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TESTING EXCHANGE RATE MODELS FOR ETHIOPIA

(A VAR approach)

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Testing Exchange Rate Models for Ethiopia (A VAR approach)

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A C K N O W L E D G E M E N T

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ABSTRACT

This paper is intended to design and select an exchange rate model that is consistent with the available information in Ethiopia. The models include: the Interest Parity Condition(IPC), a version of the Frankel's(1979) long-run exchange rate model and a Meese's(1986) model of exchange rate which is constructed from the deviation of Purchasing Power Parity(PPP). For this task, we have adopted Johansen's and Vector Autoregressive Representation(VAR) modelling methodology to conduct a test for the application of three popular exchange rate models. The validity of these models have been repeatedly analyzed under three major currencies against Ethiopian Birr.

Based on the finding of this paper, we are inclined to conclude that to construct exchange rate model for Ethiopia, Frankel's model is strongly supported by the empirical evidence. Exchange rate models representation implied by the interest parity condition and model of Meese(1986) are rejected for all currencies for Ethiopian data. The failure of the model suggested by interest parity condition and Meese's model can be capture by various econometric tests such as Johansen's cointegration and VAR modelling tests and variance ratio test.

I. INTRODUCTION

The theme of this paper is to search for an exchange rate model[1] that can represent long-run equilibrium relationship between exchange rate and market fundamentals for Ethiopia. For this task, we have adopted Johansen's and Vector Autoregressive Representation(VAR)[2] modelling methodology to conduct a test for the application of three popular exchange rate models. The validity of these models have been repeatedly analyzed under three major currencies against Ethiopian Birr.

The exchange rate models adopted for these tests include: interest parity condition, a Frankel's long-run exchange model that determined by the Purchasing Power Parity(PPP) hypothesis and Meese's(1986) model of exchange rate which is constructed from the deviation of PPP, or a random walk behaviour of RER for Ethiopia. The study selects three major trade partner countries' in order to study the behaviour of bilateral exchange rate. These countries include: USA, Germany and UK.

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[1] According to David F. Hendry and G. Mizion(1990), a model is a simplified representation intended to capture the prominent feature of some group of phenomena. Intrinsically, models represent the notions of design and a corresponding focus of interest, but are inherently approximations of reality. Thus, no model with a finite number of parameters is actually believed to give exact projections. Nevertheless, models can differ radically in their usefulness relative to the objectives of which they were constructed. Also, the extent to which the usefulness of the model depends on their actual design.

[2] A Vector Autoregressive Representation is an econometric methodology for testing restriction of a simultaneous representation of regression equations .

The analysis not only focused on the empirical evidence of exploring exchange rate model that fitted Ethiopian data but also analyzed the implication of different economic theories of exchange rate such as the PPP hypothesis and its deviation from the long-run equilibrium exchange rate.

The application and economic importance of each exchange rate models have been assessed via statistical tests based on a Wald test Statistics[3]. This test indicates that if the actual exchange rate and the market fundamentals have long-run relationship then the relevant exchange rate model is said to be applicable for Ethiopia. In this case the actual exchange rate and expected exchange rate forecast move close together. The Wald test statistics we have conducted here check the explanatory power of each exchange rate model and select the valid model.

We have also conducted a more robust cointegration tests developed by Johansen(1992). If these tests detect the existence of stable long-run relationship between exchange rate and market fundamentals then exchange rate and market fundamentals are cointegrated. While if these tests accept the hypothesis that the exchange rate and the market fundamentals are not cointegrated, then they drift too much apart and not tied together by some long-run equilibrium relationship and so the specification of the exchange rate model is invalid.

[3]The Wald test statistic employed here has an asymptotic chi-square distribution with the degree of freedom that depends on the number of restrictions on the parameters of the model.

Campbell and Sheller (1987) proposed test of the adequacy of the co-movements of the series involved in the model of exchange rate, i.e., the predicted value of exchange rate and the actual value based on their variance ratio. This ratio measures deviations of the actual exchange rate from the expected predicted by the models. Specifically, for the case of models considered here, if the model is sufficiently good, the ratio of the variance[4] of the estimated depreciation to the variance of the actual depreciation should not be significantly different from one.

There has been an increasing debate in the nature of relationship between exchange rate and market fundamentals in the last decades. There are a lot of exchange rate models proposed in international economic theories. The purchasing power parity(PPP) theory is central to many of exchange rate models. In its simplest form, PPP provides an equilibrium long-run relationship between exchange rate and national price levels. The absolute version states that the exchange rate is equal to the ratio of domestic to foreign price levels, i.e., $E_t=P_t/P^*_t$ where, E_t is the exchange rate, p_t and p_t^* are the price indexes of domestic and foreign countries, respectively. The implication is that exchange rate changes that deviate from PPP have a contemporaneous effect on a countries inflation dynamics. Dornbusch(1987) noted that the real appreciation dampens inflation and real depreciation increases inflation.

[4] The variance of the estimated depreciation can be calculated from the estimated variance covariance matrix of the VAR models' and the residuals of VAR model.

These effects of PPP deviation becomes a crucial in exchange rate theories issue and economist formulate different exchange rates model on the basis of PPP deviations.

According to Frankel's exchange rate model, the long-run value exchange rate is determined by PPP. Frankel(1979) suggested that the future expected depreciation is proportional to the deviation of exchange rate from its long-run value and the inflation differential. While in Meese's(1986) monetary model of exchange rate, the deviation of PPP is permanent. This theory of exchange rate determination is based on the fact that the equilibrium exchange rate is not stable due to external as well as internal shocks which the economy faces. In such case, the real exchange rate is not constant but varies overtime.

The portfolio balance model of exchange rate, which has been tested here uses the interest parity condition as its primary focus claims that exchange rate is determined by the supply and demand for bonds where domestic and foreign bonds are imperfect substitute. Under this model an increase in relative supply of foreign bonds as compared to domestic bonds due to say a current account surplus, causes an increase in the demand for domestic assets and this lead to an appreciation of exchange rate.

We have also looked at the prediction power provided by both exchange rate models under rational expectations assumption. The prediction power of the exchange rate models is then compared with the actual exchange rate using variance ratio tests and correlation analysis.

The organization of this paper is as follows. Section II describes the background of Ethiopian Economy. Section III provides a literature review of exchange rate theories. Then, this will be followed by a brief analytical methodology for testing the exchange rate models. The next section illustrated empirical results. Finally, chapter VI provides the summary and conclusion of the paper.

II. **Background**

2.1 Features of Ethiopian Economy

Ethiopia is one of the Least Industrialized Countries (LICs') in Africa and its economy is predominantly agriculture. The country has experienced declining trend in economic prosperity since 1974. Despite the fact that Ethiopia has relatively enormous agricultural potential with fertile land the country could only achieved a growth rate of 1.1% per annum in agricultural output and overall growth rate of 1.9% per annum during 1974-1991. Moreover, the countries population growth rate is 3% per annum and the highest among LICs'. Thus, Ethiopia is among the poorest nations in the world with estimated per capita income of US$120 in 1991 (World Bank, 1993).

The Ethiopian principal export commodity is Coffee. The volume of coffee export also declined on the average by 4.2% per year during 1984-1991. The foreign exchange earnings from this major export commodity have also declined over time. The merchandise export fell on the average by 1.9% per annum while imports rose by 9.4% per annum over the period 1974-1992. The trade balance of the country has always been in deficit and has been accelerated on the average by 1.8% per annum for the year 1974-1992. This shows that the countries domestic saving is not enough to fiance public investment program and relies on external loans and grants.

The stock of outstanding external debt reached US$ 7497.9m in 1991, while the cost of servicing long-term external debt amounted to 4% of the total revenues form export in 1991, (Felleke Mammo 1994). The trade crises in 1990 was due to lack of foreign reserves, at that time the country's capacity to import had been reduced to cover only two weeks of imports.

The economy had performed relatively better during 1969-1974 of the Emperor Haile Selassie's era. In those years, the trade sector growth rate enjoyed an appreciation record. The merchandise export grew at the rate of 16.9% per annum while imports increased at 11.6% per annum during 1970-1974. The balance of payment and the economic identities were superior relative to later years.

Ethiopian legal tender currency, the Birr, was initially issued on July 23, 1945. After the Bretton Woods agreements of

1944, the Birr was strong enough in terms of purchasing power and had a fixed gold content equal to Birr 2.5 = US$1. After the collapse of Bretton Woods System in August 1971, a new international monetary order was established in many developing countries. Pegged exchange rate system was started on the basis of major currencies. The Birr was pegged to US dollar, and other countries like Ghana, Guinea and Bolivia also pegged their currencies to US dollar.

The pegged exchange regime during that time had advantageous over the alternative floating exchange regime for at least four reasons. First, in early 1971, due to the collapse of Bretton Woods system, there was a general confusion in international market and flexible exchange rates were excessively volatile. Second, floating regime was difficult for LICs' because they lack a continuous and adequate means of adjustment, i.e., they didn't have enough foreign reserves to cope with fluctuation.

Third, Panos Varansis and Ying Qian(1992) noted that exchange rate volatility increases uncertainty in international transactions and thus discourages trade. If market participants are risk averse, they will be willing to incur an additional cost to avoid the risk associated with the exchange rate volatility. In this sense, trade will be reduced in response to added costs.

Fourth, fixed exchange rate to major currencies with low inflation countries such as USA and Germany put restrictions on monetary policies and domestic inflation move towards low inflation country to which the currency was pegged. Therefore, this institutional shift was appropriate. For instance, Ethiopia's real GDP growth rate recorded at 2.5% per annum in the period 1970-1974.

As mentioned above, Ethiopian economic growth after 1974 remained stubbornly slow and declined in the period 1984-1992. For example, real GDP growth rate fell drastically by 9.6% in 1992. There are a number of factors attributed to these crises. Ethiopia had been in continuous civil war for more than three decades. It has been also experienced adverse exogenous shocks of severe drought which greatly affected the output of agricultural sector. However, the poor economic performances of Ethiopia remains by and large a mistake of macroeconomic policy makers of the past government.

In particular, the introduction of socialist economic policy could be taken as a leading factor for the crisis. This shift in the ideology of the system introduced nationalization of major private industries, banks, and insurance companies. Private investment was prohibited, and this situation by and large aggravated the crises in the economy.

The feature of Ethiopian monetary institution arrangement after the nationalization had virtually changed to serve state property and retarded the growth of private enterprises. The pool of international private capital flows which is critical for sustainable development became blocked and the growth of private financial institutions had been abolished in their infant stage.

Consequently, the trade policy can be characterized by inward-oriented import substitution strategy; protectionism using heavily levied tax on export, import tariff and price control mechanism. This policy gave rise to weaken export. Under unfavourable world prices of export this further worsened the terms of trade of the country. Thus, the trade balance throughout the period 1975-1991 registered deficit.

Due to the Government's repeated attempt to violate varies sorts of budget constraints for example, the deficit reached 20.6% of GDP in 1990. The cumulative effect on the areas of trade, particularly, on the fixed exchange rate, the clearest result was an overvalued[5] exchange rate and the misalignment of real exchange rate from its equilibrium value. The overvalued exchange rate generally results from unsustainable fiscal policies. Rodrick(1986) elaborated that overvalued exchange rate implies that the present value of public sector expenditure would be higher than the present value of taxes, while misaligned exchange rate imply both an inter-temporal and inter-sectoral shifts in the economy's expenditure pattern.

[5] Rodrick(1986) defines overvaluation for a fixed nominal exchange rate system as the deviation of the actual real exchange rate to the real exchange rate that would prevail under flexible nominal rate caused by a forward shift in government expenditure.

Regarding the inter-temporal shift an increase in current government expenditure implies an increase in overvalued exchange rate. The inter-sectoral shift in expenditure refers to the composition between private and public sector expenditure. This shift in composition of expenditure from private to government depends on the way in which the misalignment is brought about in to the economy. Here, it must be noted that a deficit came form a shift of expenditure from private sector to the government and this deficit will be reflected in the balance of payment and affect the exchange rate. For example, if the overvaluation originated by an increase in public sector expenditure which is compensated by higher future taxes, then the outcome is a misalignment of real exchange rate from its equilibrium value.

Exchange rate overvaluation can create a parallel market for foreign exchange, Pinto(1990). However, the parallel market[6] for exchange rate typically emerged when government attempt to correct the current account deficit using exchange rate control. As a result of vast exchange control and regulated current account transactions in foreign trade, the economy moved towards a flourishing and large parallel market for foreign exchange. This parallel market has been co-existed with official market for more than a decade. The premium is also significant, and is around 20% of the official exchange rate in early 1996.

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[6] In addition the existence of excess demand situation in the exchange market is a prerequisite for a parallel market to arise, (Lindauer 1989).

The source of supply to this market is a function of the controlling systems and structure in the country. Obviously, it will be profitable to under invoice[7] the foreign currency proceeding of an export activities and divert a portion towards the parallel market. Second, favoured importer who receive foreign exchange in the official channel could over invoice[8] their imports. Thus, they will divert some of the foreign exchange to the parallel market if the parallel market price gives greater opportunity than their own marginal evaluations. Finally, remittances that channelled to the parallel market is also another source of supply.

The existence of such parallel market with substantial premium[9] in Ethiopia has crucial economic implications. Pinto(1987), Elbadawi(1993) and Lizondo(1987) elaborated the premium depends on fiscal deficit to GDP ratio, parameters of trade and exchange rate policies. The macroeconomic indicator such as inflation, foreign trade flows, and the real exchange rate has shown to be influenced by the premium or jointly determined with premium, Elbadawi(1990).

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[7] Exporter usually understate their volume of export in international market in order to shift some of the foreign exchange earning to the parallel market.

[8] Importers also over state their volume of imports in order to shift some of the excess foreign exchange allocation to the parallel market.

[9] The premium is defined as the difference between the parallel and the official exchange rate. However, in our analysis, it is defend as the difference between the logarithm of the two exchange rates, i.e., $\log(s_t) - \log(e_t)$, where s_t and e_t are parallel and the official exchange rate, respectively.

Pinto(1990) further noted that the real exchange rate varies inversely with the parallel market premium. This relation follows from the fact that the premium is an implicit tax on exports and the higher the premium the lower export earnings and the higher the price of imported inputs in home goods. Pinto(1990) further noted that there is also a trade-off between inflation and exchange rate premium. The empirical results of Elbadawi(1990) suggest that a rising premium will result worsening of terms of trade, declining foreign aid and higher expectation of future devaluation.

Economists during the 'Durg' regime analyzed the impact of exchange rate policy changes on the overall economic growth and suggested exchange rate reform in Ethiopia. However, many economists have pointed out that the economic crisis in Ethiopia was structural in nature and this crises could not be removed by exchange rate policy changes. Consequently, they proposed the economy to undertake basic structural change by giving emphasis to substantial export promotion and longer periods of adjustment in all sector of the economy.

In 1992, the Transitional Government of Ethiopia(TGE) in collaboration with World Bank and IMF adopted a stabilization programme (see PFP, 1992). This programme include the reduction of quantitative restrictions and their replacement by price measures, the lowering of tariffs, the simplification of import and export procedures and the unification of exchange rates.

The policy prescriptions of domestic financial liberalization entails movement towards a more market oriented system. The typical program of the liberalization involves two main components in the area of exchange rate. First, there is an attempt to allow exchange rate to be gradually market determined through an auction exchange market. This component facilitates the movement towards the unification process. In this process, a gradual relaxation of exchange control has been noticed in an attempt to unify the parallel and official exchange rates.

Second, because exports are so beneficial, removing regulatory and policy impediments to exporters in areas of marketing, trade restriction, and foreign investment should be among the first targets of the reform. It is also important to eliminate regulations in other sectors that impede export performance or at least reduce the negative impact on exports.

Exchange rate policies and financial service are critical to export growth. Exchange controls and hindrances to efficient service of foreign currency markets should be dismantled. Currently, a 100% advance payment for the purchase of investment equipment has been reduced to 25% through the official market. Controls on both imports and exports tried to be shifted to tariff and taxes in effect to improve the balance of payment.

World Bank and IMF Program have supported the unification based on the argument that multiple exchange rates misallocate resources. However, recent exchange rate reforms in many African countries where parallel market is active emphasized that unification process requires the parallel rate should depreciate by less than the official rate so that the premium has to fall. The process of unification has its ultimate objective to absorb and legalize the parallel market for foreign exchange eliminating the inefficiencies and market fragmentation associated with a quasi-illegal activity. Quirk(1987) points out that polices which bring the two exchange rate close to each other are important to narrow the premium during the unification period. In practice, unification attempt have the form of the adoption of a uniform floating exchange rate, i.e, a shift from auction exchange rate to floating exchange rate.

Aron & Elbadawi(1992) suggested that there is little known about auction determined exchange rate. Willem Naude and Abu(1994) elaborated that under the auction system all export receipts have to be surrendered to the central bank at a prevailing exchange rate. The central bank then decides the amount of the receipts to be auctioned at regular interval after setting aside amounts for debt servicing of imports at an official fixed exchange rate. Here, documentation was needed to accompany bids in the auction market. The auction system has been chosen because the local commercial financial institutions such as stock market for foreign exchange are under developed and it is a step to move towards floating exchange rate system. Furthermore, strong argument in favour of an auction mechanism for determining exchange rate was that the institution of such a mechanism would ensure gradual flexibility of the exchange rate and avoid the previous tendency to let the currency get over-valued subsequent to any devaluation, Dani Rodrick(1985). The movement towards a market determined exchange rate system in the form of a foreign exchange auction is a significant step in the evolution of exchange rate policy in Ethiopia.

2.2 The Objective of the Study

The main objective of this paper is to design and select an exchange rate model that is consistent with the available information in Ethiopia. The models include: the Interest Parity Condition(IPC), a version of the Frankel's(1979) long-run exchange rate model and a Meese's(1986) model of exchange rate which is constructed from the deviation of Purchasing Power Parity(PPP). All these models have been modified to some extent to fit to the multilateral exchange rate system prevailing in Ethiopia.

The result that has emerged from this paper is a correct specification of exchange rate model that is more applicable for Ethiopia. This model is also more important in determining future exchange rate and became suitable and powerful predictive model in the country. Therefore, the study has important implication for future macroeconomic studies, and the findings of the correct model of exchange rate is a fruitful avenue for further research.

Since the Ethiopian Birr is an imperfect substitute to other currencies and capital is immobile, the interest parity condition tested here is based on the assumption of imperfect substitution of birr to the major currencies and imperfect capital mobility. Frankel(1986) argues imperfect substitute currencies can not be modeled by uncovered interest parity condition[10]. However, if assets bear different risks in different places, such currencies can be modeled by a portfolio balance approach where agents are able to shift their assets holdings according to the risk and returns of the assets in the portfolio consideration.

The interest parity condition to be tested here is constructed on the basis of the future expected depreciation of exchange rate in the parallel rate is proportional to the interest rate differential and the premium. In this model, we can analyze the parallel depreciation in relation to the premium and the interest rate differential. Thus, this model might capture broad changes in the variability of exchange rate episodes.

The second key test investigated in this paper is the Frankel's(1979) long-run model of exchange rate determination. This model is a more complete model and states that exchange rate depreciation is proportional to the inflation differential and its current deviation from the equilibrium exchange rate

[10] Uncovered interest parity condition state that people face the same risk on domestic and foreign assets. Thus, people choose their portfolio considerations only based on the returns on assets.

value. Frankel(1979) suggested that the inflation differential corrects the short run exchange rate deviation from its long-run value which is determined by PPP. Under this model we have captured the relationship between inflation and the expected depreciation.

The long-run exchange rate depends on market fundamentals and this equilibrium value rely on the path of PPP hypothesis. Frankel(1979) noted that the long-run exchange rate estimated from the PPP hypothesis which defines the bilateral exchange rate as the relative prices of the two countries.

The implication is that if the authorities attempt to compensate a fall in revenue by an increase in monetary financing of fiscal deficit, then this will entail a substantial rise in rate of inflation and in the long-run this leads to a depreciation of exchange rate. Thus, in our analysis of exchange rate model in the long-run, inflation differential is found to be an explanatory variable for future expected depreciation of exchange rate changes.

The third test of exchange rate is related to the hypothesis that the deviation from PPP is a random walk[11] process. The random walk property of real exchange rate comes from internal or external shocks to the economy. If the shock

[11] A random walk is the simplest type of non-stationary series whose first difference is stationary. Usually, if s_t is a random walk process then such process can be described by the following relationship,

$$s_t - s_{t-1} = u_t$$

where, u_t is a stationary process.

is strong enough to lead permanent deviation of exchange rate from the PPP, then real exchange rate follows random walk process. The performed test is to find out whether deviation is persistent over time or not. In other words, this is a test for constant real exchange rate trend over time. If the deviation persists the real exchange rate may vary over time, in particular, follow a random walk process. This exchange rate model is often referred to as the monetary model of Meese's(1986).

In our analysis a Vector Autoregressive Representation (VAR) framework is adopted to test exchange rate models and measure the deviation of the observed exchange rate behaviour from the expected exchange rate implied by the some economic model of exchange rate. This approach has an advantage over a single equation test in which insignificant coefficients simply attributed to a failure of the model. However, for example, negative coefficients on money supply could be a simultaneous reaction of exchange rate and money supply to central bank intervention using monetary policy. In such case the exchange rate will follow a random walk process and the regression of exchange rate on market fundamentals results spurious[12] relationship. Such econometric problems have often encouraged to conduct a VAR methodology of testing exchange rate models based on market fundamentals.

[12] Sometimes in a regression equation it may be found a low Durbin- Watson statistics. This is an important warning signal for which a spurious regression has been obtained and the residual become far from stationary process.

In our analysis, careful consideration is given to econometric problems associated with non-stationarity of the exchange rate and market fundamentals. We have only estimated those regression equations that gave rise to cointegrated process and stationary residuals.

This paper will also investigate six bilateral Real Exchange Rate(RER) indexes with respect to US dollar, Germany's mark and UK's pound sterling using both official and parallel nominal rates. We have also assess tests for the hypothesis whether such indexes follow a random walk process or not. Augmented Dickey Fuller(ADF) test is used to test the stationarity of the series. In the VAR-model the behaviour of the fundamental determinants of exchange rate derived in monetary framework and the hypothesis of a random walk process for RER is tested.

It is important to note that the models already adopted here are tested under a forward-looking behaviour or rational expectation assumption. As Robert Lucas(1990) noted that Rational Expectation Hypothesis(REH) states that in the formation of expectations about future economic conditions agents use all the information available to them efficiently in exchange market. However, economists such as Pesaran(1987) comment agents lack the required information to act in this way, particularly in LICs'. Nevertheless, we will proceed to the REH as a reasonable assumption for exchange rate behaviour in Ethiopian exchange rate market.

2.3 The Significant of the Study

The Exchange rate, particularly, the parallel exchange rate is taken as an endogenous variable and strongly linked to the rest of the macroeconomy through a model of exchange rate. These models are very important building block in the macroeconomic model and link the foreign trade sector to the rest of the economy. The importance of exchange rate in a macroeconomic management and policy design is unquestionable. Therefore, testing such exchange rate models is a step before models to be used in macroeconomic framework.

We have carefully selected three popular exchange rate models which fit to the Ethiopian multiple exchange rate system and examine their economic significance to by performing a battery of statistical tests. Attempts are also made to include both the auction and parallel exchange rate in the model. The official exchange rate is assumed to be partly controlled and considered an exogenous variable while the parallel rate is taken as an endogenous variable. Other variables such as premium, inflation and interest rate differential are included as an explanatory variables.

A large information set is used in the statistical analysis and the time series properties of the variables have been carefully investigated before the actual analysis has been carried out. The analysis is based on expectational version of exchange rate models as opposed to tests based on a single monetary approach to exchange rate determination and a regression equation of exchange rate on market fundamentals. This study contains explicit treatment of expectation formation which has important implications in exchange rate modelling, i.e, agents future expectations of exchange rate depreciation affects investment, consumption and many other macroeconomic variables.

We have examined the unification process of the exchange rate during the trade reform and on the way of testing the three exchange rate models. The study is limited to the period between January 1991 to September 1995, because monthly data is available for most of market fundamentals in Ethiopia during the period mentioned above only. The sample size, however, may have some effect on the merit of the analysis.

2.4 **Data**

In this paper attempts have been made to test three exchange rate models for major trade partner countries of Ethiopia (i.e., USA, Germany, and UK) using monthly data on a bilateral exchange rate of Birr against US Dollar, Mark and Pound Sterling. We selected these currencies because of the fact that USA, Germany and UK are among the leading major trade partner of Ethiopia. These countries share 33% of the total trade in Ethiopia. The power of the performance of the models have been assessed using the available monthly data for USA, Germany and UK.

Data on money supply (narrow money, m_1), interest rate (time deposit rate), nominal exchange rate and the consumer price index(CPI) for USA, Germany and UK are available in IFS publications. Monthly official exchange rate (i.e., auction exchange rate), a parallel exchange rate and money supply, m_1 are available in National Bank of Ethiopia(NBE) publications and domestic CPI is also taken from Central Statistics Authority(CSA) publications.

However, monthly data of GDP are not available for Ethiopia. But, using an econometric technique, we have disaggregated the actual yearly GDP into monthly data. The technique used here is simply a regression approach. In this approach, we have followed the following important steps. First, we have assumed that income is a linear function of imports. Second, the model specification is selected based on diagnostic tests and significance of the parameter involved in the regression of GDP on imports including their lags. Third, based on the result obtained from the regression estimation, we are able to generate the first 11 months series from the corresponding monthly imports. Lastly, the 12^{th} month real GDP can be calculated by subtracting annual GDP from the first 11 months of estimated values. In other words, the fitted value from the regression on income have taken as a proxy for monthly real GDP data. Finally, the monthly real GDP is calculated by deflating the estimated monthly nominal GDP by CPI.

The period of analysis is from January 1991 to September 1995 based on monthly data. The time period reflects the period for which monthly data available for Ethiopia. During this period, the official exchange rate elapsed two different exchange rate regimes. The first period is fixed exchange rate regime of Birr 2.07=U$1. This regime has remained from January 1991 to October 1992. After four months the new economic reform commenced a devaluation of the Birr against the US dollar on September 1992 and established a new rate of Birr 5=US$1. This large devaluation of Birr create a new exchange rate episode during the period of analysis and narrowed the premium gap substantially. Second, in April 1994, the exchange rate policy marked significant change and started to implement a managed or auction determined exchange rate. A continuous depreciation of the auction exchange rate also further reduces the over valued aspect of the official exchange rate.

III. LITERATURE REVIEW

The most common currency value of a nation is the bilateral exchange rate quoted by a foreign exchange market often reported in a news paper. This nominal exchange rate is the number of units of one currency that is offered in exchange for a unit of another. According to Dornbusch(1980), there are basically three views of the exchange rate. The first takes the exchange rate as relative price of money; the second, as the relative price of goods; and the third, as the relative price of bonds. Actually all these views are a partial picture of exchange rate determination. Other insights of this decade researchers views foreign exchange as a financial asset.

The implication of this definition is that the current exchange rate reflects expected value of future exchange rate as a function of exogenous variables discounted back to the present. Of course, This is analogous to the notion that a security's price reflects the present value of expected future cash flows. A second implication is that the price of currency is determined by the demand for it as a financial asset relative to the demands for other currencies. This is based on the currency utility as a medium of exchange, store of value and unit of account.

3.1 <u>Interest Parity Condition (IPC)</u>

The most important dichotomy in the interest parity condition is whether or not domestic and foreign assets are assumed to be perfect substitutes in portfolio[13] balance considerations. Perfect capital mobility between countries means the actual portfolio composition adjusts instantaneously to desired portfolio composition. Therefore, assuming no exchange controls, perfect capital mobility insures covered interest parity(CIP). This CIP condition states that the interest rate on domestic asset is equal to the interest rate on a similar foreign asset plus the forward premium on foreign exchange. However, in Ethiopia capital is assumed immobile and CIP condition does not hold. Thus, we can't apply this

[13] The portfolio balance approach is the view of exchange rate as a relative price of assets. The imperfect capital mobility and imperfect currency substitution are crucial assumptions in the construction of the portfolio balance exchange rate models.

condition to model exchange rate for Ethiopia.

We can also formulate IPC under the assumption of perfect substitution of domestic and foreign assets. Perfect substitution of assets would imply uncovered interest parity condition(UIRP). Here, the interest rate on a domestic bond is equal to the interest rate on a foreign bond plus the future expected rate of depreciation. Perfect substitution is not reasonable assumption for Ethiopia. This assumption imply domestic and foreign assets have the same risk. Under this condition, asset holders are indifferent to choose their asset portfolios as long as the risk in holding foreign and domestic asset is the same since their expected return on investment is the same.

However, trade in many situations involve exchange rate risk. If the currency is completely fixed, this risk become almost zero. But most currencies including, Ethiopian Birr, are somewhere between completely floating and fixed exchange rate. Even the auction exchange rate which is close to fixed exchange rate often exhibit the characteristic of exchange rate risk. One way of dealing with this risk is to buy foreign currency forward through forward exchange contract. A forward exchange rate contract is a contract specifying delivery of one currency for another at a letter date and at fixed price. For example, consider an importer who has to pay say 1000 USD within three months. The dollar rate of 3 months from now is unknown. If the importer waits and pays the invoice on the last day, the exchange rate might depreciate and he might lose a lot of money. The opposite might also happen if the rate might appreciate leading to a profit. The importer has to deliver a certain amount of foreign currency in the future at an exchange rate unknown at this time. This exchange rate is what we often call the future expected exchange rate.

In many developed countries where domestic and foreign asset are perfect substitute the forward rate is unbiased estimate of future exchange rate depreciation. In such countries, uncovered interest parity condition will hold. The uncovered interest rate parity(UIRP) condition takes the following relationship.

$$E_t s_{t+1} - s_t = r_t - r_t^* \qquad \ldots (1)$$

Where, E_t is the expectation operator, s_t is the logarithm of exchange rate and r_t and r_t^* are domestic and foreign nominal interest rates. This relation states that the expected exchange rate depreciation between time t and t+1 is equal to the interest rate differential. The risk premium are assumed to be negligible. Here, a wealth holder who is choosing between domestic and foreign asset will not only compare interest rates but also tries to calculate future exchange rate to know the future value of his investment.

Intuitively, we can further elaborate the above UIRP condition. Consider a wealth holder who deposited X_0 Birr in local bank at time t. Next year, his amount reach to $X_0(1+r_t)$ at r_t domestic interest rate. The investor has also an alternative to deposit his money in foreign banks. However, first he has to convert his Birr to foreign currency. Thus, he has X_0/s_t amount of foreign currency at s_t exchange rate. Next year, his amount will be $(X_0/s_t)\ (1+r^*_t)$ foreign currency at r^*_t foreign interest rate. This amount could be converted to local currency at future exchange rate, say $E_t s_{t+1}$. Thus, his foreign investment will be $X_0 E_t s_{t+1}/s_t(1+r^*_t)$ in local currency. If the risk premium on domestic and foreign investment is assumed the same, equating the amount earned in both countries, upon some rearrangement and taking logarithm of both sides we can arrive at the UIRP[14] condition, i.e, equation(1).

However, in many LICs' including Ethiopia UIRP fail to operate due to imperfect substitution of domestic and foreign bonds. Such behaviour can also be modeled in portfolio balance approach. Frankel(1976) noted that asset holders wish to allocate their portfolio share that are well defined function of expected rate of return.

In modelling the exchange rate for Ethiopia, however, one can construct a general form of IPC which include the imperfect substitution and imperfect capital mobility. It is also necessary to take the account of the prevailing phenomenon of the multiple exchange rate, i.e., the parallel and official

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14 $$X_0\ (1+r^*_t) = X_0 E_t s_{t+1}/s_t(1+r^*_t)$$
$$(1+r_t)\ /\ (1+r^*_t) = E_t s_{t+1}/s_t$$
$$\text{or}\quad E_t s_{t+1} - s_t = r_t - r^*_t$$

During the derivation, we have assumed the following approximation,

$$\log(1+r_t) \approx r_t$$
$$\log(1+r^*_t) \approx r^*_t$$

rate. Because the expected depreciation depends on both exchange rates, particularly, the parallel exchange rate depreciation depends on the level of official exchange rate, the parallel market premium and the interest rate differential. Considering the above economic phenomenon, we suggest the following interest parity condition.

$$E_t s_{t+1} - s_t = \sigma (r_t - r_t^*) + \beta (s_t - e_t)$$

$$0<\sigma<1,\ 0<\beta<1 \quad .... \quad (2)$$

Where, E_t is the expectation operator, s_t is the logarithm parallel exchange rate, e_t is the official exchange rate, r_t and r^*_t are the domestic and foreign nominal interest rates. σ and ß are measures the degree of capital mobility and substitution, respectively.

The interest parity condition in equation(2) states that the expected future depreciation in parallel market is proportional to the interest rate differential and the premium. The sign of σ, the coefficient of interest rate differential is expected to be positive. The restriction, $\sigma=0$ implies capital is perfectly immobile. On the other hand, when the value of σ is between zero and one, $0<\sigma<1$, it is the case of some degree of capital mobility while $\sigma=1$ is the case of perfect capital mobility situation. Since capital is immobile in Ethiopia, the value of σ is expected to be close to zero.

The coefficient of the premium, ß, measures the rate of change of depreciation with respect to the change in the premium. In equation(2) the official exchange rate acts like a policy variable for excessive depreciation of the parallel exchange rate. If the unification process is to be successful the rate of change in depreciation of parallel rate should be less than the rate of change in the official rate. Thus, the rate of change of premium will decline over time. Otherwise, the premium increases over time and the sign of ß is likely to be positive given agents expectations of parallel rate is depreciation. However, the unification process requires the premium to decline over time and eventually, ß become zero.

In equation(2) ß=0 implies perfect substitution case as $\sigma=1$ implies perfect capital mobility. But,the double restrictions, ß=0 and $\sigma=0$ is the case of fixed exchange rate. Therefore, the most probable case in Ethiopia during the study period is the case of $\sigma=0$ and 0<ß<1. Intuitively, this is the case of capital immobility and imperfect substitution. Here, depreciation will only be proportional to the premium.

Since, we estimated three bilateral exchange rates for major trade partner countries, we should expects different estimates of the parameters σ and ß. But all estimates are expected to reflect the characteristics of Ethiopian exchange rate markets. However, such interest parity condition does not mean it can capture all the risk that exist in holding foreign exchange in Ethiopia. There are certain risks that can't be captured by the model. We can see at least three kind of risks involved in exchange rate market.

First, there is a default risk. There is a possibility that agents including firms and government might go bankrupt or default during the investment period. The second type of risk is an inflation risk. Here, the expected value of an investment must be evaluated in terms of real purchasing power, i.e., the amount of goods that the investor can purchase after the investment is made. Since the investor is consuming both domestic and foreign goods he/she must consider relative rate of inflation, and how this inflation rate are correlated with exchange rate. Such inflation risk can be reduced by taking into account the inflation differential in the model. Of course, this would not be a problem if the absolute PPP holds, this means all tradeable goods cost the same in domestic and foreign countries.Later, we will see long-run exchange rate modelling with inflation differential as an explanatory variable.

The third risk is labelled as "realignment risk" or often referred to us the 'peso problem'(see, Svensson 1992). These is not a risk in financial transaction sense. However, it has to do with the way investors and trade agents make predictions about future exchange rate. Here, agents might calculate the probability of policy changes to compensate their portfolio adjustment. In this context a government which is committed to a policy of auction determined official exchange rate might still decide to change the exchange rate regime. Also, it might change the value of its currency in the future through devaluation. This policy change is what we call 'peso problem'.

Our test strategy for testing the interest parity condition of Equation(2) assumes the absence of the risks specified above. Econometric tests of the interest parity condition, however, possibly reject the hypothesis of the model in equation(2). If the tests reject the hypothesis, as theories explain, the rejection will be as a consequence of the risk premium which is not explained by the model.

The results from literature of empirical test in developing countries are mixed. Early studies of parallel market tended to reject the idea of risk premium. For instance, Huang(1984) noted that the rejection of the hypothesis of UIRP can be explained as the outcome of badly specified models in combination with an inadequate testing of the models. Other attribute the rejection to chance. However, in this situation where many exchange rate models are tested, it must be expected that conventional statistical methods will lead to the wrong conclusions in at least five out of a hundred tests.

The relationship in the models can be tested in several ways. Following Gaab and Horner(1986), such tests can be divided into strong or weak tests. A weak test of interest parity condition requires the average rate of depreciation in both market to be equal to the sum of the average of relevant variables included in the interest rate parity equation (i.e., the sum of the average of interest rate differential, the official exchange rate depreciation and the premium). Another test, which should be labelled as weak, calculates the deviation from the interest rate parity condition and regress this against the different specifications of the variables in the information set. If the model is valid, the deviation has no relationship with the available information set.

A semi-strong test of interest parity condition requires that the variation in risk premium is small in comparison with the variation in the expected depreciation.

$$\mathbf{Var(r_{pt}) \quad < \quad Var(E_t \; \Delta s_{t+1})}$$

Where, r_{pt} is the risk premium and Δs_{t+1} is the expected rate of depreciation . This test is somewhat dubious. The variance are often calculated by decomposing the total estimated variance of the parameter in the interest parity condition. The variance will only be correct if the estimated equation is correct. In addition, omitting a relevant variables will lead to inefficient estimates of the variance.

A test is labelled as strong test, if the predicted exchange rate depreciation differs from the actual by a forecast error which is orthogonal to the information set. This implies that excess returns from the interest parity condition specified in the model should be unpredictable. This argument has important implications. In particular, the econometric interpretation is that a projection of the excess return process onto the information set must have statistically insignificant coefficients.

Also, this result is reminiscent of the more general result of orthogonal test which is equivalent to testing the cross-equation restriction of the VAR model. This can be obtained from the imposition of the rational expectation assumption on Vector Autoregressive Representation(VAR)[15] methodology in the underlying model of exchange rate. Abel and Mishkin(1983) noted that the immediate consequence of this equivalence is that test of cross-equation restrictions are valid tests of the underlying model even when relevant information is excluded from econometrician information set. In addition, Abel and Mishkin(1983) demonstrated a VAR orthogonal test that is more robust and yield superior information about economic agents.

The usefulness of the more complicated VAR approach to testing exchange rate models lies on its ability to offer valuable insights pertaining to the economic significance of such models. Moreover, the test provided by the VAR approach has major advantage over single equation test of rational expectations models.

Indeed, Mishkin(1989) noted that the VAR approach can be used to generate an alternative test of how successfully the model explains the data, telling us how valuable the model is economically. In addition, Campbell and Sheller(1987) proposed test of the adequacy of the co-movements of the series involved

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[15] A survey of the VAR approach to testing exchange rate models can be found in Baille(1989) also Cambell and Shiller(1987) provide detailed applications of VAR-models.

in the model of exchange rate, i.e., the predicted value of exchange rate and the actual value based on their variance ratio. This ratio measures deviations of the actual exchange rate from the expected predicted by the models. Specifically, for the case of models considered here, if the model is sufficiently good, the ratio of the variance[16] of the estimated depreciation to the variance of the actual depreciation should not be significantly different from one.

It is worth commenting at this point that the difference of the method used here from other tests. The case used here is the difference between the two spread that include not only the model specification error under the VAR model but also the specification error of the forecasting mechanisms. Deviations from the model can be measured by the difference between the estimated depreciation and actual depreciation. Therefore, rejection of the hypothesis of zero difference can be attributed to specification error of the model. This is because any specification error in the forecasting mechanism will bias the forecasts in the same way. However, the assumption of linear dynamics for the variables will be maintained throughout this paper[17].

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16 The variance of the estimated depreciation can be calculated from the estimated variance covariance matrix of the VAR models' and the residuals of VAR model.

17 Resent studies have shown that many macroeconomic series are characterized by non-linear dynamics which call for models of non-linear dependence of exchange rate models, Hgieh(1992).

Durlauf and Hall(1988) used an unobserved component model to measure the specification error or noise associated with exchange rate models. Their approach suggests that the implications of the present value model are exhausted by the speed of depreciation under perfect foresight assumption using single equation approach. This condition, however, is implied by the set of restrictions that the model places on the VAR representation of the available information. Thus, the VAR approach for testing models of exchange is more general than single equation methodology.

3.2 <u>**The PPP Hypothesis**</u>

National Economies are linked to the foreign sector by exchange rate and commodities through trade. The speed and efficiency in which the arbitrage mechanism works determines the extent to which the economies are open or closed. The issue is whether domestic prices are primarily determined by domestic supply and demand (a closed economy) or by world wide supply and demand (an open economy). In other words, the question is whether PPP holds in short-run as well as in the long-run.

We have distinguished the short-run as well as long-run PPP properties of exchange rate in order to test exchange rate models accordingly. The long-run exchange rate relationships directly related to some form of absolute PPP, and state that the bilateral equilibrium exchange rate between domestic and foreign currency equals to the ratio between domestic and foreign prices. This is a hypothesis that the long-run exchange rate is determined by domestic prices relative to foreign prices. In other words, a unit of currency should have the same purchasing power over time, Shapiro(1983).

The short-run exchange rate model also relies on a relative version of PPP. This doctrine modifies exchange rate determination by stating that the proportionate change in the equilibrium exchange rate between domestic and foreign currency equals to the proportionate change in the ratio of domestic and foreign prices.

The condition of absolute PPP is usually derived in two country setting in which the two countries trade a wide range of tradeable goods. In each case the law of one price has to hold for each of the goods traded.

$$E = p_i/p^*_i \qquad i = 1,2,\ldots, n.$$

where, E is domestic price of foreign currency, p_i and p^*_i are domestic and foreign price of the good, respectively. The law of one price, for example, says, if the price of oil in Addis Ababa is 240 Birr per barrel, we expect the price in New York is $40 USD per barrel when the exchange rate is 6 Birr per US Dollar. Thus, if for some reason the relative price is greater than the exchange rate, it would be profitable to ship the good from the foreign country to the domestic country there by forcing the domestic value of foreign goods up and domestic price of the traded goods down until equality between the two prices and exchange rate restored.

The doctrine of PPP, however, usually pertains to broad aggregate of goods. The absolute PPP requires that exchange rate equalize the ratio of prices of a market basket of goods in the two countries. In other words, by summing the prices of all of the tradeable goods in each country and giving both prices the same weight in the sum, we obtain the condition of absolute PPP.

$$E_t = p_t/p_t^* \qquad \ldots \qquad (3)$$

Where, E_t is the exchange rate, p_t and p_t^* are the tradeable price indexes of domestic and foreign countries, respectively. Since the composition of market baskets of tradable goods and prices indices varies substantially across countries, and because many goods are subject to tariff, it is unlikely that the absolute PPP will hold in the real world, particularly, in short-run.

The restrictiveness of the equation(3) in the case of Ethiopia is important. First, the existence of multiple exchange rates in Ethiopia, i.e., the parallel exchange rate and official exchange rate will further complicated the hypothesis to choose between the two the exchange rates. Second, the existence of transportation cost and impediments to trade, such as tariff and quotas will prevent condition of absolute PPP to hold properly. However, if the first factors (transport cost and tariff) are assumed constant overtime, and the condition can be expected to hold in logarithmic transformation of the equation(3),

$$\log E_t = \log P_t - \log P_t^* \qquad \ldots \qquad (4)$$

$$e_t = p_t - p^*_t$$

Where, the lower case letters now indicate that the level of the variables have been transferred using the natural logarithm. Finally, we can express the above equation in changes and arrive to a condition known as relative PPP, which state that the percentage exchange rate depreciation is equal to the difference between domestic and foreign inflation. The first restriction, however, can be solved by assuming the relative PPP holds for the parallel exchange rate or official exchange rate. Therefore, we can form the relationship as,

$$\Delta s_t = \Delta e_t = \Delta p_t - \Delta p_t^* \qquad \ldots . \qquad (5)$$

Where, s_t and e_t are the logarithm of parallel and official exchange rates and p_t and p^*_t are the logarithm of domestic and world price levels. Under this condition, the percentage exchange rate depreciation in parallel or official market is equal to the difference between domestic and foreign inflation.

In equation(5) there are an array of factors such as central bank intervention and capital control that keep the official exchange rate away from its relative PPP determined rate. However, the parallel exchange rate might move in line with its PPP rate because this exchange rate is determined by supply and demand for foreign exchange.

In an attempt to estimate either the absolute or relative PPP, researchers are immediately confronted with the issue of the appropriate price index series to use. If one could construct price series based on the price consisting of internationally traded goods then estimating relative PPP would be relatively clear and straight forward. However, in practice such attempt will not be practical as some price indexes such as tradable goods, producers and wholesalers price indexes are not available for Ethiopia. Since the producers and wholesalers price indexes incorporate prices of non tradable goods, we may take consumer price index as a proxy for wholesaler price index. Using consumer price index absolute PPP condition are perhaps more likely to hold in long-run.

3.3 Real Exchange Rate(RER)

Real exchange rate expresses the value of a currency in terms of real purchasing power. A PPP real exchange rate index measures the competitiveness of the country in question relative to other countries. A PPP real exchange rate does not provide precise information on how relative prices affect exchange rate on the evolution of international trade and the different accounts of the balance of payment. It fails to capture changes in relative incentives and guiding resource allocation across tradeable and non-traded sector. Such measures are captured by defining RER to be the ratio of the price of tradeable to non-traded goods. However, due to lack of data we choose PPP real exchange rate indexes for our analysis. Such RER, takes the following form,

$$RER_t = E_t \quad p_t / p^*_t$$

Where, RER_t is the bilateral exchange rate, p_t is domestic price index and p^*_t is foreign price index. This definition of RER is helpful in the long-run exchange rate model because such model assume that absolute purchasing power parity will be maintained at equilibrium, i.e., RER is constant over time.

Sebastian Edwards(1989) noted that facing with practical decision of constructing real exchange rate indexed for developing countries one could confronted with fewer options than those suggested by more theoretical discussions. The construction of actual indexes are surrounded by a number of problems ranging from which price index to use. Since in Ethiopia there are multiple rates generated by the parallel market, we face additional problem in choosing exchange rate. However, we can define the following real exchange rate(RER) indexes.

$$\begin{aligned} RER_{ot} &= e_t + p^*_t - p_t \\ RER_{pt} &= s_t + p^*_t - p_t \qquad .....(6) \end{aligned}$$

Where, s_t and e_t are the log of bilateral official and parallel exchange rates. p^*_t is log of foreign price index and p_t is log of domestic price index. RER_{ot} and RER_{pt} are real exchange rate indexes calculated from the official and parallel exchange rates, respectively.

The findings of Sebastian Edwards(1989) indicate that for most countries the selection of price indexes used in the construction of the RER measure is a major practical problem. The empirical results for developing countries also shows that the bilateral real exchange rate constructed in official exchange rate alone and parallel rate alone can move in opposite direction. It should be noted that such measure exhibit significant departure from bilateral real exchange rate calculated from official exchange rate. This investigation indicates that the parallel RER indexes capturing some of the distortions introduced by the existence of control in official exchange market. This real exchange rate indexes provide a measure of the degree of competitiveness of a country relative to its trade partner.

Actually, there is no reason for the parallel market RER index should move in the same direction with the index constructed from official exchange rate. Sebastian Edwards(1989) noted that for countries with exchange rate controls excessive these two RER indexes will tend to move in opposite direction for some time. This will be the case, for example, when there is a massive domestic credit creation in the presence of exchange control. Under these circumstances, the higher growth of domestic credit will simultaneously generate an appreciation of the official RER and a depreciation of the parallel RER. For instance, in Ethiopia in the analysis period the correlation for Birr-Dollar official and parallel exchange rate is negative 0.34. Therefore, the two real exchange rate can move in opposite direction.

Table(1a). **The mean & standard deviation of the official and parallel exchange rate**

Trade Partner Country	Exchange Rate	Mean of RER	S.D*. in %	Ratios**	Share of trade in %
USA	Official	-1.0838	44.6	5.7	17.3
	Parallel	-0.4657	11.7	1.5	
Germany	Official	-0.4774	45.5	5.8	9.9
	Parallel	0.1406	7.8	1.0	
UK	Official	0.1125	37.9	4.8	5.8
	Parallel	0.7305	15.1	1.9	

NB:
* S.D. is standard deviation.
** The Ratio is the highest S.D. to the smallest S.D.

The difference in RER variability across trade partner countries can be better illustrated by looking the ratio of the highest to lowest standard deviation. For example, low S.D. of the parallel RER shown in Table(1a) indicates that the parallel RER is quite stable for all trade partners countries, i.e., USA, Germany and UK. And this condition will be important for smooth trade. Of course, there have been some abrupt jumps in official RER usually as a result of major nominal devaluation. The degree of RER instability in trade may be compared in relation to the share of trade with the trade partner country. The higher the share of trade, the higher variance of the official RER with respect to USA and Germany. This indicates that trade is unstable with these countries. The negative RER also shows that trade with USA is highly uncompetitive relative to both Germany and UK. Since Ethiopia uses US Dollar as a reference currency it is important to keep low variability and positive RER with USA. RER index of Ethiopia with respect to USA is of particular importance because real depreciation of the Dollar with respect to other major currencies necessarily result real depreciation of Birr with respect to other currencies.

Constructing parallel RER can be seen from the fact that Ethiopia parallel market has been quite significant market for foreign exchange transactions. In addition, the coverage of parallel market is found to broad and relevant for most transactions including illegal trade. The parallel RER for UK shows relatively higher than other countries. Probably this indicates that the instability of illegal trade with this country.

Generally speaking, the parallel market premium will become higher as exchange rate controls become more pervasive and fewer and fewer transactions are allowed through the official market. In fact under such condition, the RER indexes computed using official exchange rate become more and more irrelevant for transection in particular for import and exports. Therefore, the parallel RER by large shows a good picture of the Ethiopian economy. This can be one of the good reasons for constructing parallel RER index. It is also shown from Table 1a that this RER has low S.D. in all trade partner countries. In addition, the parallel RER figures indicate that Ethiopia's trade with Germany is quite stable relative to UK or USA but the official RER shows quite the opposite.

Constructing RER index is quite helpful for testing whether the RER series have behaved according to the PPP theory of exchange rates. Parallel real exchange rate series in most currencies are characterized as being a stationary process. That is any deviation of exchange rate from PPP or from its equilibrium level should be completely random. This argument has an implications on the analysis of RER misalignment. If RER behaves as non-stationary then any large deviations from its PPP level in long-run will reflect instability of the exchange rate regime.

A question referring to whether the time series of RER have unit root or characterized as a non stationary process is an important issue in economics. This property of RER has a number of important implications. First, under non stationary we face spurious regression or the problem of interpreting standard regressions that attempt to explain the behaviour of RER. In these cases the estimated parameters of regressions are meaningless because the residuals become autocorrelated. Second, if RER is a random walk process then RER can only be explained by its own lag not by other real variables such as inflation, real interest rate and real income.

The empirical evidence conducted for 25 countries by Edwards(1989) can not accept the hypothesis of RER to follow a random walk process, i.e., RER is stationary. Edwards(1989) in his empirical research found that in 19 out of 33 countries can not accept the hypothesis of a random walk.

3.4 Models of Exchange Rate

Many empirical studies have examined the relationship between the bilateral exchange rate and a set of independent variables. The purpose, of course, is to forecast and examine the effect of economic policies on the exchange rate. Most of the relationships are based on the PPP hypothesis and monetary approach to exchange rate determination. We have already discussed an alternative exchange rate model which is constructed from PPP deviation and a portfolio balance approach in the interest parity condition.

The early Flexible Price Monetary Models (FPMM) relied upon the assumption of continuous PPP and the existence of stable money demand functions for domestic and foreign economies. Under the two countries framework and assuming perfect substitution it is possible to derive the exchange rate as a function of relative money supply, relative real income and the interest rate differential.

It has been demonstrated by Frankel(1979), Dornbusch(1976), and Meese(1976) that the bilateral exchange rate is a function of both nominal variables (eg. current and anticipated money supply) and real variables (real income and real interest rate differential). Algebraically, this relationship can be written as,

$$s_t = (m_t - m_t^*) - \phi\ (y_t - y_t^*) + \sigma(r - r^*) \qquad \ldots \quad (7)$$

Where, s_t is the logarithm of bilateral exchange rate, m_t is the logarithm of domestic money supply, y_t is logarithm of domestic real income, r_t is nominal interest rate and foreign variables are denoted by an asterisk. Initiatively, an increase in the relative money supply of the domestic country will increase the foreign value of the bilateral exchange or raise the price of foreign currency. Anything that raises the relative demand for domestic currency such as an increase in relative income, y_t, a decrease in future capital loses, or a rise in interest rate differential will have the opposite effect on exchange rate.

The analysis of the relation between exchange rate and prices is relevant for assessing whether the exchange rate model was successful in providing national economies with an added degree of insulation from foreign shocks and whether this model provides the authorities as additional instrument for the conduct of macroeconomic policy.

However, regarding the FPMM has many problem to apply for LICs'. For example, to start from the money demand functions, it is difficult to specify the same explanatory variables for the demand for money in developing countries and developed countries. The demand for money function for LDCs' does not respond to interest rate but for developed countries the interest rate is sensitive to the money demand.

Since the bilateral exchange rate can be estimated on the assumption of PPP we can assume different money demand equation in the two country framework. The demand for real balance in LDCs' is specified as a function of real income, the expected rate of inflation and the difference between the rate of depreciation of domestic currency in parallel market and expected foreign inflation. Here, the expectation is formed at period t condition on information available at t-1, Agenor(1990).

$$m_t - p_t = \alpha_0 + \alpha_1 y_t - \alpha_2 \pi_t - \alpha_3 \Omega_t \qquad \ldots \text{(8a)}$$

Where, $\Omega_t = \Delta s_t - \Delta q_t$

m_t = **the logarithm of domestic money supply**

p_t = " " " **price level**

y_t = " " " **real income**

π_t = **the expected inflation**

Ω_t = **the return on holding for foreign asset**

q_t = **the logarithm of world price**

Δs_t = **change in the parallel exchange rate**

Δq_t = **world inflation**

In the demand equation(8a) α_1 measures the elasticity of income, α_2 is the elasticity response of inflation and α_3 is the elasticity of money demand to the return on holdings of foreign asset. The demand for money in dual market for foreign exchange rate measures the opportunity cost of money holdings in terms of domestic real assets. Foreign exchange can be bought and sold in the parallel market because of the public desires to alter the composition of its money holdings. This implies that the depreciation of the domestic currency in parallel market net of world inflation, Δq_t, influences the demand for domestic currency.

The coefficient of inflation is expected to be negative. Because when expectations of a depreciation in parallel rate are revised upward, the expected return from holding foreign currency increases and agents tend to substitute foreign money for domestic cash balance as the opportunity cost of holding domestic money rises. This tends to reduce money demand for domestic currency in real terms.

On the other hand, the demand for money in developed countries assumed to depend on real income, the expected inflation and the level of foreign interest rate. Therefore, we can write the demand for foreign money as,

$$m_t^* - p_t^* = ß_0 + ß_1 y_t^* - ß_2 \pi_t^* - ß_3 r_t^* \qquad \ldots (8b)$$

Where, m^*_t - **the logarithm of foreign money supply**

p^*_t - **the logarithm of foreign price level**

y^*_t - **the logarithm of foreign real income**

π^*_t - **the expected inflation**

r^*_t - **the foreign interest rate at levels.**

In the demand equation(8b) $ß_1$ measures the elasticity of income, $ß_2$ is the elasticity response of inflation and $ß_3$ is the interest elasticity of money demand. The above two money demand equations (8a) and (8b) cannot provide a complete model of exchange rate determination. As Frankel and Mussa(1985) noted that a link between domestic and foreign prices through some form of PPP is an essential part of any monetary model of exchange rate determination. One of the popular assumption is that PPP holds, particularly, in long-run. However, Nottsen Bahmani(1993) argue that PPP in levels for LICs' doesn't hold and perhaps the bilateral exchange rate in logarithm form may hold and stay close to absolute PPP in long-run. This relationship between bilateral exchange rate and the price levels can be described below through some form of PPP like the following form,

$$p_t = \tau \; (s_t + p_t^*) \qquad \ldots \qquad (9)$$

Where, s_t is the bilateral exchange rate and P_t is the logarithm of domestic price level, and P_t^* is the logarithm price level of foreign country. From equation(9) therefore we can simplified the LICs' PPP as,

$$s_t = (1/\tau) \; p_t - p^*_t \qquad \ldots \qquad (10)$$

Where, s_t is the bilateral exchange rate. If τ=1 then PPP holds in the long run. We combine equation (8a), (8b), and (10) to obtain the monetarist equation of exchange rate determination,

$$\begin{aligned} s_t = (1/\tau)\,(m_t - \alpha_1 \; y_t + \alpha_2 \; \pi_t + \alpha_3 \; \Omega_t) \\ - \; (m_t^* - ß_1 \; y_t^* + ß_2 \; \pi_t^* + ß_3 \; r^*_t) \quad \ldots (11) \end{aligned}$$

The above equation says that the bilateral exchange rate, s_t, as the relative price of currency is determined by supply and demand for money. An increase in supply of domestic money causes a depreciation of exchange rate and an increase in domestic income or a decrease in expected domestic inflation rate raises the demand for domestic money and causes an appreciation. This equation has been widely estimated using econometric methods.

There are two ways to test the monetary approach of exchange rate determination. First, one recognized that a continuous PPP is an essential part of the monetary approach and directly tests whether PPP prevails in the VAR-model. The second, examines the explanatory power of single econometric equation. For example, a test for $\tau=1$ in equation(9) implies PPP holds in long-run. However, there is an ample evidence accumulating not only does the short-term exchange rate deviate from a PPP path but also there are cumulative deviations from the path that show substantial persistence, Dornbusch(1980).

The empirical evidence against PPP for Ethiopian official exchange rate is overwhelming. The enormous real depreciation of the Birr against US Dollar during 1991-1995 convinced any remaining doubters. For example, as can be seen from Table(1b) below the standard deviation of the real exchange rate from its mean equals to 7.8 % for Birr-Dollar parallel exchange rate, 11.7 % for Birr-Mark parallel rate; and 45.5 % and 44.6% for Birr-Dollar and Birr-Mark official rate, respectively. The computed serial correlation coefficient for PPP deviations are 0.86 and 0.76 for Birr-Dollar and Birr-Mark parallel rate and 0.96 and 0.96 for official exchange rate on monthly basis, respectively. The serial correlation coefficient is of interest because it is equal to one minus the speed of adjustment to PPP.

$$E_t\ s_{t+1} - s_t = -\alpha(s_t - s_{Lt}) \quad \ldots \quad (12)$$

Where, s_{Lt} is long-run equilibrium exchange rate value given by PPP and α is the speed of adjustment to PPP and as usual E_t is the expectation operator. If $0<\alpha<1$ the exchange rate is stabilized and $\alpha<0$ is the case where the economy is destabilized, and the border line, $\alpha=0$, is static expectation.

It is important to note that equation(12) could be fully consistent with rational expectation in various models. For example, expectation could be rational in sticky price monetary i.e., over shooting models of Dornbusch(1976) where the value of α depends on the speed of adjustment of the prices level. And the static expectation model could be rational if the real exchange rate process is a random walk, Frankel and Meese(1976).

The deviations from PPP can be estimated from the following autoregessive equation,

$$RER_t - RER_{mt} = AR\ (RER_{t-1} - RER_{mt}) \quad \ldots. \quad (13)$$

where, AR is autoregressive coefficient, RER_t is bilateral exchange rate index defined in equation(5), and RER_{mt} is the mean of RER_t and AR is $1-\alpha$ where α is the speed of adjustment.

The estimated speed of adjustment and the autoregressive coefficient, AR, for official and parallel exchange rate of Ethiopia is estimated in Table(1b) below.

The serial correlation in the deviation of PPP for Birr-Dollar auction exchange is estimated to be 0.96, with a mean standard deviation of 45.5%. This means that the estimated speed of adjustment to PPP is 1-0.96 = 0.04 or 4% per month. Thus one can easily reject the hypothesis of instantaneous adjustment because this speed of adjustment is sufficiently low and one can accept the hypothesis that it is zero, i.e., static expectation. In other words, we can't reject the hypothesis that the auto-regressive coefficients is 1.0 for auction determined official exchange rate. Since AR is close to one for the official RER index it is characterized as a not-stationary series.

Table(1b) - **Purchasing power parity and its deviation between Ethiopia and major trade partner countries.**

Exchange Rate	Trade Partner	S.D. in %	C.V.	Autoregressive (AR) deviation
Parallel rate	USA	7.7	0.5523	0.8622
	Germany	11.7	0.2510	0.7175
	UK	15.1	0.2068	0.8856
Auction official rate	USA	45.5	0.9527	0.9636
	Germany	44.6	0.4116	0.9577
	UK	37.9	3.3669	0.9581

On the other hand, as shown in Table(1b) the auto-correlation coefficient of the deviation of PPP for parallel Birr-Dollar rate is estimated to be 0.86 for Birr-Dollar and 0.72 for Birr-Mark rate . This means the speed of adjustment to PPP is 14% and 28% per month, respectively. In this case one can't accept that AR is 1.0. Therefore, real exchange rate constructed from parallel rate appears to be close to stationary series.

However, testing the null hypothesis of an autoregressive coefficient of 1.0 one can't legitimately use the standard t-test derived from a regression because under the null hypothesis its variance is infinite. There are a number of ways of dealing with this non-stationarily test. For example we can simply apply the corrected or Augmented Dickey-Fuller(1979) cumulative probability distribution.

The unit root test using Augmented Dicky Fuller (ADP) shows that all the bilateral and multilateral exchange between Birr against Dollar, Mark and Pound Sterling shows non-stationarity processes, i.e., parallel and official exchange rates. As Frankel and Meese(1979) noted that the non-stationarity in bilateral exchange rate does not create problems from standard theories of exchange rate determination.

In monetary models, if the money supply is non-stationary in levels even in changes, then the exchange rate will be non-stationary in levels or in changes. However, the non-stationarity in the real exchange rate is considered more serious. Frankel(1976) noted that if the real exchange rate follow a random walk then there is no tendency to return to PPP and seemingly no limit on how far one country price can get from another's.

This means that the apparent inability to forecast future exchange rates using either macroeconomic fundamental, the forward exchange rate and the past time series of the process. Thus, exchange rate is only explained by its own lag series. The market fundamental are unable to explain the movements of exchange rates. Monetary models most of the time failed and market fundamentals may not explain exchange rate movements. There are at least two reasons for this failure. First, the demand for money function may be misspecified. Second, coefficient are constrained to be symmetric across countries and output and interest rate are assumed exogenous but may not be always true.

Real exchange rate series in most empirical works follow a stationary process. The failure to reject a random walk in the real exchange rate can be found by Roll(1979), Frankel(1981) and Adler and Lehman(1983), among others. Hakkio(1984) provides evidence of a unit root in the real exchange rate using Dickey Fuller(1979) test statistics. However, this test statistic is powerful enough to reject a random walk.

The model that concerned the deviation of PPP follow a random walk is the Meese's(1986) version of monetary approach to exchange rate determination. This model assumes the deviation from PPP are persistent and it takes the following relationship,

$$\tau(s_t + P_t^*) - P_t = U_t$$
$$U_t - U_{t-1} = \epsilon_t \qquad \ldots\ldots \qquad (14)$$

Where, U_t is a random walk process and ϵ_t is a white noise process. Here, the PPP deviation denoted by the error term U_t and this deviation is modeled to follow a random walk.

As we have seen in many developing country literature, deviations from PPP are in fact large. But, if those deviation were purely random they could be subsumed in the error term U_t. In other words, in this model the auto-correlation coefficient will be one and the real exchange rate is thought to follow a random walk process. This is equivalent to the version of the monetary model demonstrate by Meese(1986).

The deviation from PPP arise primarily from price level stickiness and this is thought to be dumped over time. For example, deviation from PPP may follow an AR(1). In this case, the expectation correctly reflect the tendency to return to long-run equilibrium. And a move complete and general model is Frankel's(1979) structural model of exchange rate. This model often known as real interest differential exchange rate model. This model can be specified as,

$$E_t\, s_{t+1} - s_t = -\alpha(s_t - s_{Lt}) + \sigma(\pi_t - \pi^*_t) \qquad \ldots(15)$$

where, α is the long-run adjustment parameter, s_{Lt} is the long-run equilibrium value of the exchange rate given by PPP, and π_t and π_t^* are domestic and foreign inflation, respectively. According to the Frankel's exchange rate model given in equation(15), the expected depreciation of the parallel rate is proportional to short-run deviation of exchange rate from its long-run equilibrium value and inflation differential. Frankel(1979) argues that a short coming of exchange rate model are that they did not allow a rate for the difference in secular rate of inflation, i.e., the interest rate differential.

This model helps to analyze the deviation of exchange rate movements from long-run value. Such analysis serves for the crucial question of disequilibrium condition of exchange rate which is usually associated with economic shocks. Frankel(1979) noted that the main point that is being emphasized is that there is an important intrinsic difference between exchange rate and the price levels. Exchange rates are more sensitive to expectations concerning future events than national prices, as a result in periods which are dominated by 'news' and alter expectations. Finally, he suggested that exchange rate are more likely to be depart from PPP value, particularly, in short run.

3.5 Rational Expectation Hypothesis

It is firmly established that expectations play a central role in the determination of exchange rates. Moreover, it is difficult to know the exact nature of expectations. Of course, the problem with empirically testing the hypothesis of exchange rate expectation is that expectations are not observable. However, the assumption of expectation formation is important for testing exchange rate models.

Expectation formation in exchange market has traditionally been modeled as 'adaptive'. In adaptive expectation agents updates their previous expectation by a proportion of the current forecasting error. This process may be rationalized by providing the optimal forecast and hence adaptive forecasts can be systematically beaten (Pesaran, 1987). Recently, therefore, economists have tended to focus on a more general approach known as rational expectation.

The rational expectation hypothesis(REH) states that in the formulation of expectation about future economic conditions agents use all the information available to them efficiently, Begg(1982). The implication is that expectation can be modelled using all the past and the present information available. Some economists have viewed REH as too strong; because agents lack the required information to act in this way and it is too costly for agents to act in such way. According to their suggestion agents don't know or are obliged to learn the underlying model and are unable to form REH.

In this paper REH is assumed to be a sensible general framework within which the expectation formation of future exchange rate is a forward-looking behaviour. The REH has some important implications for the exchange rate behaviour and in the technique in which we used to test exchange rate models (i.e., the VAR-model). First, the REH imposes testable cross-equation restrictions on the parameters of distributed lags of the VAR-model.

Second, the REH provides a framework within which one can analyze exchange rate reactions to other anticipated future developments. Third, REH has implications about the behaviour of exchange rates, and in particular about departures from market fundamentals.

As a way to explain the different expectations, Frankel(1990) suggested that participants in foreign exchange market may be using two different types of forecasting techniques. For long-run forecasts, the predominant method is market fundamentals analysis based on PPP to hold in long-run. For short-run up to medium term the market is dominated by chance or 'chartists' who concentrated on the recent pattern of price mechanism.

IV. The Methodology

4.1 General

Empirical researchers investigated the various exchange rate models to a battery of statistical tests to select an applicable exchange rate model for a particular country. At present there is a general consensus that some structural asset market models have failed to offer a rational for the unprecedented exchange rate volatility. For example, the results of Meese and Rogott(1983) suggested that a simple random walk outperforms structural exchange rate models in forecasting exchange rate movements. Still some researchers provide evidence against the random walk properties of exchange rate and switched in favour of structural model of exchange rate determination. Empirical work on portfolio balance models also provide a convincing argument, and statistical tests support their validity for developing countries.

This research paper attempts to test the application of three exchange rate models which are believed to reflect the Ethiopian exchange rate market. These models include: a test for interest parity condition, a structural model of long-term deviation of exchange rate from PPP, and a test for real exchange rate behaviour for un-unified exchange rate systems.

For this task a Vector Auto-regressive Representation (VAR) methodology is adopted. Such framework is used to measure the deviations of observed exchange rate behaviour from the present value relations implied by some exchange rate theories. VAR approach differs in several ways from many empirical test on exchange rate models.

The analysis in VAR approach is focused on the present value relations for the exchange rate or the so-called expectational versions of asset market models as opposed to tests based on simple regression of the exchange rate on market fundamentals. Thus, this approach contains explicit treatment of expectation formation which as Mussa(1979) pointed out that expectation is an integral part of testing exchange rate theories. Estimates of the deviations from the present value models are based on a large information set which includes all available information that market participants observed. This information is then used to evaluate the theories from an economic view point, a task which has not been previously been carried out for Ethiopian exchange rate market.

The economic importance of the exchange rate theories is assessed via statistical tests based on Wald statistics which seek to detect whether a rejection of the cross-equation restrictions of the parameters in the VAR model is due to deviation of expected from the actual exchange rate movements. Thus, if this test suggests that the actual and expected exchange rate move close together, then the relevant exchange rate model specification will be economically significant but if the underlying cross-equation restrictions are statistically rejected then the model specification is invalid.

4.2 Testing procedure

Consider the general form of a present value model for exchange rate.

$$s_t=\theta(1-\delta)\sum_{i=o}^{\infty}\delta^i E_t Z_{t+i} \qquad \ldots (16)$$

Where, s_t is the logarithm of parallel exchange rate, Z_t is a linear combination of market fundamentals(including the auction exchange rate, money supply, real income, etc.). E_t denote the expectation operator conditioned on the information set available to market participants at time t, and θ and δ are parameters.

Here, one can raise two issues regarding equation(16). First, why did we use parallel exchange rate instead of official or auction exchange rate in the present value model? Second, what is the use of the expectation formulation in the test procedure? Since the auction determined exchange rate is partly controlled, we assumed it is a predetermined variable by the authorities. Thus, it is the parallel exchange rate that is more appropriate, and has a better relationship with market fundamentals. On the other hand equation(16) has little empirical content because it involves unobserved expectation, Z_{t+i} and represent an exact linear rational expectation model. This rational expectation formation, however, imposes a restriction on the stochastic relationship, specifically, on the VAR model. The VAR model of order p can be formulated for Δs_t and ΔZ_t as followers,

$$\Delta Z_t = a(L)\ \Delta Z_{t-1} + b(L)\ \Delta s_{t-1} + U_{1t}$$
$$\Delta s_t = c(L)\ \Delta Z_{t-1} + d(L)\ \Delta s_{t-1} + U_{2t} \quad \ldots\ldots \quad (17)$$

where, Δ is the first difference operator. s_t is parallel exchange rate and Z_t is a linear combination of market fundamentals. And a(L), b(L), c(L) and d(L) are polynomials all of order p in lag operator L, and L is the back-shift operator of the form, $L^n x_t = x_{t-n}$. Thus , the coefficient structure in the system of the polynomial equations have the following form.

$$a(L) = a_1 + a_2L + a_3L^2 + \ldots + a_pL^p$$
$$b(L) = b_1 + b_2L + b_3L^2 + \ldots + b_pL^p$$
$$c(L) = c_1 + c_2L + c_3L^2 + \ldots + c_pL^p$$
$$d(L) = d_1 + d_2L + c_3L^2 + \ldots + d_pL^p \quad \ldots (18)$$

In the VAR model the linear regression variables, s_t and Z_t are required to be stationary series. However, it is found that these two variables are not-stationary in their levels. For this reason, we used their first differences, i.e., Δs_t and ΔZ_t in the VAR model or equation(17) because these series are found to be characterized by stationary processes.

The above VAR model can be rewritten more conveniently in a matrix form as,

$$X_t = A\ X_{t-1} + U_t$$
$$X_t = [\Delta Z_t, \Delta Z_{t-1}, \ldots, \Delta Z_{t-p+1}\ \ \Delta s_t, \Delta s_{t-1}, \ \ldots,\ \Delta s_{t-p+1}]' \quad \ldots (19)$$

Where, X_t is vector of lag variables Δs_t and ΔZ_t, A is coefficients of the companion matrix or coefficients of the system of equation(17) (see Appendix) and U_t is a vector of random error terms. The procedure and the detail steps of the VAR model estimation have been discussed in the estimation chapter in section 5.2.

As we have mentioned earlier, the rational expectation assumption places system of restrictions on the VAR framework. To make simple, let us assume e_1 and e_2 be 2px1 vectors (p is the lag order in VAR) with zero everywhere except the first and $p+1^{th}$ rows, respectively. Using the rational expectation assumption, one can derive a set of 2p non linear cross-equation restrictions of the form:

$$e'_2 A = \theta(1-\delta)e'_1 A[I-\delta A]^{-1} \quad \ldots \quad (20)$$

The restriction of equation(20) implies that if the assumption of REH is valid hypothesis then the VAR model will give us insignificant set of cross-equation restrictions using a relevant test statistics. Similarly, the validity of the above mentioned exchange rate models can be tested equivalently by the significance of the cross-equation restrictions obtained from the VAR model under the assumption of REH. To check the validity and significance of equation(20) we need test statistics. Since this equation includes non-linear restrictions we need an asymptotic test statistics. The appropriate statistic is Wald statistics which has an asymptotic chi-square distribution with degree of freedom equal to the number of restrictions in the VAR-model, i.e., 2p. This Wald test statistic takes the following form,

$$W=R'(I-\delta A)\,[B'var(b)B]^{-1}(I-\delta A)'R \rightarrow \chi^2(2p)$$

where,

$$R'=e_2'A-\theta(1-\delta)\,e_1'A(I-\delta A)^{-1}$$

... **(21)**

Here, W is the Wald statistics, $B(I-\delta A)^{-1}$ is the partial derivative matrix with respect to the coefficient parameters in VAR-model and involves highly non-linear expressions in parameter b but can be calculated numerically. The variance-covariance matrix, Var(b), can be estimated using an econometric package such as Microfit. The matrix Var(b) is a heteroscedastic consistent covariance estimator of White(1980). In estimating the variance-covariance matrix we have assumed U_{1t} and U_{2t} in the VAR-model are contemporarily and serially uncorrelated. The estimated variance-covariance matrix of parameters adjusted for White's Heteroscedasticity consistence matrix is of the form given below.

$$\mathbf{Var(b)} = \begin{bmatrix} \mathbf{Var(b_1)} & 0 \\ 0 & \mathbf{Var(b_2)} \end{bmatrix}$$

... **(22)**

where, $Var(b_1)$ and $Var(b_2)$ are a 2p x 2p variance-covariance matrices obtained for each regression equations in the VAR model of equation(17). The dimension of the matrices in Wald statistics in equation(21) in the are very important for our analysis. R' is a 1 x 2p, A is 2p x 2p, B is 4p x 2p and var(b) is 4p x 4p. Therefore, the Wald statistic, W, will have a dimension of 1x1 or a scalar which can be compared with tabulated chi-square values in order to test the validity of the model. In the next section, we will proceed to the test for the validates of the three popular exchange rate models in which this paper is most concerned about.

4.3 **Test Procedure for Interest Parity Condition**

According to IPC to be tested here, the hypothesis of the interest parity condition (IPC) states that the expected future depreciation in the parallel market is proportional to the parallel premium and the interest rate differential. Thus, the interest parity condition can be postulated as,

$$E_t\ s_{t+1} - s_t = \sigma(r_t - r_t^*) + ß\ (s_t - e_t) \qquad \ldots \qquad (23)$$

Where, s_t and e_t denote the logarithm of the parallel and official auction exchange rates, respectively. r_t and r_t^* are the domestic and foreign nominal interest rates σ and ß are the adjustment parameters.

This IPC designed in equation(23) reflects the repatriation of the principal on foreign bonds at parallel exchange rate and interest receipts from foreign investment converted at the auction exchange rate. In other words, it is assumed that principal on foreign bonds is acquired and repatriated at parallel rate, however, the interest income or a current account item is repatriated at official exchange rate. Clearly, the model can be grouped under portfolio balance approach of exchange rate determination under the assumption of imperfect substitution of domestic and foreign assets.

The purpose, of course, is to test the application of IPC for Ethiopian case. To do this, first we need to solve for market fundamental. Therefore, we can rewrite equation(23) in the following form,

$$E_t s_{t+1} - (1+ß) s_t = Z_t$$

Where , $Z_t = \sigma(r_t - r_t^*) - ß e_t$ ... (24)

In equation(24) Z_t represents a market fundamentals and all the variables in Z_t can be observed. These variables include the nominal domestic and foreign interest rate, and the official exchange rate, e_t. We can apply the VAR model on the first difference of s_t and Z_t, i.e, Δs_t and ΔZ_t. However, the parameters σ and ß should be estimated by a single regression equation estimation technique.

The Rational Expectation Hypothesis(REH) imposes a set of testable 2p cross-equation restrictions on the VAR-model. For the variables appearing in the interest parity condition the cross-equation is slightly different from the general form of rational expectation cross-equation restriction described earlier and takes the form,

$$e'_2 A = -\delta e'_1 A (I-\delta A)^{-1} \quad \ldots \quad (25)$$

Where, $\delta = 1/(1+ß)$. And equation (25) contains testable set of 2p non-linear cross-equation restrictions. The validity of this interest parity hypothesis restrictions in equation(25) can be tested by Wald test statistics.

4.3.1 **Estimation Procedure for the Parameters ß and σ**

Before we go to monetary models of exchange rate two issues must be examined. These issues are concerned with the treatment of expectations in each exchange rate model and the money demand function. Consider the procedure used to estimate expectational variable of the model (i.e., current and one period ahead exchange rate and real rate of return on foreign currency holdings). Expectations are assumed to be "rational" or more appropriately and perhaps less controversially "consistent" with the underlying model. One approach of implementing this assumption empirically is to estimate unrestricted reduce-form equations for the relevant expectational independent variables by using the predicted values as proxies for expectations[18]. For example , the unobserved future exchange rate depreciation can be estimated after we have regressed the following rational expectation

[18] Such a procedure is known as "substitution" method and has been widely used in econometric application of the rational expectation hypothesis, see Barro(1970).

regression equation,

$$\Delta s_t = K_1 \Delta s_{t-1} + K_2 \Delta s_{t-2} + \ldots + K_p \Delta s_{t-p} + u_t \quad \ldots(26)$$

From the above regression we can find the forecasted values of future depreciation, Δs_{t+1}, using a one time forward forecasting technique. Now the above depreciation can be equated to the future expected depreciation in order to substitute the unobserved component.

$$E_t s_{t+1} - s_t = \Delta s_{t+1} = D_F$$

Where, Δs_{t+1} or D_F is the future forecasted depreciation from the regression equation(26). Therefore, we can estimate the parameters σ and ß by using two-stage least square regression method based on the following econometric relationship.

$$D_F = \Delta s_{t+1} = \sigma(r_t - r^*_t) + ß\ (s_t - e_t) + u_t \quad \ldots \quad (27a)$$

However, if the restriction $\sigma=0$ is imposed on the above equation then the regression equation will be reduced to,

$$D_F = \Delta s_{t+1} = ß\ (s_t - e_t) + u_t \quad \ldots \quad (27b)$$

4.4 <u>The PPP hypothesis</u>

As we indicated earlier the PPP is considered as a theory of exchange rate, and according to this theory exchange rate is determined by the two countries relative price as shown below,

$$s_t = p_t - p_t^* \qquad \ldots \qquad (28)$$

This relationship shows that if the PPP holds the bilateral exchange rate should be equal to the relative prices. However, Genberg(1978) has argued that the "law of one price" hinges on the integration of commodity markets. The implication for LDCs' is that markets are not internationally integrated and PPP for LDCs' may not hold. However, we would like to provide an empirical test of the PPP hypothesis for Ethiopia relying upon a more comprehensive test that incorporates major trading partners based on the relationship,

$$p_t = \tau \ (s_t + P^*_t) \qquad \ldots. \qquad (29)$$

Where, p_t = the logarithm of domestic price

p^*_t = the logarithm of the price of the major trade partner

s_t = the logarithm of the domestic price of foreign unit currency in parallel market.

The theory of PPP implies $\tau = 1$ in equation(29) reflecting the fact that in the long-run domestic inflation should be equal to the foreign inflation adjusted for each major trading partner countries with the exchange rate s_t.

4.5 Estimation Procedure for Money Demand Equations

The actual holdings of real money balances (m_t-p_t) are assumed to adjust with a lag to the difference between the desired holdings $(m_t-p_t)^d$ in the current period and the actual holdings at the end of the previous period. This partial adjustment mechanism can be described as in Equation(30).

$$\Delta(m_t - p_t) = v\ [(m_t - p_t)^d - (m_{t-1} - p_{t-1})] \qquad \ldots \quad (30)$$

where, v denotes the speed of adjustment.

Long-run Money Demand Equation

$$(M_t - p_t)^d = \alpha_0 + \alpha_1 y_t - \alpha_2 \pi_t - \alpha_3 \Omega_t + u_t \qquad \ldots(31)$$

Short-run Money Demand Equation

$$m_t - p_t = \alpha_0 v + \alpha_1 v Y_t - \alpha_2 v \pi_t - \alpha_3 v\ \Omega_t + (1-v)(m_{t-1} - p_{t-1}) + v_t \qquad \ldots(32)$$

Equation(31) is the long-run demand equation for real balances and specified as a function of real output, the expected rate of inflation, and the difference between the rate of depreciation of domestic currency in the parallel market and expected foreign inflation.

The expected inflation rate measures the opportunity cost of money holdings in terms of real domestic assets. As discussed above, foreign exchange is bought and sold in the parallel market because the public desires to alter the composition of its money holdings. This implies that the expected rate of depreciation of the domestic currency in parallel market net of foreign inflation influences the demand for domestic currency. The coefficient of the variable Ω_t is expected to be negative. When expectations of a depreciation of parallel rate are revised upwards, for example, the expected return from holding foreign currency increases and agents tend to substitute foreign money for domestic cash balances as the opportunity cost of holding domestic money rises. This leads to a reduction in the money demand for domestic currency in real terms.

Equation(31) implies that the composite disturbance term is correlated with regressors and so Ordinary Least Squares(OLS) estimators become inconsistent. Therefore, consistent estimates are obtained by an appropriate Cochrane-Orcutt iterative method or OLS estimation of equation(32).

4.6 **Test Procedure for Frankel(1979) Exchange Rate model**

Consider the Frankel's(1979) assumption about expected depreciation of the parallel exchange rate,

$$E_t s_{t+1} - s_t = - \alpha(s_t - s_{Lt}) + \epsilon \ (\pi_t - \pi_t^*) \qquad ...(33)$$

Where, s_{Lt} is the long-run equilibrium value of the exchange rate given by PPP, and π_t and π_t^* are domestic and foreign expected inflation rates, respectively. According to the above equation, expected exchange rate depreciation is proportional to the short-run deviations of the exchange rate from its long-run equilibrium value and the expected inflation differential.

If the future expected depreciation is substituted by the forecasted depreciation, D_F, assuming the PPP holds in long-run and upon rearrangement we can arrive at the following regression equation,

$$p_t = \tau(s_t + p_t^*) - \tau\ \epsilon/\alpha\ (\pi_t - \pi_t^*) + \tau/\alpha\ D_F \quad \ldots \quad (34)$$

where, D_F is the forecasted depreciation estimated from equation(26). Thus, the regression equation(34) can be used to estimate the parameters τ, α and ϵ by using Two-Stage Least Squares(2SLS) regression estimation method.

The equation described above shows the feedback from inflation to further depreciation of exchange rate. Frankel(1981) similarly wrote the equation where inflation rate is considered to be independent variable and exchange rate as dependent variable. The logic is that domestic inflation at a given exchange rate shifts demand away from domestic goods towards foreign goods which brings an increase in the demand for foreign exchange and eventually put downward pressure on the value of domestic currency.

Now let us define the long-run equilibrium exchange rate value, s_{Lt} and the market fundamental Z_t,

$$s_{Lt} = (1/\tau)\ p_t - p_t^*$$

$$Z_t = \alpha\ s_{Lt} + \epsilon\ (\pi_t - \pi_t^*) \quad \ldots \quad (35)$$

where, the actual value of inflation will be proxy by the expected inflation and the value of α and ϵ can be estimated from regression equation(34), and the market fundamental, Z_t, can then easily be constructed from equation(35).

The imposition of REH to the Frankel's model of exchange rate gives a set of 2p cross-equation restrictions of the form[19],

$$e'_2\, A = -\delta\, e'_1\, A(I-\delta A)^{-1}$$

$$\text{Where,} \quad \delta = 1/(1+\alpha) \qquad \ldots \qquad (36)$$

Thus the validity of the long-run exchange rate model can be tested using the Wald test statistic described earlier.

4.7 **Test Procedure for Meese's model of exchange rate**

Assume a modified Meese's(1982) model of exchange rate determination which assumes that deviation from PPP follow a random-walk process,

$$\tau\ (s_t + p_t^*) \ - p_t = u_t$$

$$u_t - u_{t-1} = \epsilon_t \qquad \ldots \qquad (37)$$

Where, ϵ_t is white noise random error term and u_t follows a random walk process, the price p_t and p_t^* are the logarithm of prices level of domestic and foreign trade partner country, respectively and s_t is the parallel exchange rate.

[19] The derivation of this cross-equation restriction are given in the appendix B.

However, this model can only be tested in VAR approach if we have additional money demand equations. The demand for money equations (8a) and (8b) provide a complete model of exchange determination. These equations are money demand equations for domestic and a major foreign trading partner countries. The money demand equation for Ethiopia is assumed to be a function of the logarithm of real income, y_t, the expected domestic inflation rate π_t, and the return on holdings of foreign asset, Ω_t. According to Agenor(1990), in multiple exchange rate system, holding foreign currency is positively related to the return on this currency and negatively to the return on domestic assets. The opportunity cost of holding money is negatively related to expected domestic inflation and the return on holdings of foreign asset, Ω_t. The variable Ω_t is defined as,

$$\Omega_t = \Delta s_t - \Delta q_t \qquad \ldots \qquad (38)$$

where, s_t is logarithm of parallel exchange rate and q_t is world price. The demand for money in foreign country is defined as a function of the logarithm of real income y_t^*, inflation of the country, π_t and the nominal interest rate level, r_t^*.

In order to test the modified Meese's exchange rate model we need to derived the fundamentals[20], Z_t,

[20] The derivation is shown in the appendix B.

$$Z_t=(1/\tau)\,(m_t-\alpha_1 y_t+\alpha_2\pi_t+\alpha_3\Omega_t)-(M_t^*-\beta_1 y_t^*+\beta_2\pi_t^*)-(\beta\beta_3/\sigma)\,e_t-\beta_3 r_t \quad \ldots. \ (39)$$

All the variables in Z_t can be found and the parameters involved can be estimated by the regression equation (27), (32) and (34). The parameters α_j and $ß_j$ for j=1,2,3 in the equation(39) can be estimated from demand equations which we have been discussed earlier in section 4.5.

The imposition of REH will yield a set of testable 2p cross-equation restrictions on the VAR-model. For this model the cross-equation restrictions will take the form of,

$$e'_2\ A= \theta_1^{-1}\ \ e'_1(I-\delta A)^{-1}$$

Where,

$$\delta = \theta_2 / \theta_1$$

$$\theta_1= 1 + [(1+ß)\ ß_3 /\sigma]$$

$$\theta_2= ß_3/\sigma \qquad \ldots \ (40)$$

Thus, all the parameters ß, ß3 and Õ can be estimated from the regression equation (8a), (8b), and (27a) which has been mentioned earlier.

V. Empirical Results

5.1 Estimation of parameters

A model may not be congruent to a particular data set in this case the model might require reparameterization of the model to obtain explanatory variables that are near orthogonal to the data and interpretable in terms of the final equilibrium relationship.

However, before testing the exchange rate models we have to estimate the parameters involved in each of the exchange rate models. Here, we inspect the estimation of parameters that are involved in money demand equation and parameters of each exchange rate models. In the estimation the treatment of diagnostic tests and significant t-ratio have been given considerable attention. In this case, the estimation incorporates extensive analysis of the residuals and diagnostic tests are used to see the predictive performance of each regressions aiming at finding the weakness of the models designed in the methodology section. This procedure of estimation play important role in the analysis of exchange rate models. In addition, the estimation methods are based on OLS or Two Stage least squares(2SLS) regression analysis.

5.1.1 Parameter Estimation of Money Demand Equations.

The results of the estimation of money demand equation can be summarized in a number of common characteristics. All the estimated parameters have significant t-ratios, the variables have the anticipated sign and the coefficient of correlation, R^2, which measure explained variation of the regression is quite high and more than 90% of the variation in the money demand is explained by the variables included in the regressions.

The Durbin-Watson(D.W.) statistics are uniformly low for Ethiopian money demand equations for all currencies. Partricio Anaua(1991) suggested that in many previous studies low D.W. statistics in money demand equation have been taken as evidence for portfolio changes occurred gradually and partial adjustment scheme might be warranted, particularly, for developing countries. More recently, low D.W. statistics has been reinterpreted as yet another way of assessing whether individual variables are stationary or whether a cointegrated vector has been found, Engle and Granger(1987). Thus, the low D.W statistics of these money demand equations are consistent with the Augmented Dicky Fuller test results which indicated the individual variables are non-stationary.

The Ethiopian demand for money equations have been repeatedly estimated for Birr-Dollars, Birr-Mark and Birr-Pound Sterling exchange rates (see Table 2a). The income elasticity of money demand, α_1, is estimated to be 0.31 for Birr-Dollar rate, 0.29 for Birr-Mark and 0.34 for Birr-Pound Sterling exchange rates, respectively. Therefore, the average income elasticity estimate is about 0.31. The elasticity response of inflation, α_2, is also highly significant in all currencies.

In demand for money equation of Ethiopia, the elasticity of inflation is -9.9 for Birr-Dollar exchange rate, -9.7 for Birr-Mark and -10.1 for Birr-Pound exchange rate. The average value is about -9.9 and equal to the value of Birr-Dollar exchange rate.

As shown in Table(2b) the estimated foreign money demand equations all the variables have the anticipated sign. For the USA money demand equation, the income elasticity of money demand, $ß_1$ is estimated to be 0.42 and the inflation elasticity, $ß_2$, is -10.95 and the interest elasticity of money demand, $ß_3$, is -0.06. For Germany, the income elasticity is 0.5, the inflation response of money demand is -4.08 and the interest elasticity of money demand is -0.08. For the UK, the income elasticity of money demand is 0.41 and the inflation elasticity is -3.49 and the interest elasticity of money demand is about -0.07.

The estimated response of inflation, the opportunity cost of holding money appears to be highly significant in all currencies. Even if inflation is low in Ethiopia the result indicate that during the periods of higher inflation the demand for money indeed tend to be very low. A low income elasticity of Ethiopian money demand equation is consistent with the higher variability of production and consumption in Ethiopia.

From the results, it is easy to find out that explanatory power of inflation and income are higher than the other regressor. In other words, income and inflation captured the higher proportion of the explained variation in money demand equation. It is also interesting to note that the higher the inflation of the country the larger the response of inflation than low inflation countries.

Table 2a. ETHIOPIAN MONEY DEMAND EQUATIONS

For Birr-Dollar exchange rate

$$m_t - p_t = \underset{(27.4250)}{0.3100\, y_t} - \underset{(-3.2721)}{9.9320\, \pi_t} - \underset{(-2.0334)}{0.9612\, \Omega_t}$$

$R^2 = 0.9579$ $\quad F(5.47) = 214.28$

$DW = 1.7767$

For Birr-Mark exchange rate

$$m_t - p_t = \underset{(9.4931)}{0.2869\, y_t} - \underset{(-2.6937)}{9.6949\, \pi_t} - \underset{(-1.4786)}{0.5079\, \Omega_t}$$

$R^2 = 0.9525$ $\quad F(4,47) = 235.57$

$DW = 1.7127$

For Birr-Pound exchange rate

$$m_t - p_t = \underset{(31.1143)}{0.34454\, y_t} - \underset{(-2.7145)}{10.0890\, \pi_t} - \underset{(-1.2145)}{0.2240\, \Omega_t}$$

$R^2 = 0.9529$ $\quad F(5,46) = 186.23$

$DW = 1.6652$

Table 2b. FOREIGN ETHIOPIAN MONEY DEMAND EQUATIONS

USA Money Demand Equation

$$m_t^* - p_t^* = \underset{(10.8469)}{0.4197\, y_t^*} - \underset{(-2.4099)}{10.9488\, \pi_t^*} - \underset{(-2.1220)}{0.0649\, r_t^*}$$

R^2 = .9541 F(4,48) = 249.54
DW = 2.2258

Germany Money Demand Equation

$$m_t^* - p_t^* = \underset{(11.8102)}{0.4959\, y_t^*} - \underset{(-4.1174)}{4.08\, \pi_t^*} - \underset{(-4.3197)}{0.07727\, r_t^*}$$

R^2 = 0.9344 F(3,52) = 247.03
DW = 2.4527

UK Money Demand Equation

$$m_t^* - p_t^* = \underset{(2.6493)}{0.4115\, y_t^*} - \underset{(-5.623)}{3.49\, \pi_t^*} - \underset{(-3.6949)}{0.0658\, r_t^*}$$

R^2 = 0.9200 F(3,52) = 225.45
DW = 2.0864

5.1.2 Estimation of Parameters σ and ß for the Interest Parity Condition

We have two parameters that have to be estimated in the interest parity conditions. These parameters are the coefficient of interest rate differential, σ, which is a measure of capital mobility and the coefficients of the premium, ß, which is a measure of substitution. The unobserved variables in the model i.e., the future expected exchange rate, $\Delta \bar{s}_{t+1}$, requires treatment. One must agree that sensible treatment of expectations are likely to undermine many of the restrictions econometrician had been used to think as most reliable. It is used to be that when expected future value of a variable were thought to be important in a behaviourial equation, they were replaced by appropriate distributed lag of the same variable. In order to evaluate this variable we have estimated the expected future depreciation, Δs_{t+1}, from the regression equation(26). Using the forecasted value of Δs_{t+1} we can apply two-stage least squares regression method to estimate the parameter σ and ß that are presented in Table(3) below.

The estimates of parameters σ and ß in the interest parity condition have common characteristic in all currencies. Most of the estimates have significant t-ratios and the variables have the anticipated sign. The insignificance of the coefficient, σ, in the estimated result indicates that interest rate differential has low explanatory power in the interest parity condition. Thus, we conducted a test for $\sigma=0$ and this restriction has been found statistically accepted for all currencies except for Birr-Mark exchange rate. Intuitively, this test manifest the fact that capital is immobile in Ethiopia.

In Birr-Dollar and Birr-Mark exchange rates the coefficient of the premium, ß, is significant indicating that premium captures some of the variations of exchange rate depreciation. The coefficient of determination, R^2, is uniformly low for all currencies. Generally, low value of R^2 provide the indirect evidence that the model is not sufficiently adequate to explain the relationship betweenexchange rate and the market fundamentals involved in interest parity condition.

Table 3. **Regression Equation of the Interest Parity Condition**

Regression of $\Delta s_{t+1} = \sigma(r_t - r^*_t + ß(s_t - e_t)$

Exchange rate/ Parameters	**Estimate**	**T-ratio**	**R^2,DW**	**Test for $\sigma=0$ $X^2(0.05,2)$**
Birr-Dollar				
σ	$0.6075\text{x}10^{-3}$	2.3512	R^2=0.203	
ß	0.0366	2.3028	DW=2.11	3.5319
Birr-Mark				
σ	$0.9593\text{x}10^{-3}$	2.0066	R^2=0.153	
ß	0.0454	2.3828	DW=1.77	8.344
Birr-Pound				
σ	$0.6793\text{x}10^{-3}$	1.1932	R^2=0.116	
ß	0.0304	1.3714	DW=1.95	2.9789

5.1.3 Estimation of α, ϵ and τ of the Frankel's Model

The Frankel's model of exchange rate incorporates three parameters. The estimation of these parameters, i.e., α, ϵ, and τ can be obtained from the regression equation(34) (see the methodology section in pp. 67). The parameter α is the speed of adjustment coefficient of the deviation of the short-run exchange rate from its equilibrium value, ϵ is the coefficient of the inflation differential and τ is the parameter that measure the presence of PPP in long-run.

The estimates of the parameters are shown in Table(4) below. All the equation have the desired sign and all of the estimated parameters have significant t-ratios except for ϵ in Birr-Pound Sterling exchange rate. The R^2 is quite very high. Thus, most of the variations have been explained by the explanatory variables. This is the evidence for adequacy of the model in explaining the variation in exchange rate depreciation and provide initial evidence supporting the Frankel's model fitting Ethiopian data.

The parameter τ has important interpretation, $\tau=1$ implies PPP holds in the long-run. From the result of the estimated regressions, τ is close to one in all currencies indicating PPP holds in the long-run. The t-ratios of these estimate are also highly significant. The long-run adjustment coefficient, α is negative in all currencies. The inflation differential coefficient, ϵ, appears to be significant only for Birr-Dollar exchange rate. This may be due to the fact that domestic price is largely sensitive to the foreign inflation of the trade partner country that has a greater share of trade in Ethiopia.

The regression equation in Table(4) are estimated using 2SLS method. These regressions are estimated by regressing domestic price on exchange rate plus foreign price, inflation differential and expected depreciation, D_F. The results of the parameter estimation is based on the following relationship,

$$p = A_1 \ (p^* + S_t) + A_2 \ (\pi_t - \pi^*_t) + A_3 \ D_F \qquad \ldots \qquad (41)$$

where, $\alpha = A_1/A_3$

$\epsilon = -A_2/A_3$

$\tau = A_1$

Table 4. Regression[21] Equation of Frankel's model.

$$p_t = \tau(p^*_t + s_t) - \tau\epsilon/\alpha\ (\pi_t - \pi^*_t) + \tau/\alpha\ D_F$$

Exchange Rate/ Parameters	Parameter estimates	T-Ratio	R^2	D.W.
Birr-Dollar				
α	-0.0118	-11.04		
ϵ	0.0423	1.7945		
τ	0.9904	801.84	0.85	1.42
Birr-Mark				
α	-0.14723	-11.538		
ϵ	0.0675	0.528		
τ	1.0758	276.71	0.81	1.32
Birr-Pound				
α	-0.0885	-22.42		
ϵ	0.0188	0.849		
τ	0.9238	754.0	0.83	1.02

5.2 Procedure of Empirical Estimation of the VAR Model.

After the estimation of parameters, the next step is to conduct the VAR methodology for testing exchange rate models. As Sims(1980) indicated it is possible to summarize the procedure in four important steps,

[21] The derivation of the regression equation is shown in the appendix.

1. Transform the exchange rate models in such a way that a VAR can be fitted to it.

2. Choose the order as large as possible for the VAR using Likelihood Ratio(LR) test and choose the number of variables compatible with the date set available.

3. Fit the resulting VAR-model.

4. Try to simplify the VAR by imposing some arbitrary 'smoothing' restrictions upon the coefficients of the parameters in VAR system and test the restriction using the appropriated test statistics, i.e., Wald Statistics.

Step 1

This is important step. The individual variables expressed in VAR need to be stationary. After this test much more care is required in identifying the correct format of the variables to be included in VAR. Thus, this step requires to conduct a test for stationarity of the individual variables then the stationary variables need to put in a proper format when they entered in a VAR model.

Step 2

Both the length of lag and the number of variables in VAR need to be specified before we regress the VAR. Empirical studies show that conclusion may be sensitive to the choice of lag length. However, the selection of the variable can be reduced to two variables, i.e., exchange rate and market fundamentals. Here, all the variables except the parallel exchange rate have be included in market fundamentals.

Therefore, we have selected two variables in the VAR because it is easy to estimate VAR with endogenous and exogenous variable set up, otherwise, it become too large to be estimated for all coefficients of the variables in VAR. For example, a VAR model involving five variables and five lags has 125 parameters. Thus, we set up the parallel exchange rate as endogenous variable and all other variables included in the market fundamentals are assumed to be exogenous.

Step 3

This step requires the imposition of prior restriction upon the VAR model of the relationship between exchange rate and market fundamental. The popular strategy for exchange rate model testing is to impose the expectation formation, i.e., the assumption of rational expectation.

5.3 Empirical Results of the Test

According to the steps mentioned above it is appropriate to start with the test for stationarity of the variables involved in each exchange rate models. For this reason a test for unit roots and cointegration were conducted. A simple asymptotically valid test for testing a unit root is to apply the Augmented Dicky Fuller(ADF) test, (see Dicky - Fuller 1981). This test is a transformed t-statistic corresponding to regression of the first difference of a variable on its lagged level with and without a linear trend.

Table(10) (in the appendix C) shows that most of the series are non-stationary. The parallel rate(s_t) and official exchange rate (e_t), money supply (m_t), the interest rate are non-stationary. The estimated income (y_t), Germany's price levels are found to be stationary. From Table 5 it appears that time-series of Germany's money supply, the price level of Germany and Ethiopia are likely to posses deterministic trend component and characterized as trend stationary. The same battery of tests are applied on the first difference of individual variables confirmed that all the variable are difference stationary, i.e., they are integrated to order one or simply denoted by I(1).

As can be seen from Table(11) (again in the appendix C), the test for a unit root on the market fundamental of each model shows that the market fundamentals, Z_t is non-stationary. This is due to the fact that most of the variables involved in the market fundamentals are non-stationary. However, the ADF test on the first difference of exchange rate and the market fundamentals indicate that they are first difference stationary.

From Table(12) (in the appendix C), ADF test of unit root enable us to determine the order of integration of market fundamentals and exchange rate before we proceed to the fitting of the VAR model. Therefore, ADF test indicate that the first difference of exchange rate, Δs_t and the market fundamentals,

ΔZ_t, are the appropriate format of the variable that should be included in the VAR.

Table 5. **LR test for the lag order.**

LR test Statistics	**Calculated X^2 value** **$X^2(.05,4) = 9.49$**
LR(1/2)	23.53*
LR(2/3)	21.94*
LR(3/4)	18.15*
LR(4/5)	14.21*
LR(5/6)	8.59
LR(6/7)	5.76

NB: A 95% critical value with 4 degree of freedom, $X^2(0.05,4)$, is 9.49.

*** - Indicates significant lag lengths.**

The next step in the analysis is then to determine the lag length of the VAR using likelihood ratios(LR) test statistics. The test statistics have a limiting chi-square distribution with M^2 degree of freedom and M is the number of variables. The procedure or the specification search for the right lag length is to test up from p=1 until the addition of last parameter lag does not lead to significant improvement in the fit. This test is reported in Table 8 above.

In Table(5) LR(5/6) means the LR test for the validity of a fifth order lag length of VAR against the alternative of sixth order lag length. According to the results reported, we finally chose a VAR of order five lag length given a 5% critical value of 9.49. Since the null hypothesis of five lag order is insignificant, we chose order five in the VAR. Because the test for LR(5/6) is close to the critical value we have also included a VAR of order six L(6/7) for the same battery of statistical tests.

The next step in the analysis is cointegration test of exchange rate and market fundamentals for each model. This test is helpful to determine cointegrated relationships and allow to get stable long-run relationship between the market fundamental and exchange rate. If we can find at least one cointegrated vector for the model being tested then the series of exchange rate and market fundamentals don't drift too much apart and tied together by some long-run equilibrium relationship.

In order to sketch and find out the existence of cointegration, the Johansen(1990) likelihood ratio test statistics for cointegration can be used to test the null hypothesis that there are at most r=2 linearly independent cointegrated vectors of exchange rate and market fundamentals.

The essence of the Johansen procedure lies with the realization that the combinations of the market fundamental and exchange rate produce a high correlation. Further, the standard technique of correlation will provide estimates of all the distinct cointegrating vectors which link a set of variables together and the associated eigen values have been used to construct a likelihood ratio test of the number of distinct cointegrated vectors.

Johansen's test for cointegration between parallel exchange rate and a linear combination of market fundamentals is reported in Table(6). The test statistics are computed for VAR lag of order five(p=5). Critical values are given in the parenthesis below r for the cases with and without trend. As suggested by Johansen(1992), the test is conducted as follows. For each model and currency one should look at the test statistic from left (starting from r=0) to right and stop at the first statistic for which the null hypothesis is not rejected either without trend or with trend.

Table 6. <u>Johansen's test for cointegration of parallel exchange rate and market fundamentals (including official exchange rate</u>.

<u>NB</u>: **(A 95% critical value are given in parenthesis below r).**

Model / Exchange Rate	**Without trend)**		**With trend**	
Interest Parity Condition	r=0 (15.67)	r=1 **(9.24)**	r=0 **(14.90)**	r=1 **(8.17)**
Birr-Dollar	8.88	7.45	8.87	7.47
Birr-Mark	9.95	4.86	5.92	4.83
Birr-Pound	12.75	4.44	13.72	5.44
Frankel Model				
Birr-Dollar	27.02	9.61	26.78	9.44
Birr-Mark	18.76	9.04	18.33	8.52
Birr-Pound	26.14	7.52	25.92	7.53
Meese Model				
Birr-Dollar	9.55	2.57	9.58	2.63
Birr-Mark	8.46	2.84	8.48	2.62
Birr-Pound	2.68	1.15	2.95	1.17

From the results of tests shown in Table(6) for the interest parity and the Meese's model of exchange rate the hypothesis of at most zero cointegrating vectors is accepted when the test is based on the maximum eigenvalue of the stochastic matrix for all currencies. Thus, relatively robust test of Johansen(1992) suggest that the exchange rate and market fundamentals of the interest parity and the Meese's model of exchange rate determination are not cointegrated. This is an indirect evidence against these models in which this paper has been concerned.

However, in the case of Frankel's model, the hypothesis that there is at most one cointegrated vector is accepted for all currencies. Therefore, parallel exchange rate and market fundamentals are cointegrated in the Frankel's model of exchange rate determination. However, for the interest parity condition and the Meese's no evidence are found for the existence of long-run relationships between market fundamentals and exchange rate for all currencies we have considered.

The Johansen(1992) test results are quite interesting. As Baille and Pecchenino(1991) suggested the findings of cointegration of exchange rate and market fundamentals in the Frankel's long run exchange rate model for currencies of Birr-Dollar, Birr-Mark and Birr-Pound Sterling may suggest the fact that the real exchange rate index constructed for these currencies are stationary. By the same taken the deviation from PPP for currencies of Birr-Dollar, Birr-Mark and Birr-Pound exchange rates do not follow a random walk process implied by Meese(1986).

The fundamental test statistic used in this paper is Wald test statistics. It is a long process to calculate Wald test Statistic given in equation(21). The ultimate result of the validity of the exchange rate models depends on the calculated value of these statistics. The procedure in calculating the Wald Statistics is as follows. In each case, the coefficient of VAR system is estimated by OLS. The estimation of the coefficients of VAR system are important in constructing the companion matrix A and the restriction matrix R given in equation(21). In addition, matrix B can be derived from the elements of A and R matrices (see the formulae in appendix A).

Lastly, the residuals of the OLS estimate are used to compute the variance covariance matrix VAR(b) in equation(21). The matrix VAR(b) has a dimension of 4p x 4p and can be computed from alternative estimate of the variance-covariance matrix using the method of Heteroscedastic-consistent estimation of White(1980).

The results of Wald test statistic of each model restriction are reported in Table(7) given below. In each case, if the calculated value is greater than the tabulated chi-square value we are going to reject the cross-equation restrictions. In other words, we are rejecting the congruency of the exchange rate model for Ethiopian data.

An interesting finding of this paper is that the restrictions implied by the interest parity condition and model of Meese's(1986) are rejected for all currencies. However, the Wald test statistic detects that the restriction for long-run exchange rate model of Frankel(1979) is accepted for Birr-Dollar, Birr-Mark and Birr-Pound Sterling exchange rates. This result supports the above finding, i.e., the same result have been found using the Johansen's cointegration test for exchange rate and market fundamentals. Therefore, in constructing exchange rate models for Ethiopia, Frankel's model is strongly supported by our empirical analysis. It is also interesting to note that changes in the lag length don't change the results reported in Table(7). For both lag lengths five and six the restrictions implied by the interest parity condition and model of Meese(1986) are rejected, however, restrictions for long-run model of Frankel(1979) is accepted.

In order to see whether these rejections of the interest parity and Meese's(1986) are due to temporary deviations of actual exchange rate behaviour from implied by the models or may be attributed to permanent deviations to which our test statistics could capture. Thus, we have presented summary statistics from linear projections of actual depreciation on expected(forecasted) depreciation for all models and currencies in Table(8).

In all cases the regressor $E(\Delta S_t)$ is obtained from the VAR regression with 5 and 6 lags and the actual depreciation is regressed on the VAR forecast of each exchange rate model, i.e., $E(\Delta S_t)$. The coefficient, ß, is the regression coefficient of the regression of actual depreciation on the change in the forecasted depreciation, $E(\Delta s_t)$. R^2 is the correlation coefficient, DW is the Durbin-Watson test statistics. In all cases, the coefficient of determination, R^2, explained small fraction of the total variation in the actual depreciation. However, the highest value reported for Frankel model supports the above findings.

Table 7. **Wald Test Statistics for Model Restrictions.**

Model/Exchange Rate/ VAR lag	calculated X^2	Critical value $X^2(0.05,2p)$
Interest Parity		
Birr-Dollar		
Lag 6	87.41	21.03
Lag 5	34.69	18.31
Birr-Mark		
Lag 6	113.31	21.03
Lag 5	102.15	18.31
Birr-Pound		
Lag 6	440.01	21.03
Lag 5	205.79	18.31
Frankel Model		
Birr-Dollar		
Lag 6	11.46	21.03
Lag 5	10.75	18.31
Birr-Mark		
Lag 6	10.14	21.03
Lag 5	10.87	18.31
Birr-Pound		
Lag 6	13.58	21.03
Lag 5	13.10	18.31
Meese Model		
Birr-Dollar		
Lag 6	67.15	21.03
Lag 5	45.17	18.31
Birr-Mark		
Lag 6	118.14	21.03
Lag 5	119.86	18.31
Birr-Pound		
Lag 6	156.14	21.03
Lag 5	172.73	18.31

NB: p denotes the lag length.

D.W. test statistics in Table(8) shows the absence of first order serial correlation and the F-statistics shows the joint significance of the parameters of the regression equation and highest value attained by the Frankel model and the goodness of fit decreases as we move to other models.

We have also conducted a volatility test for each exchange rate model based on variance ratio test and correlation between expected depreciation of the VAR forecast and actual depreciation of exchange rate. As variance ratio gets close to one the result indicates the validity of the model. The outcome of this test further supports the above findings. As shown in Table(9), the calculated variance ratio for Frankel's long-run model of exchange rate is more close to one than the other models of exchange rate.

However, the economic importance of all the models can be seen from the sign of the correlation coefficient reported in Table(9). The positive sign of the correlation coefficient indicates the expected depreciation and the actual depreciation move together for all the models. The relationship become stronger as the correlation close to one. The value of correlation by large supports the economic significance of Frankel's Model as applied to Ethiopian data. In particular, the results of VAR forecast for Frankel's model guarantee the economic importance of the structural models in long-run equilibrium relationship.

Table 8. Summary Statistics for the Regression
$\Delta S_t = \beta_0 + \beta\, E(\Delta S_t) + U_t$

Model/Exchange Rate/ VAR lag	Estimate of ß	T-ratio	R^2	D.W.	F-test
Interest Parity					
Birr-Dollar					
Lag 6	1.0017	3.9580	0.2500	2.0381	15.67
Lag 5	0.9989	3.6679	0.2189	1.9776	13.45
Birr-Mark					
Lag 6	0.9830	3.1610	0.1753	1.8445	9.99
Lag 5	0.9675	2.5896	0.1226	1.9740	6.71
Birr-Pound					
Lag 6	1.0027	3.5994	0.2161	1.8823	12.96
Lag 5	0.9998	3.0923	0.1661	2.0507	9.56
Frankel Model					
Birr-Dollar					
Lag 6	1.0024	5.4737	0.3843	2.0294	29.96
Lag 5	1.0225	4.9884	0.3368	2.1129	24.88
Birr-Mark					
Lag 6	1.1455	3.2255	0.1781	2.1045	10.40
Lag 5	1.2373	3.3841	0.1894	2.1551	11.45
Birr-Pound					
Lag 6	1.0236	4.9826	0.3409	1.8929	24.83
Lag 5	1.0606	4.9005	0.3289	2.1031	24.02
Meese Model					
Birr-Dollar					
Lag 6	1.0124	2.3537	0.1863	1.0294	9.94
Lag 5	1.0225	2.5864	0.1368	2.1129	7.87
Birr-Mark					
Lag 6	1.0119	2.8592	0.1482	1.9149	8.18
Lag 5	0.9910	2.6383	0.1267	1.9646	6.92
Birr-Pound					
Lag 6	1.0139	2.8626	0.1405	1.8923	8.83
Lag 5	1.0105	2.9005	0.1288	2.1031	6.02

Table 9. Volatility Test

Model/Exchange Rate/VAR lags	Variance Ratio	Correlation
Interest Parity		
Birr-Dollar		
Lag 6	0.4991	0.4999
Lag 5	0.4682	0.4692
Birr-Mark		
Lag 6	0.4259	0.4187
Lag 5	0.3542	0.3563
Birr-Pound		
Lag 6	0.4636	0.3849
Lag 5	0.4131	0.3570
Frankel Model		
Birr-Dollar		
Lag 6	0.6186	0.5212
Lag 5	0.5678	0.5120
Birr-Mark		
Lag 6	0.5666	0.5035
Lag 5	0.5467	0.5831
Birr-Pound		
Lag 6	0.5647	0.5213
Lag 5	0.5205	0.5183
Meese Model		
Birr-Dollar		
Lag 6	0.3803	0.3481
Lag 5	0.3574	0.3258
Birr-Mark		
Lag 6	0.3118	0.3603
Lag 5	0.3986	0.3253
Birr-Pound		
Lag 6	0.3561	0.3958
Lag 5	0.3172	0.3857

NB: The variance ratio can be denoted by $Var(E(\Delta S_t)/Var(\Delta S_t)$. And the above Correlation is between $E(\Delta S_t)$ and ΔS_t.

VI. Conclusion

The focus of this paper is to design a criteria for the test that can select an exchange rate model which is consistent with the available information in Ethiopia. There are many recognized techniques which enable us to design a criteria for testing exchange rate models. All of these methodologies are used as an evaluation device (checking data coherency) and a constructive instrument for finding and selecting an exchange rate model which simplified and represent Ethiopian exchange rate economy. Such methodologies are also used as a selection device to filter out poor designs.

Therefore, this paper is interested, in particular, to find out the exchange rate model that can represent long-run equilibrium relationship between exchange rate and market fundamentals using Ethiopian data. For this task, we have adopted Johansen's and VAR methodology to carry out a test on three popular exchange rate models. The validity of these models have been repeatedly checked under three major currencies against Ethiopian Birr. The different tests we have conducted here checks the explanatory power of each exchange rate models under different empirical test statistics which is available in econometrics.

Based on the finding of this paper, we are inclined to conclude that most of the variation of exchange rate are explained by the Frankel's model of exchange rate determination. The restriction implied by the interest parity condition and model of Meese(1986) are rejected for all currencies. The failure of the model suggested by interest parity condition and Meese's model can be capture by various econometric tests such as Johansen's cointegration and VAR restriction tests and variance ratio test.

However, the Wald test statistic for long-run model restrictions of Frankel(1979) are accepted for Birr-Dollar, Birr-Mark and Birr-Pound sterling exchange rates. The same result have found using the Johansen's cointegration test for exchange rate and market fundamentals. Therefore, to construct exchange rate model for Ethiopia, Frankel's model is strongly supported by the empirical evidence. It is also interesting to note that changes in the lag lengths don't change the results reported in Table 10. For both lag lengths five and six the restrictions implied by the interest parity condition and model of Meese(1986) are rejected, however, for long-run model restrictions of Frankel(1979) are accepted.

The assurance of Frankel's model is based on our selection criteria such as a VAR modelling methodology, Johansen's cointegration test, and variance ratio tests are satisfied within sample of three major currencies against Ethiopian Birr. Conversely, the models already invalidated within sample are the fact that the selection device filtered out as poor designs and not applicable for Ethiopia. Thus, the congruency of Frankel model for Ethiopian data provides a set of necessary condition for reliable model design and many policy makers and researchers undoubtedly take this advantage to extend their research and policy design based on the model we have recommended.

The Frankel model is a dependable model and proved to be valuable for Ethiopia. This paradigm of exchange rate is formulated with sufficient generality that can adequately characterize the Ethiopian exchange rate economy. Therefore, one would have gained new knowledge from this information alone. In other words, this paper contributes to improve research efficiency because researchers do not require the estimation of thousands of models before finding a reasonable one and provides the durability of Frankel's model of exchange rate which is less likely to suffer predictive failure when new information become available.

The Frankel exchange rate model is sound and filtered out by this research in its favour. Especially, policy makers and analysts are expected to appraise the empirical evidence we have found out because the replication of this work play an essential role to enhance and develop Ethiopian economic policies related to exchange rate and it is also increases the forecasting ability of Ethiopian future exchange rate.

It should be clear that forward looking expectation formation, i.e., rational expectation hypothesis is our assumption throughout this paper. However, agents may look at other expectation formation about future exchange rate. Other treatment of expectations are clearly an important area for future work. An alternative treatment to the one just presented here is the assumption that expectation could be adaptive.

It may also be recommended for the models that we have been rejected here, poor forecasts may lead to rethink alternative specification of the methodology. In addition, recent studies have shown that many macroeconomic series are characterized by non-linear dynamics which call for models of non-linear dependence of exchange rate models, Hgieh(1992). Therefore, we recommended to test the same exchange rate models by using non-linear testing methodology. However, we hope that the ultimately outcome will be the same.

The paper contributes its part on the design and foundation of an exchange rate model that is congruent with the available information in Ethiopia. Therefore, this paper plants a tree for future research efficiency on exchange rate forecast and exchange rate policy design.

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APPENDIX A: Definitions of the Matrices that are involved in the Methodology.

The companion matrix, A, can be defined as in the following form,

$$
A = \begin{bmatrix}
a_1 & a_2 & \dots & a_p & b_1 & b_2 & \dots & b_p \\
1 & 0 & \dots & 0 & 0 & 0 & \dots & 0 \\
0 & 1 & \dots & 0 & 0 & 0 & \dots & 0 \\
\dots & & & \dots & \dots & & & \dots \\
0 & 0 & \dots & 1 & 0 & 0 & \dots & 0 \\
c_1 & c_2 & \dots & c_p & d_1 & d_2 & \dots & d_p \\
0 & 0 & \dots & 0 & 1 & 0 & \dots & 0 \\
0 & 0 & \dots & 0 & 0 & 1 & \dots & 0 \\
\dots & & & \dots & \dots & & & \dots \\
0 & 0 & \dots & 0 & 0 & 0 & \dots & 1
\end{bmatrix}
$$

The unit matrices e_1' and e_2' are also important matrices to pick up the coefficients in matrix multiplication in the methodology and simplifying of the underlying models. They are defined as in the following form,

$$e_1' = [1\ 0\ \dots\ 0\quad 0\ 0\ \dots\ 0]'$$

$$e_2' = [0\ 0\ \dots\ 0\quad 1\ 0\ \dots\ 0]'$$

The restriction matrix, R, and the partial derivative matrix, B, in the Wald statistics can be constructed using the above three matrices using the following formulae,

$$R' = e_2' A - \theta(1-\delta) e_1' A [I - \delta A]^{-1}$$

$$B = \begin{bmatrix} [\delta R_1 - \delta c_1 - \theta(1-\delta)] I_{2p} \\ \delta(R_{p+1}-d_1) I_{2p} + I_{2p} - \delta A \end{bmatrix}$$

where, R_1 and R_{p+1} are the first and the p+1[th] rows of the restriction matrix, R.

APPENDIX B : The Derivation of some of the Equations involved in Methodology.

1. Interest Parity Condition(IPC)

Let us start from IPC and derive the restriction of this Hypothesis under the assumption of rational expectations,

$$E_t s_{t+1} - s_t = \sigma(r_t - r_t^*) + \beta(s_t - e_t)$$

Grouping all the exchange rates, s_t, terms together to the left, we can arrive at the following relationship,

$$E_t s_{t+1} - (1+\beta) s_t = \sigma (r_t - r_t^*) - \beta e_t$$

Then, we can put the market fundamentals, Z_t, of this model as,

$$Z_t = \sigma (r_t - r_t^*) - \beta e_t$$

Thus,

$$E_t s_{t+1} - (1+\beta) s_t = Z_t$$

Using difference and the forward operator, F, we can rewrite the above equation as follows,

$$-(1+\beta)\,[1-(1+\beta)^{-1}F]\,E_t(\Delta s_{t+1}) = E_t(\Delta Z_{t+1})$$

where, the forward operator , F, transform and update X_t in the form of, $F^n\ X_t = \ X_{t+n}$

Upon rearrangement, we can rewrite the above equation as,

$$E_t(\Delta s_{t+1}) = -(1+\beta)^{-1}[1-(1+\beta)^{-1}F]^{-1}E_t(\Delta Z_{t+1})$$

However, the forward operator can be changed to a geometric series of the form,

$$[1-(1+\beta)^{-1}F]^{-1} = 1 + (1+\beta)^{-1}F + (1+\beta)^{-2}F^2 + (1+\beta)^{-3}F^3 + \ldots$$

substituting this geometric series in the above equation we can arrive at the following relationship,

$$E_t(\Delta s_{t+1}) = -(1+\beta)^{-1}\sum_{j=0}^{\infty}(1+\beta)^{-j}E_t(\Delta Z_{t+j+1})$$

but, $E_t(\Delta s_t) = e_2' \ A \ X_{t-1}$

$E_t(\Delta Z_{t+j+1}) = e_1' \ A^{j+1} \ X_{t-1}$

And the summation can be reduced to the form,

$$\sum_{j=0}^{\infty}(\delta A)^j = (I-\delta A)^{-1}$$

Using differencing and the forward operator, F, we can transform and rewrite the above equation as,

$$\theta_1[1-\delta F]E_t\Delta(s_t) = E_t\Delta Z_{t+1}$$

The forward operator can be changed to a geometric series of the form,

$$E_t(\Delta s_t) = \theta_1^{-1}\sum_{j=0}^{\infty}\delta^j E_t(\Delta Z_{t+j+1})$$

$$e_2' A X_{t-1} = \theta_1^{-1}\sum_{j=0}^{\infty}\delta^j e_1' A^{j+1} X_{t-1}$$

Then, substituting this we arrive at a set of 2p restriction of IPC exchange rate model in the form of,

common we can arrive at,

$$e_2'A=-\delta e_1'A[I-\delta A]^{-1}$$

where,

$$\delta=\frac{1}{1+\beta}$$

$$\theta=\frac{-\delta}{1-\delta}=-\frac{1}{\beta}$$

2. Frankel's Exchange Rate Model

The Frankel's model of exchange rate can be represented as in the form of,

$$E_t s_{t+1}-s_t=-\alpha(s_t-s_{Lt})+\epsilon(\pi_t-\pi_t^*)$$

Grouping all the exchange rate(s_t) terms together to the left, we get the following relationship,

$$E_t s_{t+1}-(1-\alpha)s_t=\alpha s_{Lt}+\epsilon(\pi_t-\pi_t^*)$$

The market fundamental of this model takes the following form,

$$Z_t=\alpha s_{Lt}+\epsilon(\pi_t-\pi_t^*)$$

The equilibrium exchange rate s_{Lt} is ,

$$s_{Lt}=\frac{1}{\tau}p_t-p_t^*$$

Using differencing and the forward operator, F, we can rewrite the above equation as,

$$-(1-\alpha)^{-1}[1-(1-\alpha)^{-1}F)]E(\Delta s_{t+1})=E(\Delta Z_{t+1})$$

$$E_t(\Delta s_{t+1}=-(1-\alpha)^{-1}\sum_{j=0}^{\infty}(1-\alpha)^j E(\Delta Z_{t+j+1})$$

The restriction of this model is

$$e_2'A=-\delta e_1'A[I-\delta A]^{-1}$$

Where,

$$\delta=\frac{1}{1-\alpha}$$

$$\theta=-\frac{\delta}{1-\delta}=\frac{1}{\alpha}$$

3. Meese's Model

The Meese's model takes the following two equations

$$p_t=\tau(s_t+p_t^*)=u_t$$

Where, u_t is a radome walk process

$$u_t = u_{t-1} + \epsilon_t$$

By substituting the prices from the demand equations, we can get the exchange rate in the following form

$$s_t = \frac{1}{\tau}(m_t - \alpha_1 y_t + \alpha_2 \pi_t + \alpha_3 \Omega_t) - (m_t^* - \beta_1 y_t^* + \beta_2 \pi_t^*) + \beta_3 [\frac{1}{\sigma}(E_t s_{t+1} - s_t - \beta(s_t - e_t)$$

Thus, the market fundamentals takes the following form,

$$Z_t = \frac{1}{\tau}(m_t - \alpha_1 y_t + \alpha_2 \pi_t + \alpha_3 \Omega_t) - (m_t^* - \beta_1 y_t^* + \beta_2 \pi_t^*) + \frac{\beta\beta_3}{\sigma} e_t - \beta_3 r_t$$

Grouping all the exchange rate(s_t) terms together

$$s_t - \frac{\beta_3}{\sigma}[E_t s_{t+1} - s_t - \beta s_t] = Z_t$$

Upon re-arrangement,

$$s_t - \frac{\beta_3}{\sigma} E_t s_{t+1} + \frac{(1+\beta)\beta_3}{\sigma} s_t = Z_t$$

$$-\frac{\beta_3}{\sigma} E_t s_{t+1} + (1 + \frac{(1+\beta)\beta_3}{\sigma}) s_t = Z_t$$

Let us put,

$$\theta_1 = 1 + \frac{(1+\beta)\beta_3}{\sigma}$$

$$\theta_2 = \frac{\beta_3}{\sigma}$$

Thus,

$$\theta_1 s_t - \theta_2 E_t s_{t+1} = Z_t$$

Taking θ_1 common we can also arrive at,

$$\theta_1 [s_t - \frac{\theta_2}{\theta_1} E_t s_{t+1}] = Z_t$$

Using differencing and the forward operator, F, we can transform and rewrite the above equation as,

$$\theta_1 [1 - \delta F] E_t \Delta (s_t) = E_t \Delta (Z_{t+1})$$

The forward operator can be changed to a geometric series of the form,

$$E_t (\Delta s_t) = \theta_1^{-1} \sum_{j=0}^{\infty} \delta^j E_t (\Delta Z_{t+j+1})$$

Thus,

$$e_2' A X_{t-1} = \theta_1^{-1} \sum_{j=0}^{\infty} \delta^j e_1' A^{j+1} X_{t-1}$$

Therefore, the restriction of this model is,

$$e_1'A=\theta_1^{-1}e_1'A[I-\delta A]^{-1}$$

Where,

$$\delta=\frac{\theta_2}{\theta_1}$$

$$\theta=\frac{1}{\theta_1-\theta_2}$$

4. **The Derivation of Equation(41) in page 80**

As usual the Frankel's exchange rate model takes a form of

$$E_t s_{t+1}-s_t=-\alpha(s_t-s_{Lt})+\epsilon(\pi_t-\pi_t^*)$$

Also, from equation(26) depreciation is equal to the forecasted depreciation, D_F

$$E_t\ s_{t+1}\ -\ s_t\ =\ D_F$$

Therefore,

$$-\alpha(s_t-s_{Lt})+\epsilon(\pi_t-\pi_t^*)=D_F$$

also,

$$-\alpha s_t+\alpha s_{Lt}+\epsilon(\pi_t-\pi_t^*)=D_F$$

But, the equilibrium exchange rate equals to,

$$s_{Lt}=\frac{1}{\tau}p_t-p_t^*$$

Substituting s_{Lt} in the above equation, we have the following relationship,

$$-\alpha s_t+\alpha\left(\frac{1}{\tau}p_t-p_t^*\right)+\epsilon(\pi_t-\pi_t^*)=D_F$$

$$-\alpha(s_t+p_t^*)+\frac{\alpha}{\tau}p_t+\epsilon(\pi_t-\pi_t^*)=D_F$$

$$\frac{\alpha}{\tau}p_t=\alpha(s_t+p_t^*)-\epsilon(\pi_t-\pi_t^*)+D_F$$

Finally, we can arrive at the estimable regression equation of the form,

$$p_t=\tau(s_t+p_t^*)-\tau\frac{\epsilon}{\alpha}(\pi_t-\pi_t^*)+\frac{\tau}{\alpha}D_F$$

Appendix C: A Unit Root test for the Variables Involved in the Models.

Table 10. ADF Unit-Root tests.

Variables	Without trend (-2.9147)*	With trend (-3.4919)*
s_{US}	-1.7270	-1.7060
s_{GER}	-1.6562	-2.0698
s_{UK}	-2.2674	-2.2097
e_{US}	-1.1203	-1.7737
e_{GER}	-0.7979	-2.0307
e_{UK}	-0.8300	-1.9414
m_{ETH}	-1.0587	-2.3648
m_{US}	-2.0959	-0.6355
m_{GER}	-0.9576	-3.5298
m_{UK}	-2.5937	-2.9743
y_{ETH}	-4.2746	-4.5604
y_{US}	-3.6673	-5.4102
y_{GER}	-3.9633	-4.2081
y_{UK}	-0.6142	-5.8560
p_{ETH}	-1.8259	-3.7583
p_{US}	-1.4629	-1.9338
p_{GER}	-4.2053	-4.2835
p_{UK}	-1.0337	-3.3824
r_{ETH}	-1.0000	-1.9797
r_{US}	-1.0143	-1.4904
r_{GER}	-0.2327	-1.7888
r_{UK}	-2.3240	-0.7258

NB:

* - indicates a 95% critical value for ADF test statistics.

Table 11. ADF Unit-root tests on change variables.

Variable	Without trend (-2.9157)*	With trend (-3.4935)*
$\Delta\ s_{US}$	-4.4949	-4.4581
$\Delta\ s_{GER}$	-5.2179	-5.1132
$\Delta\ s_{UK}$	-5.5128	-5.2532
$\Delta\ e_{US}$	-5.3461	-5.3235
$\Delta\ e_{GER}$	-5.5092	-5.4622
$\Delta\ e_{UK}$	-5.9314	-5.8859
$\Delta\ m_{ETH}$	-3.9047	-3.8763
$\Delta\ m_{US}$	-7.6123	-8.4221
$\Delta\ m_{GER}$	-7.2107	-7.1534
$\Delta\ m_{UK}$	-8.0542	-8.7031
$\Delta\ y_{ETH}$	-7.3754	-7.3169
$\Delta\ y_{US}$	-6.8746	-6.8069
$\Delta\ y_{GER}$	-5.7873	-5.7262
$\Delta\ y_{UK}$	-7.8652	-7.9378
$\Delta\ p_{ETH}$	-5.8315	-5.7165
$\Delta\ p_{US}$	-2.9157	-1.4935
$\Delta\ p_{GER}$	-8.5703	-8.5058
$\Delta\ p_{UK}$	-4.8955	-4.8655
$\Delta\ r_{ETH}$	-5.1962	-5.1454
$\Delta\ r_{US}$	-3.1439	-3.9388
$\Delta\ r_{GER}$	-3.9059	-4.7697
$\Delta\ r_{UK}$	-4.1631	-4.4680

NB:

* - indicates a 95% critical value for ADF test statistics.

Table 12. ADF Unit-root test for Market Fundamentals.

Variable/Model	Without trend (-2.9137)*	With trend (-3.4904)*
Interest Parity Condition		
Z_{US}	-1.1203	-1.7737
Z_{GER}	-0.5391	-1.6619
Z_{UK}	-0.8301	-1.9414
ΔZ_{US}	-5.3461	-5.3235
ΔZ_{GER}	-5.4438	-5.3897
ΔZ_{UK}	-5.9314	-5.8859
Frankel Model		
Z_{US}	-1.8827	-2.8827
Z_{GER}	-1.6094	-1.9411
Z_{UK}	-1.1073	-2.8164
ΔZ_{US}	-6.0836	-6.0348
ΔZ_{GER}	-7.9222	-7.8475
ΔZ_{UK}	-5.4496	-5.3805
Meese Model		
Z_{US}	-2.5473	-3.5861
Z_{GER}	-2.8512	-2.7731
Z_{UK}	-2.4067	-3.0627
ΔZ_{US}	-5.6178	-5.6201
ΔZ_{GER}	-6.4670	-6.3666
ΔZ_{UK}	-6.0442	-5.9532

NB:
* - indicates a 95% critical value for ADF test statistics.

Date July 1, 1996

Declaration

This thesis is my original work and exchange rate modeling for Ethiopia has not been done for a degree in any other university.

Signature _______________

Elias Mulugeta