An Applied Macro-econometric Model for Supply Constrained African Economy: A Rwandan Macro Model

Alemayehu Geda[*] & Addis Yimer[**]

Abstract

In this study we have developed a macro-econometric model for a typical supply constrained African economy. This is aimed at developing a theoretical and empirical template for such policy tools that are increasingly being demanded in African ministries of finance and central banks. We have concretized it by building a macro-econometric model for Rwanda. The Rwanda macro-econometric model has 107 equations, of which 72 are endogenous. In addition, a supplementary ARIMA based model with 33 equations for exogenous variable is built to make the model useful for forecasting. The fiscal, balance of payment and money supply block of the model is fairly disaggregated to offer an adequate picture of the macro economy. An econometric estimation of the core behavioral equations of the model using equilibrium [error]-correction approach, with the database that stretches from 1960 to 2009 is made. The model can easily be further extended to the support budgeting, forecasting and macro-economic policy analysis work at the relevant ministries and central banks in Africa. We have managed to successfully solve the model and reproduced historical values from 1999 to 2009, and forecasted major macro variables for the year 2010 to 2015. We have also used the model to conduct a policy and external shock related simulation exercise that is very important for policy makers. We hope this model offers a theoretical and empirical framework for building similar applied macro models across Africa.

Key words: *macro-econometric model, error correction model, macro-economic policy, supply constrained models Rwanda, Africa, developing country models*

JEL Classification: C01, C3, C32, C5, C50, C52, C53, C59, E12, E17, E2, E6, H6

Introduction

Macro-economic policy making in Africa is increasingly being informed by medium to long-term plans such as the Poverty Reduction Strategy Paper (PRSP). This is closely linked to a widely used budgeting approach called the Medium Term Expenditure Framework (MTEF). Both the realization of a

---

[*]

[**]

strategy such as the PRSP and the use of MTEF require an overall macro-economic framework that ensures consistency in defining the aggregate resource envelop of a country and how it is going to be spent, as well as forecasting major macro aggregates three to four years ahead. A macro-econometric model is an invaluable instrument in achieving that since both the preparation of the budget and forecasting of key macro variables are made in a consistent framework and, hence, does not allow the components of the budget to be changed in a discretionary manner. In addition, such forecasts could be used to monitor the economy with reference to the government's current economic strategy, and to suggest modifications, either of substance or of the tactics.

Another important justification for having macro modelling in many African countries is its capability to help policy makers take informed decisions by conducting policy analysis using policy simulation. This is crucial for policy makers because it will help them to assess the implications of proposed policy packages before their actual implementation. Policy analysis conducted with the aid of such models avoids a partial analysis, and hence partial understanding, of issues of national significance. It has the advantage of taking all possible inter-linkages in the economy that are not easily tractable by human mind. In addition, macro models are also instrumental to carry macro-economic research by allowing macro policy research institutions to organize their research across the major components (block) of the macro model and carry out an in-depth analysis of major issues in each block such as inflation or fiscal deficit. This in turn improves the model and hence policy formulation (see Huizinga et al., 2001; Huizinga & Geda, 2004).

Despite such important use of a macro model, the use of macro models in Africa is limited. Recently, however, many countries are showing interest to have such models. Thus, there is a need to come up with a template macro model for the majority of countries in the continent by ensuring that such a model is grounded on African reality, applicable and built based on rigorous analysis. The building of the Rwandan macro-econometric model in this study is primarily motivated to develop such template. We will be doing that by: (a) developing a macro-econometric model well-grounded in theory and rigorous econometric analysis; and (b) illustrating the use of such model using actual macro-economic policy issues in Rwanda, creatively combining it with expert opinion. Our experience in building and using such models in Kenya and Ethiopia shows that notwithstanding the weakness of macro models in forecasting, in practice, things are not as bad as they look at first. This is because a model outcome is not meant to be used by itself, but jointly with expert opinion for additional information. This information may be based on events that have just been realized and will affect the immediate future. Also, expert opinion from different parts of the government may be incorporated into the macro model's forecast. Examples here are specialists on government expenditure and revenue,

and specialist on different sectors of the economy. In turn, these specialists benefit from this exchange as well, since they get a better picture of the overall economy. Adding such outside information significantly reduces the forecast uncertainty (see Huizinga et al., 2001; Huizinga & Geda, 2004).

Generally, a translation has to be made from the shocks or policy proposals to be analyzed into actual input for the model, as the model is not tailor-made to the often complex shocks and policy proposals. This requires a thorough understanding of how the model works, and even then some simplifications and additional assumptions are needed to make a proper analysis. Also here, expert opinion is often necessary to do this properly. Thus, the practical use of a model of the type developed in this study requires institutional building at relevant ministries such as the ministry of finance and central banks. Such institutionalization is important not only for appropriate use of the model but also for its sustainability. It is clear that the model will only be as good as the resources that are used in designing, operating and maintaining it. Above all, the key to the success of an applied macro model is to determine the measures that are necessary to sustain and institutionalize it, thereby ensuring that the model remains operational and is continually updated. In short, institutionalization and sustainability requires, *inter alia*: accuracy and timeliness of the data, trained staff who are assigned to maintain and operate the model, expert opinion that will ensure the accuracy of the relationships specified within the model and help to design scenarios and interpret the results of the policy simulations and forecasts; and the users who are expected to benefit from the analytical and forecasting activities (See Huizinga et al., 2001; Huizinga & Geda, 2004).

The rest of the paper is organized as follows. In section two we attempt to offer a brief theoretical framework of the model. We think that there are two strands of applied modelling practice in Africa that might be relevant in this context. One is to focus on the typical aggregate demand and aggregate supply framework. In such models the supply side is not generally emphasized. The KIPPRA-Treasury model of Kenya, as well as the recent macro-econometric model of the Central Bank of Kenya, are good examples of such models. Such models are generally demand-driven in the spirit of Keynes (see Huizinga et al., 2001; Were et al., 2013). Another strand of the approach is to emphasize the supply constrained nature of the African economy in question. The latter generally tally with the stylized facts in the continent -- we may call this a *structuralist* version of the aggregate demand-aggregate supply modelling. The theoretical framework for such models is developed in Huizinga and Geda (2004, and also in Geda (2011); and applied in the macro model of the Ministry of Finance of Ethiopia, as well as in Ghana (Geda & Yimer, 2015). In this paper we have followed the latter approach, which we think is relevant for most countries in Sub-Sahara Africa (SSA), where the agricultural and informal sectors are crucial, and are generally supply constrained. Section three

presents the method used in estimating the behavioral equations of the model, and the findings of such exercise. Section four, by way of illustration, discusses the use of the model for policy analysis. Section five concludes the study.

2. The Theoretical Framework and Estimated Results of the Model
2.1   The Theoretical Model

The model is built along the lines of the aggregate demand-aggregate supply (AD-AS) framework by emphasising the supply constrained nature of the economy in question.[1] This is done, unlike in typical demand-driven Keynesian models, by explicitly modelling the supply side of the economy. The supply side will contain three main components: the formal sector, the informal sector and the agricultural sector. Agriculture will be subdivided into cash crops (exports) [traded sector] and food production for the domestic market [non-traded sector]. This could, if the need arises, readily be subdivided further by major types of agricultural products. The informal sector consists mainly of small-scale industry and handicrafts, informal trade such as street vendors and informal restaurant services. The formal sector consists mainly of the government and the formal (modern) private sectors of industry and services. The latter include, for instance, large and medium scale manufacturing, formal trade, hotels and restaurants, transport and communications, banking, insurance and real estate.

Thus, the modelling of the real sector incorporates the basic linkages within and between the three sectors as shown in Fig. 1. Once we have this prototype, the model may be expanded up to the full scale of the short-run model, using the AD-AS framework. The formal and informal sectors both have constant-elasticity-of-substitution (CES) production functions. The shares of inputs are different, however. The level of capital used in the formal sector is far greater than in the informal sector. As a result, the employment response to demand fluctuations is far greater in the informal sector than in the formal sector. The formal private sector will be modelled along neoclassical lines, based on the theory of profit maximization, described in detail in Huizinga and Geda (2004), and offered briefly in Appendix 1. With a monopolistically competitive firms in view, prices are set as a mark-up over costs, which consist of labour costs and the cost of intermediate goods and raw materials. Demand for labour and capital follow from a CES production function, which allows us to model wages and capital formation/investment.

---

[1] This section is based on Huizinga and Geda (2004; see Geda, 2011) and it heavily draws from that. Readers are advised to consult Huizinga and Geda (2004) for a full and detailed picture of the theoretical framework. Here in an effort to save space we have attempted to give just the gist of the theoretical framework with a summary of the algebra given in Appendix I. A demand-driven version of this model's theoretical framework is given in Geda *et a*l (2002) and heavily influenced the theoretical formulation of recent model of the Central Bank of Kenya (see Were *et al* 2013).

Formal sector output in the short-run is demand driven. In the long-run, there is a supply component, as investment may be used to increase capacity. The degree to which this happens depends to a large extent on factors outside the firm's control, such as the quality of infrastructure, and an overall stable economic and political climate. This is especially true if overseas physical and financial investment is to play a major role. Investment in the formal sector, therefore, has both a cyclical component following GDP and a structural component following infrastructure and overall macro-economic stability considerations.

Demand for labour in the formal sector exhibits a large degree of labour hoarding, especially during bad agricultural seasons, when reduction in domestic demand will be mostly absorbed by a reduction in profits, and relatively little by layoffs. This is partly based on the high search costs for relatively highly skilled and hence scarce labour force; and partly based on implicit contract considerations. Skilled labour will, therefore, be relatively insulated from the cyclical variations in economic growth, both in terms of income and employment. Thus, in the formal sector, wages will be based on a mixture of bargaining and efficiency consideration as well as structural productivity. Wages of the unskilled are purely based on efficiency considerations, as there is an excess supply of unskilled labour. This means that wages are a mark-up over subsistence levels, without much regard to economic activity in the short-run (See Huizinga et al., 2001; Huizinga and Geda, 2004).

The agricultural sector, on the other hand, is mostly supply driven. Output is determined by land, the quality of seeds and fertilizer, labour, some capital, and most importantly, rainfall. Thus the modelling starts with the agricultural sector as shown in Fig. 1. It has a production function based on land, capital, labour, rainfall, and technology. Labour consists mostly of family labour, which is exogenously determined by population growth. There are strong decreasing returns to scale with respect to labour, reflecting the current excess labour supply. Since all elements of the agricultural production function are exogenous, so is total agricultural output.

Part of the labour force in agriculture normally moves to the urban areas to find jobs in the formal and informal sector. Because of low skill level these workers start out in the informal sector. The wage rate in the informal sector is a mark-up over the subsistence level in the agricultural sector because, among other things, of efficiency wage considerations. As a result, there are always agricultural workers, especially young ones, who would prefer to work in the informal sector and would move there if job conditions improve. Because of the constant excess supply of labour to the informal market, the wage is constant in the short-run. Similarly, the wage in the formal sector is a mark-up over that in the informal sector, also based on efficiency wage considerations. Workers in the informal sector would prefer a job in the formal sector and, therefore, there is also always

excess supply to the formal sector. Again we may assume that the wage in the formal sector is constant in the short-run as there will be an excess supply of labour in the Lewisian (1955) sense. This is not visible in the form of unemployment in rural areas because of the family nature of farm production (i.e., there is a disguised unemployment). Still, mostly young people may leave the farm because they cannot get their own land (which is very small in size even if they managed to get one due to population pressure) and search for employment in the urban informal sector, thus maintaining the excess labour supply in the non-agricultural sector (Huizinga & Geda, 2004).

Short-run aspect of the macro economy relates to modelling output volatility. This is in particular assumed to prevail in the agricultural sector. The most important determinant of cyclical variation in output is rainfall. If there is an adverse external shock such as a bad agricultural season, the supply of food to the market is sharply reduced. As a result, the price of food rises. As food is a major component of the CPI in many African countries, rainfall has a major effect on CPI. As nominal wages are not indexed, real wages of urban workers drop sharply when there is a shortage of food. This will reduce domestic demand for industrial products both from the formal and the informal sector. In the informal sector, reduced demand leads to reduced employment, which further reduces demand. In the formal sector, the effects are less dramatic. One reason is that part of the demand for the formal sector comes from abroad. Export demand is not directly affected by the bad agricultural season. Another reason is that the formal sector is better able to absorb a temporary reduction in demand through a reduction in profits (in the case of the private sector), or a deficit (in the case of the government sector). The informal sector bears the brunt of the cyclical variation in economic growth. Unlike the formal sector, it cannot afford to keep employment intact during a cyclical downturn or a drought. So, a reduction in demand will reduce output, employment and investment immediately. The flip side is that it is relatively easy to reactivate economic activity if demand picks up again. Labour will be readily available and the capital stock is not a major input. So, the informal sector is completely demand-driven with constant excess supply, and a production function-based mostly on low skilled labour (see Huizinga & Geda, 2004).

The long-term growth is modelled as follows. It is reasonable to assume that through a combination of better seeds, the use of fertilizer, and better infrastructure, the output of the agricultural sector can be increased substantially. This leads, other things remaining intact, to a drop in food prices and a rise in real wage of urban workers. The increase in disposable income leads to a rise in consumption demand to the formal and informal sectors. In the formal sector, this leads to increased profits, investment and eventually employment. In the informal sector, it leads to increased employment and eventually increased investment and profits. The key issue in terms of poverty reduction is that the

demand for labour in the formal and informal sectors continuously grows faster than population growth, which adds to the excess supply of labour, assuming that the food sector will not constrain this growth through inflation in a familiar Kaleckian fashion (see Geda & Kibrom, 2011).

In sum, the overall model for the short-run consists of two blocks that form the aggregate supply side of the model: the agricultural sector, whose output is determined by exogenous, but widely fluctuating supply conditions; and the formal and informal sectors, which in the short-run are mostly demand-determined. The link between the two components is the price of food, which is set such that the demand for food in the formal and informal sectors equals the exogenous supply of food. This real sector modelling is briefly summarized by Fig. 1. In the real sector modelling, the aggregate demand (consumption, investment, government spending, and exports) will determine the level of imports and total value-added. This value-added is disaggregated into agricultural, formal, and informal sector as noted. Out of the components of value-added, the value-added in the informal sector is assumed to be the residual given the data problem in many African countries about this sector. With this, the injection from the aggregate demand, which in turn creates the demand for value-added, is assumed to generate demand for factor inputs (capital, labour and imports). The choice of this factor inputs is assumed to follow from an optimization problem of agents in each sector using a CES productions function as given in Appendix 1.
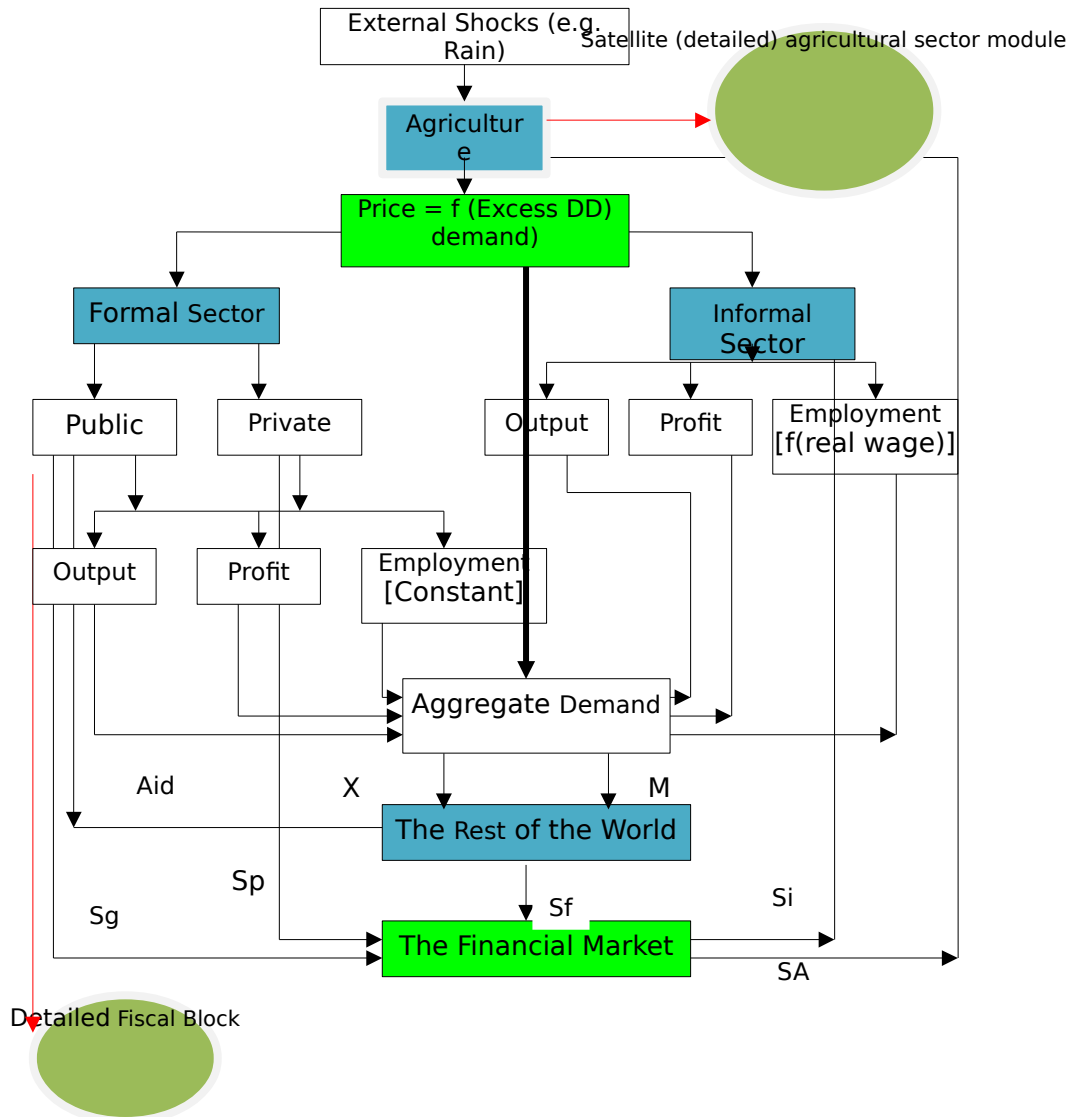
Figure 1: A *Flow Chart for Rwandan Macro Model - The Real Sector*
Source: Huizinga and Geda (2004).

The model is designed in such a way that it has a tendency to return to equilibrium with 'normal' capacity utilisation and unemployment rates in the medium and long-run. The main feedback mechanisms in the real economy works through the wage-price spiral, the interest rate and the real exchange rate, which are modelled as a nominal sector of the model and depicted in Fig. 2. The mechanisms in the

model can be illustrated by considering a supply shock, like a favourable rainfall, that raises output in the agricultural sector.

The increased supply of food leads to a lower price of food and a rise in real wages. This leads to a rise in consumption demand in the informal and formal sectors. Both sectors increase output. The formal sector also increases investment financed in part by increased profits. Employment in the formal sector is much less responsive in the short-run. The informal sector is far more employment-based and does not feature labour hoarding, and therefore, immediately increases employment. In addition, increased demand and profits leads to more investment, but this may be less important numerically. The increase in investment and employment further increase demand to the informal and formal sector, and also demand for food from the agricultural sector. The model converges because of leakage in the form of increased savings, increased imports and increased prices in the formal sector, leading to erosion in competitiveness (See Figs. 1 and 2; Huizinga & Geda, 2004).
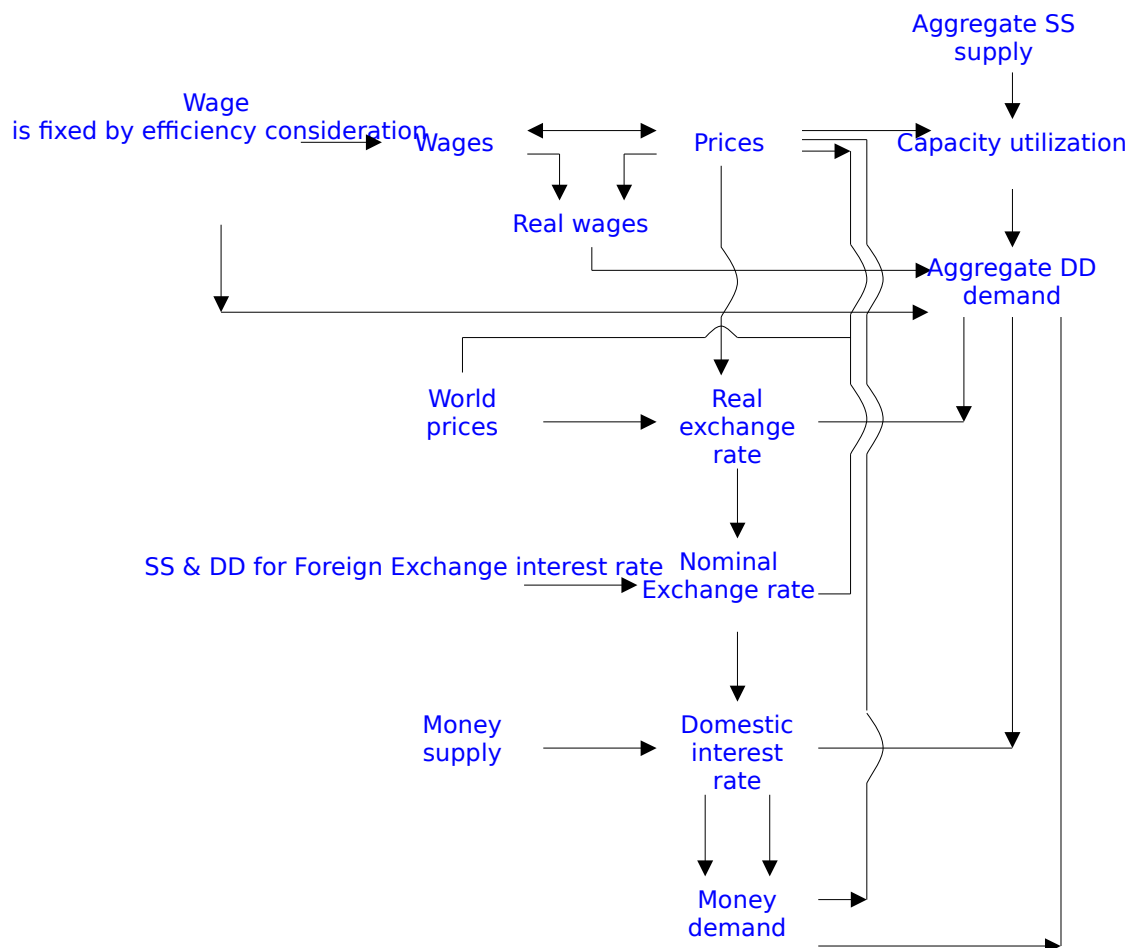
Figure 2: *A Flow Chart for Rwandan Macro Model - The Nominal Side*
Source: Huizinga and Geda (2004)

Fig. 2 gives an overview of the nominal side of the economy. The light shaded (yellow) boxes denote demand and supply in the labour, goods and services, and the money market. The white (green) boxes denote endogenous prices and the dark (light blue) ones exogenous variables. The arrows indicate direction of causation or determination. Six prices are determined endogenously in the model (The price of goods and services; the nominal and real wage; the nominal and real exchange rates, and the domestic nominal interest rate (Huizinga & Geda, 2004).

Wages and prices are determined in the labour and product markets. Wages and prices also depend on each other as indicated by the double arrow, so that there is a wage-price spiral in the model. The exchange rate and the interest rate are determined in the financial market. The financial market is subdivided into markets for domestic money, domestic bonds, and a market for foreign assets. By Walras' law we only have two models of these markets; and if these are in equilibrium, so is the third. The markets for domestic money and for foreign assets are modelled here; leaving the market for domestic bonds implicit. The exchange rate is floating (or managed floating), so that money supply is available as an exogenous policy instrument. Money demand is determined by aggregate demand, price level and interest rates. The interest rate moves to clear the money market, so that the interest rate is a function of money supply, real demand and prices. The exchange rate clears the market for foreign assets. A rise in the domestic interest rate relative to foreign interest rates makes domestic assets relatively more attractive, and thus causes an appreciation. The real exchange rate follows by definition from the nominal exchange rate, the domestic price level and the foreign price level (see Fig. 2, and Huizinga & Geda, 2004).

A brief summary of the theoretical model equations of the model, including definition of symbols that are used in the estimated equations in the next section are offered in Appendix I. A detailed theoretical framework of the model is given in Huizinga and Geda (2004), and also in Geda (2011).

I.2 Applied Macro-econometric Models in Eastern and Southern Africa[2]: A Review of Literature

Following the economic events of the 1970s and early 1980s, a large number of macro-economic models have been constructed for many African countries.[3] In the heated debate of the 1970s and early 1980s, as to the role of additional external resources and domestic adjustment measures in economic recovery in Africa,

---

2 The survey in this section focuses on applied macro models and in Eastern and Southern African countries mainly to save space and also to remain focused on the objective of this study-applied macro models.

3 A survey of modelling efforts in Africa in the past by Harris (1985) showed that there were about 184 macroeconomic models on various African economies, 33 of which were on Nigeria.

Horton and McLaren (1989) used a supply constrained macro-econometric model of the Tanzanian economy to examine (using model simulation) the effects of several alternative strategies. Their results highlight the problems of either a strategy of devaluation or of more external aid alone (Horton and McLaren, 1989).

Elliott et al. (1986) presented a description of a macro-economic model of the Kenyan economy, as a small and open developing economy that is vulnerable to conditions in world commodity and credit markets. The theoretical structure of the model, which consists of markets for domestic output, labour, money and the balance of payments, is described. Elliott et al (1986) provided a complete listing of the model equations with numerical results of the estimated equation. Finally, Elliott et al (ibid.) used the model for forecasting and policy simulations of alternative policies. Similarly, Musila and Rao (2002) developed a demand-oriented macro-econometric model of the Kenyan economy, whose equations are estimated using the co-integration technique. The model is used to perform various policy simulation experiments to determine the sensitivity of key macro-economic variables to changes in exchange rate, net government current expenditure, and nominal interest rate. The results reveal that exchange rates and fiscal policies are relatively more effective than monetary policy in influencing the level of economic activity (Musila & Rao, 2002).

Notwithstanding Elliott's (1986) and Musila and Rao's (2002) models, which are academic-based works, two applied macro-econometric models are currently in use in Kenya: the CBKMM (see Were et al., 2013), and the KIPPRA–Treasury Macro Model (KTMM) (see Huizinga et al., 2001). The theoretical basis of both models is the Keynesian demand-driven model that is set up in a typical aggregate demand (AD) aggregate supply (AS) framework. Their fundamental difference lies in the fact that the KTMM consolidates the monetary aspect of the model while having a detailed government (fiscal) sector. This is because it was designed to meet government needs in the national budgetary and planning process. On the other hand, the CBK model has a more detailed monetary sector tailored to the needs of the monetary policy process, while consolidating the fiscal block of the model. Both models are currently used for forecasting, policy analysis and budget preparation.

Asmerom (1991) developed a detailed economic-demographic model for Ethiopia and tried to study the interaction between the two, considering various demographic variables as being endogenous. The model aims, *inter alia*, to assess the effect of changes in these demographic indicators on some economic parameters. Asmerom (1991) developed the economic-demographic interactions in a schematic form by identifying the direction of variable associations and then recording the various structural equations and identities. He estimated the parameters of the model using time-series data. He then presented alternative simulation outcomes of the model under different assumptions.

Coming to applied models in Ethiopia, Alemayehu and Huizinga (2004) developed a supply-constrained macro-econometric model for Ethiopia, for use by the Ministry of

Finance and Economic Development. The core behavioural equations of the model are estimated using an error-correction modelling approach. Like that of the KTMM of Kenya the fiscal, balance of payment and money supply block of their model is fairly disaggregated to offer an adequate picture of the macro economy. The model has been used for forecasting and budget preparation at the Ethiopian Treasury.

Musila (2002) estimated a small-open economy macro-economic model for Malawi in which the structure of the model consists of production, expenditure, government, monetary, employment sectors and prices. The short-run version of the model was estimated using the co-integration estimation technique. The model is used for policy analysis. For instance, the dynamic simulation results indicate that a sustained devaluation of the Malawi kwacha improves the real trade balance, but leads to higher inflation and reduces real GDP growth. Bond-financed increases in government consumption expenditures are less inflationary, lead to higher real GDP growth, but worsen the real trade balance position (Musila, 2002).

Tjipe et al. (2004) developed a macro-econometric model for the Namibian economy. Based on previous experience and understanding of the functioning of the different sectors of the economy, Tjipe et al. (2004) model is informed by a theoretical framework that incorporates all essential features of the economy. The model equations are estimated using error correction modelling approach and their forecasting performance is assessed. Then, Tjipe et al. (2004) constructed the model and carried out policy analysis and external shocks simulations to examine different scenarios. This is aimed at giving further insight in the future path of the main economic variables of the model.

Finally, the Bank of Uganda (2010) has also built a small scale macro-economic model for Uganda. The model consists of five equations: a price equation, an aggregate demand equation (IS curve), a money demand equation (LM), an exchange rate equation and a policy rule. These equations are estimated using quarterly data for the period 1999-2009. The model is used to conduct policy simulation experiments to analyze the effect of different external shocks on inflation, output, exchange rate and interest rates. The simulation results suggest that government expenditure (fiscal policy) is quite effective in raising aggregate demand, while money supply (monetary policy) has little impact on inflation and interest rates but no effect on output.

Despite the importance of such applied macro-econometric models in many Africa countries, which is an encouraging trend, there are a number of problems associated with these models and their use. The first important challenge relates to the limited emphasis most applied macro models make on the supply constrained nature of African economies, and the importance of the informal sector in such countries, and hence their modelling. Another problem that is widespread in most

of African macro-econometric models relates to the macro-economic modelling tradition that is largely framed without a consistent analytical framework, but is used for either policy analysis or model-based forecasting exercises. As Haris(1985) argued, equation specifications have also been an exercise in the search for those that can give better explanatory power, rather than rooted in any framework of economic behaviour. The emphasis of the models is on 'tracking history', and the long-run sustainability of policy actions is largely ignored. Thus, the inter-temporal budget constraints are not observed, and these models are not robust for analyzing the consequences of major policy shifts (Haris, 1985).

In addition, although a large number of macro-economic models have been constructed for Africa, most of the models on individual African countries (see, e.g., Horton & McLaren, 1989; Elliott et al., 1986; Soludo, 1989; Musila, 2002; Musila & Rao, 2002) are either the products of doctoral theses, represent one-shot research efforts to write journal articles, or the models are built to analyze specific issues and not maintained thereafter. This shows the challenge of moving from academic modelling work towards applied macro modelling for policy analysis and its institutionalization.

3. Estimation Method and Results

3.1 Estimation Method

The modelling and estimating strategy in this study involves an application of the Johansen (1988, 1991) approach. Individual behavioural equations are estimated in a co-integration framework using single equation error correction modelling approach, where short-run and long-run dynamics is modelled simultaneously.

Following Johansen (1988, 1991) we may consider a VAR model given by equation [1a], where Y represents a vector of variables with *n* lags:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_4 Y_{t-n} + \mu_t \qquad \text{[1a]}$$

Generally, economic time series exhibit non-stationary process and, hence, VAR systems like equation [1a] can be expressed as equation [1b] through repeated parameterization to tackle this problem (Alemayehu et al., 2012):

$$A_j \Delta Y_{t-n-1} + ¿\phi D + \phi \mu_i \quad [1b]$$

$$A_j \Delta Y_{t-2} - ¿\sum_{j=i}^{n} ¿$$

$$A_j \Delta Y_{t-1} - ¿\sum_{j=3}^{n} ¿$$

$$(I - A_i) Y_{t-1} - ¿\sum_{j=2}^{n} ¿$$

$$\Delta Y_t = -\sum_{i=1}^{n} ¿$$

Where: *D* is a vector of exogenous dummy variables or exogenous variables,

or

$$\Delta Y_t = \Pi Y_{t-1} \sum_{j-i+1}^{n-1} \Phi_i \Delta Y_{t-n+1} + \phi D + \phi \mu_i$$

With

$$\Pi = \left(I - \sum_{i=1}^{n} A_t \right) \quad \text{and} \quad \Phi_i = \left(I - \sum_{j=i+1}^{n} A_j \right) = -A*(L)$$

The model estimated in this study is based on the VECM formulation given as equation [1b], which is a traditional first difference VAR model, except for the term ΠX_{t-1}. The Johansen procedure is based on an examination of matrix Π, which contains information about long-run relationships. The analysis of a long-run relationship in the model is based on examining the rank of this matrix. The most interesting possibility is when 0 < rank $\Pi = r < p$, which implies there are $p*r$ matrices α (the adjustment vector) and β (the long-run co-integration vector) such that $\Pi = \alpha\beta'$. The co-integration vector β has the property that $\beta' X_t$ is stationary even though X_t itself is non-stationary. The Johansen procedure helps to determine and identify this/these co-integrating vector(s). The empirical study in this study used this approach to identify such co-integrating vector(s).

Equation [1b] is estimated based on auto-regressive distribution lag model (ADL) formulation of the VAR given as equation [1a], which is re-paramatrized to offer equation [1b]. In general, in ADL formulation, a long-run (equilibrium) relationship between two variables, *Y* and *X*, could be given by equation [2]:

$$Y_t = K X_t^\gamma = \gamma_1 + \gamma_2 X_t [2]$$
Where

K, γ_1 and γ_2 are constants

$\gamma_1 = log K$

As this equilibrium relationship cannot be observed, the observable disequilibrium formulation of this long-run (equilibrium) relationship between Y and X, in a simplified from, can be given by equation [3]. Equation [3] is a simple ADL (m,n,p) [where m is the number of lags, n & p the number of endogenous and exogenous variables, respectively], ADL (1,1,1), formulation of equation [2]:

$$Y = \beta_0 + \beta_1 X_t + \beta_2 X_{t-1} + \alpha Y_{t-1} + u_t \quad 0 < \alpha < 1 \qquad [3]$$

With some re-parametrization[4], the ECM representation of equation [3], which is the estimable version of equation [1], could be given by equation [4] (Benerjee et al., 1993; Thomas, 1993; Hendry, 1995; Alemayehu, 2002; Morales & Raei, 2013):

$$\Delta Y = \beta_1 \Delta X_t - (1-\alpha)\left[Y_{t-1} - \gamma_1 - \gamma_2 X_{t-1}\right] + u_t \qquad [4]$$

Where:

$$\gamma_1 = \frac{\beta_0}{1-\alpha};$$

$$\gamma_2 = \frac{\beta_1 + \beta_2}{1-\alpha}; \text{ and}$$

$$\left[-(1-\alpha)\right] = \text{the ECM term that should be negative}$$

This formulation could be generalized for a general ADL of the form:

$$Y_t = \beta_0 + \sum_{i=1}^{m+1} \beta_i X_{t-i+1} + \sum_{i=1}^{m+1} \alpha_i Y_{t-i} + u_t \qquad [5]$$

The estimable ECM formulation of [5] could be derived in similar way as:

$$\Delta Y_t = \gamma_0 + \left(1 - \sum_{i=1}^{m} \alpha_i\right)\left[Y_{t=m} - \gamma_0 - \sum_{i=1}^{m} \gamma_i X_{t-m}\right] + \sum_{i=1}^{m} \beta_i \Delta X_{t-m+1} \quad [6]$$

Where:

$$\gamma_0 = \frac{\beta_0}{1 - \sum_{i=1}^{m} \alpha_i} \text{ is the constant; and}$$

---

4 Subtracting Yt-1 from either side of equation [3] and adding and subtracting X t-1 in the right hand side of the resulting equation gives equation [4].

the long-run coefficients are given by $\gamma_i = \dfrac{\sum\limits_{i=1}^{m+1} \beta_i}{1 - \sum\limits_{i=1}^{m} \alpha_1}$

3.2 Estimated Results

Before estimating the model, we carried out a test for stationarity of the variables in the model and found that all the variables to be integrated of order one, I(1). The individual behavioural equations estimated had a good fit. In addition, the estimated individual equations passed all post-estimation diagnostic tests carried exhaustively and reported for each of the estimated equations. Such tests include: normality test, heteroskedasticity test, test for serial correlation, model specification and stability test (Table 2). The number of lags used in the LM and Ramsey Reset test is given in Table 2. Table 1 presents the short-run and long estimated coefficients for each of the behavioural equations from their ECM formulation. We generally found the theoretical expected sign in the estimated equations.

Table 1: Estimated Equations of the Model

1 Private Consumption

$\Delta(LnRPC) = -3.18 + 0.52\,\Delta(LnRGDI) - 0.02\,\Delta(LnDIR) - 0.26\,ECM_{t-1} + 0.$
   (-2.24)   (11.93)   (-0.58)   (-2.70)   (5.37)

$\qquad - 0.06\,LnDIR_{t-1}$
   (-2.03)

2 Private Investment

$\Delta(LnRPRINV) = -6.59 - 0.51\,\Delta(LnRPUINV) + 2.13\,\Delta(LnRGDP) - 1.70\,\Delta($
   (-1.39)   (-4.60)   (4.46)   (-2.74)

$\qquad - 0.22\,\Delta(\ln INVP) - 0.98\,ECM_{t-1} - 0.22\,LnRPUINV_{t-1} + 1.06\,$
   (-0.40)   (-34.75)   (-1.15)   (2.77)

$\qquad - 1.28\,LnGDPDEF_{t-1} - 0.97\,\ln INVP_{t-1} + 0.19\,@\,trend$
   (-2.58)   (-6.13)   (3.85)

3 Food Demand

$\Delta(LnFC) = -7.72 + 0.12\,\Delta(LnCPI) + 1.75\,\Delta(LnRGDI) - 0.42\,ECM_{t-1} + 0.93$
   (-2.33)   (0.36)   (13.36)   (-2.70)   (3.07)

$\qquad - 0.65\,LnCPI_{t-2} + 1.01\,LnRGDI_{t-1} + 0.44\,DUM_{90}$
   (-2.04)   (2.96)   (3.65)

4 Agricultural Production

$\Delta(LnRAGVA) = -15.49 + 2.38\,\Delta(LnAGLF) + 1.01\,\Delta(LnCS) - 0.42\,ECM_{t-1} +$
   (-1.75)   (11.08)   (4.03)   (-2.27)   (2.01)

$\qquad + 0.55\,LnCS_{t-1} + 0.05\,@\,trend$
   (4.85)   (3.49)

5 Non Agricultural Production

$\Delta(LnRNAGVA) = -10.42 + 3.08\,\Delta(LnNAGLF) + 0.79\,\Delta(LnCS) - 0.24\,ECM$
   (-4.56)   (9.41)   (3.06)   (-2.59)

$$+0.97\,LnNAGLF_{t-1}+0.24\,LnCS_{t-1}+0.07\,@trend$$
$$\quad(2.81)\qquad\qquad(3.76)\qquad\qquad(8.37)$$

6 Export Demand

$$\Delta(LnRX)=3.05+0.20\,\Delta(LnRER)+0.48\,\Delta(LnINVGDP)+0.43\,\Delta(LnINCTR$$
$$\quad(3.84)\quad(1.20)\qquad\qquad(2.45)\qquad\qquad(3.71)$$

$$-0.53\,ECM_{t-1}+0.03\,LnRER_{t-1}+0.56\,LnINVGDP_{t-1}+0.33\,LnINCTRAD_{t-}$$
$$\quad(-11.24)\qquad(0.27)\qquad\qquad(9.35)\qquad\qquad(.45)\qquad\qquad(-8.79)$$

7 Import Demand

$$\Delta(LnRM)=-16.64-0.50\,\Delta(LnRER)+1.29\,\Delta(LnAID)+0.58\,\Delta(LnRGDP)-$$
$$\quad(-1.92)\qquad(-1.87)\qquad(0.77)\qquad(1.47)\qquad\qquad(-2.11)\quad(0.42)$$

$$+0.08\,LnRER_{t-1}+0.14\,LnAID_{t-1}+0.91\,LnRGDP_{t-1}+1.33\,DUM_1-0.05\,@$$
$$\quad(0.42)\qquad\qquad(1.44)\qquad\qquad(1.98)\qquad\qquad(2.24)\qquad(-1.95)$$

8 Exchange Rate

$$\Delta(LnNER)=-0.52+1.20\,\Delta(LnM)-0.14\,\Delta(LnXA_{DS})-0.13\,ECM_{t-1}+0.28$$
$$\quad(-1.69)\qquad\quad(8.56)\qquad\qquad(-6.68)\qquad\qquad(-2.72)\qquad(8.91)$$

$$+0.25\,LnXA_{DSt-1}$$
$$\quad(-13.95)$$

9 Wage Rate

$$\Delta(LnNWR)=-4.14+0.42\,\Delta(LnCPI)-0.46\,\Delta(LnUNEMPTRATE)+0.15\,\Delta$$
$$\quad(-2.79)\quad(1.46)\qquad\qquad(-0.10)\qquad\qquad\qquad(0.46)$$

$$-0.95\,ECM_{t-1}+0.37\,LnCPI_{t-1}-1.46\,LnUNEMPTRATE_{t-1}+0.7$$
$$\quad(-6.76)\qquad\qquad(1.40)\qquad\qquad(-1.99)\qquad\qquad\qquad(4.76)$$

$$+0.05\,@trend$$
$$\quad(1.08)$$

10 Money Demand

$$\Delta(LnM2)=-1.07+0.75\,\Delta(LnCPI)-0.10\,\Delta(LnIRD)+0.51\,\Delta(LnRGDP)$$
$$\quad(-0.60)\qquad\quad(3.50)\qquad\qquad(-1.86)\qquad\qquad(9.47)$$

$$-0.06\,ECM_{t-1}+0.11\,LnCPI_{t-1}-0.10\,LnIRD_{t-1}+2.17\,DUM_{06}+0$$
$$\quad(-2.12)\qquad\qquad(2.35)\qquad\qquad(-1.99)\qquad\qquad(6.56)\qquad\quad(4.45)$$

11 Consumer Price

$$\Delta(LnCPI)=17.09+0.39\,\Delta(LnCUR)+0.03\,\Delta(LnM2)-0.27\,\Delta(LnFC)+0.51$$
$$\quad(9.93)\qquad\qquad(3.67)\qquad\qquad(1.87)\qquad\qquad(-5.19)\qquad(4.63)$$

$$+0.06\,\Delta(LnMP)-0.47\,ECM_{t-1}+0.49\,LnCUR_{t-1}+0.59\,LnLIR_{t-1}+0.0$$
$$\quad(0.70)\qquad\qquad(-4.99)\qquad\qquad(6.06)\qquad\qquad(4.90)\qquad\qquad(0.17)$$

$$+0.06\,LnM2_{t-1}-0.41\,LFC_{t-1}+0.05\,DUM_{94}+0.14\,DUM_{96}+0.04\,@trend$$
$$\quad(2.05)\qquad\qquad(-8.68)\qquad\quad(1.86)\qquad\qquad(-3.58)\qquad\quad(5.59)$$

12 Export Price

$$\Delta(LnXP)=-6.61+1.92\,\Delta(LnPUC)+0.51\,\Delta(LnCUR)+0.13\,\Delta(LnRIR)+0.3$$
$$\quad(-5.08)\qquad\quad(2.55)\qquad\qquad(2.90)\qquad\qquad(1.41)\qquad\qquad(3.52)$$

$$-0.92\,ECM_{t-1}+2.34\,LnPUC_{t-1}+0.41\,LnCUR_{t-1}+0.25\,LnRIR_{t-1}+0.05\,Ln$$
$$\quad(-5.06)\qquad\qquad(5.08)\qquad\qquad(1.79)\qquad\qquad(2.00)\qquad\qquad(0.31)$$

13 Investment Price

$$\Delta(LnINVP)=0.04-0.53\,\Delta(LnCUR)+0.01\,\Delta(LnCUP)+0.61\,\Delta(LnMP)+0.$$

$$\begin{array}{ccccc}(0.07) & (-3.15) & (-0.01) & (2.67) & (2.45)\end{array}$$

$$-0.36\,ECM_{t-1}+0.13\,LnCUR_{t-1}+0.28\,LnPUC_{t-1}+0.49\,LnMP_{t-1}$$
$$\begin{array}{cccc}(-3.16) & (1.21) & 1.06) & (2.49)\end{array}$$

$$+0.11\,LnRIR_{t-1}+0.46\,DUM_{91}+0.03\,@trend$$
$$\begin{array}{ccc}(1.07) & (0.46) & (-4.17)\end{array}$$

Note: ECM_{t-1} is the Error Correction Term; t-values in Parenthesis

Table 2: Diagnostic Test of the Estimated Behavioral Equations

Equation	R^2	$\bar{R}^2$	F-Statistic	LM Serial Correlation test	White Hetroske-dasticity test	Normality test(JB)	Ramsey Reset test
Private Consumption	0.92	0.90	46.03 (0.00)	0.24 (0.62)	20.08) (0.34)	2.55 (0.28)	1.18 (0.29)
Private Investment	0.82	0.69	44.00 (0.00)	4.09 (0.13)	17.95 (0.10)	1.87 (0.37)	10.92 (0.01)
Food Demand	0.93	0.90	37.67 (0.00)	0.03 (0.86)	9.21 (0.24)	2.45 (0.29)	3.78 (0.07)
Agricultural Production	0.44	0.29	2.87 (0.03)	0.66 (0.79)	28.37 (0.25)	8.59 (0.01)	0.10 (0.75)
Non Agricultural Production	0.69	0.61	7.90 (0.00)	0.52 (0.77)	27.35 (0.24)	0.53 (0.77)	0.10 (0.75)
Export Demand	0.86	0.80	14.08 (0.00)	2.07 (0.15)	4.31 (0.89)	0.79 (0.67)	0.10 (0.75)
Import Demand	0.68	0.48	3.35 (0.02)	0.17 (0.68)	7.59 (0.58)	0.10 (0.95	0.04 (0.84)
Exchange Rate	0.57	0.46	5.04 (0.00)	1.29 (0.26)	12.95 (0.84)	0.53 (0.77)	12.16 (0.00)
Wage Rate	0.99	0.98	107.35 (0.00)	1.02 (0.31)	6.84 (0.55)	0.08 (0.96)	0.44 (0.54)
Money Demand	0.98	0.97	128.61 (0.00)	0.12 (0.73)	8.48 (0.49)	0.48 (0.79)	1.32 (0.26)
Consumer Price	0.88	0.75	6.80 (0.00)	2.36 (0.13)	12.99 (0.53)	0.97 (0.62)	6.87 (0.02)
Export Price	78.91	0.61	5.10 (0.00)	1.61 (0.21)	4.60 (0.87)	1.96 (0.38)	2.78 (0.12)
Investment Price	0.74	0.53	3.43 (0.02)	0.67 (0.41)	9.20 (0.60)	0.13 (0.94)	1.90 (0.19)

Note: P-Values in Parenthesis

Having these estimated equations and a consistent macro database, we have developed the model in Eviews platform. A solution to the fully fledged model requires incorporating identities and bridging equations. The list of these bridging equations is given in Appendix 1b. The use the model, as illustrated in the next section, is done after calibrating the model, as well as running it repeatedly to see its stability, its capacity to reproduce historical values of the macro-economy, as well as the sensibility of its forecast values. The model is found to reproduce historical values and offers reasonable forecast values. It is also found to be stable.

4. The Use of the Model: A Policy Simulation Experiment for Rwanda

In this section, we report some policy simulations related to the Rwandan government plan which is contained in the 'Budget Framework Paper 2012/13-2014/15. This is aimed at showing the used o the model both for forecasting and policy analysis. The government of Rwanda noted in the preparation of this budget that its budget could have macro-economic risks that may result from its proposed policy and possible external shock such as those shows in Box 1.

BOX 1: EXTERNAL AND POLICY SHOCKS EXAMINED IN THE SIMULATION EXERCISE

Government Policy 1
1) The **Government expenditure stipulated in the budget framework** contains (see Table B1):
    (a) Change in the total government expenditure in line with the proposed budget (an annual growth of 10% during the budget period)
    (b) Change in composition of this expenditure: Annual growth of 13 and 5% for current and capital expenditure, respectively.

Table B1: Level and Growth of Government Expenditure in the Budget Framework

	July 2011- June 2012	2012/ 13	2013/ 14	2014/ 15	
Model Years	**2011**	**2012**	**2013**	**2014**	**Average**
Current Expenditure(in Billion RWF)	596.3	670	782	8.57	726.3
Annual Growth		12.4	16.7	9.6	12.9
Capital Expenditure(in Billion RWF)	508.6	651.6	715	6.25	624.9
Annual Growth		28	9.8	-12.6	8.4
Total Government Expenditure	1104.9	1321.1	1497	1482	1351.3
Annual Growth		19.6	13.3	-1	10.6

Government Policy 2
2) The new **Wage Pay and Retention** Policy: RWF46.7 billion which is about 8% of current expenditure or 4% of the total government expenditure.
3) The Proposed **Efficiency Saving**: This is assumed to bring 4.2% cut on the allocation of each of the budge lines outlined in the budget to generate the 1.1 billion RWF proposed (which is 0.1% of the budget) for the airport project.

The External Sector Risk Stipulated in the Budget

4) The probable **Slowdown in the World Economy**: impact of the global economy on the planned budget. This takes two forms:
    (a) Change in foreign price (import price increase) 5 to 10% which is the record in the last 5 years. We simulated the relatively optimistic scenario of a 5% rise in import price.
    (b) A decline in exports (say due to Global economic slowdown. Rwanda's

However, these probable macro-economic risks are not quantified in the budget because of the lack of a macro-economic model in Rwanda. Thus, our task here is to show the use of the model developed in this study by focusing on macro-economic risks, if any, this planned budget has on macro-economic stability. Apart from showing the short-term forecasting ability of the model built in the context of this study, we are hoping to demonstrate the use of such models to tackle real world policy problems.

The simulation exercise in relation to the scenarios noted in Box 1 is focused on the following major macro-economic outcomes (see Box 2) that need to be examined to see what might be their likely direction, and hence the implied macro-economic stability of the country during the realization of the proposed budget; which in turn is fundamental for sustainable growth, poverty reduction and social and political stability. Thus, we have carried a simulation exercise for all the shocks outlined in Box 1. However, we have presented here only two of them (one policy and one external shock each) to save space. Interested readers can refer to our working paper for detail (Geda & Addis, 2013).

BOX 2: MACRO-ECONOMIC OUTCOME INDICATORS SELECTED TO GAUGE TREND OF THE MACRO ECONOMY

1. GDP and GDP Growth

2. Investment (Private and Total)

3. Private Consumption

4. Inflation (CPI)

5. Exchange rate (Nominal and Real)

6. Fiscal Issues

7. Eternal Sector/Balance of Payment

   7.1 *Export of Goods and Non-factor Services*

   7.2 *Import of Good and Non-factor Services*

   7.3 *Current/Overall Balance of Payment*

We commenced our policy analysis by producing what is called a base-run value of the model. The current version of the model could be solved from 1999 to 2009 and can fairly reproduce the actual/historical figures. It is also used to forecast major macro variables for the year 2010-2015, given the evolution of exogenous variables that are forecasted using the supplementary ARIMA model with 33 endogenous equations built for this purpose.

The first policy simulation relates to the effect of the proposed total government spending during the planning period. The result of this simulation exercise is given as Fig. 1.

4.1 The Effect of Government Policy 1: Planned Government Spending.

In this simulation we have raised the level of total public spending from its base run value, generated using the forecasting ability of the model, to the level

stipulated in the new budget, which is a growth rate of about 10% per annum from 2009 to 2014. The result of this simulation is provided in Fig. 1.

As can be gleaned from Fig. 1, the result shows that the proposed spending during the fiscal period will generally be compatible with stable macro-economic environment. The effect on real GDP is almost none, and hence the GDP growth rate will remain as that of the base-run forecast. Similarly, the effect on inflation, nominal as well as real exchange rate, is negligible as the deviation from the base-run is in the range of 0.01% to 0.05% with this policy.
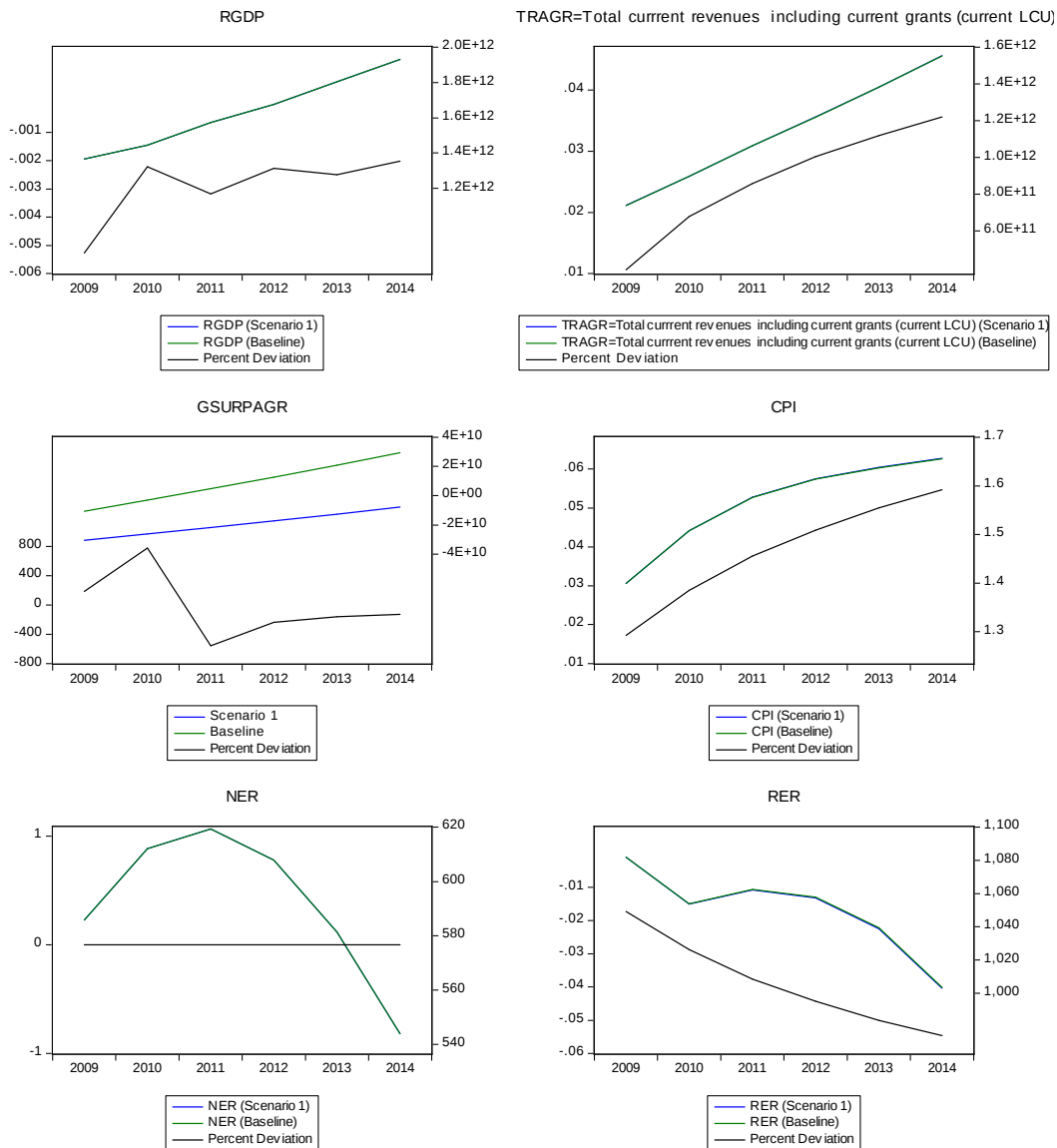
Figure 1: *The Effect of the proposed government spending (Deviation from Base-Run, in %)*

However, it has an effect in the level of fiscal deficit. The deficit will rise initially from -0.5% of GDP in the base run to -1.4% of GDP with the policy in the first year; and from -0.11% to -1.0% in the second year. It then stabilizes at about -0.5% of GDP by the end of the planned period. Notwithstanding the effect of the total spending above, the model also shows that the composition of this spending

does matter in terms of its macro-economic effect (not reported). See Geda and Yimer (2013) for details.

4.2 The Effect of the External Economy (Possible External Shock).

The external shock simulation relates to a 5% rise in import prices, and a possible decline of exports by 5% owing to a possible slowdown in the world economy (see Fig. 2). The effect of this probable adverse external shock is to reduce GDP (by -1.3%), private investment (by -5%), exports (by about -4.5%), and imports (by about -1%) in the first period.

Figure 2: *The Effect of a Possible Slow Down in the World Economy (Deviation from Base Run, in %)*

This will lead to an improvement (a decline) in fiscal deficit in the first two years, and to its deterioration thereafter.[5] The balance of payment effect is moderate and improved over the course of the planned period for it is accompanied by a decline in imports and recovery in exports. Thus, the balance of payment as well as the government deficit will show a recovery. This part of the simulation exercise shows the significant macro-economic risk that could be associated with such an external shock, and hence the need to be cautious and to take appropriate policy response if such an event does occur.

4. Conclusion

In this study we have developed an applied macro-econometric model for a typical supply constrained African economy. This is aimed at developing a template for such policy tools that are increasingly demanded in Africa. The Rwanda macro-econometric model built along this line has 107 equations; of which 72 are endogenous. In addition, a supplementary ARIMA based model of 33 equations, which is necessary for handling the forecasting of exogenous variable needed for the overall forecasting ability of the model is built. The fiscal (including financing), balance of payment and money supply block of the models are fairly disaggregated to offer an adequate picture of the macro economy. A single equation equilibrium correction [error-correction] modelling framework is used for estimation of the core behavioural equations of the model. The model is similar to successful applied macro models in the region such that that of the KIPPRA-Treasury model, as well as the Central Bank of Kenya's recent model. The model could easily be further extended to support budgeting, forecasting and macro-economic policy analysis work at relevant ministries such as the Ministry of Finance of Rwanda. We have managed to successfully solve the model from 1999 to 2009; and have been able to forecast major

---

5The decline of the fiscal deficit by about 120% in 2010 in Figure A2 shouldn't be regarded as big figure, as the magnitude of the deficit as percentage of GDP is very small (it has changed from -0.01% to 0.05% of GDP in that year) and hence the percentage change appears big.
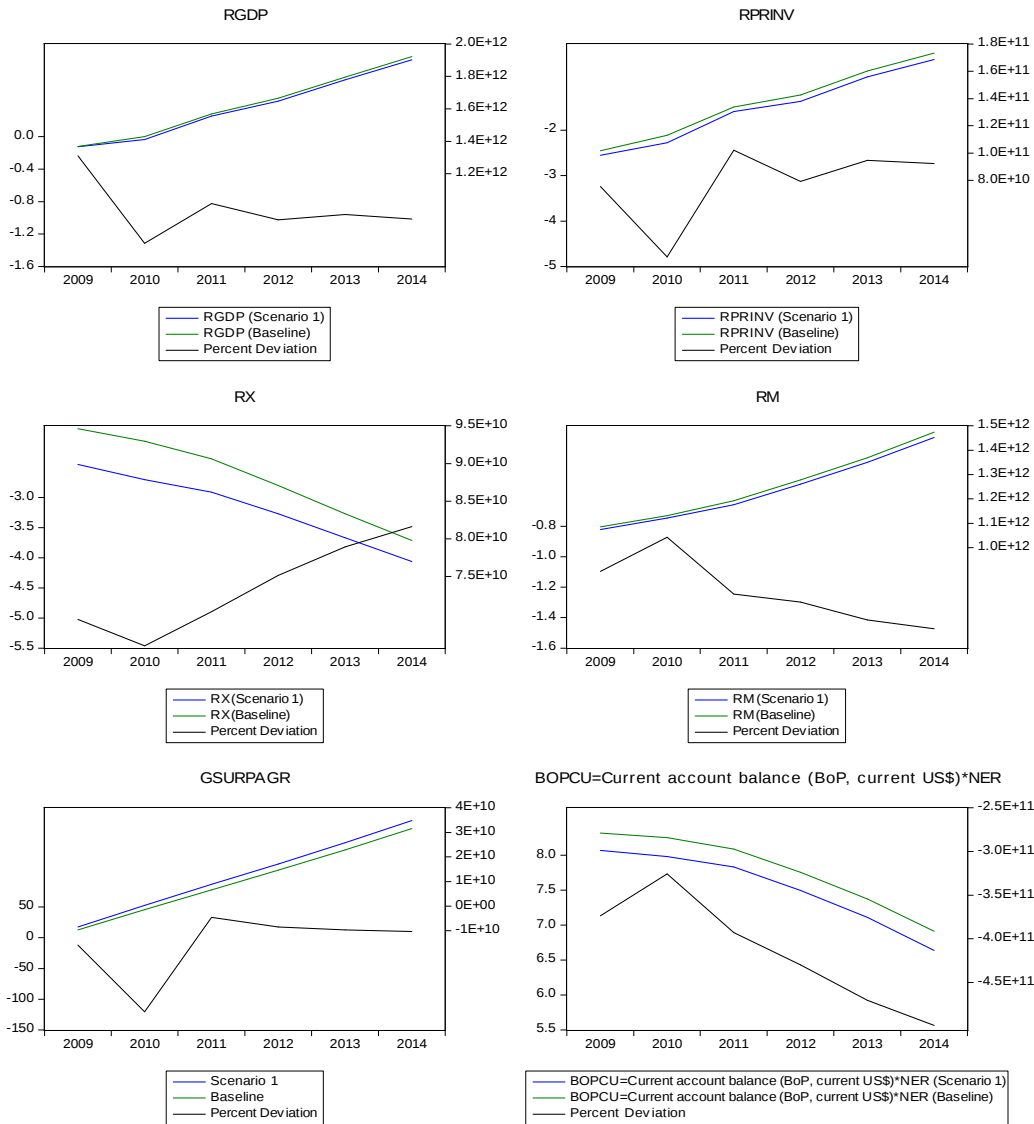
macro variables until the year 2015. The use of the model is illustrated by a real world policy analysis about the Rwandan economy through a simulation exercise.

In the simulation exercise an attempt to understand the implications of the government of Rwanda's budget related policy as contained in its 2012/13-2014/15 Budget Framework Paper is made. The analysis has focused in identifying major macro-economic outcomes in the planning period that could arise from the government's proposed policy, and probable external shocks. The following major conclusion regarding the macro-economic aspects of the economy (both prospects

and risks) that might be encountered in the planning period can be read from the policy simulation exercise.

First, the forecasted macro-economic outcome of the model in the planning period (2012/13-2014/15) is compatible with forecast offered by the Ministry of Finance and Planning. This underscores the importance of this macro model for the future works of the Ministry. Second, our simulation exercise revealed that the planned spending is compatible with stable macro-economic environment. Thus, there seems to be no macro-economic risk as it stands. Third, however, the Rwandan economy may face a limited macro-economic risk if the world economy slows down and prices of imports (in particular fuel price) increase in the planning period. This requires the need to have a policy response, such as a flexible exchange rate policy, encouraging tourism, etc., to contain the probable macro-economic risks. Fourth, in terms of fiscal policy, given the level and forecast of inflation, there seems to be even a limited room for pro-poor fiscal expansion. This fiscal expansion is, however, conditional on an expansion of food supply, and hence growth in the agricultural sector. If the latter is feasible, the financing strategy proposed by the government of Rwanda (i.e., shying away from domestic debt), and delay in spending in the face of shortage of external resources, is a good strategy that needs to be pursued. In relation to this, the government deficit after grant is generally good. However, grants are above 10% of GDP, and may lead to vulnerability if that level is failed for some reason. Thus, the government needs to be cautious about it. Finally, we note in conclusion the potential use of this model at policy making circles in Rwanda. It is an excellent macro-economic policy tool for policy analysis and forecasting if, in particular, it is accompanied by expert opinion in Rwanda. The model will even be more effective if it is further extended and institutionalized at relevant ministries such as the Rwandan Ministry of Finance or the country's central bank.

References

Banerjee, A., J. Dolado, J.W. Galbraith & D.F. Hendry. 1993. *Co-Integration, Error-correction, and the Econometric Analysis of Non-Stationary Data.* Oxford: Oxford University Press.

Bank of Uganda (BoU). 2010. A Small Scale Macro-economic Model for Uganda. *Bank of Uganda Working Paper*, BOUWP/07/10,Kampala,Uganda.

Elliott, J., S.Y. Kwack & G. S. Tavlas. 1986. An Econometric Model of the Kenyan Economy. *Economic Modelling,* 3(1): 2–30.

Geda, A. 2002. *Finance and Trade in Africa: Macro-economic Response in the World Economy Context*. London/Basingstoke: Palgrave-McMillan.

—. 2011. *Readings on the Ethiopian Economy*. Addis Ababa: Addis Ababa University Press.

Geda, A. & A. Yimer. 2013. A Macro-econometric Model for Rwanda' *IAES Working Paper NO 2*, at www.IAESAfrica.com or www.Alemayehom

Geda, A. & K. Taffere. 2011. The Galloping Inflation in Ethiopia: A Cautionary Tale for Aspiring Developmental African Countries. (Unprocessed, Department of Economics, Addis Ababa University; and also in A. Geda. *Readings on Ethiopian Economy*. Addis Abeba: Addis Abeba University Press.

Geda, A., N. Nudng'u & D. Zerfu. 2012. *Applied Time Series Econometrics: A Practical Guide for Macro-economic Researchers in Africa.* Nairobi: University of Nairobi Press.

Harris, J.R. 1985. A Survey of Macro-economic Modelling in Africa. Paper presented at a meeting of Eastern and Southern Africa Macro-economic Research Network, December 7–13, Nairobi, Kenya.

Hendry, D. F. (995. *Dynamic Econometrics*. Oxford: Oxford University Press.

Horton, S. & J. Mclaren. 1989. Supply Constraints in the Tanzanian Economy: Simulation Results from a Macro-econometric Model. *Journal of Policy Modelling,* 11(2):297–313.

—. 2004. The Theoretical Model of the Ethiopian Ministry of Finance and Economic Development Model. *MoFED Working Paper,* Ministry of Finance and Economic Development, government of Ethiopia (also in Geda, 2011).

Huizinga, F., A. Geda, N.S. Ndung'u & S.N. Karingi. 2001. Theoretical Base for the Kenya Macro Model: The KIPPRA-Treasury Macro Model. *KIPPRA Discussion Paper No. 11,* KIPPRA, Nairobi, Kenya (http://www.kippra.org)

Johansen, S. 1988. Statistical Analysis of Co-integration Vectors. *Journal of Economic Dynamics and Control*, 12:231–54.

—. 1991. "Estimation and Hypothesis Testing of Co-integration Vectors in Gaussian Vector Autoregressive Models" *Econometrica,* 59(6): 1551–1580.

Kidane, A. 1991. *A Macro-economic-Demographic Model for Ethiopia.* African Economic Research Consortium. Research Paper NO 7.

Morales, R. A. & F. Raei. 2013. The Evolving Role of Interest Rate and Exchange Rate Channels in Monetary Policy Transmission in EAC Countries. *IMF Working Paper,* No WP/13/X. Washington, D.C.: IMF.

Musila, J. W. 2002. An Econometric Model of the Malawian Economy. *Economic Modelling,* 19(2): 295–330

Musila, J. W. & U.L.G. Rao. 2002. A Forecasting Model of the Kenyan Economy. *Economic Modelling,* 19(5):801–814.

Pesaran, M. H. & R. Smith. 1998. Structural Analysis of Co-integration VARs. *Journal of Economic Surveys,* 12: 471–505.

Pesaran, M.H., Shin, Y., Smith, R.J. 2001. Bounds Testing Approaches to the Analysis of Level Relationships. *Journal of Applied Econometrics,* 16: 289–326.

Republic of Rwanda, Ministry of Finance and Economic Planning. 2012. Consolidated Annexes to the 2012/13–2014/15 Budget Framework Paper

Thomas, R.L. 1993. *Introductory Econometrics: Theory and Application.* London: Longman.

Tjipe, T., H. Nielsen & E. Uanguta. 2004. *Namibia Macro-econometric Model (NAMEX).* Bank of Namibia Research Department, Macro-economic Modelling and Forecasting Division. Namibia.

Were, M., A. W. Kamau, M. M. Sichei & M. Kiptui. 2013. A Theoretical Framework for Kenya's Central Bank Macro-econometric Model. Africa *Growth Initiative Working Paper No 10*, May 2013.

Appendix I: The Theoretical Model

Appendicx1a:
The Core Behavioral Equations of the Theoretical Model

The theoretical model reported in this appendix is the basis for the empirical model developed and reported in the main text of this study. This theoretical framework draws from the theoretical framework developed in detail by Geda and Huizinga (2004; also in Geda, 2011) and offered here briefly.

I. The Real Side
1.1 Production Functions

$$Y_A = A\left[\beta_L L_A^{-\lambda} + \beta_K K_A^{-\lambda} + \beta_R R_A^{-\lambda}\right]^{-1/\lambda} \qquad [1]$$

$$Y_F = A\left[\beta_L L_F^{-\lambda} + \beta_K K_F^{-\lambda} + \beta_Z Z_F^{-\lambda}\right]^{-1/\lambda} \qquad [2]$$

$$Y_A + Y_F] = = AL_I^{\beta} I \qquad [3]$$

$$Y_I = Y - ¿$$

Where *Y* is the GDP.

1.2 Demands for Factor Inputs
1.2.1 Employment in the Formal Sector

$$L_F = (\beta_L)^{\delta} (Y_F) \left(\frac{w}{p_y}\right)^{-\sigma} where \ \sigma = \frac{1}{1+\lambda} [4]$$

We have in terms of percentage changes:

$$\hat{L}_f = \hat{Y}_f - \sigma\left(\hat{w} - \hat{p}_y\right) [5]$$

1.2.2 Investment

$$K = (\beta_k)^{\sigma} Y \left(\frac{p_k}{p_y}\right)^{-\sigma} [6]$$

From this we get,

$$\frac{K}{k-1} = \hat{Y} - \sigma\left(\hat{p}_k - \hat{p}_y\right)[6a] \ or$$

$$\frac{i}{K-1} = \hat{Y} - \sigma \left(\hat{p}_k - \hat{p}_y \right) + \delta [6b]$$

$$\frac{i}{K-1} = \hat{Y} - \sigma \left(\hat{p}_k - \hat{p}_y \right) + \delta + \lambda \left(\frac{\pi}{K} \right)_{t-1} + \mu (q-1) + \eta \hat{I}_g$$

$$¿ \hat{Y} - \sigma \left(\hat{p}_k - \hat{p}_y \right) - \sigma \frac{dr}{r+\delta+r} + \delta + \lambda \left(\frac{\pi}{K} \right)_{t-1} + \mu (q-1) + \eta \hat{I}_g \quad [6c]$$

Relationship with the Incremental Capital Output Ratio (ICOR) which is widely used in Africa

$$\Delta K = ICOR \left(\Delta Y \right);$$

where

$$\Delta K = I - d^{¿} Y_{t-1} \text{ and } d \text{ is the depreciation rate}$$
$$I_{gross} = ICOR^{¿} \Delta Y + d^{¿} K_{t-1}$$
$$I_{gross} = ICOR^{¿} \Delta Y + d^{¿} ICOR^{¿} Y_{t-1}$$

1.2.3 Demand for Imports

This is the percentage change in imports due to output effects, assuming constant import shares, that is, constant relative prices. To add the effect of relative prices we write:

$$\hat{m} = \hat{z}_m - \sigma \left(\hat{p}_m - \hat{p}_y \right) [7a]$$

Where: P_m denotes price of imports in local currency (Birr).

Note that, by implication, z_m is proportional to a geometric average of the components of gross output z (or GDP).

$$Z_m \alpha C \frac{m_c}{M} I \frac{m_i}{M} G \frac{m_g}{M} X \frac{m_x}{M} [7b]$$

The price of imports equals the (exogenous) price of imports in foreign currency, $p_M(\$$. times the exchange rate (e. times 1 plus the import tariff rate.

$$\hat{p}_m = \hat{p}_m (\$) + \hat{e} + \frac{\Delta t_m}{1 + t_{m-1}} [7c]$$

1.2.4 Labour Supply and Unemployment

Labour supply is modelled exogenously as the product of the population within working age times the labour activity ratio plus employment in non-working age. The equation for labour supply is:

$$l^s = \varphi \, \text{population}_{\text{working age}} + \text{employment}_{\text{non-working age}} [8\,a]$$

Where : φ is the exogeneous labour activity ratio

$$u = l^{econ} - l[8\,b]$$

The unemployment rate ur is given by the number of unemployed divided by the labour supply.

$$ur = \frac{u}{l^s} [8\,c]$$

1.3 Final Demand for Goods

1.3.1 Consumption

Consumption is determined by a model of intertemporal optimization (simplified to two periods here).

$$agromax(c_1, c_2) : \log_{c_1} + \frac{1}{1+\delta} \log_{c_2}$$

Subject to:

$$c_1 + \frac{1}{1+r} c_2 = y_1^d + \frac{1}{1+r} y_2^{d,e} + \log_{c_2} + \text{wealth}_0 [9\,a]$$

$$C1 = \left(1 + \frac{g}{2+r}\right) y_1^d + \left(\frac{\text{wealth}_0}{2+r}\right) [9\,b]$$

$$c = y^d - r[9\,c]$$

1.4 Disaggregation by Sector

$$Y_d^{\dot{\iota}} = Y_d - p_a \dot{c}_a [9\,d]$$

In nominal terms consumption of food is given as,

$$p_a c_a = a_a Y_d^{\dot{\iota}} + p_a \dot{c}_a [9\,e]$$

An increase in disposable income also raises food consumption but reduces the relative share of agricultural consumption. Consumption of non-food (c_{na}) is a function of disposable income after expenditure on necessities. This could be given by:

$$p_{cna} c_{na} = a_{na} Y_d^{\dot{\iota}} [9\,f]$$

Where: P_{cna} is price of non-food consumption.

1.3.2 Exports

$$X = Y_N^{\beta_1} \left(\frac{ep_x}{p_d} \right)^{\beta_2} \left(\frac{i}{y} \right)^{\phi} [10\,a] \quad \text{or in log}$$

$$\hat{X} = \beta_1 \hat{Y}_N + \beta_2 \left(\hat{p}_x + \hat{e} - \hat{p}_d \right) + \phi \left(\frac{i}{y} \right)_{-1} [10\,b]$$

1.3.3   Government Spending and Revenue

Government spending (G) and revenue (T) in the model are formulated using a number of semi-behavioural equations (see Appendix 1b) which took the following generic form.

$$G = \sum G_i = \sum (\alpha_i + \beta_i Z_i)[11]$$

$$T = \sum T_i = \sum (\alpha_i^{\iota} + \beta_i^{\iota} Z_i)[12]$$

Where: G_i and T_i denotes the vectors of different spending and revenue categories, respectively, and Z_i a vector of determinants of G_i. & T_i , α and β (α * and β *) are parameters.

2. The Nominal Side

2.1 Price Determination in the Agricultural Sector

$$p_a c_a = a_a Y_d^{\iota} + p_a \acute{c}_a [13\,a]$$

Supply equals

$$p_a^{\iota} y_a + ep_f m_{ca} [13\,b]$$

Where*: m_{ca} is the real import of consumption of agricultural goods (imported food. *e* the nominal exchange rate and p_f price of imports (foreign price).

Equating supply and demand gives,

$$p_a (y_a - \acute{c}_a) + (ep_f m_{ca}) = a_a Y_d^{\iota} [13\,c]$$

$$p_a = \frac{a_a Y_d^{\iota} - (ep_f m_{ca})}{y_a - \acute{c}_a} [13\,d]$$

2.2 Price and Wage Determination in the Formal Sector

We assume that output prices are set by firms who operate in a market structure of monopolistic competition. That is, we assume that for each good, there exits an inverse demand curve $p^f = p^f(z$. with p^f denoting the price at factor cost and *z* gross output. The price at factor cost is exclusive of indirect taxes and subsidies, and thus

equals the price the firm actually receives for its product. We also assume that there exists a well behaved cost function $c = c(z)$. Profit maximization then leads to:

$$argmax(z):(1-t_\pi)\big[p^f(z)z-c(z)\big]\,[14\,a]$$

Where: t_π the profit tax.

Profits are maximized by setting the price p^f equal to,

$$p^f=\left(1-\frac{1}{\varepsilon}\right)^{-1}mc\,[14\,b]$$

Where ε is the price elasticity of demand and *mc* denotes marginal cost: This optimization, including the effect of competitive price can lead the following final form for general price (see Huzinga and Geda, 2004 for detail) $mc = dc/dz$. Note that the profit tax has no influence on the price, since both marginal revenue and marginal cost are reduced by the same amount. The market price, denoted p_y, is related to the factor cost price p^f by:

$$p_y=p^f(1+t_z-s_z)\,[14\,c]$$

$$\hat{p}_y^{m,s}=(1-\gamma)\left(\alpha_w(\hat{w}-\hat{h})+\alpha_k\hat{p}_k+\alpha_m\hat{p}_m+\beta 1\Delta q+\beta 2(q-1)+\frac{\Delta t_z+\Delta s_z}{1+t_z-s_z}\right)$$
$$+\gamma\, p_{comp}\,[14\,d]$$

Where: t_z and s_z are the indirect tax and subsidy rates.

The relation for the market price is therefore

Price of Aggregate Goods in the Formal Sector, $\hat{p}^{ag}$.

$$\hat{p}^{ag}=(1-\lambda)\hat{p}_y^{m,s}+\lambda\hat{p}^p\,[14\,e]$$

Where: the superscript *p* denotes policy-determined.

2.3. Price and Wage Determination in the Informal Sector

$$w_I=w_A(1+g_A)\,[15]$$

$$P_I=w_I(1+g_I)\,[16]$$

Thus, the general prices level should be a weighted average of the price in the formal and informal sector and that of the agricultural sectors:

$$P^{GDP}=\beta_1 P^{agr}+\beta_2 P^{formal}+\beta_3 P^{informal}\;where\;\beta_1+\beta_2+\beta_3=1\,[17]$$

2.4 The Money Market and the Exchange Rate

2.4.1 Money Demand and Supply, and the Domestic Nominal Interest Rate

$$M^d = \alpha Y + \beta P - \gamma i \,[18\,a]$$

Where*: M^d* denotes nominal demand for money, *Y* stands for *GDP,* and *i* the nominal interest rates on bonds (the rest of the symbols being parameters).

$$i = \frac{1}{\gamma}\left(\alpha Y + \beta P - MS^{i}\right)[18\,b]$$

With the inflation targeting monetary policy rule is given by

$$\Delta MS^{i} = \alpha\,\Delta Y + \beta\,\Delta P^{i} + \beta_1\left[\Delta P - \Delta P^{i}\right] where\ \beta_1 < \beta\,[18\,c]$$

Where *P** is the target level of inflation.

2.4.2 Exchange rate (e. w where M, money, X, export; A, aid; FX^{dd} , demand for foreign exchange

$$e = \beta_0 + \beta_1 M - \beta_2 \lfloor X + A - FX_g^{dd} \rfloor [19]$$

The real exchange (RER) is derived by definition:

$$RER = e + p_f - p_d \qquad\qquad [20]$$

Appendix 1b:
Identities and Bridging Equations

1) General

NGDI = NGDP - TXR

RC = RPC + RGC

RGDI = NGDI / GDPDEF

RPRINV = NPRINV / INVP

RINV = RPRINV + RPUINV

PF = 0.5 * (XP + MP)

RER = NER * (PF / CPI)

RGDP = RPC + RINV + RGC + RX - RM

RTVA = RAGVA + RNAGVA

GDPDEF * RGDP = RPC * CPI + RINV * GDPDEF + RGC * CPI + RX * XP - RM * MP

NGDP = GDPDEF * RGDP

3) The Balance of Payment Block

BOPCU = (X - M + NDINROW + NCUTR)

BOPOVERALL = BOPCU + BOPCA

2) The Fiscal Block
A) Government Revenue

TRBGR = TXR + NONTXR + CAPREV

TXR = DTX + IDTX + FTRTX

DTX = DTX(-1) * (NGDP / NGDP(-1)) + Discrepancy

IDTX = IDTX(-1) * (FCONEX / FCONEX(-1)) + Discrepancy

FCONEX = RPC * CPI + RGC * CPI

FTRTX = IMPORTAX + EXPORTAX

X = RX * XP

M = RM * MP

IMPORTAX = IMPORTAX(-1) * (M / M(-1)) + Discrepancy

EXPORTAX = EXPORTAX(-1) * (X / X(-1)) + Discrepancy

TRAGR = TRBGR + GR

CAPREV = NETBORROWING_EXT + OTHCAPIREV

B) Government Expenditure, Fiscal Balance and Debt

TGEX = GCUREX + GCAPEX

GCUREX = WS + TINTEXPE + AMORT_EXT + OTHCUREXP + Discrepancy

WS = (WS(-1)) * (EMPT / EMPT(-1)) * (WRATE / WRATE(-1))

DEBT_DOM = DEBT_DOM(-1) + NETBORROWING_DOM + Discrepancy

EXTDEBT = EXTDEBT(-1) + NETBORROWING_EXT

TINTEXPE = INTPAYDOMDEBT + INTPAYEXTDEBT

OTHCUREXP = OTHCUREXP(-1) * (NGDP / NGDP(-1)) + Discrepancy

GCAPEX = GCAPEX(-1) * ((NETBORROWING_EXT + GR) / (NETBORROWING_EXT(-1) + GR(-1))) + Discrepancy

GSURPAGR = (TRAGR - TGEX)

GSURPBGR = TRAGR - TGEX - GR

4) The Monetary Block

GOVSUGRLessEA = GSURPAGR - NETBORROWING_EXT - AMORT_EXT

TOTAL_FINANCING = - 1 * (GOVSUGRLessEA)

NETBORROWING_DOM = TOTAL_FINANCING - NETBORROWING_EXT

NETBORROWING_EXT = GROSSBORROWING_EXT - AMORT_EXT

OFICALEXCHANGERESERVES = OFICALEXCHANGERESERVES(-1) + CHANGEINRESERVES (-1)

CHANGEINRESERVES = BOPOVERALL - STATDESCREPANCY1

M2 = OFICALEXCHANGERESERVES + (DOM_CREDIT_CALIMSONGOVT(-1) + NETBORROWING_DOM) + DOMCRED_CLAIMS_OTHERS + STATDESCREPANCY2

Appendix 1c:
List of Variables used in the Estimated Model

Name	Label
AID	Net Official Development Assistance and Official Aid Received
AGLF	Agriculture Labor Force, Absolute Value
AMORT_EXT	External Loan Amortization ,Nominal
BOPCA	Balance of Payment, Capital, Nominal
BOPCU	Balance of Payment, Current, Nominal
BOPOVERALL	Balance of Payment, Overall ,Nominal
CAPREV	Capital Revenue, Nominal
CHANGEINRESERVES	Changes in net reserves ,Nominal
CPI	Consumer Price Index
CS	Total Capital Stock, Real
CURN	Capacity Utilization Rate ,Nominal
CURR	Capacity Utilization Rate, Real
DUM_1	Period dummy,(1991-2009==1) and 0 otherwise
DUM_{90}	Impulse Saturation Dummy,1990=1 and 0 otherwise
DUM_{91}	Impulse Saturation Dummy,1991=1 and 0 otherwise
DUM_{94}	Impulse Saturation Dummy,1994=1 and 0 otherwise
DUM_{95}	Impulse Saturation Dummy,1995=1 and 0 otherwise
DUM_{96}	Impulse Saturation Dummy,1996=1 and 0 otherwise
DUM_{06}	Impulse Saturation Dummy,2006=1 and 0 otherwise
DUM_{07}	Impulse Saturation Dummy,2007=1 and 0 otherwise
DIR	Deposit Interest Rate, Nominal
DOM_CREDIT_CALIMSONGOVT	Claims on Central Government ,Nominal
DEBT_DOM	Domestic Debt, Nominal
DOMCRED_CLAIMS_OTHERS	Claims on Others, Nominal
DTX	Direct Tax, Nominal
EMPT	Total Employment, Absolute Value
EXCESDDFOOD	Excess Food Demand
EXPORTAX	Export Tax, Nominal
EXTDEBT	External Debt Stock, Nominal
FCONEX	Final Consumption Expenditure, Nominal Total
FTRTX	Foreign Trade Tax, Nominal
GCAPEX	Government Capital Expenditure, Nominal
GCUREX	Government Current Expenditure, Nominal
GDPDEF	GDP Deflator, Period Average
GR	Grant, Nominal
GROSSBORROWING_EXT	Gross External Borrowing, Nominal
IDTX	Indirect Tax, Nominal
IMPORTAX	Import Tax, Nominal
INCTRAD	Income of Trading Partners, Real
INF	Inflation(Change in CPI)
INTPAYDOMDEBT	Interest Payment on Domestic Debt, Nominal
INTPAYEXTDEBT	Interest Payment on External Debt, Nominal
INVGDP	Investment to GDP Ratio, Real
INVP	Investment Price
LnAGLF	The Natural Log of Agriculture Labor Force, Absolute Value
LnABPRO	Labor Productivity, Real
LnAID	The Natural Log of Net Official Development Assistance and Official Aid Received
LnCPI	The Natural Log of Consumer Price Index
LnCS	The Natural Log of Total Capital Stock ,Real

LnCURN	*The Natural Log of Capacity Utilization Rate, Nominal*
LnCURR	*The Natural Log of Capacity Utilization Rate, Real*
LnDIR	*The Natural Log of Deposit InterestRate, nominal*
LnDTX	*The Natural Log of Direct Tax, Nominal*
LnEMPT	*The Natural Log of Total Employment, Absolute Value*
LnFC	*The Natural Log of Real Food Consumption*
LnGDPDEF	*The Natural Log of GDP Deflator, Period Average*
LnINCTRAD	*The Natural Log of Income of Trading Partners, Real*
LnINVGDP	*The Natural Log of Investment to GDP Ratio, Real*
LnINVP	*The Natural Log of Investment Price*
LnIR	*Lending Interest Rate*
LnLABPRO	*The Natural Log of Labor Productivity*
LnM	*The Natural Log of Import of Goods and Services, Nominal*
LnM2	*The Natural Log of Money Supply(M2)*
LnMD	*The Natural Log of Money Demand*
LnMP	*The Natural Log of Import Price*
LnNAGLF	*The Natural Log of Non-Agricultural Labor Force*
LnNER	*The Natural Log of Nominal Exchange Rate, Period Average*
LnNGDP	*The Natural Log of Nominal GDP*
LnNPRINV	*The Natural Log of Nominal Private Investment*
LnNPUINV	*The Natural Log of Nominal Public Investment*
LnNWR	*The Natural Log Nominal Wage Rate*
LnPUC	*The Natural Log of Per Unit Cost of Out Put*
LnRAGVA	*The Natural Log of Real Agricultural Value Added*
LnRER	*The Natural Log of Real Exchange Rate*
LnRES	*The Natural Log of Reserves, Nominal*
LnRGC	*The Natural Log of Real Government Consumption*
LnRGDI	*The Natural Log of Real Disposable Domestic Income*
LnRGDP	*The Natural Log of Real GDP*
LnRIR	*The Natural Log of Real Interest Rate*
LnRM	*The Natural Log of Real Import of Goods and Services*
LnRNAGVA	*The Natural Log of Real Non-Agricultural Value Added*
LnRPC	*The Natural Log of Real Private Consumption*
LnRPRINV	*The Natural Log of Real Private Investment*
LnRPUINV	*The Natural Log of Real Public Investment*
LnRX	*The Natural Log of Real Export of Goods and Services*
LnUNEMPTRATE	*The Natural Log of Unemployment Rate*
LnXP	*The Natural Log of Export Price*
M	*Imports of goods and Services, (BOP ,nominal)*
M2	*Money Supply(M2)*
MD	*Money Demand ,Nominal*
MP	*Import Price*
NAGLF	*Non-Agricultural Labor Force, Absolute Value*
NAGVA	*Nominal Agricultural Value Added*
NCUTR	*Net current transfers (Bop, Nominal)*
NDINROW	*Net Direct Income(ROW, BoP, Nominal)*
NER	*Nominal Exchange Rate, Period Average*
NETBORROWING_DOM	*Net Domestic Borrowing, Nominal*
NETBORROWING_EXT	*Net External Borrowing, Nominal*
NGDI	*Nominal Domestic Disposable Income*
NGDP	*Nominal GDP*
NGDPP	*Nominal GDP Potential*
NNAGVA	*Nominal Non-Agricultural Value Added*
NONTXR	*Non-Tax Revenue, Nominal*
NPRINV	*Nominal Private Investment*
NPUINV	*Nominal Public Investment*
NWR	*Nominal Wage Rate*
OFICALEXCHANGERESERVES	*Official Exchange Reserve, Nominal*

OTHCAPIREV	*Other Capital Revenue*
OTHCUREXP	*Other Current Expenditure*
PC	*Nominal Private Consumption*
PF	*Foreign price*
PUC	*Per Unit Cost of Output*
RAGVA	*Real Agricultural Value Added*
RER	*Real Exchange Rate*
RGC	*Real Government Consumption*
RGDI	*Real Disposable Domestic Income*
RGDP	*Real Gross Domestic Product*
RGDP_BELGIUM	*Real GDP of Belgium*
RGDP_KENYA	*Real GDP of Kenya*
RGDP_SWITHERLAND	*Real GDP of Switzerland*
RGDPP	*Real GDP Potential*
RINV	*Real Total Investment*
RIR	*Real Interest Rate*
RM	*Real Import of Goods and Services*
RNAGVA	*Real Non-Agricultural Value Added*
RPC	*Real Private Consumption*
RPRINV	*Real Private Investment*
RPUINV	*Real Public Investment*
XP	*Export Price*
X	*Export of goods and services,(BoP, Nominal)*
WS	*Wages and Salaries, Nominal*
WRATE	*Wage Rate, Nominal*
TGEX	*Total Government Expenditure*
TXR	*Total Tax Revenue, Nominal*
TRBGR	*Total Revenue Before Grant, Nominal*
TRAGR	*Total Revenue After Grant, Nominal*
TOTALDEBT	*Total Government Debt, Nominal*
TINTEXPE	*Total Interest Expense, Nominal*
STATDESCREPANCY 1	*Statistical Discrepancies 1*
STATDESCREPANCY 2	*Statistical Discrepancies 2*
RX	*Real Export of Goods and Services*
RTVA	*Real Total Value Added*