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An Applied Macro-econometric Model for Rwanda

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Preface

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Abstract

This study develops a macro-econometric model for a typical supply constrained African economy aimed at developing a theoretical and empirical template for such policy tools that are increasingly being demanded by African ministries of finance and central banks. We concretize it by building a macro-econometric model for Rwanda. The Rwanda macro-econometric model has 107 equations of which 72 are endogenous. In addition, we also build a supplementary ARIMA based model with 33 equations for the exogenous variable to make the model useful for forecasting. We disaggregate the fiscal, balance of payments and money supply blocks of the model to offer an adequate picture of the macro-economy. We also do an econometric estimation of the core behavioral equations of the model using the error correction modeling approach for the period 1960-2009. The model can be easily extended further to the support budgeting, forecasting and macroeconomic policy analyses in the relevant ministries and central banks in Africa. We successfully solve the model and reproduce historical values from 1999 to 2009 and forecast major macro-variables for 2010 to 2015. We also use the model to conduct a policy and external shock related simulation exercise that is important for policymakers.

Keywords: Macro-econometric model, macroeconomic policy, simulation, Rwanda, Africa.

JEL Classification Codes: C51; C52; C53; E60.

1. Introduction

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

Another important justification for having macro-modeling in many African countries is its capability to help policymakers take informed decisions by conducting policy analyses using policy simulation. This is crucial for policymakers because it will help them assess the implications of proposed policy packages before their actual implementation. Policy analyses conducted with the aid of such models avoid a partial analysis and hence a 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 the human mind. In addition, macro-models are also instrumental in carrying out macroeconomic research by allowing macro-policy research institutions to organize their research across the major components (block) of the macro-model and carrying 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 (Huizinga and Geda, 2004; see Huizinga et al., 2001).

Despite such important uses of macro-models, their use in Africa is limited. Recently, however, many countries are showing an interest in such models. Thus, there is a need to come up with a template for a macro-model for a majority of the countries on the continent by ensuring that such a model is grounded in African reality and is applicable and built based on a rigorous analysis. Our building of the Rwandan macro-econometric model is primarily motivated to develop such a template. This is done by: (a) developing a macro-econometric model well-grounded in theory and a rigorous econometric analysis; and (b) illustrating the use of such a model using actual macroeconomic policy issues in Rwanda and 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 because a model's 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 happened but which will affect the immediate future. Also, expert opinions from different segments of the government may be incorporated into the macro-model's forecast and examples of this include specialists in government expenditure and revenue and specialists in different sectors of the economy. These specialists also benefit from this exchange since they get a better picture of the overall economy. Adding such outside information significantly reduces the forecast's uncertainty (see Geda and Yimer, 2013; Huizinga and Geda, 2004; Huizinga et al., 2001).

Generally, a translation of shocks or policy proposals has to be done before they can be used as actual inputs 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. Even then some simplifications and additional assumptions are needed to make a proper analysis. It is often necessary to use expert opinion to do this properly. Thus, the practical use of a model of the type developed in our study requires institution building in relevant ministries such as the Ministry of Finance and central banks. Such institutionalization is important not only for an appropriate use of the model but also for its sustainability.

2. The Theoretical Framework of the Model

Our model is built along the lines of the aggregate demand-aggregate supply (AD-AS) framework by emphasizing the supply constrained nature of the economy in question.[1] Unlike in typical demand-driven Keynesian models this is done by explicitly modeling the supply side of the economy. The supply side contains three main components: the formal sector, the informal sector and the agricultural sector. Agriculture is sub-divided into cash crops (exports) (traded sector) and food production for the domestic market (non-traded sector). If the need arises this could readily be sub-divided further by major types of agricultural products. The informal sector consists mainly of small-scale industries 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 large and medium scale manufacturing, formal trade, hotels and restaurants, transport and communications, banking, insurance and real estate.

Thus, the modeling of the real sector incorporates basic linkages within and between the three sectors (Figure 1). Once we have this prototype, the model can 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. However, the shares of inputs are different. The level of capital used in the formal sector is far greater than it is in the informal sector. As a result, the employment response to demand fluctuations is far greater in the informal sector than it is in the formal sector. The formal private sector is modeled along neoclassical lines based on the theory of profit maximization described in detail in Huizinga and Geda (2004) and given briefly in Appendix 1. Keeping in view monopolistically competitive firms, we set the prices as a mark-up over costs, which consist of labor costs and the cost of intermediate goods and raw materials. Demand for labor and capital follows from a CES production function which allows us to model wages and capital formation/investment.

Formal sector output is demand driven in the short-run. In the long-run it has a supply component as investments may be used to increase capacity. The degree to which this happens depends to a large extent on factors outside a firm's control such as the quality of infrastructure and an overall stable economic and political climate. This is especially

[1]This section is based on Huizinga and Geda (2004; also 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. To save space we give just the gist of the theoretical framework with a summary of the algebra given in Appendix 1. A demand-driven version of this model's theoretical framework is given in Geda et al., (2002) and this heavily influenced the theoretical formulation of a recent model of the Central Bank of Kenya (see Were et al., 2013).

true if overseas physical and financial investments are to play a major role. Therefore, investments in the formal sector have both a cyclical component following GDP and a structural component following infrastructure and overall macroeconomic stability.

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

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

Normally a part of the labor force in agriculture moves to urban areas to find jobs in formal and informal sectors. Because of their low skill levels 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 of efficiency wage considerations among other things. As a result, there are always agricultural workers, especially young ones, who prefer to work in the informal sector and move there if job conditions improve. Because of the constant excess supply of labor in the informal market, the wages are constant in the short-run. Similarly, the wages in the formal sector is a mark-up over that in the informal sector; this is also based on efficiency wage considerations. Workers in the informal sector prefer jobs in the formal sector and, therefore, there is also always excess supply in the formal sector. We may assume that the wages in the formal sector are constant in the short-run as there is an excess supply of labor in the Lewisian sense (see, Lewis, 1954). This is not visible in the form of unemployment in rural areas because of the family nature of farm production (that is, there is disguised unemployment). Young people in general may leave the farms because they cannot get their own land (even if they manage to get land it is very small in size due to population pressures) and they look for employment in the urban informal sector thus maintaining the excess labor supply in the non-agricultural sector (Huizinga and Geda, 2004).

The short-run aspects of the macro-economy relate to modeling output volatility. In particular, this is assumed to prevail in the agricultural sector. The most important determinant of cyclical variations in output is rainfall. If there is an adverse external shock such as a bad agricultural season, food supply to the market reduces sharply. As a result, the prices of food items increase. As food is a major component of 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 reduces domestic demand for industrial products in both formal and informal sectors. 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 in the formal sector comes from abroad. Export demand is not directly affected by a bad agricultural season. Another reason is that the formal sector is able to absorb a temporary reduction in demand better 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 cyclical variations 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 reduces output, employment and investments immediately. The flip side is that it is relatively easy to reactivate economic activity if demand picks up again as labor is readily available and the capital stock is not a major input. Hence, the informal sector is completely demand-driven with constant excess supply and a production function based mostly on low skilled labor (see, Huizinga and Geda, 2004).

In modeling long-term growth it is reasonable to assume that the output of the agricultural sector can be increased substantially through a combination of better seeds, use of fertilizers and better infrastructure. Other things remaining intact this leads to a drop in food prices and a rise in urban workers' real wages. The increase in disposable incomes leads to a rise in consumption demand in the formal and informal sectors. In the formal sector, this leads to increased profits, investments and eventually employment. In the informal sector, it leads to increased employment and eventually increased investments and profits. The key issue in terms of poverty reduction is that the demand for labor in the formal and informal sectors continuously grows faster than population growth which adds to the excess supply of labor, assuming that the food sector will not constrain this growth through inflation in a familiar Kaleckian fashion (see, Geda and Tafere, 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 are mostly demand-determined in the short-run. 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 modeling is briefly summarized in Figure 1. In real sector modeling, the aggregate demand (consumption, investments, government spending and exports) determine the level of imports and total value-added. This value-added is disaggregated into agricultural, formal and informal sectors. Given the data problem on this sector in many African countries the value-added in the informal sector is assumed to be the residual. With this, an injection from aggregate demand, which in turn creates demand for value-added, is assumed to generate demand for factor inputs (capital, labor and imports). It is assumed that the choice of these factor inputs follows from an optimization problem of agents in each sector using a CES production function as given in Appendix 1.

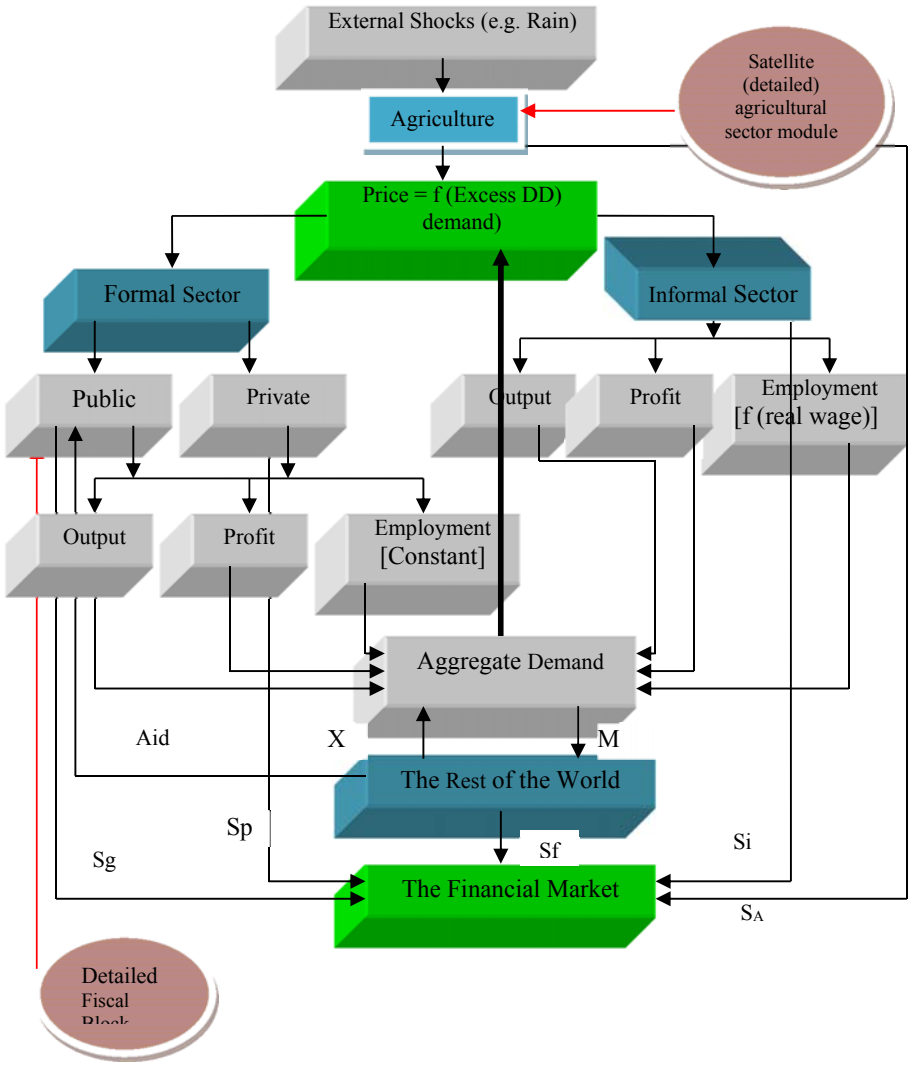

Figure 1: A Flow Chart for Rwandan Macro-Model - The Real Sector
Source: Huizinga and Geda (2004).

Our model is designed in such a way that it tends to return to equilibrium with 'normal' capacity utilization and unemployment rates in the medium and long-run. The main feedback mechanisms in the real economy work through the wage-price spiral, the interest rate and the real exchange rate which are modeling as a nominal sector of the model and depicted in Figure 2. The mechanisms in the model can be illustrated by considering a supply shock, like favorable rainfall that increases output in the agricultural sector.

The increased supply of food leads to lower prices and an increase in real wages. This leads to an increase in consumption demand in the informal and formal sectors. Both sectors increase their output. The formal sector also increases investments which are in part financed 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 labor hoarding and therefore immediately increases employment. In addition, increased demand and profits lead to more investments, but this may be less important numerically. Increase in investments

and employment further increase demand in the informal and formal sectors and also demand for food from the agricultural sector. The model converges because of leakages in the form of increased savings, increased imports and increased prices in the formal sector leading to erosion in competitiveness (Figures 1 and 2) (Huizinga and Geda, 2004).

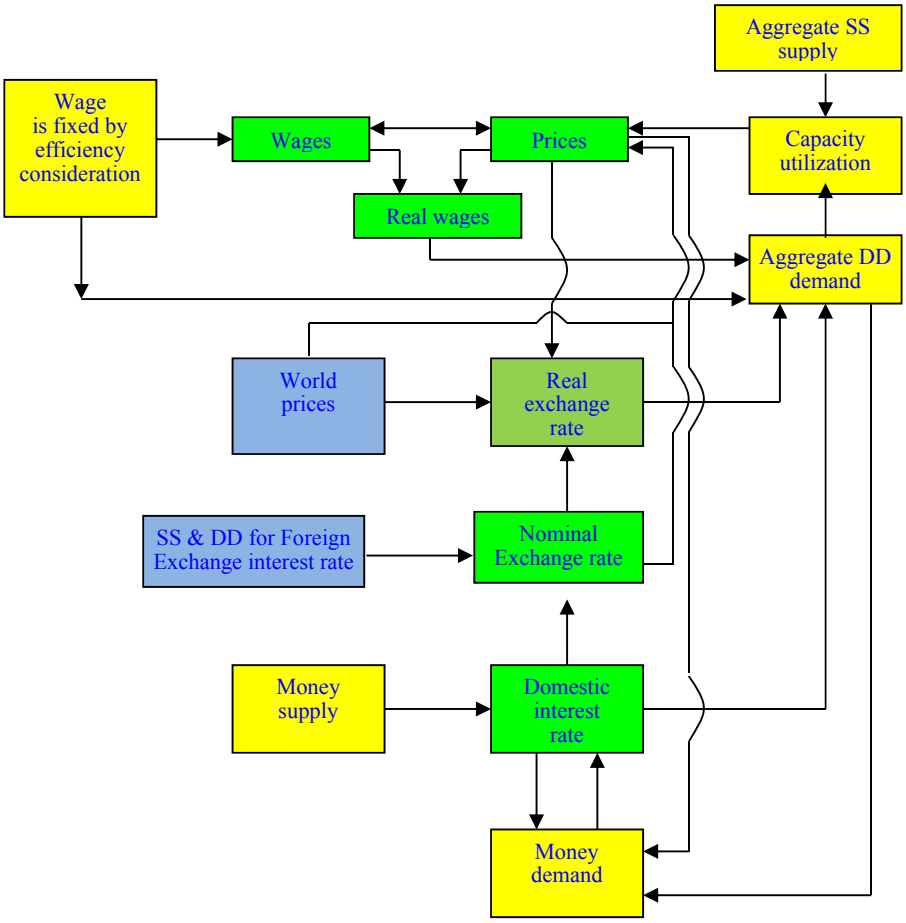

Figure 2: A Flow Chart for Rwandan Macro-Model - The Nominal Side
Source: Huizinga and Geda (2004).

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

Wages and prices are determined in the labor and product markets. Wages and prices also depend on each other as indicated by the double arrow so 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 sub-divided into markets for domestic money, domestic bonds and 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 modeling 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 it 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 the foreign interest rate makes domestic assets relatively more attractive and thus causes an appreciation. By definition, the real exchange rate follows from the nominal exchange rate, the domestic price level and the foreign price level (see Figure 2) (Huizinga and Geda, 2004).

3. 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 macroeconomic models have been constructed for many African countries.[3] In the heated debate of the 1970s and early 1980s on the role of additional external resources and domestic adjustment measures in economic recovery in Africa, Horton and McLaren (1989) used a supply constrained macro-econometric model of the Tanzanian economy to examine the effects of several alternative strategies. Their results highlight the problems of either a strategy of devaluation or of more external aid alone.

Elliott et al., (1986) give macroeconomic model of the Kenyan economy as a small and open developing economy that is vulnerable to conditions in world commodity and credit markets. They describe the theoretical structure of the model, which consists of markets for domestic output, labor, money and the balance of payments. They provide a complete listing of the model equations with numerical results of the estimated equation and use 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 cointegration technique. They use this model to perform various policy simulation experiments to determine the sensitivity of key macroeconomic variables to changes in exchange rate, net government current expenditure and nominal interest rate. Their results show that exchange rates and fiscal policies were relatively more effective than monetary policy in influencing the level of economic activity.

Notwithstanding Elliott et al., (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 the 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 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

[2] The survey in this section focuses on applied macro-models in Eastern and Southern African countries.

[3] A survey of modeling 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.

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 analyses and budget preparation.

Kidane (1991) developed a detailed economic-demographic model for Ethiopia and studied the interaction between the two considering various demographic variables as being endogenous. His model aimed, inter-alia, to assess the effect of changes in these demographic indicators on some economic parameters. He 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 and then presented alternative simulation outcomes of the model under different assumptions.

Musila (2002) estimated a small open-economy macroeconomic model for Malawi in which the structure of the model consists of production, expenditure, government, monetary and employment sectors and prices. The short-run version of the model was estimated using the cointegration estimation technique. The model is used for policy analyses. For instance, the dynamic simulation results indicate that a sustained devaluation of the Malawi kwacha improved the real trade balance, but led to higher inflation and reduced real GDP growth. A bond-financed increase in government consumption expenditures was less inflationary and led to higher real GDP growth but worsened the real trade balance position.

Tjipe et al., (2004) developed a macro-econometric model for the Namibian economy. Based on experience and their understanding of the functioning of the different sectors of the economy, this model was informed by a theoretical framework that incorporated all essential features of the economy. The model equations were estimated using an error correction modeling approach and their forecasting performance was assessed. The authors constructed the model and carried out a policy analysis and stimulations of external shocks to examine different scenarios to give further insights into the future path of the main economic variables of the model.

Huizinga and Geda (2004) developed a supply-constrained macro-econometric model for Ethiopia for use by the Ministry of Finance and Economic Development. They estimated the core behavioral equations of the model using an error-correction modeling approach. Like that of KTMM in Kenya, fiscal, balance of payments and money supply blocks of their model were fairly disaggregated to offer an adequate picture of the macro-economy. The Ethiopian treasury has used the model for forecasting and budget preparation.

Finally, the Bank of Uganda (2010) built a small-scale macroeconomic 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 for conducting policy simulation experiments to analyze the effect of different external shocks on inflation, output, exchange rate and interest rate. 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 and 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 one relates to the limited emphasis that most applied macro-models have on the supply constrained nature of African economies and the importance of the informal sector in such countries and hence their modeling. Another problem that is widespread in most African macro-econometric models relates to the macroeconomic modeling tradition that is largely framed without a consistent analytical framework but is used for either policy analyses or model-based forecasting exercises. As Harris (1985) argues, equation specifications have also been an exercise in the search of those models that can give better explanatory powers, rather than being rooted in any framework of economic behavior. The models' emphasis is on 'tracking history' and they largely ignore the long-run sustainability of policy actions. Thus, inter-temporal budget constraints are not observed and these models are not robust for analyzing the consequences of major policy shifts (Harris, 1985).

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

4. Estimation Method and Results

4.1 Estimation Method

The modeling and estimating strategy in our study involves an application of the Johansen (1988, 1991) approach. We estimate individual behavioral equations in a cointegration framework using the single equation error correction modeling (ECM) approach, where short-run and long-run dynamics are modeled simultaneously.

Following Johansen (1988, 1991) we may consider a VAR model given by:

(1a) $$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_4 Y_{t-n} + \mu_t$$

where, Y represents a vector of variables with *n* lags.

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

(1b) $$\Delta Y_t = -\sum_{i=1}^{n}(I - A_i)Y_{t-1} - \sum_{j=2}^{n} A_j \Delta Y_{t-1} - \sum_{j=3}^{n} A_j \Delta Y_{t-2} - \sum_{j=i}^{n} A_j \Delta Y_{t-n-1} + \phi D + \phi \mu_i$$, where, *D* is a vector of 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 that we estimate 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 cointegration vector) such that $\Pi = \alpha\beta'$. The cointegration vector β has the property that $\beta' X_t$ is stationary even though X_t itself is non-stationary. The Johansen procedure helps determine and identify this/these cointegrating vector(s). The empirical part of our study uses this approach to identify such cointegrating vector(s).

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

(2) $\quad Y_t = KX_t^{\gamma} = \gamma_1 + \gamma_2 X_t$

where, K, γ_1 and γ_2 are constants and $\gamma_1 = logK$.

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 which is simple $ADL\ (m, n, p)$ where m is the number of lags and n and p are the number of endogenous and exogenous variables respectively, $ADL\ (1,1,1)$. Formulation of Equation 2:

(3) $Y = \beta_0 + \beta_1 X_t + \beta_2 X_{t-1} + \alpha Y_{t-1} + u_t\ , \quad 0 < \alpha < 1$

With some re-parametrization,[4] the ECM representation of Equation 3, which is the estimable version of Equation 1, can be given by Equation 4 (Geda, 2002; Hendry, 1995; Morales and Raei, 2013; Thomas, 1993):

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

where, $\gamma_1 = \frac{\beta_0}{1-\alpha}; \gamma_2 = \frac{\beta_1+\beta_2}{1-\alpha};$ and $\{-(1-\alpha)\}$ = the ECM term that should be negative.

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

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

The estimable ECM formulation of Equation 5 can be derived in a similar way as:

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

where, $\gamma_0 = \frac{\beta_0}{1-\sum_{i=1}^{m} \alpha_i}$ is the constant; and the long-run coefficients are given by $\gamma_i = \frac{\sum_{i=1}^{m+1} \beta_i}{1-\sum_{i=1}^{m} \alpha_1}$

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

4.2 Estimated Results

Before estimating the model, we carried out a test for stationarity of the variables in the model and found all the variables to be integrated of order one, I (1). In addition, the Johanson test for cointegration proved the presence of a long run relationship among the variables in each of the behavioral estimates. Table 1 presents the short-run and long estimated coefficients for each of the behavioral equations from their ECM formulation. We generally found the theoretical expected sign in the estimated equations. The number of lags used in the LM and Ramsey RESET test is given in Table 2.

Table 1: Estimated Equations of the Model

1 Private Consumption

$$\Delta(LnRPC) = -3.18 + 0.52\Delta(LnRGDI) - 0.02\,\Delta(LnDIR) - 0.26ECM_{t-1} + 0.37LnRGDI_{t-1}$$
(-2.24) (11.93) (-0.58) (-2.70) (5.37)

$$-0.06LnDIR_{t-1}$$
(-2.03)

2 Private Investment

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

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

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

3 Food Demand

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

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

4 Agricultural Production

$$\Delta(LnRAGVA) = -15.49 + 2.38\,\Delta(LnAGLF) + 1.01\,\Delta(LnCS) - 0.42ECM_{t-1} + 0.37LnAGLF_{t-1}$$
(-1.75) (11.08) (4.03) (-2.27) (2.01)

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

5 Non-Agricultural Production

$$\Delta(LnRNAGVA) = -10.42 + 3.08\,\Delta(LnNAGLF) + 0.79\,\Delta(LnCS) - 0.24ECM_{t-1}$$
(-4.56) (9.41) (3.06) (-2.59)

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

6 Export Demand

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

$$-0.53ECM_{t-1} + 0.03LnRER_{t-1} + 0.56LnINVGDP_{t-1} + 0.33LnINCTRAD_{t-1} - 0.82DUM_{94}$$
(-11.24) (0.27) (9.35) (.45) (-8.79)

7 Import Demand

$$\Delta(LnRM) = -16.64 - 0.50\,\Delta(LnRER) + 1.29\,\Delta(LnAID) + 0.58\,\Delta(LnRGDP) - 0.45ECM_{t-1}$$
(-1.92) (-1.87) (0.77) (1.47) (-2.11) (0.42)

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

8 Exchange Rate

$$\Delta(LnNER) = -0.52 + 1.20\,\Delta(LnM) - 0.14\,\Delta(LnXA\_DS) - 0.13ECM_{t-1} + 0.28LnM_{t-1}$$
(-1.69) (8.56) (-6.68) (-2.72) (8.91)

$$+0.25LnXA\_DS_{t-1}$$
(-13.95)

9 Wage Rate

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

$$-0.95ECM_{t-1} + 0.37LnCPI_{t-1} - 1.46LnUNEMPTRATE_{t-1} + 0.71LnLABPOR_{t-1}$$
(-6.76) (1.40) (-1.99) (4.76)

$$+0.05@trend$$
(1.08)

10 Money Demand

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

$$-0.06ECM_{t-1} + 0.11LnCPI_{t-1} - 0.10LnIRD_{t-1} + 2.17DUM_{06} + 0.20DUM_{07}$$
(-2.12) (2.35) (-1.99) (6.56) (4.45)

11 Consumer Price

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

$$+0.06\,\Delta(LnMP) - 0.47ECM_{t-1} + 0.49LnCUR_{t-1} + 0.59LnLIR_{t-1} + 0.02LnMP_{t-1}$$
(0.70) (-4.99) (6.06) (4.90) (0.17)

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

12 Export Price

$$\Delta(LnXP) = -6.61 + 1.92\,\Delta(LnPUC) + 0.51\Delta(LnCUR) + 0.13\,\Delta(LnRIR) + 0.33\,\Delta(LnMP)$$
(-5.08) (2.55) (2.90) (1.41) (3.52)

$$-0.92ECM_{t-1} + 2.34LnPUC_{t-1} + 0.41LnCUR_{t-1} + 0.25LnRIR_{t-1} + 0.05LnMP_{t-1}$$
(-5.06) (5.08) (1.79) (2.00) (0.31)

13 Investment Price

$$\Delta(LnINVP) = 0.04 - 0.53\,\Delta(LnCUR) + 0.01\Delta(LnCUP) + 0.61\,\Delta(LnMP) + 0.12\,\Delta(LnRIR)$$
(0.07) (-3.15) (-0.01) (2.67) (2.45)

$$-0.36ECM_{t-1} + 0.13LnCUR_{t-1} + 0.28LnPUC_{t-1} + 0.49LnMP_{t-1}$$
(-3.16) (1.21) 1.06) (2.49)

$$+0.11LnRIR_{t-1} + 0.46DUM_{91} + 0.03@trend$$
(1.07) (0.46) (-4.17)

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

As can be seen from the Adjust R^2 in Table 2 the estimated individual behavioral equations have a good fit. In addition, the estimated individual equations passed all post-estimation diagnostic tests reported for each of the estimated equations. Such tests included normality test, heteroskedasticity test, test for serial correlation, model specification and stability test (Table 2).

Table 2: Diagnostic Tests of the Estimated Behavioral Equations

Equation	Adjusted R^2	F-Statistic	LM Serial Correlation test	White Hetroske-dasticity test	Normality test(JB)	Ramsey RESET test
Private Consumption	0.90	46.03	0.24	20.08)	2.55	1.18
		(0.00)	(0.62)	(0.34)	(0.28)	(0.29)
Private Investment	0.69	44.00	4.09	17.95	1.87	10.92
		(0.00)	(0.13)	(0.10)	(0.37)	(0.01)
Food Demand	0.90	37.67	0.03	9.21	2.45	3.78
		(0.00)	(0.86)	(0.24)	(0.29)	(0.07)
Agricultural Production	0.29	2.87	0.66	28.37	8.59	0.10
		(0.03)	(0.79)	(0.25)	(0.01)	(0.75)
Non-Agricultural Production	0.61	7.90	0.52	27.35	0.53	0.10
		(0.00)	(0.77)	(0.24)	(0.77)	(0.75)
Export Demand	0.80	14.08	2.07	4.31	0.79	0.10
		(0.00)	(0.15)	(0.89)	(0.67)	(0.75)

Import Demand	0.48	3.35	0.17	7.59	0.10	0.04
		(0.02)	(0.68)	(0.58)	(0.95	(0.84)
Exchange Rate	0.46	5.04	1.29	12.95	0.53	12.16
		(0.00)	(0.26)	(0.84)	(0.77)	(0.00)
Wage Rate	0.98	107.35	1.02	6.84	0.08	0.44
		(0.00)	(0.31)	(0.55)	(0.96)	(0.54)
Money Demand	0.97	128.61	0.12	8.48	0.48	1.32
		(0.00)	(0.73)	(0.49)	(0.79)	(0.26)
Consumer Price	0.75	6.80	2.36	12.99	0.97	6.87
		(0.00)	(0.13)	(0.53)	(0.62)	(0.02)
Export Price	0.61	5.10	1.61	4.60	1.96	2.78
		(0.00)	(0.21)	(0.87)	(0.38)	(0.12)
Investment Price	0.53	3.43	0.67	9.20	0.13	1.90
		(0.02)	(0.41)	(0.60)	(0.94)	(0.19)

Note: P-values in parenthesis.

With these estimated equations and a consistent macro database we developed the model in the 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 model was used after calibrating it and by running it repeatedly to see its stability, its capacity to reproduce historical values of the macro-economy and the sensibility of its forecast values. The model was found to reproduce historical values and offers reasonable forecast values. It was also found to be stable.

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

In this section we report some policy simulations related to the Rwandan government's plan which is contained in the 'Budget Framework Paper 2012/13-2014/15'. The aim of this is showing the use of the model both for forecasting and policy analysis. The Government of Rwanda noted that its budget could have macroeconomic risks that may result from its proposed policy and possible external shocks (Box 1).

However, these probable macroeconomic risks are not quantified in the budget because of the lack of a macroeconomic model in Rwanda. Thus, our task here is to show the use of the ur model by focusing on macroeconomic risks and if there are any then the planned budget has no macroeconomic stability. Apart from showing the short-term forecasting ability of the model built in the context of our study, we also 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 some major macroeconomic outcomes (see Box 2) that need to be examined to see what their likely direction may be, and hence the implied macroeconomic stability of the country during the realization of the proposed budget. This in turn is fundamental for sustainable growth, poverty reduction and social and political stability. Thus, we carried out a simulation exercise for the shocks outlined in Box 1.

Box 2: Macroeconomic Outcome Indicators Selected to Gauge the 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
   6.1 *Government Revenue (before and after grants)*
   6.2 *Government Expenditure*
   6.3 *Government Surplus/Deficit*
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*

5.1. The Base run values and Forecast

We start 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 actual/historical figures. Given the evolution of the exogenous variables that are forecast using the supplementary ARIMA model with 33 endogenous equations built for this purpose we also used it to forecast major macro-variables for 2010-15.

There are two advantages of the base run. First, it gives us the evolution of the economy without policy interventions and external shocks. We use this as the benchmark to measure the effect of the government's planned activities, as outlined in Box 1. Second, it also shows the potential of the model for making macroeconomic forecasts which are important for policymakers. Some of the major values of the base run and forecast values are reported in Table 3 and Figure 3.

Table 3: Base run and Forecast Values of Major Macroeconomic Outcomes Forecast

Year	Growth	Real GDP	Real Private Investment	Real Private Consumption	Real Exports	Real Imports	Total Government Expenditure	Total Revenue after grants
2009	5.6	1366.8	104.3	1545.6	94.8	1093.3	780.4	738.0
2010	5.7	1444.8	118.2	1659.0	93.5	1134.1	909.6	897.7
2011	8.9	1574.1	135.5	1837.3	90.7	1199.3	1044.0	1063.1
2012	6.4	1675.0	145.5	2024.1	86.6	1285.3	1168.5	1219.0
2013	7.7	1803.9	162.3	2237.1	82.5	1377.9	1299.8	1382.8
2014	7.0	1930.6	175.8	2463.6	78.9	1482.5	1435.3	1552.4

Year	Government Fiscal Surplus after grants (as per cent GDP)	Government Fiscal Surplus before grants (as per cent of GDP)	Current Account deficit (as per cent of GDP)	BOP Overall (as per cent of GDP)
2009	-0.5	-17.8	-12.0	-6.8
2010	-0.1	-15.5	-9.9	-5.3
2011	0.1	-13.9	-8.7	-4.6
2012	0.3	-13.4	-8.5	-4.6
2013	0.5	-13.0	-8.4	-4.6
2014	0.6	-12.9	-8.4	-4.8

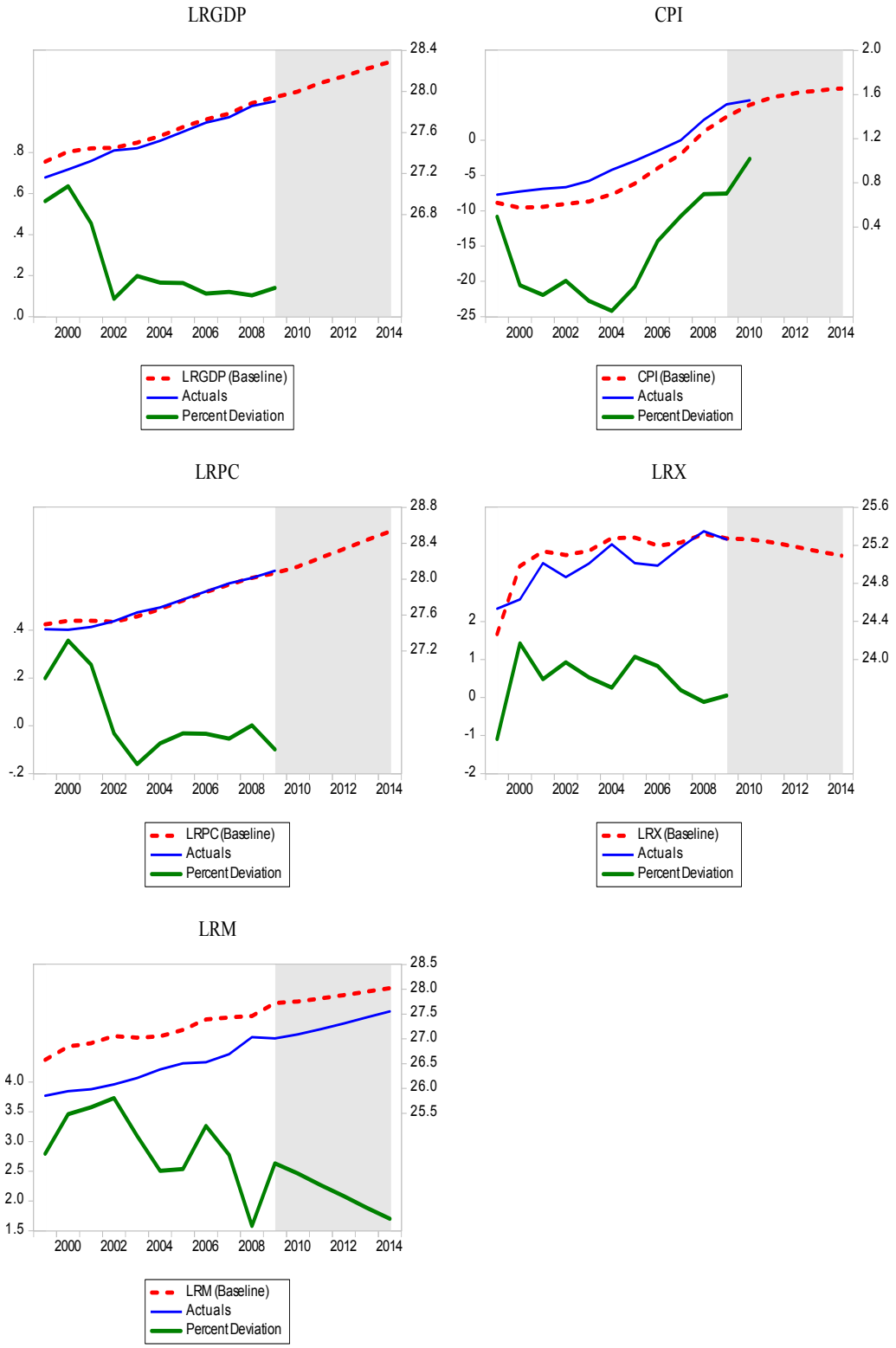

Figure 3: Base run and Forecast Values of the Major Macroeconomic Variables Forecast

5.2 Policy Simulation Outcomes

5.2.1 The Effect of Government Policy 1: Planned Government Spending

In this simulation, we 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 cent per annum from 2009 to 2014. The results of this simulation are given in Figure 4 (and Table A2(a) in Appendix 2).

The results show that the proposed spending during the fiscal period will generally be compatible with a stable macroeconomic environment (see Figure 4). The effect on real GDP is almost nil and hence the GDP growth rate will remain as that of the base run forecast. The effect on inflation, nominal as well as real exchange rate is also negligible as the deviation from the base run is in the range of 0.01 per cent to 0.05 per cent with this policy.

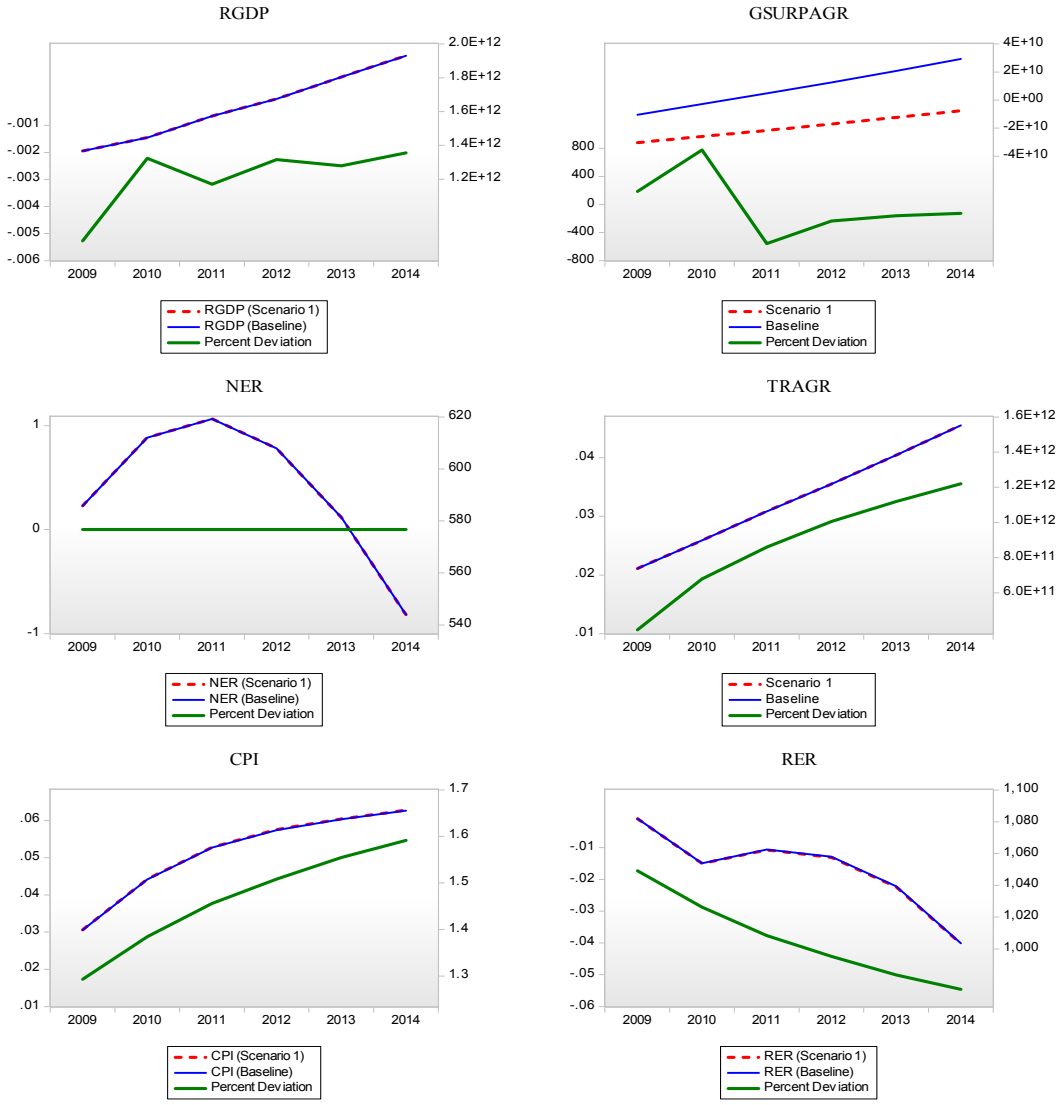

Figure 4: The Effect of the Proposed Government Spending (Deviation from Base Run, in Per cent)

Notwithstanding the effect of this total spending simulation, the model shows that the composition of this spending does matter in terms of its macroeconomic effect although it is not extremely significant in terms of magnitude (see Figure 5 and Table A2(b) in Appendix 2). As noted in Box 1 we varied the current expenditure by 13 per cent per annum and the capital expenditure by 5 per cent as stipulated in the budget framework paper (the combined effect of this is to vary the total spending by 10 per cent).

As can be seen from Figure 5 (and Table A2(b) in Appendix 2) the effect on GDP is very similar; thus, the GDP growth rate will remain as that of the base run forecast. The effect on nominal and real exchange rate also remains fundamentally unchanged. CPI (inflation), GDP and total revenue after grants have the same effect in terms of direction. However, the effect becomes stronger in this scenario. The overall magnitude of the effect is a variation of the base run value of 0.2 to 0.55 with the policy in all cases and hence it is not significant. The policy will also result in an increase in money supply of 2 to 7 per cent compared to the base run.

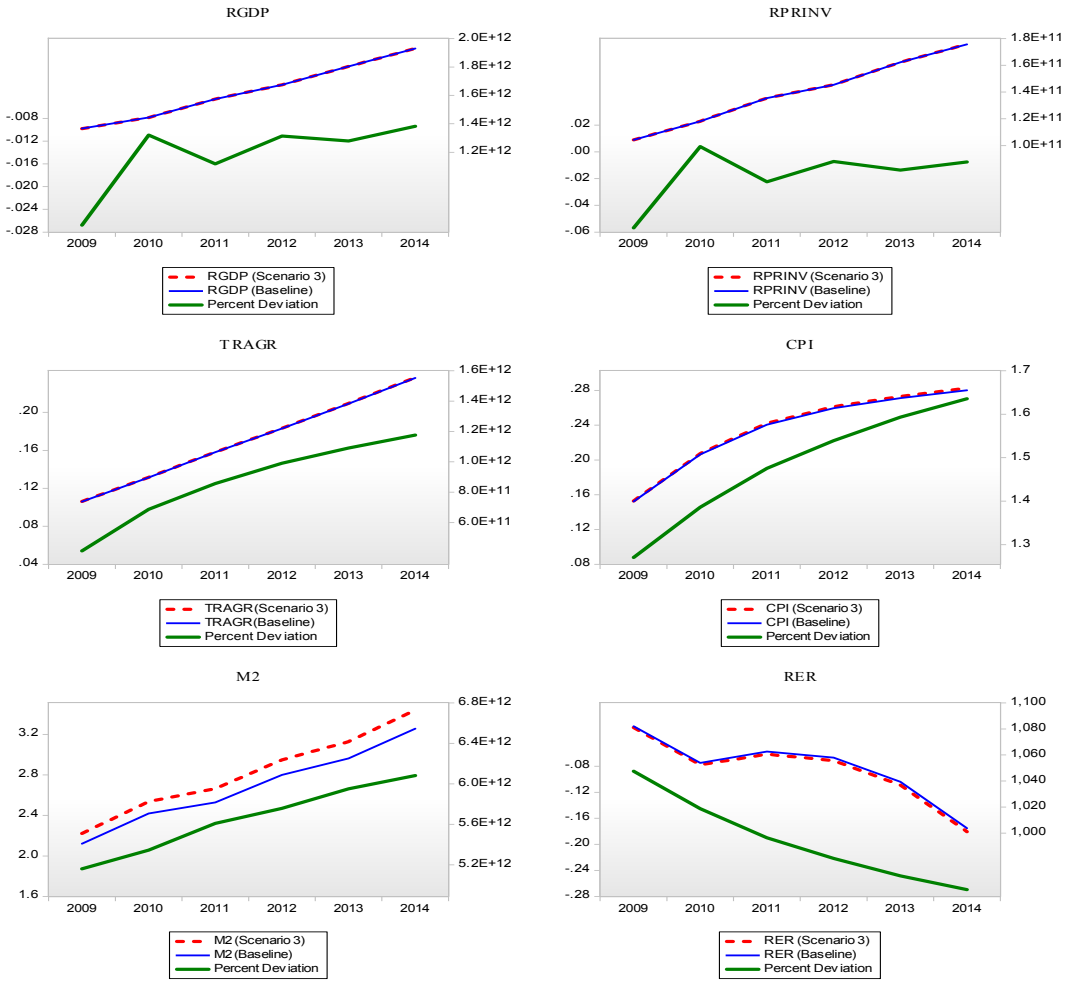

Figure 5: The Effect of the Composition of Government Proposed Spending (Deviation from Base Run, in Per cent)

5.2.2 The Effect of Government Policy 2: The Effect of the New Wage Pay and Retention Policy

The effect of the new wage pay and retention policy is to raise government spending (8 per cent of current expenditure or 4 per cent of total). Hence, its effect is similar to the simulation done earlier but less potent owing to its relative magnitude. As can be seen from Figure 6 and the associated Table A2(c) in Appendix 2, its effect is to reduce GDP, private investments and the real exchange rate. However, the magnitude is very small. In fact, the growth rate of the economy is hardly affected compared to the base run. On the other hand, it leads to an increase in total current expenditure, inflation and the money supply as expected. Again the magnitude of this is not that strong and hence the stability of the macroeconomic environment will not be affected. It will have an effect of raising the fiscal deficit after grants from about -0.5 per cent of the GDP to -3 to -5 per cent of the GDP during the planned period.

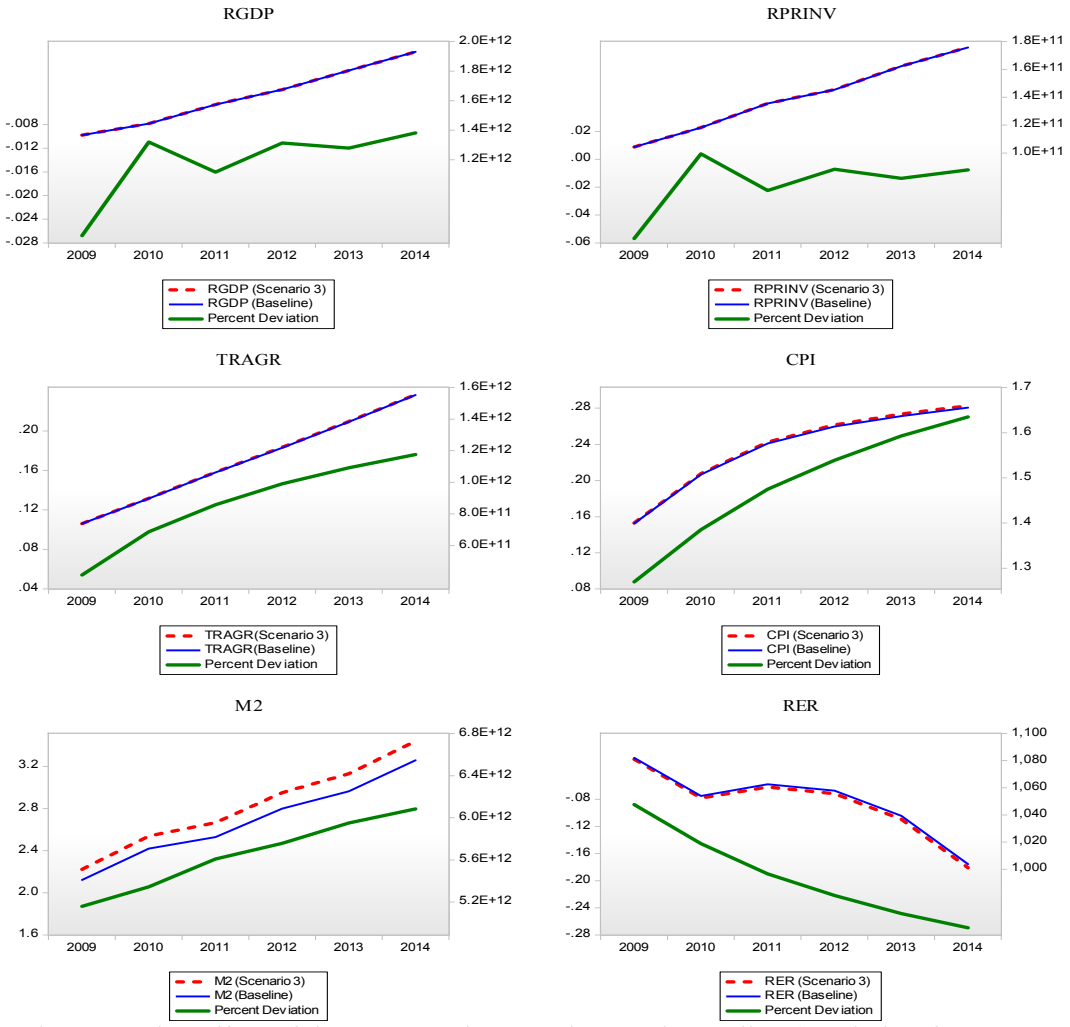

Figure 6: The Effect of the Wage and Pay and Retention Policy (Deviation from Base Run, in Per cent)

5.2.3 The Effect of the External Economy (Possible External Shock)

The effect of this probable adverse external shock is reducing GDP (-1.3 per cent), private investments (-5 per cent), exports (about -4.5 per cent) and imports (about -1 per cent) sharply in the first period (see Figure 7 and Table A2(d) in Appendix 2). This will lead to a sharp increase in fiscal deficit although the balance of payments is not affected that much in this period. However, this sharp decline will moderate over the course of the planned period accompanied by a decline in imports and recovery in exports. As a result, the balance of payments and government deficit will show a recovery. This simulation generally shows the significant macroeconomic risk implications of such an external shock and the need to be cautious in taking appropriate policy responses if such an event does occur.

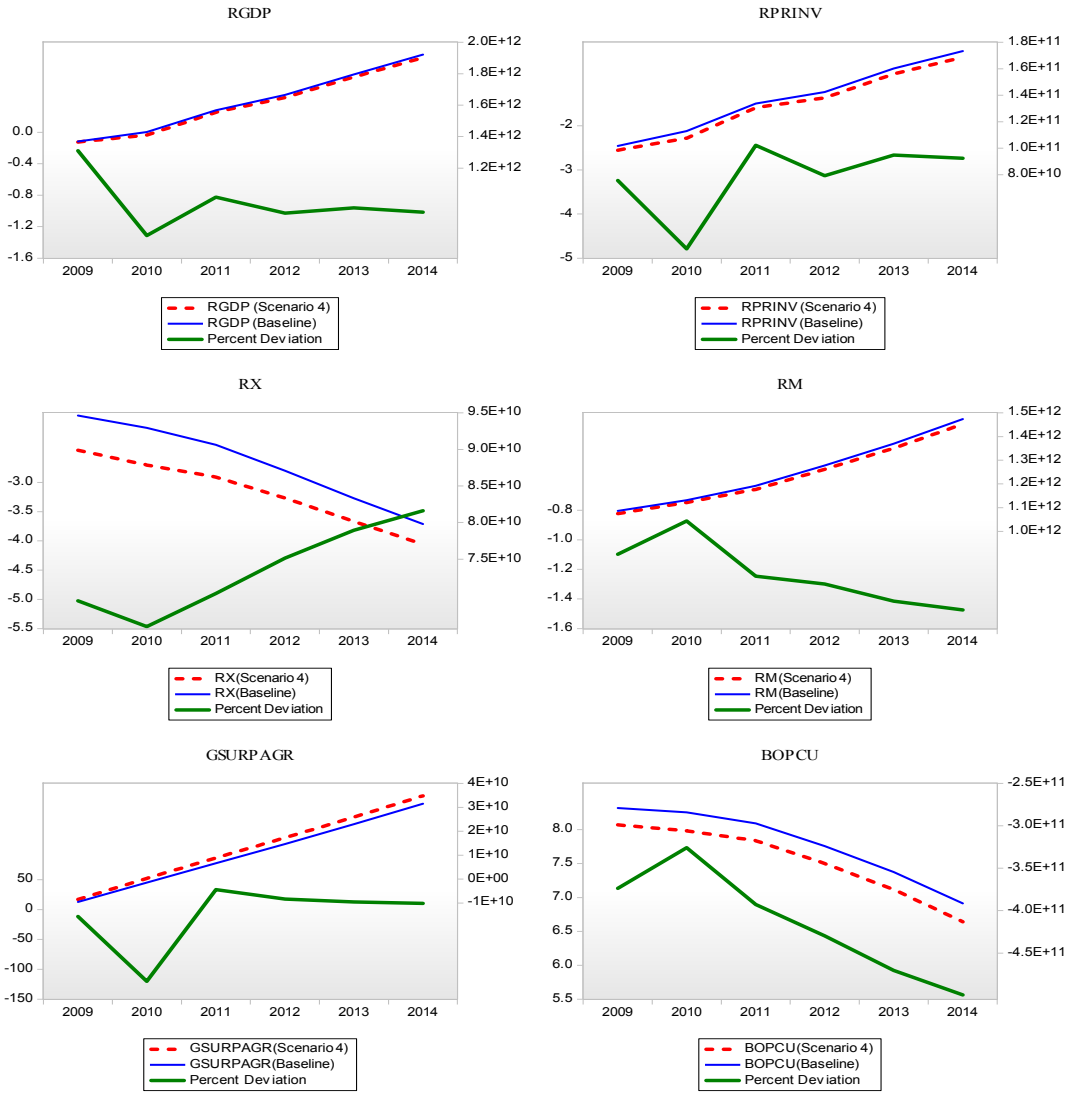

Figure 7: The Effect of a Possible Slowdown in the World Economy (Deviation from Base Run, in Per cent)

5.2.4. The Effect of a Shortfall in External Financing

This is a probable financing risk envisaged in the budget planning process (see Box 1). As Figure 8 and the associated Table A2(e) in Appendix 2 show, we can generalize that the effect of this probable risk is negligible, in particular in real GDP growth and government total expenditure terms. However, its effect on government fiscal deficit as well as total government revenue (including grants) is relatively important in percentage terms (a deterioration of 6 to 25 per cent from the base run in the first two periods). In actual terms this is not significant as it shows a deterioration of the government fiscal deficit (after grants) from -0.48 per cent of GDP in the base run to -0.51 per cent of GDP with the shock in the first year; and a similar deterioration from -0.11 per cent to -0.14 per cent of GDP in the second year. In summary, this macroeconomic risk is not significant. However, the government's strategy of 'delaying of spending' plan in such an event is an excellent cautious policy to deter any probable effect of this financing risk on the macro-economy.

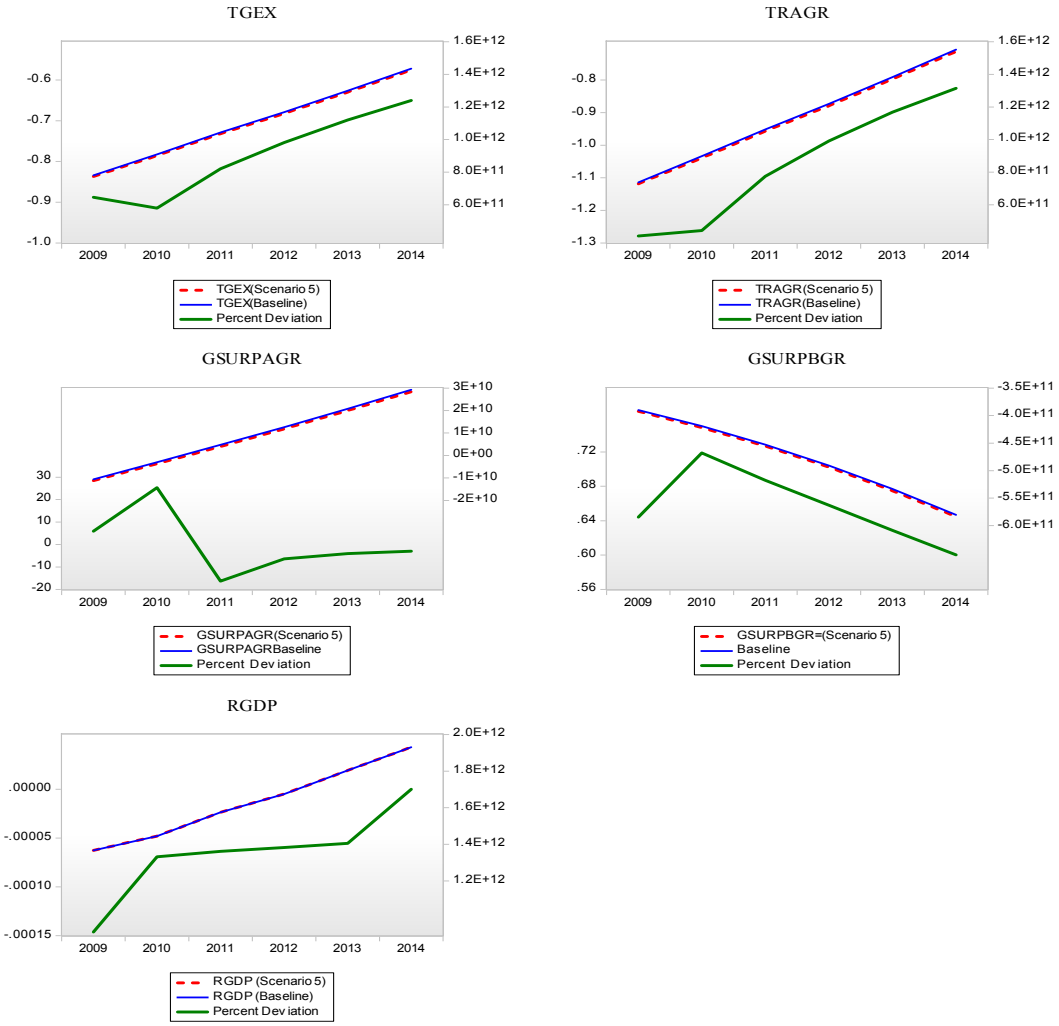

Figure 8: The Effect of a Shortfall in External Financing (Deviation from Base Run, in per cent)

6. Conclusion

We developed an applied macro-econometric model for a typical supply constrained African economy aimed at developing a template for such policy tools that are increasingly being demanded in Africa. The Rwanda macro-econometric model built along these lines had 107 equations of which 72 were endogenous. In addition, we also built a supplementary ARIMA based model of 33 equations, which is necessary for forecasting the exogenous variables needed for the overall forecasting ability of the model. The fiscal (including financing), balance of payments and money supply blocks of the models were fairly disaggregated to offer an adequate picture of the macro-economy. We used a single equation error correction modeling framework for estimating the core behavioral equations of the model. The model is similar to other successfully applied macro-models in the region such as the KIPPRA-treasury model and the Central Bank of Kenya's recent model. Our model can be further extended easily to support budgeting, forecasting and macroeconomic policy analyses in relevant ministries such as the Ministry of Finance of Rwanda. We successfully solved the model from 1999 to 2009 and forecast major macro-variables till 2015. The use of the model was illustrated by a real-world policy analysis of the Rwandan economy through a simulation exercise.

In the simulation exercise we discussed the implications of the Government of Rwanda's budget related policy as contained in its 2012/13-2014/15 Budget Framework Paper. The analysis focused on identifying major macroeconomic outcomes in the planning period that could arise from the government's proposed policy and probable external shocks. The following conclusions regarding the macroeconomic 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 forecast macroeconomic outcome of the model in the planning period (2012/13-2014/15) is compatible with the Ministry of Finance's forecast. This underscores the importance of this macro-model for the ministry's works in the future.

Second, our simulation exercise revealed that the planned spending was compatible with a stable macroeconomic environment. Thus, there seems to be no macroeconomic risk as it stands.

Third, the Rwandan economy may face a limited macroeconomic risk if the world economy slows down and prices of imports (in particular fuel price) increase in the planning period. This will require a policy response such as a flexible exchange rate policy and encouraging tourism to contain the probable macroeconomic risks.

Fourth, in terms of fiscal policy, given the level and forecast of inflation, there seems to be 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 (shying away from domestic debt) and delaying spending in the face of shortages of external resources, is a good strategy that needs to be pursued. In relation to this, the government deficit after grants is generally good. However, grants are above 10 per cent of GDP, and may lead to vulnerability if that level fails for some reason. Thus, the government needs to be cautious about this.

Finally, we note the potential use of this model in policymaking circles in Rwanda. It is a good macroeconomic policy tool for policy analyses and forecasting if it is accompanied by

expert opinion in Rwanda. The model will be more effective if it is further extended and institutionalized in relevant ministries such as the Rwandan Ministry of Finance or the country's central bank.

References

Bank of Uganda (2010). A Small Scale Macroeconomic Model for Uganda. *Bank of Uganda Working Paper, No. BOUWP/07/10*.

Elliott, J., S. Kwack, and G. 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.

Geda, A. (2011). (ed.), *Readings on the Ethiopian economy*. Addis Ababa: Addis Ababa University Press.

Geda, A. and A. Yimer (2013). A Macroeconometric Model for Rwanda. *IAES Working Paper No 2*.

Geda, A. and K. Tafere (2011). 'The Galloping Inflation in Ethiopia: A Cautionary Tale for Aspiring Developmental African Countries,' in A. Geda (ed.), *Readings on Ethiopian Economy*, Addis Ababa: Addis Ababa University Press, pp 119-152.

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

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

Hendry, D. (1995). *Dynamic Econometrics*. Oxford: Oxford University Press.

Horton, S. and J. McLaren (1989). Supply Constraints in the Tanzanian Economy: Simulation Results from a Macroeconometric Model. *Journal of Policy Modelling*, 11(2): 297–313.

Huizinga, F. and A. Geda (2004). 'The Theoretical Model of the Ethiopian Ministry of Finance and Economic Development Model', Government of Ethiopia Ministry of Finance and Economic Development Working Paper.

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

Johansen, S. (1988). Statistical Analysis of Co-integration Vectors. *Journal of Economic Dynamics and Control*, 12: 231–254.

Johansen, S. (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*.

Lewis, A. (1954). Economic Development with Unlimited Supply of Labor. *The Manchester School*, 22: 139-191.

Morales, R. and 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, DC: IMF.

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

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

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

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

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

Were, M., A. Kamau, M. Sichei, and M. Kiptui (2013). A Theoretical Framework for Kenya's Central Bank Macroeconometric Model. *Africa Growth Initiative Working Paper, No. 10*.

Appendix 1: The Theoretical Model

Appendix1a: Core Behavioral Equations of the Theoretical Model

The theoretical model 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 is offered here briefly.

I. The Real Side

5.1 Production Functions

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

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

(3) $Y_I = Y - [Y_A + Y_F] = AL_I^{\beta}$

where, $Y, Y_A, and\ Y_F$ are total, agriculture and the formal (modern sector) respectively. $L_A, L_i, and\ L_F$ is agricultural, informal and formal sector labor respectively, $K_A\ and\ K_F$ is capital in the agricultural and formal sectors. R is rainfall and Z is intermediate imports.

1.2 Demands for Factor Inputs

5.1.1 Employment in the Formal Sector

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

In terms of percentage changes we have:

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

where, w is the wage rate in the formal sector. p_y is the aggregate price level.

5.1.2 Investment

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

where, K is the optimal macro-capital stock and $p_k$is capital stock price, π is profit, q is capacity utilization rate and $I_g$is public investment. From this we get:

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

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

$+\mu(q-1) + \eta\hat{I}_g$

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

Investment relationship with the incremental capital output ratio (ICOR) which is widely used in growth analyses in Africa can be specified as:

(6d) $\Delta K = ICOR(\Delta Y)$, where $\Delta K = I - d^{*}Y_{t-1}$ and "d" 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 have:

(7a) $\hat{m} = \hat{z}_m - \sigma(\hat{p}_m - \hat{p}_y)$,

where, p_m denotes price of imports in the local currency.

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

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

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 (t_m).

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

1.2.4 Labor Supply and Unemployment

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

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

where, φ is the exogenous labor activity ratio.

Total unemployment (u) which is given as the economically active population (l^{econ}) minus employment (l) can be specified as:

(8b) $u = l^{econ} - l$

The unemployment rate (ur) is given by the number of unemployed divided by the labor supply (l^s):

(8c) $ur = \frac{u}{l^s}$

1.3 Final Demand for Goods

1.3.1 Consumption

Real consumption (c) is determined by a model of intertemporal optimization (simplified to two periods here):

$$arg\ max(c_1, c_2): log_{c_1} + \frac{1}{1+\delta} log c_2$$

Subject to:

(9a) $c_1 + \frac{1}{1+r} c_2 = y_1^d + \frac{1}{1+r} y_2^{d,e} + log c_2 + \text{wealth}_0$,

where, y_i^d is real disposable income and e denotes the expected value.

(9b) $c_1 = \left(1 + \frac{g}{2+r}\right) y_1^d + \left(\frac{\text{wealth}_0}{2+r}\right)$

where, r is the real interest rate.

(9c) $c = y^d - r$

Disaggregation by Sector

(9d) $Y_d^* = Y_d - p_a \bar{c}_a$,

where, Y_d^* is remaining nominal disposable income and $\bar{c}_a$ is minimum level of food consumption.

In nominal terms consumption of food is given as:

(9e) $p_a c_a = a_a Y_d^* + p_a \bar{c}_a$

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

(9f) $p_{cna} c_{na} = a_{na} Y_d^*$

where, P_{cna} is price of non-food consumption. c_{na} is non-food consumption.

1.3.2 Exports

(10a) $X = Y_N^{\beta_1} \left(\frac{e p_x}{p_d}\right)^{\beta_2} \left(\frac{i}{y}\right)^{\phi}$

where, X is exports, Y_n is income of trading partners, i is investment. In logarithmic form (10a) can be written as:

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

1.3.3 Government Spending and Revenue

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

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

(12) $T = \sum T_i = \sum (\alpha_i^* + \beta_i^* Z_i)$

where, G_i and T_i denote the vectors of different spending and revenue categories respectively and Z_i is a vector of determinants of G_i. *and* T_i , α and β (α^* and β^*) are parameters.

2. The Nominal Side

2.1 Price Determination in the Agricultural Sector

(13a) $p_a c_a = a_a Y_d^* + p_a \bar{c}_a$

Supply equals:

(13b) $p_a^* y_a + e p_f m_{ca}$

where, m_{ca} is the real import of consumption of agricultural goods (imported food. e is the nominal exchange rate and p_f is the price of imports (foreign price). Equating supply and demand gives:

(13c) $p_a(y_a - \bar{c}_a) + (e p_f m_{ca}) = a_a Y_d^*$

(13d) $p_a = \frac{a_a Y_d^* - (e p_f m_{ca})}{y_a - \bar{c}_a}$

2.2 Price and Wage Determination in the Formal Sector

We assume that output prices are set by firms which operate in a market structure of monopolistic competition. That is, we assume that for each good, there exists an inverse demand curve $p^f = p^f(z)$, with p^f denoting the price at factor cost and z denoting 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:

(14a) $argmax(z)$: $(1 - t_\pi)[p^f(z)z - c(z)]$, where*:* $t_\pi$the profit tax.

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

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

where, ε is the price elasticity of demand and mc denotes marginal cost. This optimization, including the effect of competitive price can lead to the following final form for general price (see Huizinga and Geda, 2004 for detail) $mc = dc/dz$. Note that 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:

(14c) $p_y = p^f(1 + t_z - s_z)$

(14d) $\hat{p}_y^{m,s} = (1 - \gamma)\left(\alpha_w(\hat{w} - \hat{h}) + \alpha_k \hat{p}_k + \alpha_m \hat{p}_m + \beta_1 \Delta q + \beta_2 (q - 1) + \frac{\Delta t_z + \Delta s_z}{1 + t_z - s_z}\right) + \gamma p_{comp}$

where, $t_z$and s_z are the indirect tax and subsidy rates.

The relation of the market price is therefore given in terms of the price of aggregate goods in the formal sector, $\hat{p}^{ag}$ as:

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

where, the superscript *p* denotes policy-determined.

2.3. Price and Wage Determination in the Informal Sector

(15) $w_I = w_A(1+g_A)$

(16) $P_I = w_I(1+g_I)$

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

(17) $P^{GDP} = \beta_1 P^{agr} + \beta_2 P^{formal} + \beta_3 P^{informal}$ $where\ \beta_1 + \beta_2 + \beta_3 = 1$

2.4 The Money Market and Exchange Rate

2.4.1 Money Demand and Supply and the Domestic Nominal Interest Rate

(18a) $M^d = \alpha Y + \beta P - \gamma_i$

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

(18b) $i = \frac{1}{\gamma}(\alpha Y + \beta P - MS^*)$

With the inflation targeting monetary policy the rule is given by:

(18c) $\Delta MS^* = \alpha\Delta Y + \beta\Delta P^* + \beta_1[\Delta P - \Delta P^*],$ where $\beta_1 < \beta,$

where, *P** is the target level of inflation.

2.4.2 Exchange rate

(19) $e = \beta_0 + \beta_1 M - \beta_2\left[X + A - FX_g^{dd}\right]$

where, M, money, X is export, A is aid and FX^{dd}, demand for foreign exchange for its international obligations such as debt servicing.

The real exchange (RER) is derived by definition as:

(20) $RER = e + p_f - p_d$

Box 1: External and Policy Shocks Examined in the Simulation Exercise

Government Policy 1

1) 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 per cent during the budget period)

(b) Change in composition of this expenditure: Annual growth of 13 and 5 per cent 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: Rwf 46.7 billion which is about 8 per cent of the current expenditure or 4 per cent of the total government expenditure.

3) Proposed Efficiency Saving: This is assumed to bring a 4.2 per cent cut in the allocation of each of the budget lines outlined in the budget to generate the Rwf 1.1 billion proposed (which is 0.1 per cent 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 per cent which is a record in the last 5 years. We simulated the relatively optimistic scenario of a 5 per cent rise in import price.

(b) A decline in exports (say due to the global economic slowdown - Rwanda's trading partners' economies). The last 5 years show a decline in exports that varies from 2.6 to 8.4 per cent. We took the average value of 5 per cent.

Financing Risk

5) Financing risk: A shortfall in external resources is proposed to be addressed by a possible delay in non-priority spending in the budget document. For this we simulated a decline in net-external borrowing of 10 per cent.

Source: Compiled from Republic of Rwanda, Ministry of Finance and Economic Planning

Appendix 1b

Table A1b: 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

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

3) The Balance of Payment Block

BOPCU = (X - M + NDINROW + NCUTR)

BOPOVERALL = BOPCU + BOPCA

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

1.

Appendix 1c

Table A1c: 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 Interest Rate, 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

Appendix 2

Simulation Results using the Rwanda Macro-econometric Model

TableA2 (a): The Effect of the proposed government spending (Deviation from Base Run, in Percentage)

Year	Growth	Gov't Fiscal Surplus After Grants (as per cent of GDP)	Gov't Fiscal Surplus Before Grants (as per cent of GDP)
2009	-0.1	-2.2	-34.3
2010	0.1	-1.8	-35.4
2011	0.0	-1.4	-35.5
2012	0.0	-1.0	-36.4
2013	0.0	-0.7	-37.0
2014	0.0	-0.4	-37.7

Table A2 (b): The Effect of the Composition of Government Proposed Spending (Deviation from Base Run, in Percentage)

Year	Growth	Real GDP	Real Private Investment	Total Government Expenditure	Total Revenue After Grants	Total Revenue Before Grants	Real Exchange Rate	M2 (Money Supply)	MD (Money Demand)
2009	-0.26	-0.01	-0.01	10.14	0.01	0.02	-0.02	0.37	0.02
2010	-0.05	0.00	0.00	10.16	0.02	0.04	-0.03	0.40	0.03
2011	-0.11	0.00	0.00	10.19	0.02	0.04	-0.04	0.46	0.04
2012	-0.10	0.00	0.00	10.24	0.03	0.05	-0.04	0.49	0.05
2013	-0.14	0.00	0.00	10.29	0.03	0.06	-0.05	0.53	0.05
2014	-0.11	0.00	0.00	10.34	0.04	0.06	-0.05	0.56	0.06

Table A2 (c): The Effect of the Wage and Pay and Retention Policy (Deviation from Base Run, in Percentage)

Year	Growth	Real GDP	Real Private Investment	Total Revenue After Grants	Total Revenue Before Grants	Current Account Deficit	BoP (Overall)	CPI (Inflation)	Real Exchange Rate	M2 (Money Supply)
2009	-0.50	-0.03	-0.06	0.05	0.10	0.02	0.03	0.09	-0.09	1.87
2010	0.29	-0.01	0.00	0.10	0.18	0.00	0.00	0.15	-0.15	2.06
2011	-0.06	-0.02	-0.02	0.13	0.23	0.00	-0.01	0.19	-0.19	2.32
2012	0.08	-0.01	-0.01	0.15	0.26	-0.01	-0.02	0.22	-0.22	2.47
2013	-0.01	-0.01	-0.01	0.16	0.29	-0.01	-0.01	0.25	-0.25	2.66
2014	0.04	-0.01	-0.01	0.18	0.32	-0.01	-0.01	0.27	-0.27	2.80

Table A2 (d): The Effect of a Possible Slow Down in the World Economy (Deviation from Base Run, in Percentage)

Year	Growth	Real GDP	Real Private Investment	Real Investment (Total)	Real Private Consumption	Real Exports	Real Imports	Total Government Expenditure	Total Revenue After Grants	Total Revenue Before Grants
2009	-4.30	-0.24	-3.24	-0.46	-0.46	-5.02	-1.10	-1.16	-0.60	-1.14
2010	-25.65	-1.31	-4.79	-0.76	-1.10	-5.46	-0.87	-0.29	0.48	0.87
2011	5.58	-0.83	-2.44	-0.44	-1.10	-4.90	-1.25	0.68	1.48	2.62
2012	-3.47	-1.03	-3.13	-0.58	-1.27	-4.29	-1.30	1.08	1.86	3.30
2013	0.91	-0.96	-2.66	-0.53	-1.31	-3.82	-1.41	1.39	2.13	3.78
2014	-0.87	-1.02	-2.74	-0.57	-1.38	-3.48	-1.47	1.54	2.24	4.01

Year	Government Fiscal Surplus After Grants as per cent of GDP)	Government Fiscal Surplus Before Grants (as per cent of GDP)	Current Account Deficit	Bopca_0	BoP (Overall)	CPI (Inflation)	Real Exchange Rate	M2 (Money Supply)
2009	-11.80	-1.18	7.13	0.00	12.04	1.13	1.77	0.35
2010	-120.24	-1.69	7.73	0.00	13.69	3.02	-0.31	0.70
2011	33.18	-1.97	6.90	0.00	12.51	4.12	-1.42	1.03
2012	17.53	-2.13	6.43	0.00	11.54	4.76	-2.07	1.31
2013	12.71	-2.22	5.92	0.00	10.43	5.13	-2.45	1.60
2014	10.31	-2.28	5.56	0.00	9.54	5.36	-2.70	1.85

Table A2(e): The Effect of A Shortfall in External Financing (Deviation from Base Run, in Percentage)

Year	Growth	Total Government Expenditure	Total Revenue After Grants	Total Revenue Before Grants	Government Fiscal Surplus After Grants (as Per cent of GDP)	Government Fiscal Surplus Before Grants (as Per cent of GDP)	Current Account Deficit
2009	-0.003	-0.89	-1.28	-2.42	5.92	0.64	0.00
2010	0.00	-0.91	-1.26	-2.31	25.33	0.72	0.00
2011	0.00	-0.82	-1.10	-1.97	-16.28	0.69	0.00
2012	0.00	-0.75	-0.99	-1.78	-6.39	0.66	0.00
2013	0.00	-0.70	-0.90	-1.62	-4.04	0.63	0.00
2014	0.00	-0.65	-0.83	-1.50	-2.98	0.60	0.00