Adjusted R-squared	0.337663	S.D. dependent var	0.084963
S.E. of regression	0.069146	Akaike info criterion	-2.316381
Sum squared resid	0.138654	Schwarz criterion	-1.968075
Log likelihood	50.85305	Hannan-Quinn criter.	-2.193587
Durbin-Watson stat	1.709923		

Wald Test:
Equation: UECM_YAGG

Test Statistic	Value	df	Probability
F-statistic	4.107230	(4, 29)	0.0093
Chi-square	16.42892	4	0.0025

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(5)	-0.384150	0.136669
C(6)	1.429576	2.339519
C(7)	0.345145	0.094052
C(8)	0.097659	0.110141

Restrictions are linear in coefficients.