



Economic Commission for Africa

Economic and Social Policy Division

The ESPD-ECA Macroeconomic Forecasting Framework

**An Applied Manual for use by
African Ministries of Finance and
Economic Development**

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Introduction: Scope and objectives of the manual

One of the major challenges that face many African governments is the lack of well-trained professionals capable of preparing consistent short- to medium-term plans or a comprehensive long-term planning framework. Moreover, over the past years, a number of factors including instability and poor governance have created a time inconsistency problem in policy making in a number of African countries: policymakers often have a short time horizon so they tend to privilege ad hoc and short-term policies with little or no incentive to adopt a consistent short- to medium-term planning instrument. However, it is expected that the recent trend towards the adoption of poverty reduction strategies that are consistent with overall macroeconomic plans will require professionals who can develop and/or use longer-term planning frameworks adapted to their economies.

Budgeting and planning exercises require forecasting major macroeconomic variables for at least three to five years. Without such forecasts, the preparation of a country's resource envelope through annual budgets or what is commonly known as 'Medium Term Expenditure Framework – MTEF' would be a difficult task. The current practice in many countries is to extrapolate values for macroeconomic variables without taking into account the interrelationships among macroeconomic aggregates. Obviously, this is unsatisfactory. What is often needed is a planning framework, such as a macro-econometric model that goes beyond simple extrapolations. Building and updating macro-econometric models require forecasting and planning experts, particularly in the ministries of finance, planning and economic development.

The Economic Commission for Africa (ECA) recognizes the difficulty many African countries face in building full-fledged macroeconomic models and in training, in a relatively short time, qualified modellers and forecasters who would provide governments with concise and timely forecasts. To assist African countries in this respect, the Commission, through its Economic and Social Policy Division (ESPD), has developed this manual, which contains a simple but consistent generic macroeconomic forecasting model that can easily be adapted by economists in ministries of finance and economic development to suite the needs of the country.

The manual is a continuation of previous ECA work in this area, including contributions by Osakwe (2002). Osakwe's (2002) initial work at ECA has provided preliminary background information on macroeconomic model building, described key stages in model building (specification, estimation, testing and forecasting), and suggested two approaches to macro modelling that can be of relevance for Africa: (a) small open economy models, which can briefly be synthesized using the national income identity; and (b) a VAR forecasting model with four endogenous variables (GDP growth rate, exports, investment, and inflation).

Osakwe's important work, which provides a bird's-eye view of modelling, attempted to produce a set of alternative models that can be used by ECA for compiling an Africa-wide growth forecasting model. The aim of the present manual is to standardize the forecasting work in African countries and eventually provide Africa with a regional forecasting framework based on a

sample of countries from the different subregions.¹ The manual adopts Osakwe's suggestion of using VAR models in African set-ups, but shifts the focus to:

- (a) Helping technocrats in ministries of finance and economic development of various African countries with the task of macroeconomic forecasting in general and growth forecasting in particular, both of increasing importance in the context of poverty reduction strategies and MTEF preparation.
- (b) Strengthening the existing practice of forecasting in African Ministries by providing these technocrats with an applicable framework of modelling that emphasizes both forecasting and macro consistency using familiar software platforms such as Microsoft Excel or Eviews.

To effectively develop and use macro models, staff requires knowledge of applied methods of forecasting, as well as a tool for organizing data in a consistent accounting framework. In addition to fulfilling this need, the manual underscores the need to update staff on underlying economic theory and relevant computer-based econometric techniques. It is hoped that, based on the generic modelling framework, the technocrats in various ministries will be able to forecast short-run growth and other major macro variables in a more systematic and consistent manner.

Besides its use in budget preparation, policy analysis and simulation exercises, the generic model provides the foundation for building full-fledged long-run macro models in African countries. To help individual countries construct long-run models using the generic model and to allow cross-country comparisons, the manual presents a list of key estimated parameters from existing African models. These parameters are contained in an Excel-based applied macro forecasting model framework that is developed in the context of this work. The use of a continent-wide consistent forecasting framework will enhance transparency in budget planning and help ESPD to get timely and consistent country data on macroeconomic aggregates to be used in the preparation of the Economic Report on Africa. Moreover, it might be possible for ECA to build a regional forecasting model-based on consistent individual country forecasting models.

The rest of the manual is organized as follows. In the next chapter we briefly assess the current practice of forecasting macro variables in African countries and its limitations. Chapter 3 presents single equation forecasting techniques with some applications. In Chapter 4 we provide a simple model-based short-term forecasting framework for Africa using software such as Excel. Chapter 5 presents practical suggestions for building a full-fledged long-run macro model, which will bring a lasting solution to the problem of forecasting and policy analysis in Africa. The chapter also provides information on the Excel and Eviews files that are used in the manual and those that could be used for exercises in training sessions.

¹ See Alemayehu (2002) for regional models of North, West & Central, and South & Eastern Africa, which are based on a sample of 20 African countries and placed in the context of a global macro model.

Macro models and growth forecasting in Africa: The current practices and constraints

In the African forecasting framework, and in other developing countries in general, the two gap model and its variants are widely used for forecasting the investment requirements to achieve a targeted growth rate. This approach to macro modelling had formed the basis for determining aid requirements in many developing countries. It estimates the gap between the available domestic resources and the investment level needed to achieve a target growth rate. The next section discusses the basis for this approach, and how it is used by the World Bank and the IMF to compute the external resource requirements of African countries.

The gap approach

The two-gap model (Chenery and Strout, 1966) basically links a simple Harrod-Domar growth model with flows of external assistance. The essential point of the model is that growth is constrained by the supply of skill and organizational ability, the level of domestic savings and the supply of imported commodities and services. The constraints to growth are generally seen in three phases: in phase I growth is limited by the ability to invest and the domestic savings-investment gap determines the amount of capital inflow required by a country to achieve a given growth rate. In subsequent phases, in addition to foreign savings, augmenting domestic savings to achieve a desired sustainable growth rate requires that exports grow faster than imports. But, this has often proved to be difficult in most developing countries. Using this model, the authors concluded that the impact of capital flows varies in different phases, though foreign economic assistance is generally productive either in supplementing domestic savings or relieving foreign exchange constraints (see Box 1).

Box 1
Theoretical Specification of a Two Gap Model

To project GDP, major macro variables as well as internal and external gaps, a simple growth model, specified along the Harrod-Domar line, could be estimated using national income data. The Harrod-Domar equation is given by

$$g = \left(\frac{1}{k}\right) \frac{I}{Y} = \frac{\Delta Y}{Y} = \left(\frac{1}{k}\right) \frac{\Delta K}{Y} \quad [1]$$

where: g is the growth rate, k the incremental capital-output ratio (ICOR) and I/Y is the investment (I) to GDP (Y) ratio. Based on the projection of I/Y it is straightforward to compute expected GDP.

According to the 'two gap' model, capital is the key constraint on growth. Accordingly equation [1] may be written as:

$$Y_{t+1} - Y_t = \frac{1}{k} I_t \quad [2]$$

Since,

$$Y_{t+1} = (1+g)Y_t \quad [3]$$

$$\text{then, } Y_{t+1} - Y_t = gY_t \quad [4]$$

If the target rate of growth is specified as 'g', the level of investment (I^*) required for achieving a desired growth rate will be given by:

$$I_t^* = gkY_t \quad [5]$$

Desired levels of saving (S^*) and imports (M^*) are, respectively, given by:

$$S_t^* = \alpha_0 + \alpha_1 Y_t \quad [6]$$

$$M_t^* = \beta_0 + \beta_1 Y_t \quad [7]$$

The level of exports is given by:

$$X_t = (1 + \varepsilon)X_{t-1} \quad [8]$$

where: ε is an exogenously given value of export growth rate.

Based on equations [5] to [8] it is possible to compute the *ex ante* saving ($I^* - S^*$) and trade ($M^* - X$) gaps.

In this version of the 'two gap' model the desired level of investment (and hence the target growth) is always met. The level of external finance (aid, A) needed is determined by the dominant gap as:

$$A = \max \{I^* - S^*, M^* - X^*\} \quad [9]$$

It is also easy to determine the *ex post* level of the two gaps by computing saving and imports as:

$$S_t = I_t - A_t \quad [10]$$

$$M_t = X_t + A \quad [11]$$

The Fund and the Bank models: the Polak and the RMSM models

According to Khan, Montiel and Haque (1990) the World Bank and the International Monetary Fund's programmes are complementary. The structure of the Fund's programme is laid on a framework that links the financial sector with the balance of payments - termed as the 'monetary approach to the balance of payments'. On the other hand, the Bank's approach is based on the two-gap or Harrod-Domar growth model for open economies as shown above. This model is commonly known as the 'Revised Minimum Standard Model (RMSM)'. Their complementarity emerges from the fact that the Bank emphasizes the real, while the Fund focuses on the financial aspects of the economy. These two approaches are outlined below.

Following Khan *et al.* (1990) the economy may be divided into four sectors: the private sector, the public sector, the foreign sector and the domestic banking sector. The private sector's budget constraint is presented as

$$Y - T - C_p - \Delta K \equiv \Delta M + \Delta F_p - \Delta D_p \quad [12]$$

where Y is nominal income, T taxes, C consumption, K investment, M money, F foreign assets, D borrowing from the banking system and subscript p denotes the private sector. On the other hand the public sector's (g) revenue (T) and spending (Cg) can define public deficit or surplus according to:

$$T - C_g \equiv \Delta F_g - \Delta D_g \quad [13]$$

The foreign sector has revenue from imports (Z) and spends it on exports (X). Any imbalance is adjusted through changes in liabilities (or assets) that can affect the level of reserves (R) in the domestic banking sector. Thus:

$$Z - X \equiv -(\Delta F_p + \Delta F_g + \Delta R) \quad [14]$$

In the money sector the above transactions will determine the supply of money as:

$$\Delta M \equiv \Delta R + \Delta D_p + \Delta D_g \quad [15]$$

Equations 12 - 15 yield:

$$Y - C_p - \Delta K - C_g - X + Z \equiv 0 \quad [16]$$

Equation [16] is a familiar national accounting identity which is basic for the analysis of the Bank's and the Fund's approach (Khan *et al.*, 1990: 155-158).

The Fund's model

One of the main objectives of the Fund is to help member states finance temporary balance of payments deficits. In this context the Fund relies on a model developed by Polak (1957) and

Robichek (1967) to analyse balance of payments problems and propose solutions. As explicitly demonstrated by Khan *et al* (1990), the Fund's approach is based on three fundamental assumptions. First, real GDP is assumed to be exogenously given, such that:

$$Y = P\bar{y} \quad [17]$$

where p denotes the domestic price level and y real GDP. The change in nominal GDP is given by:

$$\Delta Y = \Delta P \cdot \bar{y}_{t-1} + P_{t-1} \Delta \bar{y} \quad [18]$$

Second, the velocity of money (v) is assumed to be constant, so that:

$$\Delta M^D = v\Delta Y \quad [19]$$

where M^D is the demand for money. Third, the money market is specified as a *flow* equilibrium:

$$\Delta M^S = \Delta M^D = \Delta M \quad [20]$$

where M^S is the money supply. These formulations combined with equation [16] of the general framework results in one of the fundamental equations of the monetary approach to the balance of payments, which relates policy variables (marked $\hat{}$) with the balance of payments (ΔR) as follows:

$$\Delta R = v^{-1} \Delta P \bar{y}_{t-1} + v^{-1} P_{t-1} \Delta \bar{y} - (\Delta \hat{D}_p + \Delta \hat{D}_g). \quad [21]$$

Thus, "The balance of payments is expressed as the difference between the private sector's flow demand for money and the flow of domestic credit" (Khan *et al.* 1990:159). The balance of payments is also directly linked to the domestic credit level. Hence, equation (21) is sometimes used as "a rationale for the use of credit ceiling as a performance criteria in IMF programs"² (ibid.160).

The nature of the demand for money and the assumption of constant velocity are crucial in this approach. Although the latter is questioned, empirical studies are often cited to support its stability (ibid.160). The other important component of the Fund's policy framework (following credit ceiling) is a sub-ceiling on the expansion of credit to the non-financial public sector in favour of the private sector. Thus the public sector, as a policy instrument, must adjust to the targeted credit expansion to the private sector either by increasing its revenue or reducing its expenditure (ibid.164). The implicit assumption in this analysis is that the private sector can easily accommodate any external shock, an assumption that has been challenged by many economists (Fitzgerald, 1993).

The Bank's model

Unlike the Fund, the Bank is concerned with the financing of growth and development over the medium term and hence places more emphasis on savings, foreign capital inflow, investment and growth. This is articulated in the Bank's –RMSM - model, the most widely used model in developing countries. Being an accounting framework, this model focuses on the link between national income and the balance of payments to estimate the financing needs or borrowing requirements for an open economy.

² See Khan *et al* (1990), page 160-163 for a possibility of a unique solution by endogenizing the price level.

The RMSM has four basic assumptions:

1. The ICOR (Incremental Capital Output Ratio, ρ) is given; and output is a function of investment, ΔK , such that:

$$\Delta y^* = \rho^{-1} \Delta K \quad [22]$$

This helps to determine either the desired level of investment for a given (targeted) level of growth or vice versa.

2. Exports are exogenously determined.

3. There is a stable relationship between GDP (y^*) and imports (Z) so that: $Z=ay^*$.

4. There is a stable, historically given, saving rate leading to a consumption function of the form:

$$C_p = (I - s)(y^* - \hat{T}). \quad [23]$$

The assumption of fixed ICOR is unrealistic in the light of empirical studies (See Chenery *et al*, 1986: 230-232). However, the above equations combined with equation (16), which summarizes the general framework, gives the equation, which equates domestic investment with private, public and foreign savings as follows:

$$\Delta K = (y^* - \hat{T} - C_p) + (\hat{T} - \hat{C}_g) + (Z - X). \quad [24]$$

Substituting the import demand and the consumption function in the above equation, equation (16) may be rewritten as:

$$\begin{aligned} \Delta K &= s(y^* - \hat{T}) + (\hat{T} - \hat{C}_g) + (ay^* - \bar{X}) \\ &= (s + a)y^* + (I - s)\hat{T} - \hat{C}_g - \bar{X}. \end{aligned} \quad [25]$$

From the supply (technological) side investment is positively related to output as in:

$$\Delta K = \rho y^* - \rho y_{-1} \quad [26]$$

It follows that equations 25 and 26 jointly determine the level of investment and income in the Bank's model. It is worth noting that there are two policy options to raise domestic savings: reduction of public consumption and increased taxation (assuming a low tax elasticity of private saving). However, it should be clear that targeted growth and the balance of payments position can be maintained only if some degree of control over foreign finance exists such that:

$$\Delta \hat{F} = \bar{X} - ay^* - \Delta R^* \quad [27]$$

If there is a limit on foreign finance, then output determination according to the above equations will be constrained. The Bank's model will eventually converge to the basic two-gap model as outlined above. Obviously the RMSM can be a helpful tool in determining and projecting the growth consequences of different levels of finance (or the required finance for a stipulated growth). This framework is currently in use in many African countries, though critics doubt its realism (see e.g. Easterly, 1997).

Limitations of the ICOR based models

Though the ICOR and gap based approaches are the building blocks of the international financial institutions macro framework for African countries, this approach has serious limitations. Easterly (1997) discussed the theoretical and empirical failures of the approach. First, as the inventor of the model, Domar, admitted the assumption of a proportional relationship between aggregate output and capital stock is unrealistic. Second, the purpose of Domar's work was to comment on the debate on business cycles as opposed to deriving empirically meaningful growth rates. Third, by assuming that output is proportional to the stock of physical capital the approach implies that human capital does not contribute to growth.

On the empirical side, Easterly (1997) showed that the basic link between aid and investment has a very weak empirical support. Aid has a positive and significant effect on investment in 19 per cent of sampled countries, but a negative and also significant effect in 41 per cent of the sample. Moreover, econometric estimation of the two-gap model produced unsatisfactory results. While the mis-specified model that suppresses the constant produces an ICOR value of 5.35, the model with the constant included gave an unrealistic ICOR value ranging from 26 to 277. The basic assumption that investment is important for short run growth also lacks empirical support. In a nutshell, notwithstanding the wide use of the ICOR-based models in many developing countries including many in Africa, this approach is both theoretically and empirically flawed. This necessitates a different modelling framework that can capture the salient features of the economies under consideration. The approach followed in this manual is geared towards that end.

PRSP and MTEF

Since the early 1990s, policy design and analysis in Africa has been influenced by the preparation of Poverty Reduction Strategy Papers (PRSPs) and the use of Medium Term Expenditure Framework (MTEF). The PRSPs framework is in fact closely related to the preparation of the MTEF, as a vehicle for achieving poverty reduction targets. Both the preparation of PRSPs and the use of MTEF require an overall macroeconomic framework that ensures consistency in defining the aggregate resource envelope and spending priorities. It also requires forecasting of major macro variables three to four years ahead. The Prototype macro model presented in this manual is an invaluable instrument in achieving this objective in the short run. Since both the preparation of the budget and forecasting of key macro variables are made in a consistent accounting framework, it is not possible to change the components of the budget without influencing other variables in the model.

Thus, the prototype macro model is a useful device for comprehensive and dynamic policy analysis that can help policy makers to assess the consequences of proposed policy or packages of policies in a holistic manner. Policy analysis conducted with the aid of such models avoids partial analyses of issues of national significance by taking all possible inter-linkages in the economy that are not easily tractable by human mind. However, since the model used here is generic and not country-specific, its use for such exercises is rather limited. For the analysis to be informative to policy makers there is a need to develop a full-fledged country-specific model that takes account of all important relationships and constraints in the economy.

In addition to immediate policy analysis, macroeconomists in ministries of finance and similar institutions in Africa can use macro models to investigate a wide range of issues such as external

shocks and domestic responses, and the implications of alternative policy proposals. This analysis will eventually help them to develop a better understanding of the structure of the economy and how it works. This in turn can result in improved model building as well better policy formulation and forecasting.

In sum, the modelling framework presented in this manual may be used in the preparation of PRSPs and MTEF, and to a less extent in policy simulations. As a step towards building an economy-wide macro model, which is too costly, one needs to conduct forecasts using individual equations techniques and examine how they perform. The next chapter presents a detailed discussion of these techniques.

Forecasting and econometric techniques: Theory and application

Forecasting economic variables is an important element in policy design and analysis. In this chapter we introduce single equation/variable forecasting methods, involving such variables as GDP growth rate, inflation rate, and the exchange rate. The objective is to forecast how the exchange rate, for example, behaves in the next budget year in order to estimate the local currency value of capital goods that will be imported. Alternatively, we may be interested in forecasting the values of some variables either to assess how they respond to given policy changes or evaluate necessary policy responses to a given change in these variables. As an example, consider a certain increase in government expenditure needed to finance the Millennium Development Goals (MDGs). The change in government expenditure affects a range of variables such as budget deficit, money supply, the price level and output. To trace the impact of the shock in the expenditure on important economic variables, we need to forecast the variables of interest using a structural model and carry out various simulation experiments.

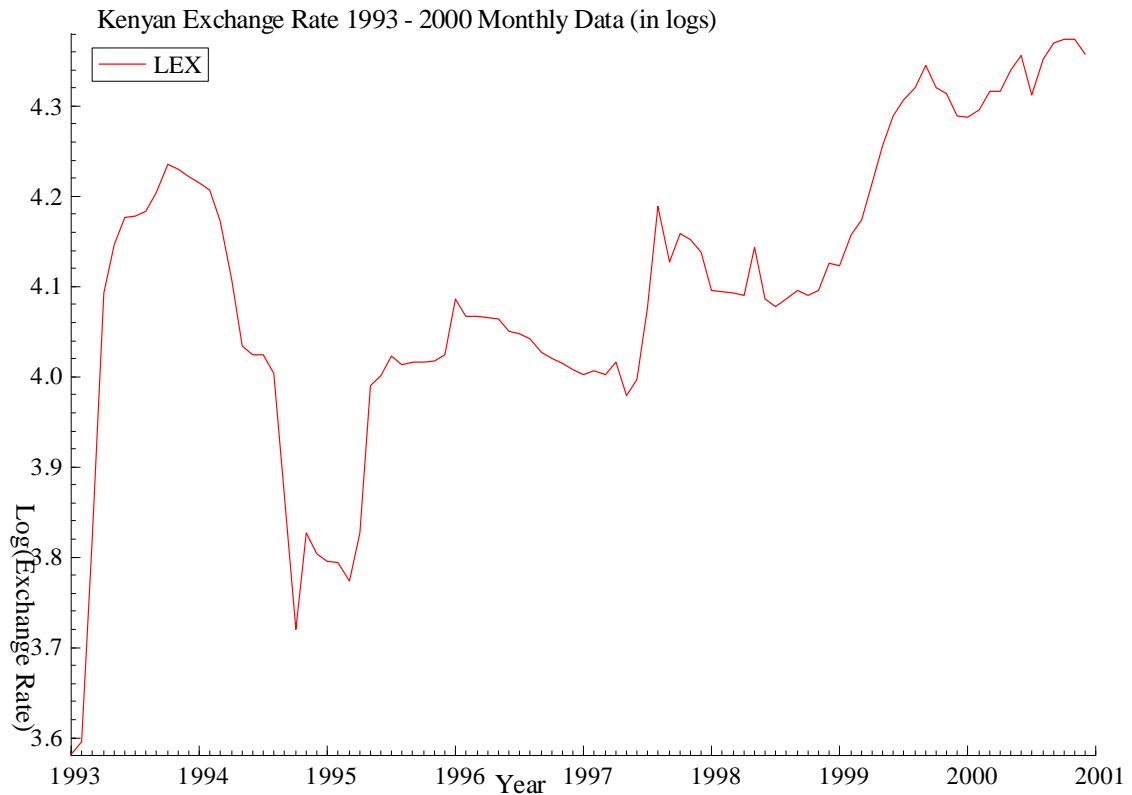
The starting point either for a univariate or multivariate forecast is to understand the behaviour of the variable(s) of interest. Economic variables are mostly composed of trend, seasonal and cyclical components. The trend component shows the long run behaviour of the variable while the seasonal component tells us about the impact of different seasonal factors on the variable. The variation in the variable that is not explained by the trend and seasonal components constitutes the cyclical component of the variable. Once we have a good grasp of the behaviour of the variable, we can fit a statistical model to forecast its future values. There are various methods to do that. In the next section, we will see how graphs can be used in studying the behaviour of an economic variable.

Graphics for forecasting

Time series graphics are important tools in understanding the behaviour of variables. Figure 1 below shows Kenya's monthly exchange rate during 1993 – 2000. The graph shows that the exchange rate (defined as the domestic currency price of a foreign currency – the US dollar) depreciated sharply during 1993 and started to appreciate until late 1994. It generally continued to depreciate thereafter with some episodes of appreciation in between. The sharp depreciation in 1993 corresponds to the abolition of the pegged exchange rate regime, while the appreciation in 1994 was due to the impact of a fall in excess liquidity.

These regime shifts and structural changes are clearly observable in the graph. For our forecasts to be robust, such deterministic shifts have to be accounted for.

Figure 1



The general message that one can get from this graph is that: (i) there is a major regime shift or structural change in 1993; and (ii) the exchange rate has shown an upward trend reflecting a continuously depreciating tendency.

Figure 2 shows Mozambique's price level during the period December 1990 to December 2001. As can be seen from the Figure, the domestic price level increased continuously until 1996 and stabilized thereafter. Figure 3 shows high volatility in the price level. The episode of high inflation until 1996 was followed by relative price stability in Mozambique. This stability may be attributed to the reform programs that the country underwent. Overall, the graphs show an upward trend in prices that is subjected to some structural changes.

The important point that emerged from our graphical analysis is that forecasting models should deal with the trends and deterministic shifts. The next section will address these issues.

Figure 2

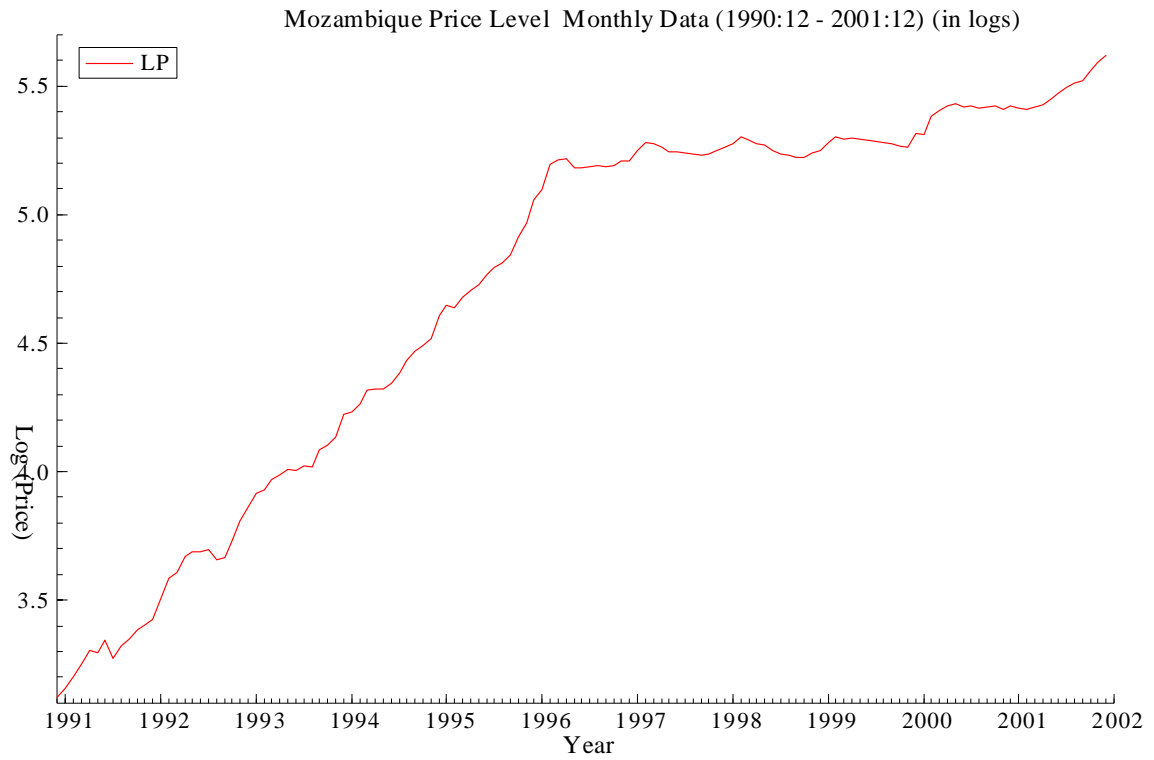
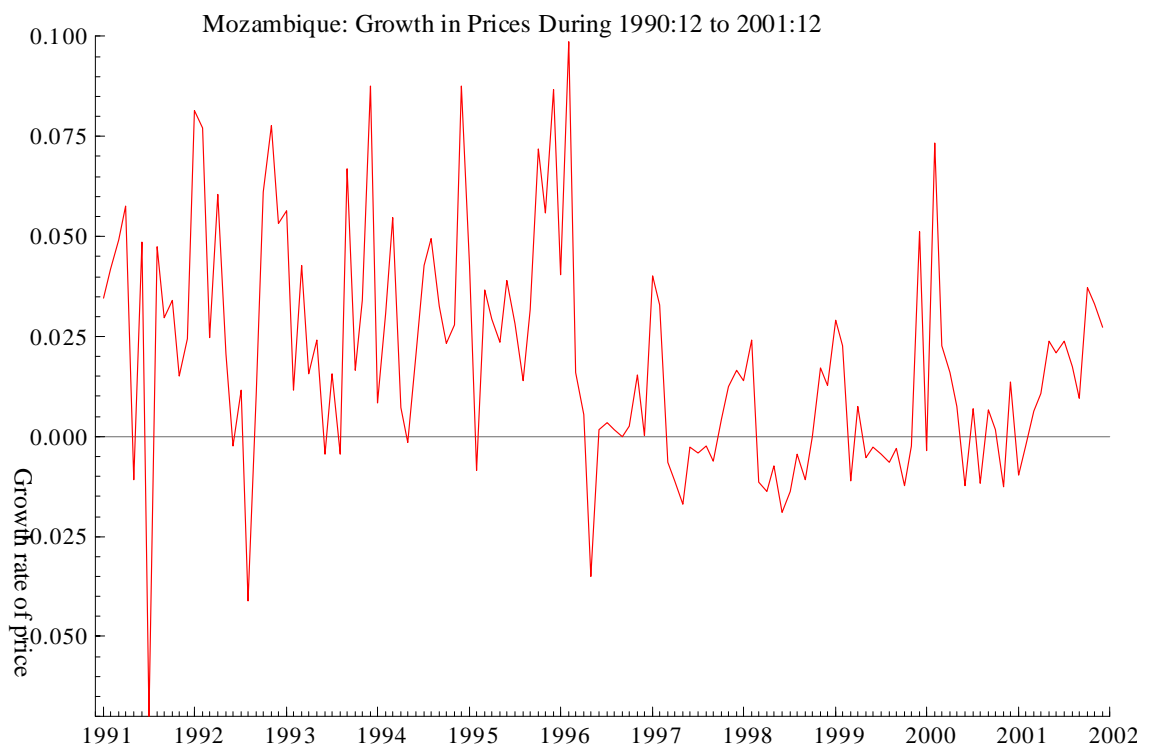


Figure 3



Modelling trends, deterministic shifts, seasonalities and cycles

Our graphic analysis underscores the importance of trends and deterministic shifts in both the Kenyan and Mozambique data. In this section, we discuss the modelling of deterministic shifts, trends and cycles using the above data set. We will also introduce the concept of seasonality and how to account for it. Finally, we will use all the components of the variable in a single forecasting exercise.

Modelling trends and deterministic shifts

We can model trends by running a simple regression of the form:

$$y_t = \beta_0 + \beta_1 T + \varepsilon_t \quad [28]$$

where T is time 1, 2, 3, ... and ε_t is the random error term.

We can either model a simple linear trend as in [28] or an exponential trend in the form of $y = \beta_0 e^{\beta_1 T}$. The exponential trend is useful when we model a variable showing constant growth rates over time. For estimation purposes, the variable can be log-linearized as follows:

$$\ln y_t = \ln \beta_0 + \beta_1 T + \varepsilon_t \quad [29]$$

In this case, β_1 is the constant growth rate of y_t .

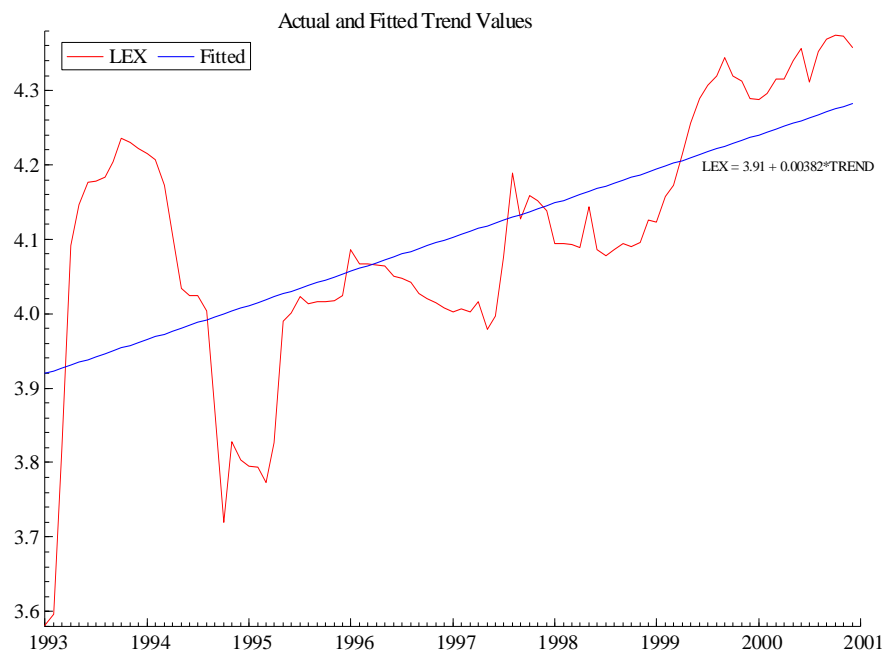
We estimated the trend in the Kenyan exchange rate in the form of equation [29] and the result is presented in Table 1 below. The result shows that the exchange rate exhibits a positive and significant trend.

Table 1
Modelling linear trend in the Kenyan exchange rate

Dependent Variable: LEX
Method: Least Squares
Date: 09/28/05 Time: 19:45
Sample: 1993:01 2000:12
Included observations: 96

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.919436	0.026616	147.2585	0.0000
@TREND	0.003821	0.000484	7.895337	0.0000
R-squared	0.398732	Mean dependent var		4.100948
Adjusted R-squared	0.392336	S.D. dependent var		0.168578
S.E. of regression	0.131411	Akaike info criterion		-1.200355
Sum squared resid	1.623281	Schwarz criterion		-1.146931
Log likelihood	59.61704	F-statistic		62.33635
Durbin-Watson stat	0.168747	Prob(F-statistic)		0.000000

Figure 4



As can be seen from actual and fitted values in Figure 4 and the low R^2 value, the linear trend does not fit the exchange rate data quite well. A quick glance at the graph also suggests that the trend is non-linear. To better fit the data, we can use a non-linear specification as in the equation below:

$$\log EX_t = \beta_0 + \beta_1 T + \beta_2 T^2 + \varepsilon_t \quad [30]$$

Table 2
Modelling quadratic trend in the Kenyan exchange rate

Dependent Variable: LEX
 Method: Least Squares
 Date: 09/28/05 Time: 20:32
 Sample: 1993:01 2000:12
 Included observations: 96

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.044631	0.035499	113.9355	0.0000
TREND	-0.004170	0.001727	-2.414386	0.0177
TREND^2	8.41E-05	1.76E-05	4.781788	0.0000
R-squared	0.517390	Mean dependent var		4.100948
Adjusted R-squared	0.507011	S.D. dependent var		0.168578
S.E. of regression	0.118364	Akaike info criterion		-1.399352
Sum squared resid	1.302935	Schwarz criterion		-1.319216
Log likelihood	70.16890	F-statistic		49.85101
Durbin-Watson stat	0.215053	Prob(F-statistic)		0.000000

The quadratic equation produced a U-shaped trend, with $\beta_1 < 0$ and $\beta_2 > 0$. The quadratic trend fits the data better as the adjusted R^2 is much higher than in the model with linear trend (0.507 compared to 0.392). The Schwarz and Akaike criterion are also lower in the quadratic trend model implying that the quadratic trend is the preferred specification.

To account for deterministic shifts, we introduced two dummy variables. DMY1993 takes the value of 1 during the pegged exchange rate regime (before October, 1993) and 0 otherwise; and it is introduced to capture the regime shift. DMY9410 is an impulse dummy taking a value of 1 in 1994:10 and 0 otherwise. It captures the break in the series due to the appreciation of the currency. The result shows that the impulse DMY9410 is statistically significant while DMY1993 is insignificant and hence dropped. The Schwarz criterion is also lower without the insignificant variable DMY1993. The results are given in Tables 3 and 4 below.

Table 3

Dependent Variable: LEX

Method: Least Squares

Date: 09/28/05 Time: 21:01

Sample: 1993:01 2000:12

Included observations: 96

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.036232	0.059309	68.05464	0.0000
@TREND	-0.003641	0.002493	-1.460665	0.1476
TREND2	7.88E-05	2.30E-05	3.427631	0.0009
DMY1993	0.019310	0.059788	0.322972	0.7475
DMY9410	-0.274387	0.118317	-2.319082	0.0226
R-squared	0.546292	Mean dependent var		4.100948
Adjusted R-squared	0.526348	S.D. dependent var		0.168578
S.E. of regression	0.116019	Akaike info criterion		-1.419440
Sum squared resid	1.224906	Schwarz criterion		-1.285881
Log likelihood	73.13314	F-statistic		27.39233
Durbin-Watson stat	0.235512	Prob(F-statistic)		0.000000

Table 4

Dependent Variable: LEX

Method: Least Squares

Date: 09/28/05 Time: 21:08

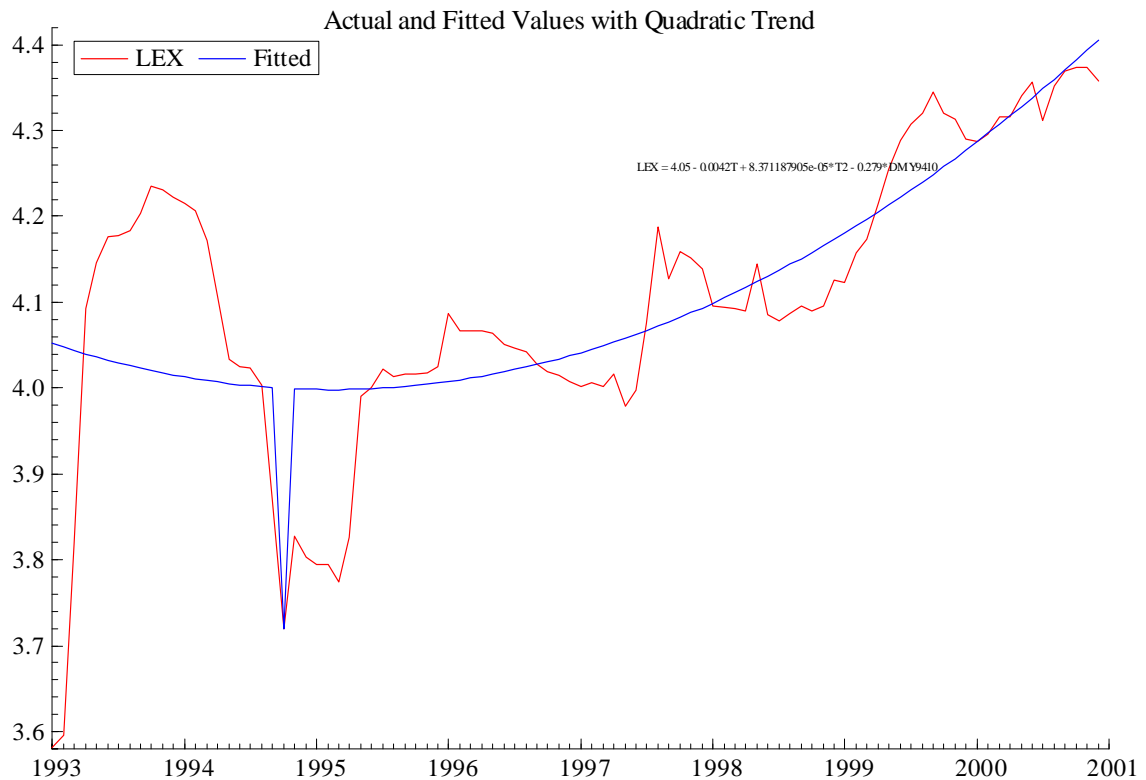
Sample: 1993:01 2000:12

Included observations: 96

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.051714	0.034752	116.5889	0.0000
@TREND	-0.004232	0.001685	-2.511756	0.0138
TREND2	8.37E-05	1.72E-05	4.878471	0.0000
DMY9410	-0.279627	0.116628	-2.397602	0.0185
R-squared	0.545771	Mean dependent var		4.100948
Adjusted R-squared	0.530960	S.D. dependent var		0.168578
S.E. of regression	0.115453	Akaike info criterion		-1.439128
Sum squared resid	1.226310	Schwarz criterion		-1.332280
Log likelihood	73.07815	F-statistic		36.84707
Durbin-Watson stat	0.238150	Prob(F-statistic)		0.000000

The graph of the fitted and actual values (Figure 5) shows that the quadratic trend with the impulse dummy fits the data better.

Figure 5



Apart from the fit of the model, there are also some summary statistics to evaluate its forecasting ability. Root mean squared error, mean absolute error, mean absolute percentage error and Theil's inequality coefficient are among the most commonly used statistics for such purpose. The first two forecast error statistics are dependent on the scale of the dependent variables; while the rest are scale invariant (i.e. unit free). In most instances unit-free measures are preferable (Challen and Hagger, 1983). As a result, Theil's inequality coefficient is used in this manual.

Theil's inequality coefficient is given as

$$T = \frac{\sqrt{\frac{1}{h+1} \sum_{t=s}^{s+h} (\hat{Y}_t - Y_t)^2}}{\sqrt{\frac{1}{h+1} \sum_{t=s}^{s+h} \hat{Y}_t^2} + \sqrt{\frac{1}{h+1} \sum_{t=s}^{s+h} Y_t^2}} \quad [31]$$

where Y and \hat{Y} are actual and forecast values, respectively. S is forecast sample and h is the length of forecast sample.

Theil's inequality coefficient can be decomposed into bias, variance and covariance proportions.

$$\text{Bias proportion} = \frac{(\bar{Y}^{\wedge} - \bar{Y})^2}{\sum (Y_t^{\wedge} - Y_t)^2 / h} \quad [32]$$

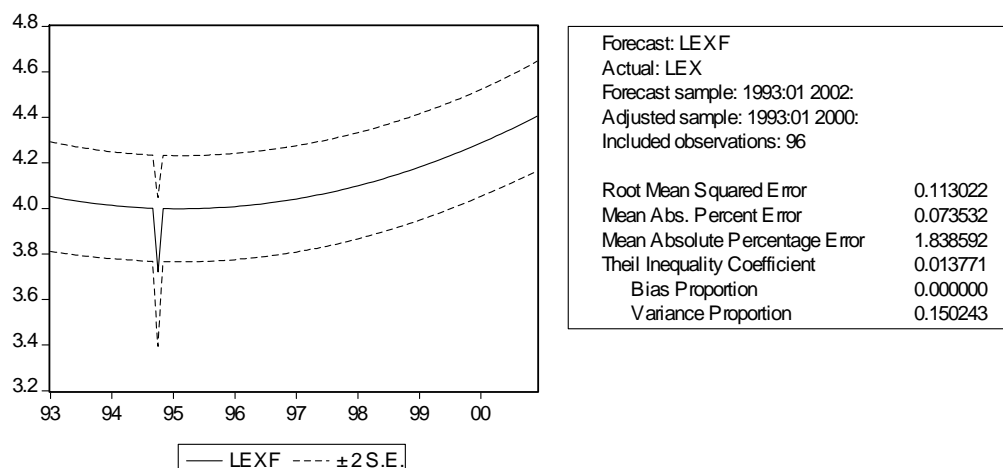
$$\text{Variance proportion} = \frac{(S_{Y^{\wedge}} - S_Y)^2}{\sum (Y_t^{\wedge} - Y_t)^2 / h} \quad [33]$$

$$\text{Covariance proportion} = \frac{2(1-r)S_{Y^{\wedge}}S_Y}{\sum (Y_t^{\wedge} - Y_t)^2 / h} \quad [34]$$

where $\bar{Y}^{\wedge}, \bar{Y}, S_{Y^{\wedge}}, S_Y$ are means and standard deviations of Y^{\wedge} and Y , respectively; and r is correlation between Y^{\wedge} and Y .

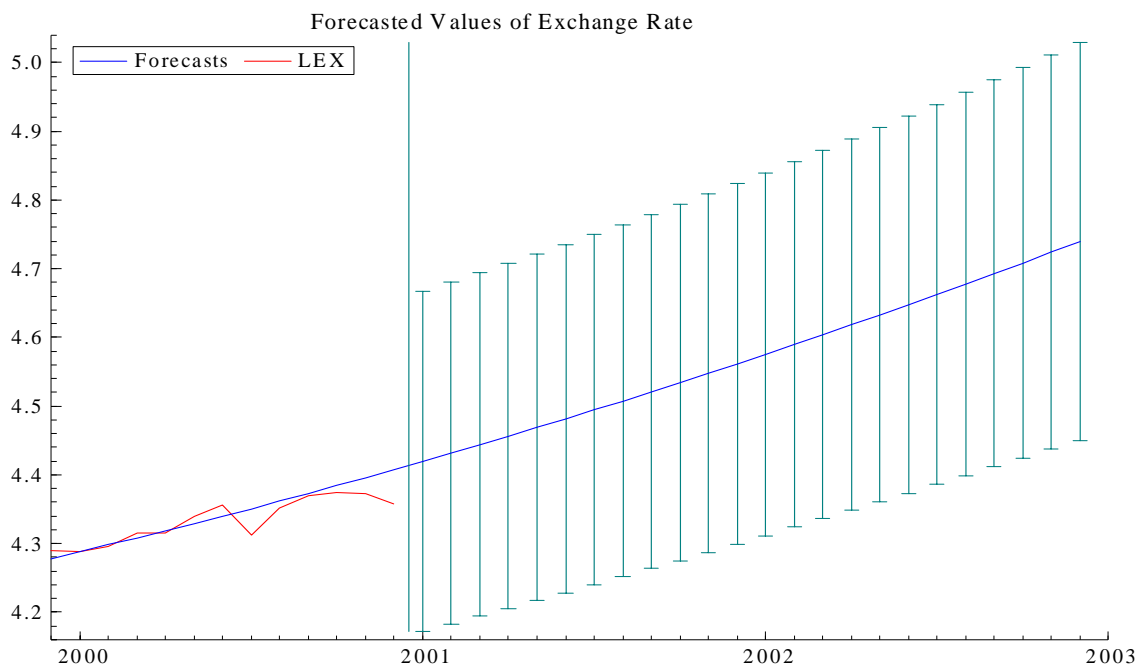
The bias and variance proportions show how far the mean of the forecast series is from the mean of the actual series and how far the variation of the forecast is from the variation of the actual series, respectively. The covariance proportion measures the remaining unsystematic forecast errors. The sum of these three measures would be unity. If the forecast is good, the bias and variance proportions should be small and thus most of the bias would be unsystematic.

These summary statistics are presented below for our quadratic trend model. The result shows that our forecast is reasonably well, given that the covariance proportion accounts for around 85 per cent of the variation.



Trend forecasting

After properly modelling the trend of a variable, the trend model can be used for trend forecasting purposes. By substituting the trend values into the estimated equation, the forecast values of the variable can be found. A statistical distribution for the accuracy of the forecast could also be derived. Using our estimated model, the forecast values of the exchange rate for 24 months ahead is presented below. The bars around the forecast line indicate that the forecast errors fall within ± 2 standard deviations suggesting that our model forecasts the trend quite well.



Modelling cycles

So far we tried to model only the long run component of the variable using trend. In the process, we filtered out the short run variations. In this section, we will address how to model the short run variation- the cycles. Before we proceed to the estimation of the cycles, we introduce the concept of covariance stationarity.

Covariance stationarity: if $\{y_t\}$ is a stationary series (i.e., time invariant variable), it would have a finite mean and variance, and the covariance between any two consecutive periods would be constant. That is,

$$E(y_t) = \mu \text{ and } Var(y_t) = \sigma_y^2$$

$$Cov(y_t - y_{t-s}) = Cov(y_{t-j} - y_{t-s-j}) = \gamma_s \quad [35]$$

where μ , σ_y^2 and γ_s are all constants.

A stationary variable is not mean-reverting while a non-stationary one diverts from its mean with time. A nonstationary variable is said to contain unit root in the autoregressive process. That is,

$$y_t = \phi y_{t-1} + \varepsilon_t$$

and

$$|\phi| \geq 1 \quad [36]$$

In such a case it is easy to show that $E(y_t) = t\mu$ and $Var(y_t) = t\sigma_y^2$.

Moving Average (MA) and Autoregressive (AR) Modelling

One method of modelling a cycle is to model it as a moving average (MA) of the innovations. The simple MA process MA(1) is represented as:

$$y_t = \varepsilon_t - \theta \varepsilon_{t-1} \quad [37]$$

This can be reparameterized as

$$\varepsilon_t = y_t + \theta \varepsilon_{t-1}$$

$$\varepsilon_{t-1} = y_{t-1} + \theta \varepsilon_{t-2}$$

$$\varepsilon_{t-2} = y_{t-2} + \theta \varepsilon_{t-3} \quad [38]$$

$$\varepsilon_{t-3} = y_{t-3} + \theta \varepsilon_{t-4}$$

$$y_t = \varepsilon_t - \theta y_{t-1} - \theta^2 y_{t-2} - \theta^3 y_{t-3} - \theta^4 y_{t-4} - \dots$$

If $|\theta| < 1$, the above system will become convergent and can be rewritten using the lag operator (L) as:

$$\frac{1}{1 - \theta L} y_t = \varepsilon_t \quad [39]$$

When the restriction that $|\theta| < 1$ is fulfilled, the system is referred to as invertible and can be estimated as a finite order AR process. Thus, the stationarity restriction becomes an important element in applying the MA and AR models as shown below.

Consider the simple AR(1) model:

$$y_t = \phi y_{t-1} + \varepsilon_t$$

$$y_t(1 - \phi L) = \varepsilon_t \Rightarrow y_t = \frac{\varepsilon_t}{(1 - \phi L)} \quad [40]$$

For convergence, the stationarity restriction that $|\phi| < 1$ will be required.

With the stationarity restrictions, the cycles can also be represented as MA(q), AR(p) or an ARMA(p, q) process. The orders (p and q) of the MA and AR terms can be determined using the Schwartz or Akaike information criterion. When the stationarity restriction fails to hold, the variable should first be transformed to guarantee stationarity. In most of the cases the appropriate transformation is achieved by differencing the series until it is stationary. The AR, MA and ARMA models can then be fitted on the transformed variable. This type of model is referred to as the ARIMA model and the additional letter 'I' implies that the series is an integrated process-i.e. stationarity is achieved after differencing. The ARIMA process is specified as (p, d, q) where d refers to the order of (the number of times one need to do) differencing needed to achieve stationarity.

We found that our Kenyan exchange rate data is nonstationary in level and stationarity is achieved after first differencing. We first estimated an MA model of order 12. Next, we dropped the insignificant MA terms and calculated the Schwartz criterion (SIC). The SIC statistics is minimized at MA(8) suggesting that the MA(8) is a reasonable specification. The results are displayed below.

Table 5a
MA(8) Model of the Kenyan Exchange Rate

Dependent Variable: D(LEX)
Method: Least Squares
Date: 09/29/05 Time: 00:01
Sample(adjusted): 1993:02 2000:12
Included observations: 95 after adjusting endpoints
Convergence achieved after 38 iterations
Backcast: 1992:06 1993:01

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003684	0.001272	2.895444	0.0048
MA(1)	0.182258	0.083264	2.188929	0.0313
MA(2)	-0.143909	0.076366	-1.884462	0.0629
MA(3)	-0.076961	0.058478	-1.316063	0.1917
MA(4)	0.131488	0.071650	1.835130	0.0699
MA(5)	0.015807	0.062646	0.252328	0.8014
MA(6)	-0.007088	0.075543	-0.093824	0.9255
MA(7)	-0.525076	0.061257	-8.571657	0.0000
MA(8)	-0.494484	0.075920	-6.513253	0.0000
R-squared	0.455361	Mean dependent var		0.008168
Adjusted R-squared	0.404697	S.D. dependent var		0.053805
S.E. of regression	0.041514	Akaike info criterion		-3.435635
Sum squared resid	0.148212	Schwarz criterion		-3.193689
Log likelihood	172.1927	F-statistic		8.987845
Durbin-Watson stat	2.038666	Prob(F-statistic)		0.000000
Inverted MA Roots	.99	.67+.72i	.67-.72i	-.14+.90i
	-.14-.90i	-.74-.53i	-.74+.53i	-.75

For the AR process AR(3) is found to be the best fit as suggested by the SIC.

Table 5b
AR(3) Model of the Kenyan Exchange Rate

Dependent Variable: D(LEX)
 Method: Least Squares
 Date: 09/29/05 Time: 00:17
 Sample(adjusted): 1993:05 2000:12
 Included observations: 92 after adjusting endpoints
 Convergence achieved after 3 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001957	0.005402	0.362275	0.7180
AR(1)	0.168717	0.093395	1.806500	0.0743
AR(2)	-0.007047	0.090819	-0.077589	0.9383
AR(3)	0.042722	0.083969	0.508782	0.6122
R-squared	0.045217	Mean dependent var		0.002881
Adjusted R-squared	0.012668	S.D. dependent var		0.041010
S.E. of regression	0.040749	Akaike info criterion		-3.520249
Sum squared resid	0.146125	Schwarz criterion		-3.410606
Log likelihood	165.9315	F-statistic		1.389191
Durbin-Watson stat	2.026387	Prob(F-statistic)		0.251404
Inverted AR Roots	.41	-.12+.30i	-.12	-.30i

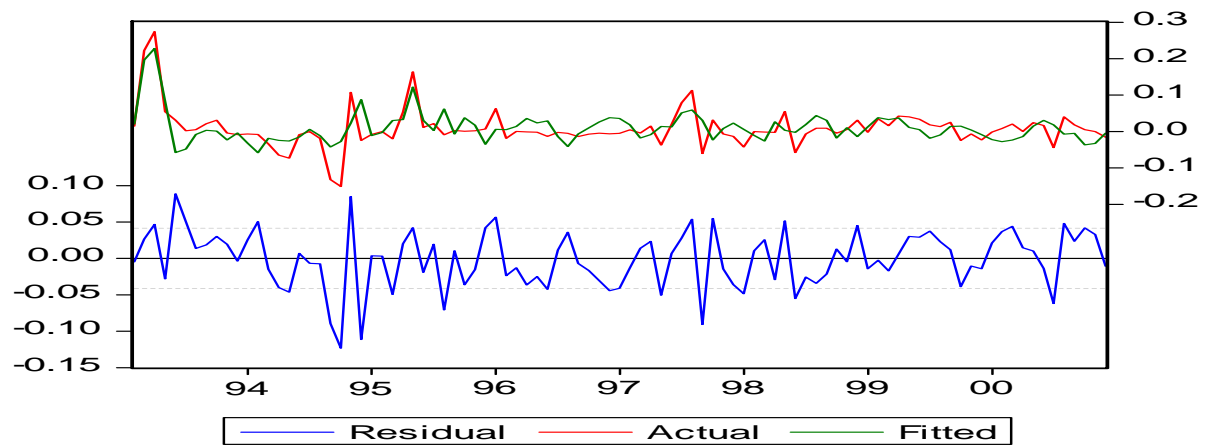
Following the same procedure, we found ARIMA (2,1,2) to be the data congruent representation of the Kenyan exchange rate variable. The result is shown in Table 5c.

Table 5c
ARIMA (2, 1, 2) of Kenyan Exchange Rate

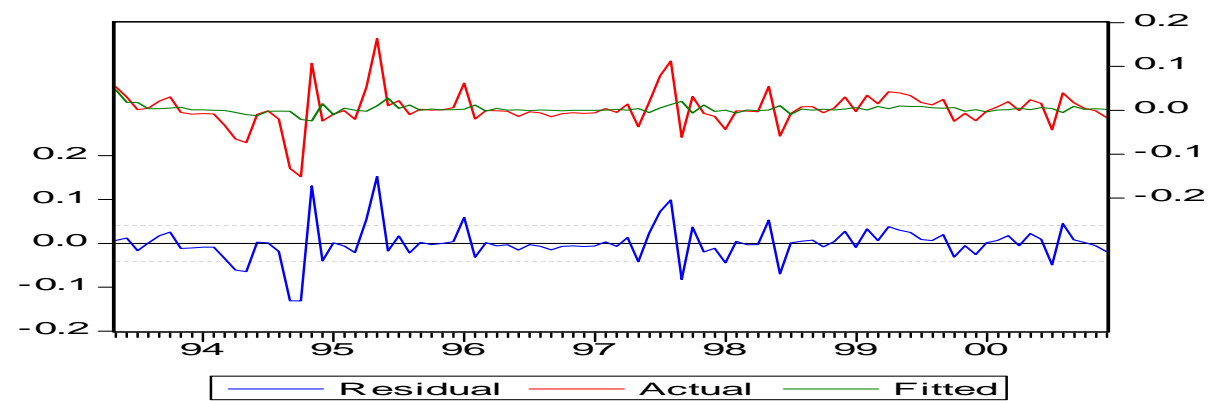
Dependent Variable: D(LEX)
 Method: Least Squares
 Date: 09/29/05 Time: 00:25
 Sample(adjusted): 1993:04 2000:12
 Included observations: 93 after adjusting endpoints
 Convergence achieved after 27 iterations
 Backcast: 1993:02 1993:03

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.002374	0.004970	0.477699	0.6340
AR(1)	0.744228	0.148032	5.027500	0.0000
AR(2)	-0.260180	0.123664	-2.103924	0.0382
MA(1)	-0.684796	0.158885	-4.310009	0.0000
MA(2)	0.264785	0.140545	1.883986	0.0629
R-squared	0.317466	Mean dependent var		0.005794
Adjusted R-squared	0.286442	S.D. dependent var		0.049525
S.E. of regression	0.041835	Akaike info criterion		-3.457886
Sum squared resid	0.154017	Schwarz criterion		-3.321724
Log likelihood	165.7917	F-statistic		10.23283
Durbin-Watson stat	1.828482	Prob(F-statistic)		0.000001
Inverted AR Roots	.37	-.35i	.37+	.35i
Inverted MA Roots	.34+	.38i	.34	-.38i

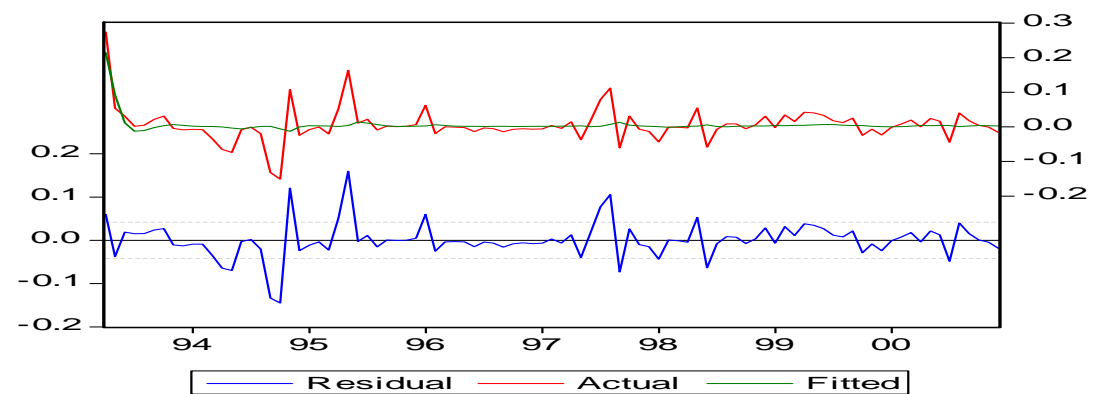
MA(8) Actual and Fitted Values



AR(3) Actual and Fitted Values



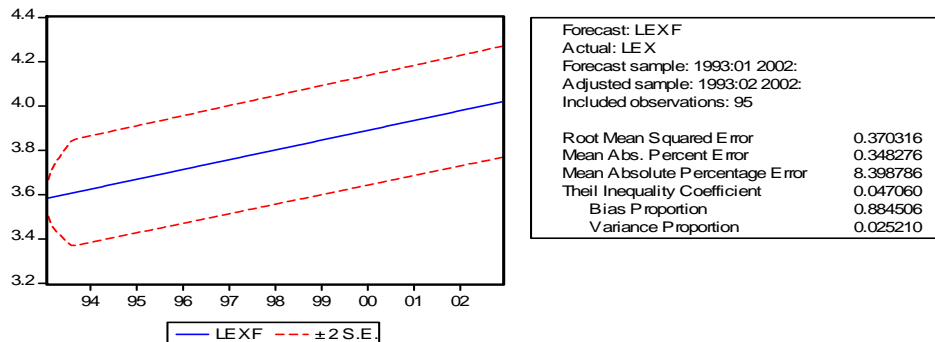
ARIMA (2, 1, 2) Actual and Fitted Values



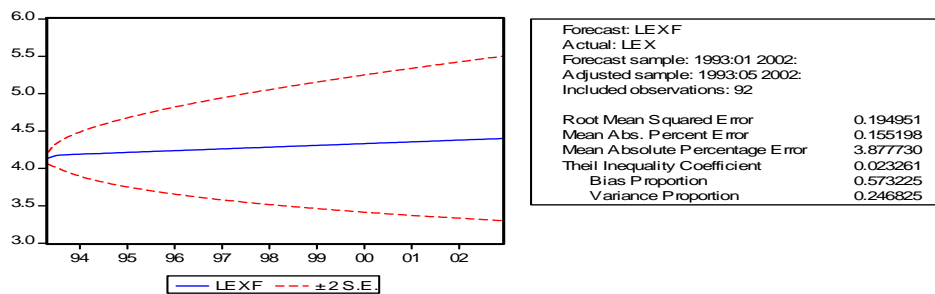
The results and the graphs suggest that the MA(8) fits the data better than both the AR and ARIMA process. We presented below the forecasts and forecast evaluation results from the

above models. In terms of the Theil inequality coefficient's disaggregation, the ARIMA(2,1,2) is the preferred forecasting model as more than 50 per cent of the variation is accounted for by the non-systematic component.

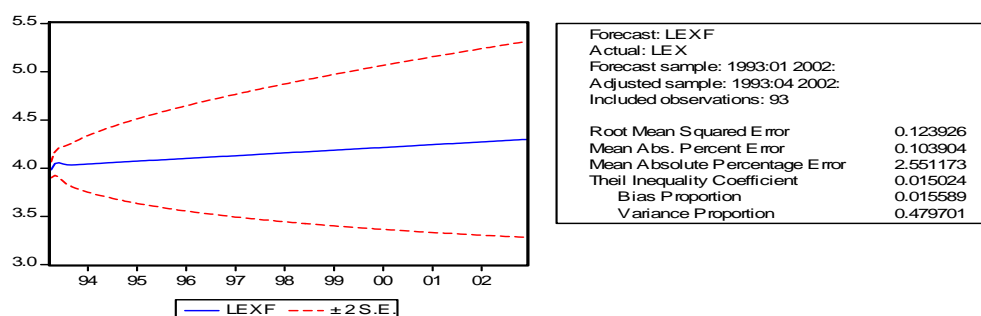
MA(8)



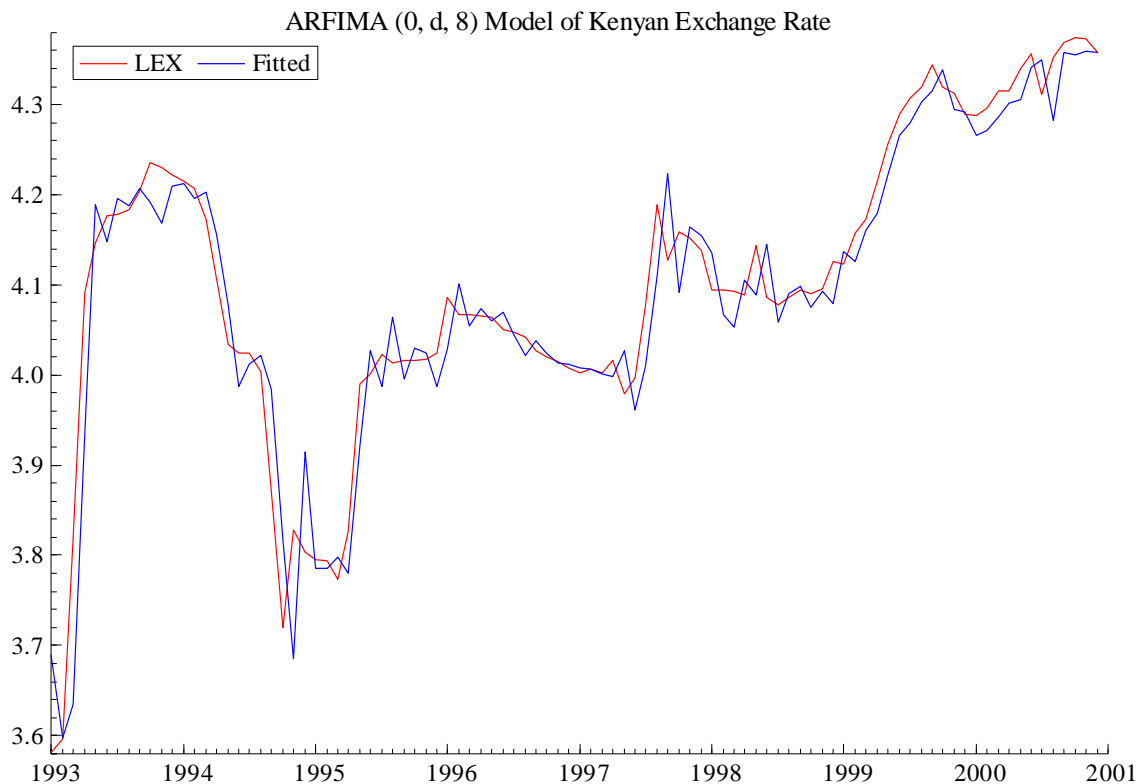
AR(3)



ARIMA (2,1,2)



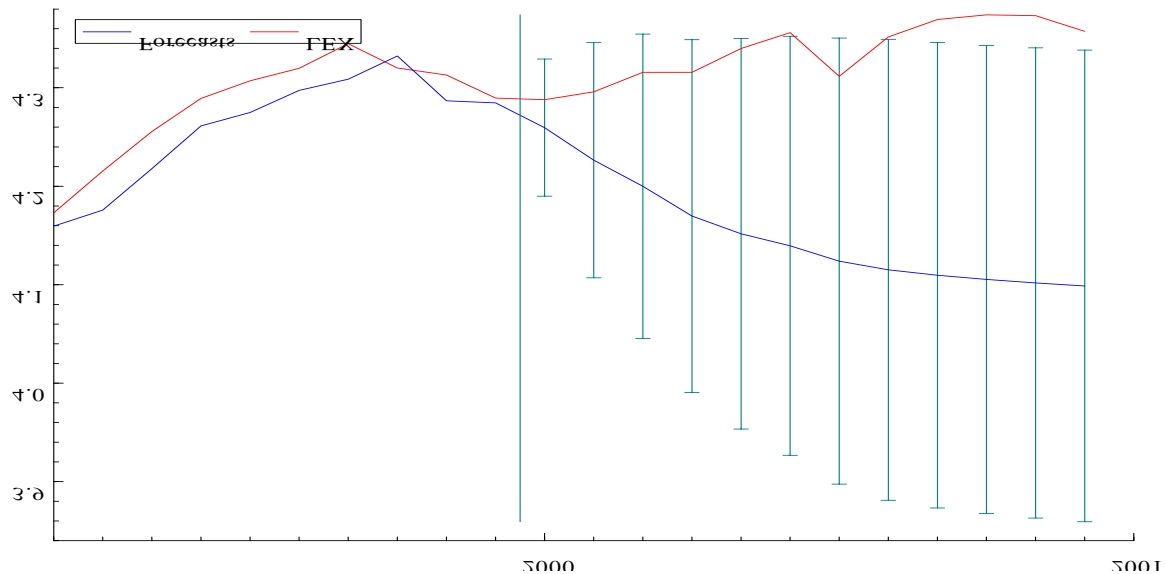
When the stationarity assumption is violated, rather than differencing the series once or twice until stationarity is achieved, the exact level of integration can be estimated in the ARMA process. This method is referred to as the fractional integration process- ARFIMA. Using this method, we found ARFIMA (0, d,8) to be the congruent model. The estimated fractional integration term (0.34) is positive and significant. The Akaike information criterion is also minimized with this specification. The graph of the actual and fitted values shown below reveals the good fit of this model.



To evaluate its forecasting behaviour, the model is estimated for the period from 1993 to the first month of 2000 withholding the data for 11 months for comparison purposes. We, then, forecast the exchange rate for the next 11 months outside our estimated sample period and compared the forecast values with the actual values. A statistical distribution for the significance of the forecast errors is also computed³. In the Figure below, this distribution with ± 2 sd (standard deviation) band is indicated by a vertical line with whiskers.

The model forecasts pretty well for the first three months and the forecast quality deteriorates continuously as the forecast horizon expands. Forecasts beyond the eighth month are outside the ± 2 sd error bands. This result is consistent with the other empirical forecasting models that show similar forecast deterioration.

³ Most standard statistical softwares such as PCGIVE derive this distribution.



Forecasting with regression

Apart from the univariate forecasting models, forecasting with regression is a popular method. The regression can take a single equation or multi equation format. The choice of the regression framework depends on the problem at hand and the feasibility for forecasting. In this section we will discuss how the single equation and multi equation forecasting models can be formulated and used. We will also briefly discuss the main estimation issues involved in multi equation models.

3.3.1 Single Equation Forecasting Models

The single equation model is the very basic forecasting framework. The model can be given as

$$y_t = \alpha + \beta x_t + \varepsilon_t \quad [41]$$

where y is the endogenous variable, x is the exogenous variable and ε is a random error term.

This simple model can be estimated by OLS or two stage least squares if we have an endogenous regressor. The equation can also be reformulated into an error correction format if there is nonstationarity in the variables. Once the coefficients of the model are obtained, the future values of the endogenous variable (y) can be forecast. The problem in this approach is that in order to obtain the forecast value of the endogenous variable, we have to supply the future values of the exogenous variable (x), which in turn necessitates forecasting the x values. In such a case the exogenous variables can be forecast in a univariate framework like ARIMA model as discussed in the previous section. The forecast values of the exogenous variable obtained from the univariate model can then be used, along with the estimated coefficients, to compute the forecast values of the endogenous variable.

The task of forecasting the exogenous variable in a univariate framework in order to forecast the values of the endogenous variable can be avoided if the aim is to forecast only one period ahead.

In this case, we can re-specify equation [10] by using the lagged value of the exogenous variable as a regressor.

$$y_t = \alpha + \beta x_{t-1} + \varepsilon_t \quad [42]$$

In this formulation a one period ahead value of the endogenous variable can be forecast using the current value of the exogenous variable. We examined the performance of this approach using the Kenyan exchange rate data. We regressed growth in the exchange rate on growth in the domestic price level for the period 1993:03 to 2000:10. Using this we can forecast the growth in exchange rate for 2000:11. According to our forecast, the exchange rate for November 2000 is expected to grow by -0.0009 per cent. The forecast accuracy is satisfactory as the forecast error is statistically insignificant with a t-value of 0.003.

Table 6.a
Single Equation Model

Dependent Variable: D(LEX)

Method: Least Squares

Date: 10/17/05 Time: 14:41

Sample(adjusted): 1993:03 2000:10

Included observations: 92 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003635	0.006088	0.597112	0.5519
D(LEX)(-1)	0.555226	0.274894	2.019780	0.0464
R-squared	0.043362	Mean dependent var		0.008457
Adjusted R-squared	0.032733	S.D. dependent var		0.054613
S.E. of regression	0.053712	Akaike info criterion		-2.988869
Sum squared resid	0.259646	Schwarz criterion		-2.934048
Log likelihood	139.4880	F-statistic		4.079511
Durbin-Watson stat	1.241066	Prob(F-statistic)		0.046380

Table 6.b
1-step Forecast Results from the Single Equation Model

Horizon	Forecast	SE	Actual	Error	t-value
2000-11	-0.000891306	0.05371	-0.000756	0.00013	0.003

Multiple equation forecasting models

Multiple equation forecasting models can take two forms- structural equations forecasting models and vector autoregression models. In the first case, we can have a set of individual structural equations that describe some behavioural relationships. These individual equations can be estimated using single equation information estimation technique (SEIE), limited information system methods, or full information system technique (Challen and Hagger, 1983). OLS, distributive lag class of models and ARIMA models can be classified as single equation techniques, while 2-Stage Least Squares (2SLS), instrumental variable estimation and limited information maximum likelihood (LIML) methods are classified as limited information system methods. Three Stages Least Squares (3SLS) and full information maximum likelihood (FIML) estimation techniques are examples of full information system methods. As their names indicate,

the main difference between these system estimation methods relates to the information content of the estimator. Another important difference is that single equation and limited information estimation techniques involve estimation of the stochastic equations one at a time while in the full information estimation methods all the stochastic equations are estimated simultaneously.

Once the individual equations are estimated, the next step is to solve the model- i.e solving for the values of the endogenous variables given the values of exogenous variables. This enables us to examine the fit of the model to the historical data since the fit of the individual equations does not guarantee a good fit in the system or in the complete model. According to Challen and Hagger (1983:164) “it is possible that every stochastic equation of the system performs adequately on the basis of the individual equation evaluation procedure but that the system as a whole gives a poor representation of the real economy in which the historical time paths of the endogenous variables were generated.” This may be the result of a more complex dynamic structure in the model as a whole than in any of the individual equations it is composed of (Oshikoya, 1990). The within-sample forecasting performance of the whole system should be assessed using standard statistical tools such as MSE, RMSE and Theil’s index discussed in the previous section.

The system methods require a sound theoretical specification, a consistent accounting framework and clear closure rules. Since Chapter 4 discusses these issues in detail, we limit the discussion here to the vector autoregression (VAR) method of forecasting.

VAR is the multivariate counterpart of the univariate autoregression framework. As opposed to the univariate model, VAR allows for cross variable dynamics. The VAR model is also important when we are not sure about the endogenous-exogenous classifications (i.e., the theoretical relationships) of the variables. In this approach all the variables are treated as endogenous. Consider the VAR model below:

$$\begin{aligned} y_t &= b_{10} + b_{11}y_{t-1} + b_{12}z_{t-1} + \varepsilon_{y_t} \\ z_t &= b_{20} + b_{21}y_{t-1} + b_{22}z_{t-1} + \varepsilon_{z_t} \end{aligned} \quad [43]$$

As can be seen from the above formulation, in a VAR model each variable is regressed on its lag and the lag of all other variables. The VAR model above is referred to as VAR (1) or VAR order 1 as the longest lag length is one. As in the univariate autoregression model, the lag length is selected using the AIC and SIC. Once the data congruent VAR is determined, it can be used to forecast the future values of the dependent variable. As all the right hand side variables are lagged values, we can have the 1-period ahead forecast easily. Using the 1-period forecast, we can forecast the subsequent period forecasts and so on. We used this approach to forecast the Kenyan exchange rate.

The first task was to determine the appropriate lag length. Given the available data, we started with VAR(4) and dropped the insignificant lag length while observing the change in the AIC and SIC in the process. Both the AIC and SIC are minimized at a lag length of two. The F-test does not reject the null hypothesis that the third and fourth lags are jointly insignificant, while the null hypothesis that all the higher order lags - except the first one - are zero is rejected. Thus, we selected VAR(2) as a congruent model describing the data properly.

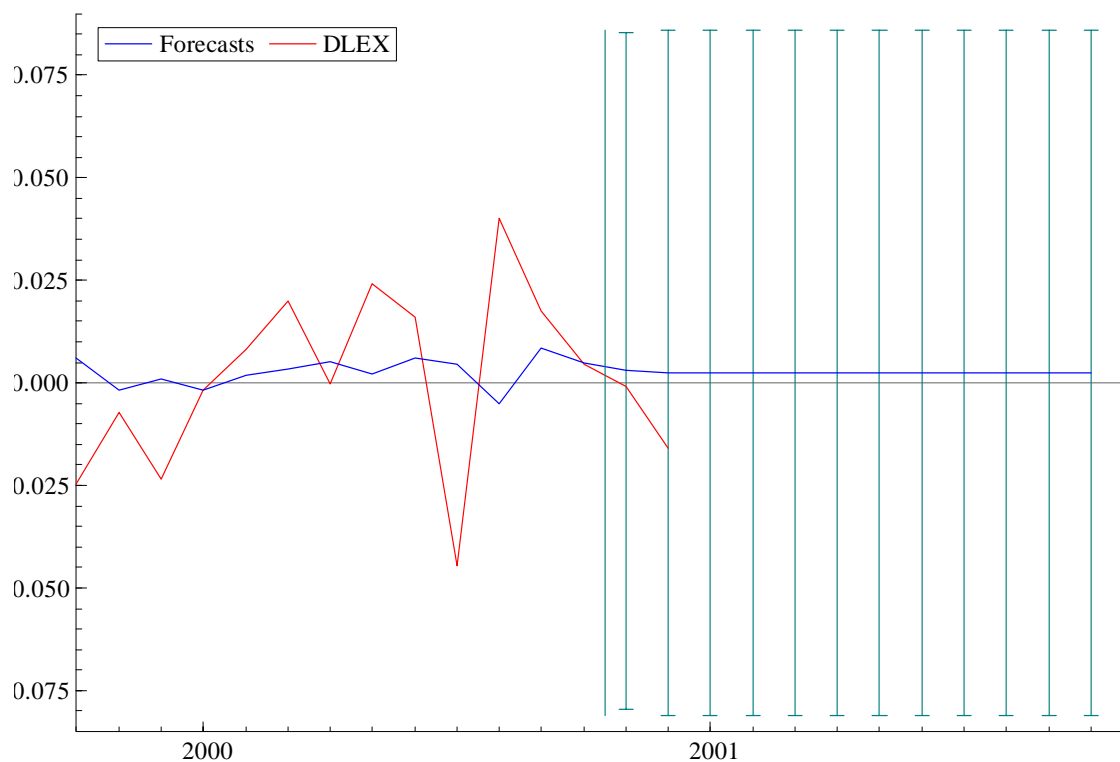
Table 7.a
Lag Length Selection

LAG	SC	HQ	AIC
4	-8.2292	-8.5296	-8.7325
3	-8.3952	-8.6288	-8.7866
2	-8.5724	-8.7393	-8.852
1	-8.6239	-8.724	-8.7917

Table 7.b
1-step Ahead Forecast Result from VAR (2)

Horizon	Forecast	SE	Actual	Error	t-value
2000-11	0.00292011	0.04123	-0.000756	-0.0037	-0.089

We estimated the model for the period 1993.03 to 2000:10 (October, 2000). Then, we forecast the growth in exchange rate for the month of November 2000. The forecast growth rate of the exchange rate for November 2000 is 0.003 per cent with the forecast error being insignificant with a t-value of -0.089 (Table 7.b). Overall, the VAR(2) model forecasts reasonably well, though the performance of the single equation model appears better (the forecast error was -0.0037 in the VAR model compared to 0.00013 in the single equation model).



Impulse response analysis using VAR models: An application with Kenyan and Ethiopian data

Impulse response is a method used for assessing the interaction among the variables in the VAR. It can be used either to assess the dynamic behaviour of the VAR or to investigate the policy impact of the variables that constitute the VAR. For instance, Chishti et al. (1992) constructed a macroeconomic model for Pakistan using a VAR approach. The VAR model contains ten 'key' macroeconomic variables used in stabilization programmes in many countries. The impulse response exercise is employed to examine the impact of conventional stabilization policies such as monetary and fiscal policy.

Impulse response analysis is carried out below by looking at the impact of a unit innovation in the random error term in the overall system. The impulse response function can easily be derived by reparameterizing our VAR model in [43] in the same way equation [37] was reparameterized into [38]. That is:

$$\begin{aligned} y_t &= \varepsilon_{yt} + b_{11}\varepsilon_{yt-1} + b_{12}\varepsilon_{zt-1} + \dots \\ z_t &= \varepsilon_{zt} + b_{21}\varepsilon_{yt-1} + b_{22}\varepsilon_{zt-1} + \dots \end{aligned} \quad [44]$$

By normalizing the MA representation by the standard deviation σ (this is usually referred to as Cholesky normalization factor), our impulse response function can be given as:

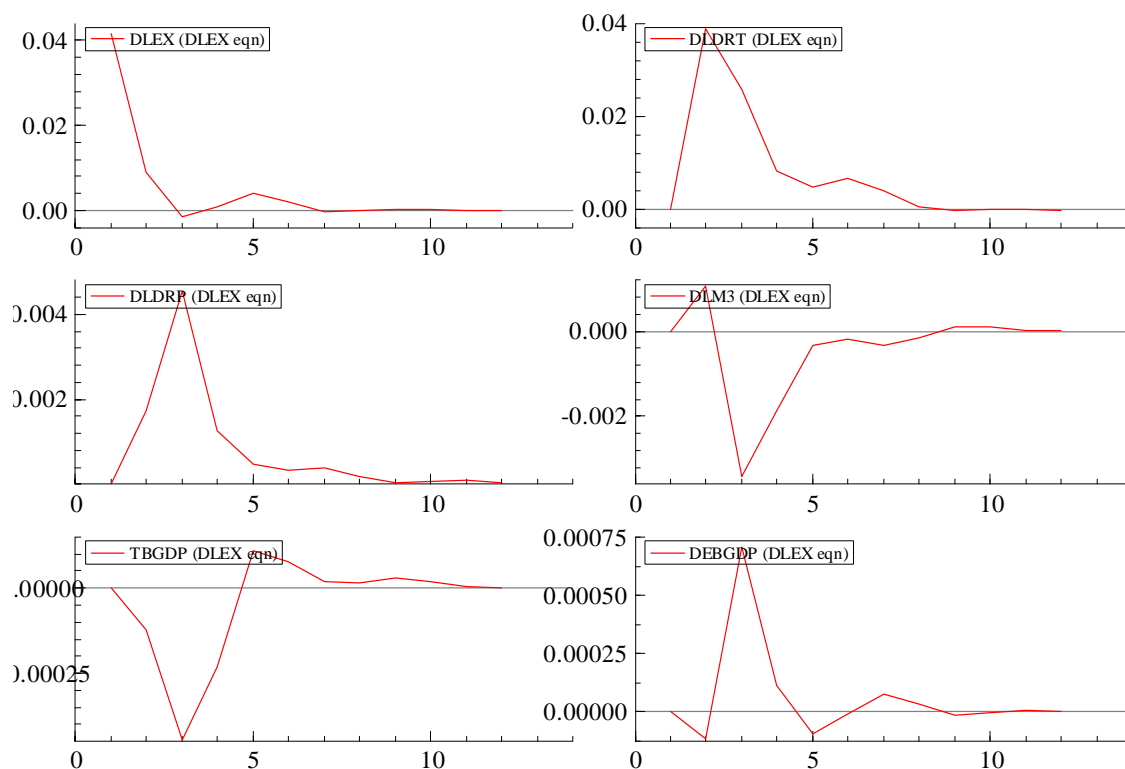
$$\begin{aligned} y_t &= \beta_{11}^0 \varepsilon_{yt} + \beta_{11}^1 \varepsilon_{yt-1} + \beta_{12}^1 \varepsilon_{zt-1} + \dots \\ z_t &= \beta_{21}^0 \varepsilon_{yt} + \beta_{22}^0 \varepsilon_{zt} + \beta_{21}^1 \varepsilon_{yt-1} + \beta_{22}^1 \varepsilon_{zt-1} + \dots \end{aligned} \quad [45]$$

The first equation contains only current innovation ε_{yt} , while the second equation contains two innovations ε_{yt} and ε_{zt} , implying that the ordering of the variables matters for our result. However, in practice, ordering does not matter. The β coefficients in equation [14] are referred to as impulse multipliers.

To show the importance of the impulse response analysis, we used the Kenyan exchange rate and Ethiopian GDP data. For the Kenyan exchange rate, we estimated VAR (1) including the exchange rate, prices, interest rate, money supply, trade balance and debt to GDP ratio. Since the data contained unit roots, we estimated the VAR in first difference except for the trade balance and the debt to GDP ratio. The impulse response's results signify that a one standard deviation shock to the innovation of the exchange rate equation leads to increases in interest rates, domestic prices and money supply, but a decrease in the trade balance. The result suggests that in an open economy, exchange rate depreciation may promote exports and lower imports, leading to improvements in the trade balance. As the demand for the local currency increases with the rise in exports, domestic currency may appreciate over time, implying that the improvement in the trade balance is only temporary. The depreciation of the currency also has a bearing on the domestic price level, depending on the weight of the import prices in overall price levels. As the figures below show, there is a hike in the price level following the depreciation of the exchange rate, which may propagate the rise in money supply to keep the real money balance constant.

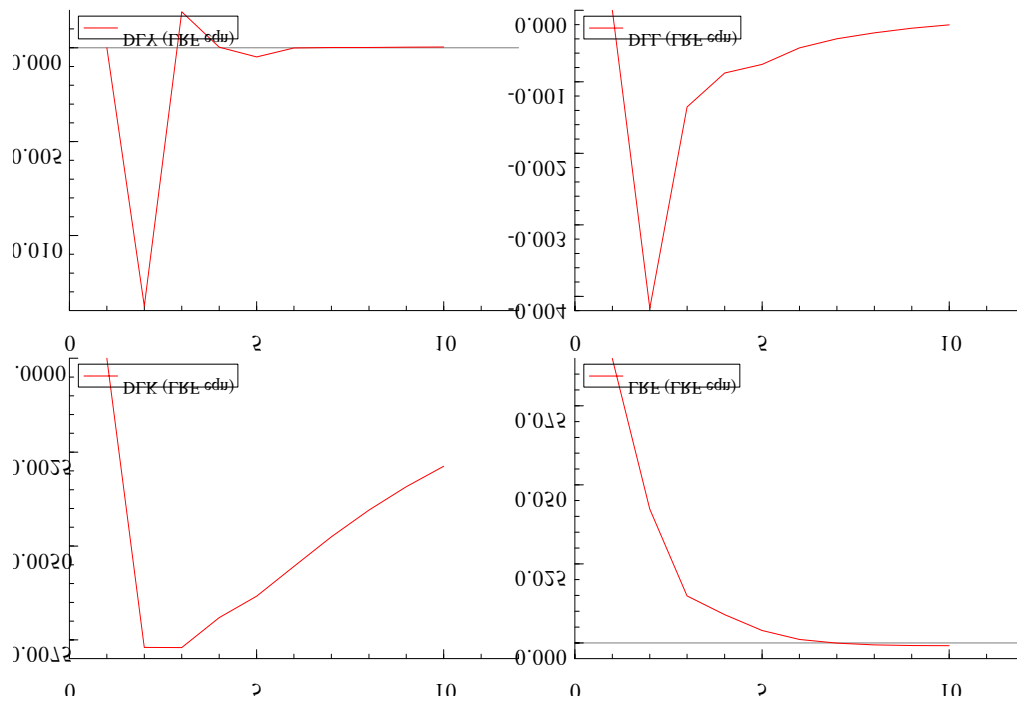
The impulse response analysis is an important and popular method for understanding how policies or shocks affect the variable in question. However, this method should be used

cautiously as its result would be altered significantly should there occur a deterministic shift that is not observed, and hence not modelled.



We used a similar approach to examine the impact of rainfall shocks on output using Ethiopian annual data. We specified our production function to include output, labour, capital and rainfall. As the data contained unit roots, we estimate the VAR in first difference. The SIC and AIC statistics suggest that VAR(1) is an appropriate specification. In estimating the VAR model, we faced a problem of ‘wrongly’ treating a purely exogenous variable- rainfall- as endogenous in our VAR model. To address this problem, we used a constrained full information maximum likelihood estimation method by constraining the coefficients of all other variables to zero in the rainfall equation. This method enables us to conduct impulse response analysis in a manner that is not possible had rainfall been treated as an exogenous variable.

The result of the impulse response analysis is presented below. The result shows that a one standard deviation shock in rainfall leads to a fall in output growth. The effect of this fall in output is observed in the period following the decline in rainfall. Since the impact of this shock is observed only in one period, the shock is clearly not persistent as it was expected. However, the impact of the shock on capital is much more persistent. The fall in capital may be explained by the consumption smoothing behaviour of agents that may involve sales of capital (such as oxen) in the face of drought to maintain the habitual (which is invariably subsistent) level of consumption.



In sum, this section shows the techniques of forecasting in a univariate and multivariate framework. Both approaches are important in forecasting economic variables and could be used in different circumstances. However, one should be aware of the limitations of this approach as forecasting is conducted in a partial equilibrium framework. Important feedback effects coming from the rest of the economy are disregarded. The next section addresses this problem by underscoring the importance of building economy-wide models for forecasting and policy analysis.

A simple model-based forecasting framework for Africa: A short-term solution

In the previous chapter we were concerned with only single and multi-equations partial equilibrium models. Although such modelling is important and useful in practical work, it is inadequate, as it does not take into account the overall interaction of macro economic variables in a consistent and theoretically sound framework. This chapter addresses this problem

Macro forecasting in a consistent accounting framework

The lack of a consistent macroeconomic data is a serious problem in many developing countries.⁴ This is particularly more acute in Africa, where the problem has two key manifestations. The first dimension relates to inconsistency across different sources in the country that provide basic economic data – namely inconsistency in macro variables obtained from different ministries or institutions. The second major data issue relates to conceptual inconsistency. As will be explained below, consistency between *National Accounts* and *Balance of Payments* data, for instance, requires that net factor payments and current transfers computed from the national accounts are the same as those computed from the balance of payments. This is often not the case in practice, however. Balance of payments data is usually compiled by central or national banks, while national accounts data is compiled by ministries of finance and economic developments that might use different conceptual approaches in data collection.

It is important to address these inconsistencies before conducting a macro model-based forecasting exercise. The rest of this section addresses these issues.

⁴ A rigorous presentation of national accounting was done in the 17th century based on the Works of William Petty in England. This has been followed by the work of Gregory King (1696) who developed national income estimates for England and Wales showing per capita income, expenditure and saving. The UN has also played a great role in standardizing national account statistics through the publication 'System of National Accounts (SNA)' which first appeared in 1953 (Luttik, 1998). The new SNA (UN, 1993) tackled much of the problems discussed in this section. It seems now that analytical consistency between BOP and SNA has been finally achieved.

National income accounting as a framework

An Integrated macro framework

Typically African countries are recipients of net foreign inflows, showing deficit in their current account balances. In addition, domestic capital expenditure normally exceeds domestic savings. Thus total domestic investment (I) is equal to domestic savings (S_n) and net capital inflows or foreign savings (F). That is:

$$I = S_n + F \quad [46]$$

F stands for net change in foreign assets and can be measured by current account deficit or surplus as follows:

$$F = M - X - N \quad [47]$$

where M and X are imports and exports of goods and non-factor services, respectively, while N represents net factor payments and current transfers from abroad. Rearranging equation [46] and disaggregating by institutional category yields:

$$\begin{aligned} (I_g - S_g) + (I_p - S_p) &= M - X - N \\ &= F_g + F_p \end{aligned} \quad [48]$$

where, as before, the subscripts g and p refer to the public and private sectors, respectively. Equation [48] states that the domestic investment- saving gap is the same as the current account balance or changes in the net foreign exchange position of the country.

The External Balance

(a) Exports and Imports

Of the three main items in the current account balance, X and M can easily be obtained from national account or balance of payments statistics.

(b) Net Factor Payments and Current Transfers from Abroad:

Net factor payments and current transfers from abroad (N) are not consistently reported in the national accounts and the balance of payments statistics of most African countries. N can be derived from national accounts data by subtracting gross domestic savings (S_d) from gross national savings (S_n). That is:

$$N = NFP + NTR = S_n - S_d \quad [49]$$

where NFP and NTR are net factor payments and net current transfers from abroad, respectively.

Major adjustment is sometimes needed when there is a discrepancy between the national accounts and balance of payments figures for net factor payments and current transfers from abroad ($S_n - S_d$). Depending on the assumption about the accuracy of national accounts data vis-à-vis balance of payments data, there are three options in dealing with this discrepancy.

First, if one assumes that the N computed from national accounts is correct, this value could be imposed on the balance of payments statistics. The resulting discrepancy in the balance of payments data will be accounted for in the variable *other net factor payments and current transfers of the private sector* (N_{po}). The second alternative is to assume that the net factor payments and current transfers computed from balance of payments data are correct. In such a situation, the value of N obtained from the balance of payments data should be used in computing the national saving rate. Assuming further that savings in the public sector are relatively accurately recorded, private sector savings could be chosen to account for the discrepancy between the N computed from national accounts and the one derived from the balance of payments data⁵. The choice between which data sources should be used depends on the nature of the analysis to be made using the data, as well as the relative confidence put on the accuracy of the two data sources. For instance, if the objective is to analyse changes in the external sector, it is reasonable to assume that the value of N computed from the balance of payments data is the correct one.

The third option is to maintain the discrepancy between data from the National Accounts and others sources (such as government finance and balance of payments) as a separate variable until the root cause of the inconsistency problem is addressed. This is the approach adopted in this manual (see the CD attached to this manual for the prototype forecasting macro model and the database).

(c) The Current Account Balance

The current account deficit (CAD) ⁶ is defined as:

$$CAD = M - X - N \quad [50]$$

As explained above CAD, X, and M are taken from national accounts. The individual items constituting the net factor payments and current transfers from abroad (N) are from the balance of payments statistics. Any inconsistency between the two data sources may be reconciled using one of the approaches outlined above.

Government Revenue and Expenditure, National Savings and Investment

(a) Government Revenue and expenditure

Government current revenue (T) and expenditure (G) represent the current revenue (including grants) and current expenditure of the public sector. Including grants (Gr) in Government current revenue (T) ensures consistency as the same item appears as a current transaction in the balance of payments. Similarly, government current expenditure (G) includes net interest payments (NIg).

Public sector savings could be derived as the difference between current government revenue and government expenditure, i.e.

$$S_g = T - G \quad [51]$$

⁵ Electronic data for 21 African countries build on the basis of these alternative assumptions could be obtained from the author.

⁶ Alternatively it is possible to define the current account BALANCE as $CAB = X - M + N$

Private sector savings could then be computed as a residual, i.e. the difference between total national savings (S_n) and public sector savings (S_g):

$$S_p = S_n - S_g \quad [52]$$

(b) Saving and Investment

Estimates of national savings and domestic investment are readily available from the national accounts statistics. These variables can be disaggregated across public and private sectors to define the resource gaps and needs of each sector: ($I_g - S_g$) and ($I_p - S_p$). This disaggregation can also be helpful in analysing changes in the balance of payments position.

Foreign Capital Inflow

The foreign capital inflow variable can be defined as the net change in the external asset and liability position of the country, i.e.

$$F = \Delta L - \Delta A \quad [53]$$

And can be disaggregated by sector as:

$$F_g = \Delta L_g - \Delta A_g + \Delta R \quad [54]$$

and

$$F_p = \Delta L_p - \Delta A_p \quad [55]$$

where ΔA and ΔL represent respective changes in assets and liabilities, F is foreign capital inflow with the subscripts denoting the public and private sectors, and ΔR denotes change in reserves.

Stocks of Assets and Liabilities of the Public and Private Sectors

Data on the long-term liabilities of the public sector (L_g) and the private sector (L_p) could be obtained from the debt data of the country. The short-term liabilities of the public sector (DS_g) could be computed as the cumulative sum of the net changes in short term liabilities that are usually reported in the balance of payments statistics. Similarly, the short-term external liabilities of the private sector (DS_p) can be calculated as the cumulative sum of net changes in its short-term liabilities. Foreign assets (reserves) owned by the public sector are derived from balance of payments statistics, while those of the private sector may be derived from various sources (see Alemayehu 1996).

Limitations and Accuracy of the Database

Although the national accounts framework allows correcting inconsistencies and disaggregating the data by institutional sectors it has many limitations that should always be remembered. First, it fails to address the root causes of inconsistency problems and merely tries to make the best use of the existing database or information. Second, the methodology of making adjustments may result in a systemic bias (over or under estimation) in the figures for some variables. Third, if the data discrepancy across different sources is high, the estimates - especially for external sector variables such as net external borrowing (F_p) - may be unreliable. Finally, when the approach of 'living with discrepancy' is adopted, policy analysis and making might be subjected to fundamental errors that might never be corrected.

Despite these limitations, the national accounts framework brings together seemingly separate statistical sources of information and provides filters for uncovering inconsistencies. The System of National Accounts (SNA) in most African countries is still based on the old concepts and standards published in 1968. It often provides a good description of the goods and services transactions (the sum of private and government consumption, private and government investments, exports and imports that determine national income), but not fail to account for the primary and secondary income transactions (i.e. wages and profit income, taxes from households and enterprises etc). However, using data from various institutional sources such as central statistical authorities, ministries of finance and planning and central banks we can construct a consistent database that is needed for the prototype African model. Based on the analytical description given in this section and discussed in detail in the Excel-based prototype model, the accounting framework on which the database is constructed is close to the revised/new System of National Accounts -NA2 - (SNA 1993).

Excel-based model for forecasting

Once a consistent database is constructed, the next step is to build a small macro model that attempts to capture the working of the economy. This mode can eventually be used as a framework for forecasting. In this section we will briefly outline the theoretical framework of such a model. The model we present in this manual is a modification of two recent models built for Kenya and Ethiopia by Micro Macro Consultants, BV of the Netherlands and Kenyan and Ethiopian experts. Theoretical discussion of the assumptions of the model is followed by a brief description of the model built in Excel platform. It is important to note that the full prototype model file is contained in the CD attached to this manual.

A. The Theoretical Underpinning of the Prototype Macro Model

The Real Model/Economy

The theoretical underpinning of the prototype model developed in this manual is based on Huizinga, *et al* (2001) and Alemayehu and Huizinga (2004). The economy is assumed to work as shown in diagrams 1 (the real sector) and 2 (nominal sector). The real sector includes private firms, parastatals and the public service sector. Output is produced according to a Constant Elasticity of Substitution (CES) production function with capital and labour as inputs. This production function may differ by sector. Demand for labour and investment depends on output level and factor costs, that is, the relative prices of capital and labour that determine firm profit. In addition to labour and capital costs, the productive sector pays indirect taxes and corporate taxes to the government and receives subsidies from it. Part of the remaining profits is distributed to households as corporate or non-wage income.

In the labour market, demand for labour is always met. Labour supply is determined by demographic factors, education, the unemployment rate (proxying the discouraged worker effect) and the net real wage. The first two factors are exogenous in the model and the latter two are endogenous. The wage rate is determined by a bargaining model, in which prices and the unemployment rate play a major role. The working of the informal labour market is usually not implicitly modelled, but it can be included in country models given the availability of data.

Income of households consists of wages and corporate or non-wage income, such as self-employment income, plus government transfers. Disposable income - gross household income less direct taxes on households - is the main determinant of consumption demand. In addition,

wealth and the interest rate may play a role. Disposable income minus consumption gives household savings.

The government receives direct taxes from households, corporate and indirect taxes (net of subsidies) from the production sector, and aid from the rest of the world. Aid is defined as grants plus the grant component of concessional loans.⁷ Government spending consists of transfers to households and government expenditure on goods and services. Tax rates are exogenous, but the tax base and thus tax income is endogenous. Aid from the rest of the world is exogenous. Transfers to households and government expenditure may be related to GDP or exogenously determined. Exceptions are payments that depend on the state of the economy and statutory obligations. The government deficit is the difference between tax and grant income and total government spending.

Exports are determined by prices in international markets, the real exchange rate, and the domestic production cost. Aggregate demand is given by the sum of investment, consumption, government expenditure and exports. Aggregate supply of goods and services comes from the rest of the world (imports) and from domestic production (value added). Import is exogenously determined. The demand for imports is modelled as a function of total demand and the real exchange rate. Total demand minus imports equals GDP at market prices. Output price depends on production costs, including the cost of intermediate imports, and the capacity utilisation rate.

For each agent the difference between income (the incoming arrows) and the spending (the outgoing arrows) represents savings (see Diagram 1). These savings may be positive (surplus) or negative (deficit). The savings of all agents flow to the financial market, where deficit units obtain financing through bonds, shares, loans and other forms. By definition the sum of lending and borrowing in the entire economy (including external transactions) is zero. Note that if the government savings are negative, i.e. it runs a deficit; funds (loans) will flow from the rest of the economy or from abroad to finance this deficit.

The nominal model

Diagram 2 gives an overview of the nominal economy. The yellow boxes denote demand and supply in the labour, goods and services, and money markets. The green boxes denote endogenous variables and the red 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 wage
- The real wage
- The nominal exchange rate
- The real exchange rate
- The nominal domestic interest rate (the 'holding' price of money)

Wages and prices are determined in the labour and product markets, as indicated above. There is a two-way relationship between wages and prices as indicated by the double arrow, so that there can be 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 the markets for domestic money and

⁷ In practice, grants are not included in the calculation of the budget deficit.

domestic bonds and the market for foreign assets. By Walras's law we only have to model two of these markets, and if these are in equilibrium, the third one will also be in equilibrium. We model the markets for domestic money and for foreign assets and leave the market for domestic bonds implicit.

We assume a floating exchange rate regime, so that money supply is an exogenous policy variable. Aggregate demand, the price level and the interest rate determine money demand. The interest is determined by the demand and supply of funds and moves to clear the money market.

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, and vice versa. The real exchange rate depends by definition on the nominal exchange rate, the domestic price level and the foreign price level.

The Main Feedback Mechanism of the Model

The model is built mostly along the standard lines of the aggregate demand – aggregate supply (AD-AS) framework. It is demand driven in the short run, with multiplier effects that work through changes in consumption and investment. We assume that any demand is actually met, that is, we assume that the price system ensures that there is always some excess capacity in the economy. High demand leads to high capacity utilisation rates of capital and low unemployment rates. This may, in turn, causes wages and prices to increase. Assuming that the resulting inflation is not accommodated by an increase in the growth rate of money, higher prices lead to higher interest rates and a real appreciation of the exchange rate, causing a reduction in investment and exports. In this way the model has a tendency to return to equilibrium with 'normal' capacity utilisation and unemployment rates in the medium and long run.

These main feedback mechanisms in the real economy – that work through the wage-price spiral – as well as the interest rate and the real exchange rate mechanisms are illustrated in Diagram 2. For instance, an increase in aggregate demand raises labour demand, reduces the unemployment rate, raises wages and starts a wage-price spiral. The resulting inflation causes a real appreciation, a reduction in competitiveness and a reduction in exports. In addition, the demand for money increases, resulting in higher interest rates and lower investment. The drop in exports and investment reduces demand again, until equilibrium is restored.

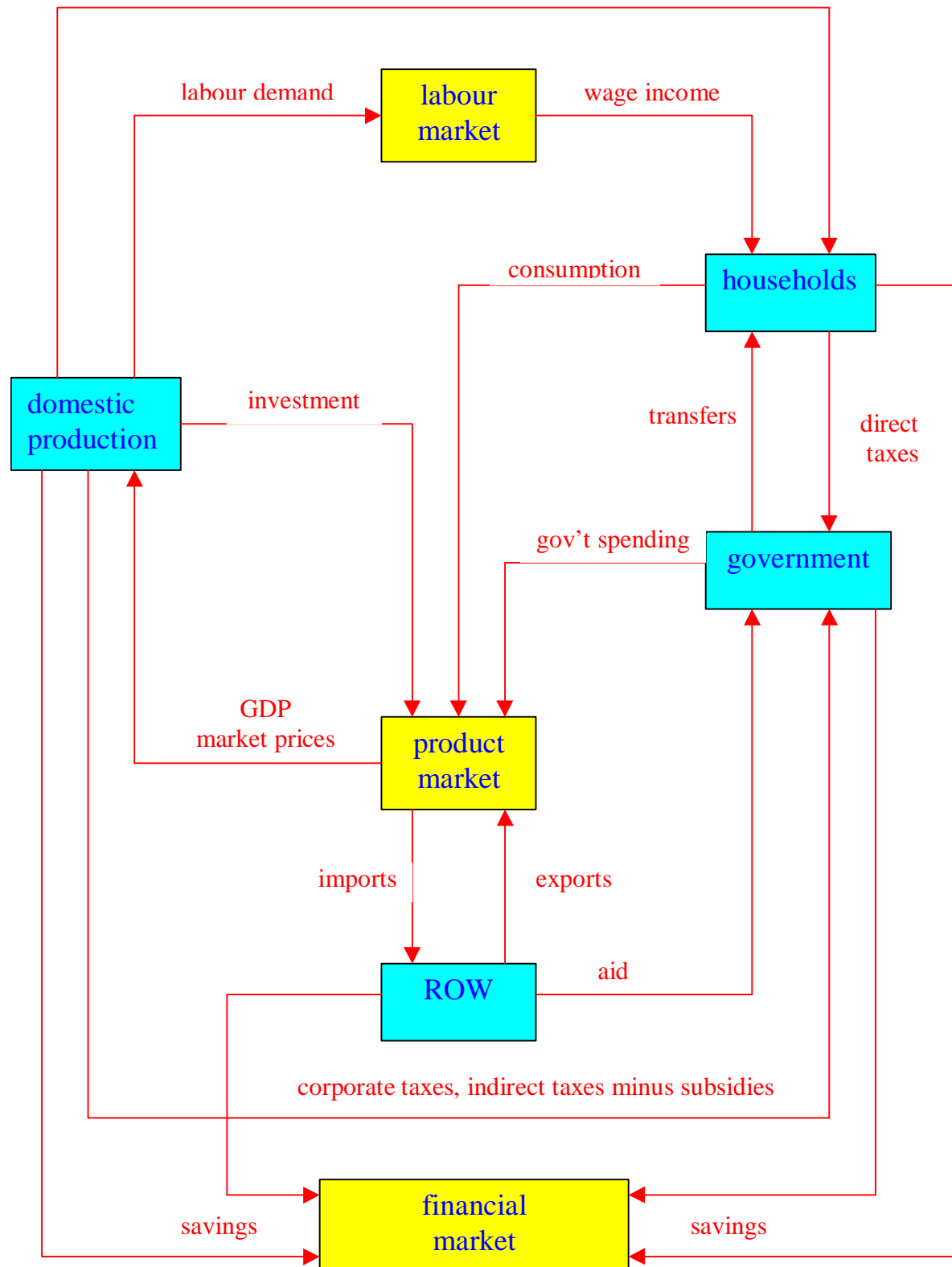
Even though total demand may be stabilised in this way, the feedback mechanism may well change the composition of demand. For instance, if the original increase in demand came from an increase in government spending, the net result will be a shift from exports and investment to government spending, resulting in a government deficit and a current account deficit.

Moreover, the above illustration is only valid if the money supply is not accommodating. If the money supply rises in response to inflation to sufficiently cover any increase in money demand, domestic interest rates will not rise, and the reduction in demand caused by higher interest rates will be neutralised. If money supply is raised even further, the nominal exchange rate will depreciate and part or all of the earlier real appreciation will be neutralised as well. Now the increase in demand is no longer countered by the feedback mechanisms, and inflationary pressure will continue⁸.

⁸ So, a policy of targeting the exchange rate so as to maintain purchasing power parity (PPP) is highly procyclical, causing large swings in the economy. (see Huizinga, et al (2001) and Alemayehu and Huizinga (2004) for detail).

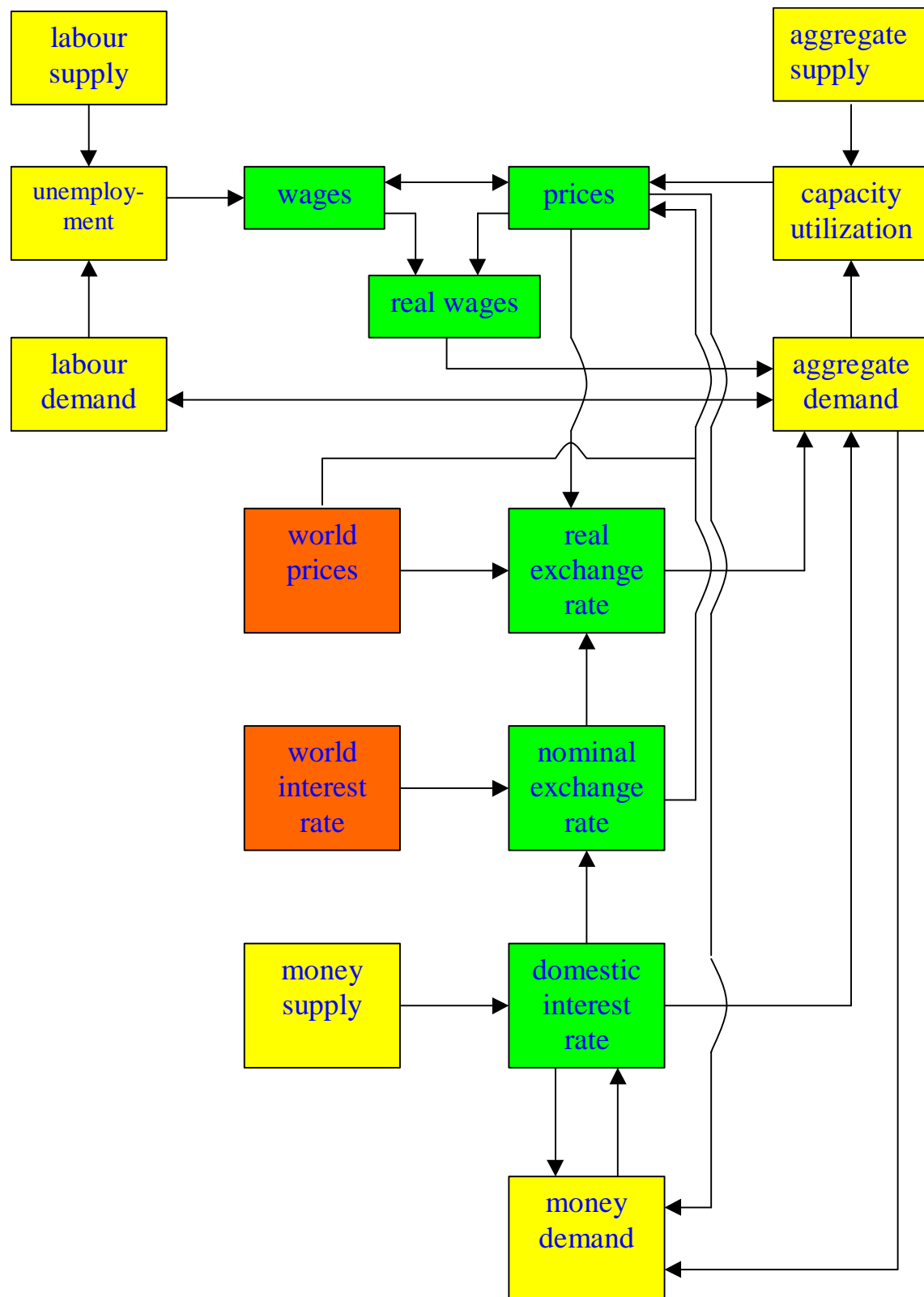
This brief theoretical description provides a framework for specifying the behavioural equations of the Excel-based prototype model. The reduced-forms of these behavioural equations are presented and discussed in the rest of this section. For the sake of brevity, we have deliberately avoided the derivation of these behavioural equations from first principles or discussing the econometric procedure required to estimate their parameters. Readers who are interested in an in-depth understanding of these models and their estimation may consult Huizinga, et al. (2001) and Alemayehu and Huizinga, (2004) and Alemayehu et al (2001).

Diagram 1: The Real Model



Source: Huizinga, et al (2001)

Diagram 2: The Nominal Model

Source: Huizinga, *et al.* (2001)

Reduced Form Behavioural Equations of the Model

We have outlined below the reduced form behavioural equations that are used in the prototype forecast model. These are equations derived from the workings of the economy as described above using the two flow diagrams.

Theory of Prices:

Consumer Prices:

For consumer prices the estimable counterpart of the reduced form equation is

$$\dot{P}_t = \beta_0 + \beta_1 \dot{W}_t + \beta_2 \dot{P}_{m,t} + \beta_3 \dot{r}_t + \beta_4 q_t + \beta_5 \dot{P}_t^{comp} + \varepsilon_t \quad [56]$$

Where the dots denote percentage changes in variables. In the above equation the consumer price (P) is specified as a function of the labour cost per unit of output (W), import prices (P_m) and real interest rate (r). q and P^{comp} are indicators of capacity utilization and competitors' price, respectively.

Export Prices

The theoretical underpinning of the export price equation is fundamentally the same as that of the consumer price equation discussed above. The estimable export price function is:

$$\dot{P}_{x,t} = \beta_0 + \beta_1 \dot{W}_t + \beta_2 \dot{P}_{m,t} + \beta_3 \dot{r}_t + \beta_4 q_t + \beta_5 \dot{P}_t^{comp} + \varepsilon_t \quad [57]$$

where $P_{x,t}$ is the price of exports and all other variables are the same as defined before.

Investment Price (cost)

Similar to the above equations, the estimable investment cost (price) equation is given by:

$$\dot{P}_{I,t} = \beta_0 + \beta_1 \dot{W}_t + \beta_2 \dot{P}_{m,t} + \beta_3 \dot{r}_t + \beta_4 q_t + \beta_5 \dot{P}_t^{comp} + \varepsilon_t \quad [58]$$

where $P_{I,t}$ is the investment cost or price; all other variables are as defined before.

Wage Rate Determination

The wage rate is given by:

$$\dot{w}_t = \beta_0 + \beta_1 \dot{p}_{t,c} + \beta_2 \dot{h}_t + \beta_3 \Delta \log(1 + s_{t,l}) + \beta_4 \Delta \log(1 - s_{t,f}) + \beta_5 \dot{u}r_t + \varepsilon_t \quad [59]$$

Wage Employment

$$\dot{L}_t = \beta_0 + \beta_1 \dot{\omega}_t + \beta_2 \dot{Y}_t + \beta_3 \dot{\pi}_t + \varepsilon_t \quad [60]$$

Where ω = real wage; and all in the difference of log (growth rate).

Private Investment

$$\left(\frac{I_t}{K_{t-1}}\right) = \beta_0 + \beta_1 \dot{Y}_{it} + \beta_2 \dot{P}_{it} + \beta_3 \dot{P}_{yt} + \beta_4 \dot{\pi}_{t-1} + \beta_5 q_t + \varepsilon_t \quad [61]$$

The constant term β_0 is an aggregate term, which captures the effect of depreciation and real interest rate changes that are not explicitly included in the equation. This simplifies estimation. It is also possible to explicitly incorporate the real interest rate at estimation level and see its plausibility.

Import Demand

The estimable import demand equation in the model is specified as follows:

$$\dot{m}_t = \beta_0 + \beta_1 \dot{z}_{t,m} + \beta_2 \dot{p}_{t,m} + \beta_3 \dot{p}_{t,y} + \varepsilon_t \quad \beta_1 \geq 1; \beta_2 < 0; \beta_3 > 0; \beta_2 = \beta_3 \quad [62]$$

This equation can be simplified using one relative price variable with GDP (Z) as a scale variable:

$$\dot{m}_t = \beta_0 + \beta_1 \dot{z}_{t,m} + \beta_2 (\dot{p}_{t,m} - \dot{p}_{t,y}) + \varepsilon_t \quad \beta_1 \geq 1; \beta_2 < 0 \quad [63]$$

The price of imports in the above equation is given by the exogenous price of imports in foreign currency ($p_m^{\$}$), the exchange rate (e) and the import tariff rate (t_m). That is:

$$\dot{p}_{t,m} = \dot{p}_{t,m}^{\$} + \dot{e} + \frac{\Delta t_{m_t}}{1 + t_{m_{t-1}}} \quad [64]$$

Employment in the Informal Sector

Employment in the informal sector is specified by earnings in the informal sector, earnings in other sectors of the economy (earnings in the formal sector used as a proxy), previous levels of employment in the informal sector and labour productivity. The wage rate for the business sector is used to represent earnings in the formal sector. Data for earnings in the informal sector is difficult to get but one may approximate it by the minimum wage rate in the formal sector.

Private Consumption

Leaving out the wealth variable for lack of reliable wealth data in many African countries will result in the estimable private consumption equation:

$$C_t = \beta_0 + \beta_1 r_t + \beta_2 Y_1^d + \varepsilon_t \quad [65]$$

where r and Y^d are real interest rate and disposable income, respectively.

Exports

$$\dot{X} = \beta_0 + \beta_1 \dot{W}_t + \beta_2 \dot{P}_{xt} + \beta_3 \dot{P}_{wxt} + \beta_3 e_t + \beta_4 \left(\frac{i}{y}\right)_t + e_t \quad [66]$$

Where W , P_{xt} , P_{mxt} and i/y are world (trading partners) income, price of exports, world price of exports and the investment to GDP ratio, respectively.

Money Demand and Domestic Nominal Interest Rate

The monetary block in the model is not very detailed. This is partly attributed to the focus of the model on budgeting and fiscal planning. Thus, the equation for money demand is specified as:

$$\hat{M}2^d = \alpha\hat{Y} - \beta\Delta i + \gamma\dot{p} \quad [67]$$

Where Y is the real GDP and i is the nominal interest rate. The estimable counterpart of equation [67] is given by:

$$\dot{M}2_t^d = \beta_0 + \beta_1\dot{Y}_t + \beta_2\dot{i}_t + \beta_3\dot{p}_t + \varepsilon_t \quad \beta_1 > 0; \beta_2 < 0; \beta_3 > 0 \quad [68]$$

The stability of this function has to be tested, as an unstable function may not augur well with a macro model. The interest rate moves to clear the money market, and the nominal interest rate is a function of money supply, real demand and prices. That is,

$$\Delta i = \frac{1}{\beta_2} (\beta_1\hat{Y} + \beta_3\hat{p} - \hat{M}2^s) \quad [69]$$

The estimable version of this equation is:

$$\Delta i = \alpha_0 + \alpha_1\dot{Y}_t + \alpha_2\dot{p}_t + \alpha_3\dot{M}2_t^s + \varepsilon_t \quad \alpha_1 < 0; \alpha_2 > 0; \alpha_3 < 0 \quad [70]$$

Note here that in equilibrium the demand for money equation can be used to assess interest rate dynamics, as the latter is an inverted form of money demand.

An observation that is made in some countries such as Kenya is the existence of a possible money supply feedback effect. The feedback effect may be specified as a function of real output growth and the inflation target. If this feedback effect is given by:

$$\dot{M}_s = \beta_1\dot{Y} + \beta_2\dot{P} \quad [71]$$

Then it can be shown that the change in interest is governed by the deviation of inflation from its target. This is given as,

$$\Delta i = \beta_2(\dot{P} - P^{target}) \quad [72]$$

These are the core behavioural equations of the model, combined with the semi-behavioural equations that define the government revenue and expenditure, to constitute the prototype model.

The working of the prototype model in an Excel platform

The Excel-based model contained in the accompanying CD has five Excel sheets that are used to organize the data and build the model. These are:

- a) Sheet 'THEORY'
- b) Sheet 'SOURCE-ORIGINAL DATA'
- c) Sheet 'MODEL'
- d) Sheet 'FORECASTING OUTPUT'
- e) Sheet 'CARRY SIMULATION'
- g) Sheet 'SIMULATION GRAPHS'

a) Sheet 'Theory': This sheet gives a brief description of the theoretical base of the macro model. It summarizes the assumed working of the economy using a flow diagram of the real and the nominal economy. It also provides the estimable behavioural equations of the model. Although these behavioural equations are derived from first principles in the Kenyan and Ethiopian models, it is their reduced form that is provided here. Interested readers may consult Huzinga et al. (2002) and Alemayehu and Huzinga (2004) for details of such theoretical work. The behavioral equations specified on the sheet 'Model' are hyperlinked with this 'Theory' sheet for easy reference.

b) Sheet 'Source-Original Data': This sheet contains all original information or data as reported by the various institutions in the country. In this Excel sheet no computation is made so as to retain the original data intact. It is imperative to have as much time series data as possible with the source of the data explicitly and exhaustively written.

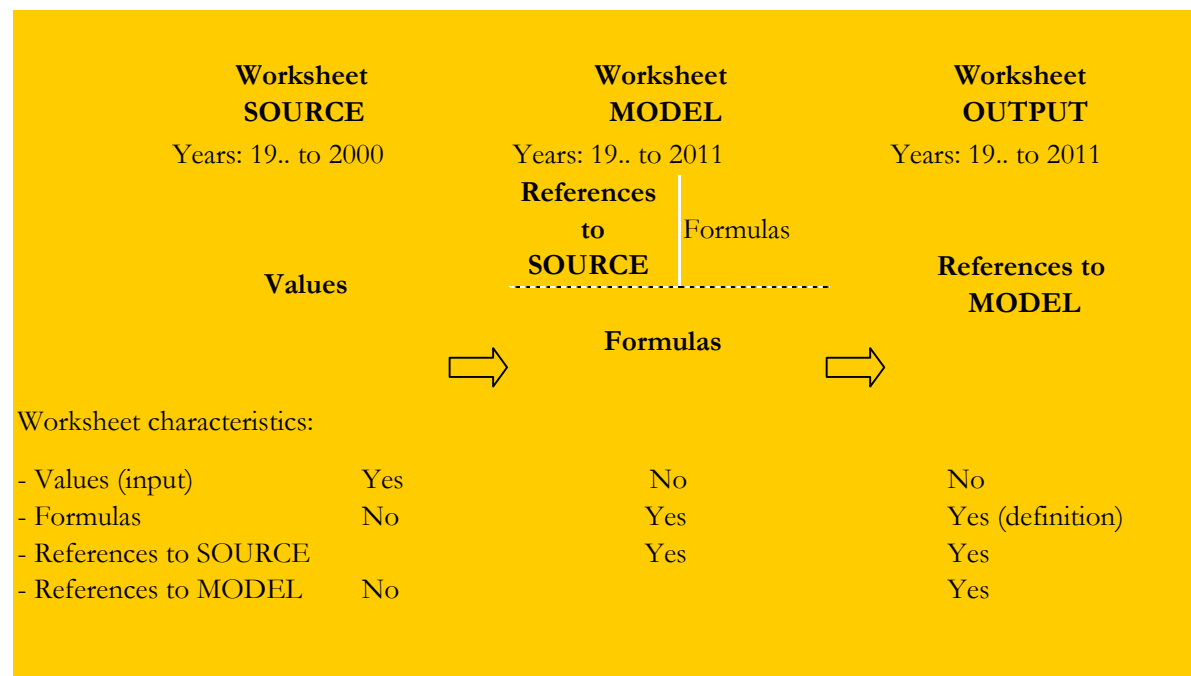
c) Sheet 'Model': In the Excel file sheet named 'Model' the values of the primary or endogenous variables are calculated based on information given in sheet SOURCE. The sheet MODEL has only formulas, no values are entered. The formulas show exactly how the primary macro variables are calculated from the source values. It is in this sheet that the construction of the consistency data framework is applied and consistency is realized. This sheet also contains the formula for the behavioural (such as investment, consumption etc.) and semi-behavioural (such government revenue) equations of the model.

d) Sheet 'Forecasting Output': In this part of the Excel file the output of the forecasting model, from sheet MODEL, for the forecasting period will be generated. This sheet could be designed in such a way that it accords to the demands of the various institutions (especially of the ministries that prepare the government budget) that need to report major macro variables. It basically picks forecast values from sheet MODEL.

e & f) Sheet 'Carry Simulation' and 'Simulation Graphs': in the 'CARRY SIMULATION' part of the Excel file based model, the experts could carry out policy simulations such as to simulate a rise in tax rate, a change in public investment, etc, to examine the overall impact of that policy on the economy. The sheet 'Simulation Graphs' provides the effect of such policy simulation in deviations from the base run (i.e. the forecast with no policy impulse) in a ready to use graphic format.

All these sheets of the Excel-based model files are hyperlinked in a consistent manner. This is to allow the model solve the endogenous variables, given exogenous (both policy related and truly external) variables of the model. This linkage is depicted in Diagram 3 below.

Diagram 3:
The Scheme of the Prototype Macro Model in an Excel Platform



Forecasting and policy analysis using expert opinion with a case study of the Kenyan macro model

There are at least two major functions of applied macro models: (a) forecasting; and (b) policy analysis. Both functions are important for applied economists (practitioners) in planning and budgeting processes as well as at the time when the government intends to introduce new policies. In this section we will explain these two functions along with a discussion on some practical issues in forecasting. Forecasting is usually characterized by the problem of uncertainty. One way of dealing with the uncertainty problem is the use of expert opinion. The sub-section begins by framing the use of expert opinion in a relevant (Bayesian) theoretical framework. This sub-section will be followed by a section in which we will explain the other important function of macro models – policy analysis by running simulation. In the section after that we will briefly present the experience of Kenya in using an applied macro model for forecasting and policy analysis.

The theoretical framework: expert opinion and the Bayesian approach to forecasting

(i) Expert Opinion / Judgment Approach

“Economic analysis is both a science and an art. Science enters through the use of sophisticated econometrics and rigorous theory. Art enters in order to deal with the shortcomings of science” (Reifschneider et al. 1997). Econometric models, whatever their level of rigor, may fail to pick up some important characteristics of the economy which may have a greater influence in forecasting the trend of the economy. More often than not, macroeconomic models are based on either quarterly or annual data, which leads to attaching zero weight to the ‘near-term’ developments. This neglect becomes significant when the ‘near-term’ developments are important in shaping the trend of the economy. Two examples illuminate this point. First, the impact of the oil price hike that happened after the latest quarterly/annual data were compiled would not be captured by the econometric model, notwithstanding its importance in influencing overall economic activity. Second, the oil price may be expected to rise due to the disruption in supply arising from, say, hurricanes. Given that the econometric model is devoid of this information, the forecast oil price may consistently be under-predicted. In both cases, the econometric model would fail to forecast reasonably. This necessitates the introduction of the ‘art’.

To augment the econometric model and include ‘extra-model’ information, we resort to the art of forecasting with extra model information. The most common art is the use of ‘judgmental’ forecast. Judgmental forecasts may involve, for instance, extracting information from sectoral experts, recent trends and expectations. The expert opinion or judgment, giving the information set that is not contained in the econometric model, may considerably diverge from the model’s prediction. This necessitates adjusting the model to replicate the experts’ judgment. The procedure to replicate the judgment is coined as ‘the add-factors’—i.e. subjective changes to the forecast depending on the forecaster’s judgment about the extra model information.

The judgmental approach has many advantages over using the econometric model alone. Macroeconomic models rely primarily on low frequency data such as annual and quarterly time-series data implying that potentially valuable information contained in monthly and weekly data is neglected. Interpreting such data is essential to explain the near-term dynamics of the economy, as we noted above. In the judgmental approach such information can be integrated with the econometric model, which improves the forecasting ability of the model.

The judgmental approach also facilitates the incorporation of anecdotal evidence into the forecast. Strikes, natural disasters, and other idiosyncratic shocks to the economy can have important timing effects on the economy, even if they rarely have persistent effects. For instance, a purely model-based approach might misinterpret a strike-induced decline in production or election-cum reduction in tax as likely to have average persistence, when a judgmental analyst would be able to recognize the shock as shorter lived (Reifschneider et al. 1997).

This approach would also serve as a framework to check for misspecification. Some important phenomena may be ignored when focusing only on one ‘robust’ model that fits the data better. It is possible that alternative specifications may be selected based on statistical tests. However, this procedure may preclude important details. For instance, a model of inflation can be specified in line with neoclassical or structural reasoning. Rather than picking one of the models based on their statistical fit, the forecaster’s judgment about the plausibility of the mechanisms of models plays an important role in reducing the problem of misspecification.

However, this approach does come with some cost. First, it is difficult to examine the judgmental model with the battery of statistical tests. Second, the flexibility in the judgmental approach gives opportunity for indiscipline and lack of rigor. This may be manifested on forecasts being heavily reliant on the most recent data observations; and on inconsistency of judgments over time even if the events are similar (Reifschneider et al. 1997).

(ii) Bayesian Approach to Forecasting

The other approach that introduces beliefs and judgment in a theoretically consistent fashion is the Bayesian approach. Under the Bayesian approach, prior beliefs about parameters are combined with sample information to create updated or *posterior* beliefs about the parameters. In the case of *empirical Bayes* estimators, the prior information comes from the sample data as well. The posterior information is proportional to the product of the prior information and the sample information.

In relation to forecasting, the Bayesian approach is important in two aspects: Bayesian model averaging and Bayesian VAR (BVAR) approach for forecasting. When there is model uncertainty – i.e. no clear evidence about a superiority of a model – relying on a single model might lead to missing important phenomena. The Bayesian model averaging (BMA) approach addresses this issue by combining different competing models. This approach is specifically important when the investigator is uncertain about the robust model and when the experts' opinions vary widely. Despite this interesting feature of the Bayesian model averaging, it is not yet part of the standard data analysis tool kit due to the fact that implementation of BMA presents serious computational difficulties.

Rather, BVAR is relatively popular. The Bayesian approach to VAR modelling starts with the assumption that the given data set does not contain information in every dimension. This means that by fitting an over-parameterised system, as in the unrestricted VAR, some coefficients turn out to be non-zero by pure chance. Since the influence of the corresponding variables is just accidental and does not correspond to a stable relationship inherent in the data, the out-of-sample forecasting performance of such models deteriorates quickly. The role of the Bayesian prior can therefore be described as prohibiting coefficients to be non-zero 'too easily' (Ramos 2003).

The BVAR approach imposes a priori values for the coefficients in the VAR. Litterman (1986) argued that determining the lag length by some criterion imposes some unreasonable truncation on the lag length and hence produces a break in ones prior information. Rather, he suggested including all the lags that are admissible computationally with a priori implying that the coefficients on the longer lags are close to zero.

The benefits of BVAR can be viewed from two perspectives. First, this approach does not require judgmental adjustment, which makes it more scientific and independent of the forecaster's belief. Second, it is simpler to run as compared to large econometric models. However, there is evidence that the forecasters' belief in BVAR is not as optimistic as in its early days. Bischoff (2000) showed that the forecasts of BVAR are inferior to other forecasts. Rather, expert opinion said large-scale models performed better on average than the BVAR. This approach is also what we suggest for users of this manual.

Bayesian VAR Modelling

Consider the VAR(p) model

$$y_t = d + \beta^* y_{t-1} + \dots + \beta_p y_{t-p} + \varepsilon_t \quad [73]$$

When the parameter vector β has a prior multivariate normal distribution with known mean β^* and covariance matrix V_β , the prior density is written as

$$f(\beta) = \left(\frac{1}{2\pi}\right)^{k^2/2} |V_\beta|^{-1/2} \exp\left[-\frac{1}{2}(\beta - \beta^*)' V_\beta^{-1} (\beta - \beta^*)\right] \quad [74]$$

The posterior density is derived as

$$f(\beta / y) \exp\left[-\frac{1}{2}(\beta - \bar{\beta})' \bar{\Sigma}_\beta^{-1} (\beta - \bar{\beta})\right] \quad [75]$$

where the posterior mean is

$$\bar{\beta} = \left[V_\beta^{-1} + (X'X \otimes \Sigma^{-1})\right]^{-1} \left[V_\beta^{-1} \beta^* + (X' \otimes \Sigma^{-1})y\right] \quad [76]$$

and the posterior covariance matrix is

$$\bar{\Sigma}_\beta = \left[V_\beta^{-1} + (X'X \otimes \Sigma^{-1})\right]^{-1} \quad [77]$$

In practice, the prior mean β^* and the prior variance V_β need to be specified. If all the parameters are considered to shrink toward zero, the null prior mean should be specified.

Litterman's (1986) prior is the popular prior. Litterman's prior is based on the belief that a reasonable approximation of the behaviour of an economic variable is a random walk around an unknown deterministic component.

For example, for a bivariate VAR(1) model, the BVAR(1) with Litterman's prior will be given as

$$\begin{aligned} y_t &= b_{10} + 1y_{t-1} + 0z_{t-1} + \varepsilon_{y_t} \\ z_t &= b_{20} + 0y_{t-1} + 1z_{t-1} + \varepsilon_{z_t} \end{aligned} \quad [78]$$

(iii) Forecasting and expert opinion:⁹ A Typical Forecasting Round

Forecasting institutions are likely to make two or three forecasts a year. When obliged by law, these forecasts are published. Publication is likely to correspond with the budget. In most cases, not all the details of the forecasts are published, where they might be very sensitive in terms of financial markets (exchange or interest rates) or for political reasons (the level of unemployment, budget deficit, public borrowing etc.).

At the start of the forecasting round in countries where this is institutionalised, Treasury ministers are invited to approve the broad assumptions of the forecasts. And at the end of the forecasting round they also approve the final forecasts. The Treasury forecasts represent the official view of the government, and the responsibility of ministers based on the advice of their officials. This approach might be criticised for being exclusive and some countries do not follow it. Hence, for institutionalisation purposes, it would be necessary to establish a group composed of economists from academia and outside academia, who publish forecasts regularly.

The typical outline of forecasting procedures is as follows:

- The first step in forecasting is usually to collect the latest data on the variables in the model. This is not a simple task. Even after the data is extracted the forecaster will need to spend some time examining the new data to check whether they are consistent with other information. Also, there is an inevitable lag between collection of data and its availability for use.
- Having assembled data (and estimates of the data) for the recent past, the next task is to assess how well (or badly) these data are explained by the model. This means calculating the residuals of each equation in turn and inspecting them for any systematic pattern.
- The next stage is to make projections of the exogenous variables. This involves the projection of the external environment as well as the setting of the economic policy. The technique explained in chapter 3 of this manual could be deployed for this purpose.
- The final element in the forecasting process is to project the residuals into the future, based on external evidence and the model's recent performance. The forecaster's judgment comes into play here.
- It is now possible to make an initial forecast. The plausibility of the forecast can then be assessed in terms of both its internal consistency and its consistency with other information about the economy, including survey evidence and other forecasts. An iterative process then begins which may lead to the final forecast diverging substantially from the initial one. A forecaster might have some clear prior expectations about products of the forecasts, and the forecast may be substantially amended to coincide with these priors.
- Then each forecast output can be examined by experts in each aspect of the model forecasts (say tax revenue experts, inflation experts etc) for their opinion. These experts will give their opinion based either on their experience or micro simulation models they might use at micro level in their respective departments. The forecasters then incorporate such opinions and re-run the model till a consensus among experts is achieved. This then will give the final forecast of the model for use in budget or plan preparation.

⁹ This section is based on Stephen Karinigi and Njuguna N'dungu (2001) and the author's experience in using the Kenyan and Ethiopian applied macro models.

In addition to forecasting, macroeconomic models could also be used for policy analysis. The methodology of policy simulations is discussed in the next section.

Policy analysis using simulation: a general approach

The small forecasting macro model presented in this manual could be used cautiously for analysis of either a particular policy or a package of policies. The former refers to a specific policy such as an increase or decrease in the VAT rate. The latter refers to a combined policy package (e.g. we may ask what is the implication of an increase in VAT rate, a reduction in excise taxes and import duties or an increase in government expenditure on major macro variables such as GDP, inflation, consumption, exchange rate etc.). By carrying out policy simulations, we can arrive at two scenarios: an outcome with and without (base run) such policy/policies. This could greatly improve the quality of proposed policies.

Policy analysis implies not only examining the implication of a particular policy on the economy but also exploring different policy options before reaching a decision point. This modelling framework can help to do such an exercise. Policy makers can experiment with different policy instruments that could bring about the desired outcome. The model could provide different scenarios for each instrument or combination of instruments used. Combined with expert opinion, this can help to make informed policy decisions.

Illustration of how to run policy simulation: Suppose you want to know what will be the effects on the economy and government finance if wages get an impulse of additional 2 per cent each year.

In the prototype model given in this manual you will go to your CARRY SIMULATION sheet and change the value 'zero' to 2 in the line item 'wages' and copy that to the forecasting period, 2006-2011. Push F9 (for recalculation if the default is not on "automatically"). Then look at the results in sheet MODEL, OUTPUT or SIMULATION GRAPHS in deviations from the base run. You will read the effect of this policy on major macro variables. In a similar way you may experiment with different policies or their combination.

Application in African set-up: the Kenyan KIPPRA-Treasure Macro Model (KTMM)

The Kenyan Treasury in collaboration with the Kenyan Institute for Public Policy Research and Analysis (KIPPRA) and Micro Macro Consultants/Institute of Social Studies (ISS), the Hague, has developed a detailed macro model from which the prototype model in this manual is developed. This model has been in operation since 2001 and the Kenyan government is using it for budgeting, MTEF and PRSP preparation and policy analysis. In this section we have briefly noted how this model is being used in Kenya.

As we noted above a macro model can be used for analysis of either a particular policy or a package of policies and their effect on major macro variables. Once a proposed policy or a package of policies is identified and plugged into the model, the model would provide the impact of the policy as deviations from the base run. A base run is the forecast of the model, say for the coming three years, without any policy impulse. The base run basically gives the model's own dynamics. The impact of the policy impulse is given as a deviation from this base run both in per cent and in absolute figures. One needs to be careful, however, to remove such policy impulses (set in sheet 'CARRY SIMULATION') from the model when running a new policy scenario.

Specific Simulations in KTMM

In the KIPPRA-Treasury Macro Model, there are two ways of running a simulation. The simplest one is to use HELP sheet where you put the desired impulse and examine the outcome. In the version that we developed in this manual this is done in the CARRY SIMULATION sheet. It is also possible to put the impulse directly in the MODEL sheet. The latter requires identifying the appropriate equation that needs to be changed and could be demanding for beginners. It is important for the model to be intensively tested by (policy) simulation runs before its use for policy analysis. This process provides the opportunity to uncover the simulation properties of the model. Examples of specific simulation questions that have been run by Kenyan treasury and KIPPRA experts are:

- What will be the effects on the economy and government finance if wages get an additional impulse of 2 per cent each year?
- What will be the effects on government finance and the economy of the 3 percentage points (from 15 to 18 per cent) increase of the VAT on local goods?
- What will be the effects on government finance and the economy of a 10 per cent increase in the corporate income tax rate?
- What will be the effects on government finance and the economy of a 10 percentage points increase in the marginal wage tax rate?

We can experiment with the effects of these proposed policies with the prototype model that we offered in this manual. Taking Kenya's experiment on the above policy issues, it could be shown that comparing the first two policy simulations shows how delicate the use of a macro model could be. For instance, in the first simulation one has to note that the impulse applies to each of the consecutive years. In the second simulation, however, because we are not interested to increase the VAT rate year after year by 3 percentage points, the impulse is only in the concerned year. The major difference lies in the way equations are modelled (in the latter case the previous period value is embodied in the current period and it forms the base). Thus, one needs to understand the model very well to properly use it. Once such policy simulation is carried out the next question is how to deal with model uncertainty (i.e. what is the guarantee that the simulated effect of a policy could possibly hold true?).

Dealing with uncertainty in macro-economic models

Once the modelling work is completed, an operational version of the model results. A baseline is constructed and the effects of various shocks and policy changes are analysed with the model. Further improvements of the model are made as the data sources become more consistent, and model equations are improved.

While these activities will certainly improve the model, it is important to recognize that they will not lead to a perfect model. Even the best macro models in any country are indeed far from perfect. It is important to realize that, and to assess what may reasonably be expected from further improvements. Thus there is a need to understand the limits to the model, the impact of uncertainty on model performance and diverse ways of dealing with them. As we noted above, one of the widely applied way of dealing with such problems is the use of expert opinions (the judgmental approach noted above). In Kenya, this has been widely done through the macroeconomic working groups that are constituted from major macro-related ministries and institutions such as the central bank, the treasury, and KIPPRA.

Forecasting

To use the KIPPRA-Treasury model as an example, there has not been a systematic check on the forecasting quality of the KIPPRA-Treasury model yet. There was an implicit check when the model was updated with the actual figures for 1999 and thereafter. The purpose of that update was to improve the baseline, but it was also apparent that whenever a significant part of the model was updated, the base forecast changed a lot. So, overriding the model forecast with the actual figures for 1999 had a big impact, which implies that the model forecast for 1999 was not very accurate¹⁰. However, recent updating reveals that the model forecasts are becoming increasingly reliable and extremely good. Although a model such as the KIPPRA-Treasury model is still very young and many improvements can still be made, poor forecasting quality is a general feature of macro models throughout the world and will, therefore, most likely also be a permanent feature of the KIPPRA-Treasury and other applied African models.

A recent study of the confidence intervals for the British HM Treasury Pre-Budget Forecast shows for instance that the 90 per cent confidence interval for the two year ahead GDP forecast has a range of 7 percentage points. More specifically, in 1997 the central forecast for 1999 GDP growth was around 1.5 per cent, and the 90 per cent confidence interval around it ranged from – 2 per cent to 5 per cent. The confidence interval for inflation, the key figure for the UK Treasury model, is equally wide.

A study of the forecasting quality of Dutch Central Planning Bureau (CPB) macro models shows similar results. The standard error for the one-year ahead forecasts for private consumption is about 2.3 percentage points, for business investment 9.6 percentage points, for non-energy exports 5.0 percentage points, for production of enterprises 2.5 percentage points, for the consumer price 2.5 percentage points and for the government deficit as a percentage of NNP 1.3 percentage points. The study also computed standard errors for four-year ahead forecasts, and they were, as expected, even wider. For instance, the standard error for the four-year ahead government deficit as a percentage of NNP is 6.0 percentage points. In general, one can say that the 90 per cent confidence intervals for the key macro indicators of models such as the HM Treasury and CPB models include almost the full range of actual post-war realizations.

The CPB study also identified four sources of uncertainty and computed the share of each of these sources to total forecast error. These sources are:

1. Preliminary data: 5 per cent
2. Model coefficients: 15 per cent
3. Non-policy exogenous variables: 50 per cent
4. Shocks in the individual equations: 30 per cent

The percentage figures give a rough indication of the relative contributions to the total forecast error variances. The study indicates that roughly 50 per cent of the total forecast errors are due to uncertainty in the non-policy exogenous variables, most importantly world trade. To a large extent the forecasts of these variables are taken from international organizations such as the IMF, World Bank, OECD etc. Since it is unlikely that their forecasting quality will improve in the near future, the 50 per cent of forecast error due to the non-policy exogenous variables is likely to stay. Improvements in theory, estimation and data collection could potentially improve the other

¹⁰ Another explanation would be that the actual figures are not very accurate, which is most likely also a true statement.

three items. However, it is widely expected that such progress will be slow and difficult, and to a large extent impossible because of the inherently complex nature of the economy and human interaction. Of course, the relative shares of the sources of uncertainty will differ by model and country (for instance data could be a major problem in many African countries), but the general conclusion still is that the degree of uncertainty quoted above is likely to be a permanent feature of model building.

What are the implications of these results? At first look, one wonders why economists still bother to build models at all. Indeed, many models have died after disappointment over such results. On the other hand, most well known institutions dealing with macroeconomic policy still use and develop models and there has been a rapid expansion of modelling activity in some regions as is happening in Africa. Why then do economists and institutions still build models? The first answer is that there is simply no alternative to use in rational decision-making. Decisions need to be made, and uncertainty is a fact of life. The best we can do in these circumstances is to make these decisions based on a coherent and consistent framework, while making due allowances for the fact that the forecast is uncertain. The latter part includes defining no regret policies, identifying the major risks to the economy through a scenario analysis and defining proper policy responses to these in advance.

Expert opinion and simulation properties

The second answer to the question why macro models are still built is that, in practice, things are not as bad as they look at first. The quoted standard errors are calculated based on the statistical properties of the model. In practice, the model is never 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 such as multi-year collective bargaining agreements or multi-year development aid programs, micro simulation models of specialized experts such as micro-tax experts.

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 specialists on different sectors of the economy. In turn, these specialists benefit from this exchange with macro economists, since they get a better picture of the overall economy. In practice, adding such outside information significantly reduces forecast uncertainty, especially for the short run. Of course, this requires that the different parts of government effectively cooperate with the modelling team.

Nevertheless, even in the best of circumstances, the degree of uncertainty in forecasting remains very high. Merely constructing a single baseline is, therefore, a risky operation, both for the modelling team and for the government that relies on it to formulate its policies. Uncertainty is, however, much less an issue when one considers the simulation properties of the model. In a simulation, one compares the model outcomes under the assumption that a particular event happens; say a change in expenditure or a change in the world price of coffee, with the baseline. These differences represent the model's response to this particular event. Within the model these differences are driven by the model's coefficients. This means that looking at the different sources of uncertainty listed above, only the second source, the coefficients, matter for simulation uncertainty. Uncertainty about non-policy exogenous variables, for instance, does not matter in the case of simulations. The reason is that whatever the level of, say, world trade, it will be the same in the baseline and in the simulation, affecting the baseline and simulation outcomes in the same way, and therefore not affecting the difference between the two outcomes. The same argument holds for the uncertainty due to preliminary variables and the shocks in the individual

equations. This implies that the simulation properties of the model are likely to be far more reliable than the forecasting quality may suggest. Indeed, in practical use, models play a far more dominant role in simulations than in forecasting. Thus the model may be fairly reliably used in formulating alternative scenarios around the baseline and in formulating no regret policies and policies to change the course of the economy in case it takes an unexpected turn.

Still, a word of caution is also important here. Generally, a translation has to be made from the shocks or policy proposals to be analysed into 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, 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. So, the full benefits of a macro model are only realized by a highly trained staff in close cooperation with experts in specific areas across the country.

Practical suggestions for building full-fledged macro models, estimated parameters and data for exercises

Major Features of Published African Models

Explaining the growth process in Africa is demanding both theoretically and empirically. The growth and adjustment literature is so wide and unsettled that it is difficult to come up with an appropriate analytical framework to help understand the growth process in many African countries. As noted by Taylor (1991) multiplicity of theories goes hand in hand with hierarchy of explanations – one can tell different stories at different levels of the economic system. At the risk of over simplifying issues we observe two strands in the literature of modelling growth and adjustment: at one level excess demand or supply may clear through movement of prices – price clearing; while at other times it may clear through quantity – quantity clearing. Which one of the approaches is appropriate in a particular country is an empirical question that is invariably informed by historical and institutional peculiarities of the country in question. Such choices need to inform the nature of macro models built in Africa.

A comprehensive survey of African macro models by Harris in the mid 1980s and other recent reviews (see Alemayehu 2002, Alemayehu and Daniel 2003) show that macro modelling in Africa is still in its infancy (Harris, 1985)¹¹. Harris surveyed most macro models of Africa, which have been constructed by North American universities and international institutions as well as published models of the African economy. He reports on a total of 184 macro models, 120 of which he evaluates. Harris classifies the 184 models, *inter alia*, based on their underlying structure: (1) demand driven Keynesian type models; (2) supply driven, general equilibrium with price adjusting to clear the market; (3) reduced form monetary driven; and, (4) models based on consistency checking, without formal closure). Tarp (1993) also provides an excellent

¹¹ This section relies on Alemayehu and Daniel (2004) and readers are advised to refer this for the citation of macro model authors given below.

assessment of the consistency of the macro framework advocated by the International Monetary Fund (IMF) and World Bank (WB) in Sub Saharan Africa, as well as the theoretical underpinnings of the ‘Stabilization’ and ‘Structural Adjustment Programs’ sponsored by these institutions.

In the African modelling literature, the framework used by the WB and IMF (and presented in chapter 2) is the most important analytical work that informs macroeconomic policy making. However, the growth and adjustment-modelling framework of the WB and IMF is critically evaluated, especially by the Structuralist School. The latter argues that this one-fits-all approach neglects the role of institutional and other unique features of each country. This limits the relevance of these models as well as policies derived from their use. Writing on policies that are derived from the WB/IMF models, Taylor (1989) states that ‘devaluation may cause output contraction; tight money may lead to price increases due to higher interest costs; inflation is likely to have its internal dynamics; and public investment may crowd-in private capital formation instead of [crowding] out. In the long run, the critics emphasise the importance of income distribution in conditioning the growth process. They are also sceptical about the virtue of liberalization and unfettered movement of trade and finance (Taylor, 1989: 4).

Apart from the WB and IMF models there are also other (published) African models, which are widely used to describe the growth and adjustment process in Africa. Some of these models could be characterized as demand driven models (see for instance Oshikoya (1990), Egawaikhide (1997) for Nigeria; El-Sheikh (1992) for Egypt). Similarly, there are also a number of applied demand-driven macro models in Kenya, the most influential ones being ‘The Macroeconomic Policy Model for Kenya – or the Chakrabarti Model’ and ‘The Medium to Long-term Macro Model for Kenya - MELT3’. There is also the new aggregate demand and supply based model called the Kenyan Institute for Public Policy & Analysis (KIPPRA)-Treasury Macro Model (KTMM). (See Karingi and Ndung’u (2000) for a review of Kenyan Models; and Huizinga *et al.* 2001 and Alemayehu *et al.* 2001 for the new model). With the dissatisfaction of demand-driven models in the 1970s and with the recognition of the supply-constrained nature of African economies, many supply-driven models were built since the 1980s (See among others, Asemerom and Kocklaeuner (1985) and Lemma’s (1993) model for Ethiopia; Lipumba *et al.*’s (1988) model for Tanzania; Van Frausum and Sahn (1993) for Malawi).

In the 1990s, CGE models began to emerge in the African modelling literature. Among others, Davies *et al.* (1994) and Decaluwé *et al.* (1994) constructed CGE models for Zimbabwe and Rwanda, respectively. Pleskovi (1989) has also constructed a computable general equilibrium model for Egypt¹² with the objective of studying fiscal incidence in that country. Benjamin *et al.* (1989)¹³ constructed a CGE model for Cameroon, which sets out to study the economic impacts

¹² Boutros-Ghali and Taylor (1980) also propose a SAM-based macro model for Egypt. However, since the formulation of this model is governed by ‘basic needs’ considerations, which are not the objective of this study, we do not examine this here.

¹³ A modified version of this model is found in Benjamin (1990). However, this model differs from the previous one in a number of important respects. Firstly, in its treatment of investment behaviour. Secondly, in how it deals with formal and informal financial markets. Thirdly, in the fact that it disaggregates sectors of the economy by institutions (both public & private). And, finally, in that it allows fiscal balance to affect interest rates and money supply. The model is then closed by making nominal exchange rate and foreign capital inflows exogenous. In this model the rate of interest (as cost of borrowing for investment and reward to saving) is given a strong role in allocation of resources, although the income effect and the inter temporal prices effect on saving and consumption is believed to offset each other. However, the rudimentary nature of most African countries’ money markets and rigidity in mobility of resources seems to contradict this basic mechanism of the 1990 model. Despite this setback the model

of an oil boom. As general equilibrium models, the common feature of these models is their closure rule that equates the demand and supply conditions in a flexi-price market set-up. Bodart and Le Dem (1996) have also constructed a macroeconometric model in a general equilibrium framework for Côte d'Ivoire. Van Frausum and Sahn (1993) have constructed an econometric model of Malawi, which sets out to measure the effects of external shocks and policies in that country. Similarly, Kwack (1989) has developed a prototype African model, which he applies to different African countries. Kouassi (1997) also constructed a structural cointegrating VAR based macro model for Côte d'Ivoire.

In sum, published macro models in Africa have generally the aim of studying the impact of external factors/shocks on the economy. Although a rigid classification of these models would be difficult since overlapping objectives are common, these models may broadly be grouped into those: (i) which focus on the impact of foreign capital and foreign exchange earnings on major macro variables (Lipumba *et al.* 1988, Oshikoya 1989, Davies *et al.* 1994); (ii) those that stress the impact of oil revenue (Olofin and Iyaniwura 1983, Benjamin *et al.* 1989, Benjamin 1990); (iii) those which focus on the impact of external shocks in general and the supply constrained nature of African economies in particular (Lipumba *et al.* 1988, van Frausum and Sahn 1993, Kayizzi-Mugerwa 1990); and, (iv) those that focus on analysing domestic macro economic conditions and government policies (Boutros-Ghali and Taylor 1980, Asmerom and Kocklaeuner 1985, Pleskovi 1989, Harton and McLaren 1989, Lemma 1993, Berhanu 1994, Decaluwé and Nsengiyumva 1994, Davies *et al.* 1994).

The lessons from these efforts to depict the workings of an African economy are manifold. First, African macro models should focus more on the supply-constrained nature of the economy. This may be done by concentrating more on the role of both intermediate imports, and hence foreign exchange constraints, (in the short to medium term) and on capital formation (as representing a longer run concern), as well as on their mechanisms of financing. This appears most relevant for most African countries. Second, sectoral adjustment (say between traded and non-traded sectors) could represent an important focus of the African models. And, finally, the government fiscal posture and the monetary sectors not only need to be linked, but also modelled taking the influence of the external sector into account. Given the burden of debt and the fiscal strain that brought on most African countries, this is also an important aspect of the African modelling literature, which a macro model needs to depict.

Notwithstanding such African modelling efforts, the current practice of modelling and forecasting in Africa has relied on the Harrod-Domar based (or ICOR-based) growth model and Gap approach. By adopting the estimated parameters from the published African models provided in the Table below, country experts may adopt this ECA based prototype model to suit their condition, which substantially departs from the Harrod-Domar based approach.

underlines the importance of observing sectoral adjustment over time, which could differ at different stages of a sectoral adjustment process. For example, in a situation of a booming sector, like that of oil in Cameroon, manufactures can contract in the short run but expand in the coming years.

Parameters form published African models

Malawi, (Musila, 2002)					
	In logs				
	capital	labor	Dlabor	Dprice	
Production Function	0.198 (one lag)	0.802	0.481	1.068	
	Disp (Y)	D(disp Y)	D(Cons) lag		
Private consumption	0.82	1.487	0.165		
	Real savings	real imported capital	govt invt exp	D(claims on pvt sector)	D(real saving)
Private investment	0.37	0.72	0.38	0.405	0.432
	Real Y	real imported capital	Real pvt invt	D(real imported capital)	D(real saving)
Government investment	0.124	1.058	0.328	0.786	0.289
	Y	DY			
Domestic tax revenue	1.123	0.794			
	Export	Dexport	DY	Dconsumer import	
Indirect tax revenue	1.577	0.426	0.576	0.229	
	Px/Pm	Y			
Export of services	-2.237	-6.944			
	Pm/P	Real Y	Forex/Pm	D(Pm/P)	D(Real Y)
Import of consumer goods	-0.639	0.445	0.149	-0.45	0.433
	Real Y	Forex/Pm	D(Forex/Pm)		
Import of plant machinery and equipment	0.812	0.107	0.15		
	Pm/P	Real Y	Forex/Pm	D(Pm/P)	D(Real Y)
Import of intermediate and services	-0.563	0.606	0.066	-0.525	0.706
	Real Y	Real foreign Y	D(Real Y)		
Labor demand	0.534	1.478	0.388		
	pop	cpi	D(CPI)	D(Real Y)	
Wage rate	1.327	0.541	0.337	1.377	
	(Wage*Labor)/Y	Pm	D(Pm)	D(M1/P)	Dwage
Price/ GDP Deflator	0.146	0.854	0.29	0.249	0.717
	(Wage*Labor)/Y	Pm	D(Pm)		
Consumer price/ CPI	0.166	0.834	0.46		

Definitions: D: First difference; disp: disposable, Pm: import price, Px: export price, Y: output; pop: population

Ff

Zimbabwe, Elbadawi et al. 1991					
In logs					
	Permanent Disposable Y/Disposable Y	Permanent real public saving/Disp Y			
Private consumption	0.12	0.67			
	Interest	Y/K	Profit/Y	Money/Y	InvtP/P
Private investment	-0.18	0.25	0.32	1.8	-0.12
	PX/PX OECD	Y OECD/Y			
Export demand	-0.06	0.07			
	nominal R (not log)	Y			
Money demand	-4.45	0.34			

Variable labels: invtP: investment price; PX OECD: price of export of OECD countries

Tanzania				
In logs				
	Disp (Y)			Source
Private consumption	0.9264			
				Tanzania, Lipumba, et al. 1988
	Non agri Y			
Domestic tax revenue	0.1361			Tanzania, Lipumba, et al. 1988
	Import			
Indirect tax revenue	0.0186			Tanzania, Lipumba, et al. 1988
	PX/ CPI	Y		
Export supply	-0.008	0.529		Tanzania, Feltenstein, et al. 2002
	Y	Inflation	lagged M	
Money demand	0.334	-0.1	0.921	Tanzania, Feltenstein, et al. 2002

Variable label: Non agri Y: Non agricultural output

Oil Importing Developing Countries					
	In logs				
	capital	Dpcom	Dpoil	M/P	Source
Production Function	0.499	-0.039	-0.026	0.072	Oil importing developing countries, Beenstock (1995)
	DY	Interest	capita/gdp	Y/K	
Private investment	21.2	-0.296	-18.89		Oil importing developing countries, Beenstock (1995)
	PX industrial/PX	DY ind country	Y ind country	M of oil exporting countries	
Export demand	0.433	0.741	0.293	0.097	Oil importing developing countries, Beenstock (1995)
	PX.E/P	capital (-1)	P of nonoil exp	P of oil	
Export supply	0.285	1.59	0.131	0.102	Oil importing developing countries, Beenstock (1995)

Variable label: P of nonoil exp: price of non oil export

The road to full-fledged macro model – a sustainable and lasting solution

In this manual we have attempted to synthesize the applied forecasting macro models of Kenya and Ethiopia for possible adoption in other countries. This effort needs to be understood as a short-term solution to address the problem of lack of a workable tool in current practice of forecasting in many African countries. The current practice, as we noted in this document, suffers from both analytical and data inconsistency problems.

It has to be understood, however, that this effort is an enormous simplification of the Kenyan and Ethiopian applied macro models (see Huzinga et al. (2001) and Alemayehu and Huzinga 2004 for detail). The actual models constructed in each of these countries are made up of hundreds of equations based on detailed sectoral and institutional information, have a deeper theoretical and econometric formulation or rigor and most importantly are specific to each country, capturing its unique features.

Thus, the way forward for the rest of African countries that may adopt this manual to address their short-run problems is to construct such an elaborate macroeconomic model that will be based on each individual country's data by capturing the specific features of the economy. Such work also needs to have a cadre of macro model experts in the relevant ministries and the academia as a back up to cope with techniques of theoretical and estimation development in a continuous manner. There is also a need to produce a cadre of modelling experts by conducting continuous training in macro modelling. This is important given the high shortage of experts in this area and the need to ensure the long-run sustainability of macro modelling exercises in Africa. Thus, African countries need to do that as a lasting solution to the problem of weak forecasting and policy analysis that they do suffer from.

The development of such modelling and data framework is also very important for the Economic Commission for Africa (ECA). This is because ECA could use the framework adopted by the pilot countries in each region to construct a regional macro database and macro model. These would be used to generate the annual growth forecasts of the continent and its constituent regions that will be used in its annual flagship publication the Economic Report on Africa.

Excel and Eviews files for practicing forecasting

This manual contains a CD Rom that includes the following:

- (a) A Manual in PDF format
- (b) The Prototype Macro Model in Excel Platform
- (c) The data used for the forecasting exercise in chapter 3, including:
 - (i) Kenya's Exchange Rate Data
 - (ii) Mozambique's Price Data
 - (iii) Ethiopia's GDP Data
 - (iv) Ghana's GDP data

References

- Alemayehu Geda (1996) Macro Data and Macroeconomic Analysis: The Relevance of A Consistent Macroeconomic Database in Ethiopia, *Ethiopian Journal of Economic*, 4(2): 1-21.
- Alemayehu Geda (2002). Finance and Trade in Africa: Macroeconomic Response in the World Economy Context. London: Pallgarve-Macmillan.
- Alemayehu Geda and Daniel Zerfu (2004) 'A Review of Macro Modelling in Ethiopia: With Lessons form Published African Models, *MOFED Working Paper Series, WPs-01*, Addis Ababa.
- Alemayehu Geda and F. Huizinga (2004) 'Theoretical Framework of the Ethiopian Ministry of Finance and Economic Development (MOFED) Macro Model (EMM)', MOFED, Addis Ababa.
- Alemayehu Geda, S. Karingi, M. Njuguna Ndung'u, M. van Schaaijak, M. Were, Willis Wasalla, J. Obere, (2001) 'Estimation Procedure and Estimation Results of the Kenya's KIPPRATreasury Macro Model', *KIPPRAT Working Paper*, No. 3.
- Asmerom Kidane and Gerhard Kocklaeuner (1985) 'A Macroeconometric Model for Ethiopia: Specification, Estimation, Forecast and Control', *Eastern African Economic Review*,
- Bacha, Edmar (1984) 'Growth with Limited Supplies of Foreign Exchange: A Reappraisal of the Two-Gap Model' in Moshe Syrquin, Lance Taylor and Larry E. Westphal (eds.). *Economic Structure and Performance: Essays in Honour of Hollis B. Chenery*. New York: Academic Press, Inc.
- Bacha, Edmar (1990) 'A Three-Gap Model of Foreign Transfers and the GDP growth rate in developing countries', *Journal of Development Economics*, 32:279-296.
- Beenstock, Michael. 1995. "An Econometric Model of the Oil Importing Developing Countries." *Economic Modelling*, 12:1, pp. 3-14.
- Benjamin, Nancy, S.Devara, R.Weiner (1989), "The Dutch Disease in Developing Country: Oil Revenue in Cameroon", *Journal of Development Economics*, 30: 71-92.
- Berhanu Nega (1994) 'A Peripheral-Socialist Model of the Ethiopian Economy' in Berhanu Abegaz (ed.) (1994). *Essay on Ethiopian Economic Development*. Aldrshot: Avebury.
- Bischoff, Charles W. 2000. "Bayesian VAR Forecasts Fail to Live Up to Their Promise." http://www.looksmartsavings.com/p/articles/mi_m1094/is_3_35/ai_64396570/pg_2?pi=monsav
- Bodart, V. And Le Dem, J. (1996) "Labour Market Representation in Quantitative Macroeconomic Models for Developing Countries: An Application to Côte d'Ivoire," *IMF Staff Papers* 43:2, 419 – 451.
- Boutros-Ghali, Youssef and Lance Taylor (1980) 'Basic Needs Macroeconomics: Is It manageable in the Case of Egypt', *Journal of Policy Modelling*, 2(3): 409-436
- Challen, D.W and Hagger, A.J (1983) *Macroeconometric Systems: Construction, Validation and Applications*, London: Macmillan Press.
- Chenery, H. and A. Strout (1966) 'Foreign Assistant and Economic Development', *The American Economic Review*, 56(4): 679-733.
- Chishti, S., Hasan, M. And Mahmud, S. (1992) "Macroeconometric Modelling and Pakistan's Economy: A Vector Autoregression Approach," *Journal of Development Economics* 38, 353 – 370.
- Davies, Rob, Jorn Rattso and Rangar Torvik (1994) 'The Macroeconomics of Zimbabwe in the 1980s: a CGE-Model Analysis' *Journal of African Economies*, 3(2): 153-198.
- Decaluwe, Bernard and Fabien Nsengiyumva (1994) 'Policy Impact under Credit Rationing: a Real and Financial CGE Model of Rwanda', *Journal of African Economies*, 3(2):262-308.
- Easterly, William (1997) 'The Ghost of Financing Gap: How the Harrod-Domar Growth Model Still Haunts Development Economics (Unprocessed, World Bank)

- Egawaikhide, F. (1997) "Effects of Budget Deficits on the Current Account Balance in Nigeria: A Simulation Exercise," *AERC Research Paper*, 70.
- El-Shekh, S. (1992) "Towards a Macroeconometric Policy Model of a Semi-Industrial Economy: The Case of Egypt," *Economic Modelling*, 9:1, 75–95.
- Elbadawi, Ibrahim A. and Schmidt-Hebbel, Klaus. 1991. "Macroeconomic Structure and Policy in Zimbabwe: Analysis and Empirical Model (1965-88)." *World Bank Working Paper*, WPS 771.
- Feltenstein, Andrew and Sarangi, Sudipta. 2002. "Macroeconomic Stabilization and Economic Growth: Analysis of Reform Policies in Tanzania." *Journal of Policy Modeling*, 24, pp. 503-21.
- FitzGerald, E.V.K. (1993). *The Macroeconomics of Development Finance: A Kaleckian Analysis of the Semi-industrialized Economy*. London: St. Martin's Press
- Harris, John (1985) 'A Survey of Macroeconomic Modelling in Africa' **Paper presented to a meeting of the Eastern and Southern Africa Macroeconomic Research Network**, December 7-13, Nairobi, Kenya.
- Harton, Susan and J.McLaren (1989) 'Supply Constraints in the Tanzanian Economy: Simulation Results from a Macro-econometric Model', *Journal of Policy Modelling*, 11(2): 297-313.
- Huizinga, F., Aelmayehu Geda, N.S.Ndung'u and S.N.Karingi (2001) 'Theoretical Base for the Kenya Macro Model: The KIPPR-Treasury Macro Model', *KIPPR Discussion Paper No. 11*, KIPPR, Nairobi, Kenya (<http://www.kippra.org>)
- Karingi, Stephen & Njuguna Ndung'u (2001) 'Applications of Macroeconomic Models: Forecasting, Policy Analysis and Research', Economic Modelling and Forecasting Workshop, Harare, Zimbabwe, 14th – 25th May 2001.
- Karingi, Stephen N. and N.S. Ndung'u (2000) 'Macro Models of the Kenyan Economy: A Review', *KIPPR Discussion Paper No. DP/02/2000*, Nairobi.
- Kayizzl-Mugerwa, Steve (1990), 'Zambia: A Note on the Macroeconomic Impacts of Copper Prices', *Eastern Africa Economic Review*, 6(2):143-147.
- Keyfiltz, Robert (1994) 'Kenya MELT3: A Macro Model for Kenya' *Technical Paper 94-02*, Ministry of Planning and National Development, The Long Range Planning Division.
- Khan, Mohsin and P.Montiel (1989) 'Growth-Oriented Adjustment programs: A Conceptual Framework', *IMF Staff Papers*, Vol. 36 No. 2 pp. 279-306.
- Khan, Mohsin, P.Montiel and N.U.Haque (1990) 'Adjustment with Growth: Relating the Analytical Approaches of the IMF and the World Bank', *Journal of Development Economics*, Vol. 32, pp. 155-179.
- Kwack, S. Y. (1989) 'Overview of the Prototype African Model' in D. Salvatore (1989). **African Development Prospects: A Policy Modelling Approach**. New York: Taylor & Francis.
- Kouassi, E. (1997) "A Macroeconometric Model for Côte d'Ivoire," Unpublished, AERC, Nairobi, Kenya
- Lemma Mered (1993) 'modeling the Ethiopian Economy: Experience and Prospects' (memo).
- Lipumba, Nguyuru, Benno Ndulu, Sue Horton and Andr J. Plourde (1988) 'A Supply Constrained Macro-econometric Model of Tanzania', *Economic Modelling*, 5(4): 354-380.
- Litterman, Robert B. 1986. "Forecasting with Bayesian Vector Autoregressions: Five Years of Experience." *Journal of Business and Economic Statistics*, 4:1, pp. 25-38.
- Luttik, Joke (1998). *Trade and Finance in a World Accounting Matrix*. London: Pallgrave- Macmillan.
- Musila, Jacob Wanjala. 2002. "An Econometric Model of the Malawian Economy." *Economic Modelling*, 19, pp. 295-330.
- Osakwe, Patrick (2002) 'A Primer in Macroeconomic Forecasting and Policy Evaluation Models', *ESPD Discussion Paper No 1*, ECA.
- Oshikoya, T.W. (1990) *The Nigerian Economy: A Macroeconometric and Input-Output Model*, New York: PRAEGER.
- Oshikoya, W.T. (1989) 'Foreign Borrowing, Agricultural Productivity, and the Nigerian Economy: A Macro-sectoral Analysis', *Journal of Policy Modelling*, 11 (4): 531-546.

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- Pleskovi, Boris (1989) 'Inter-industry Flows in a General Equilibrium Model of Fiscal Incidence: An Application to Egypt', *Journal of Policy Modelling*, 11(1): 157-177.
- Rattso, Jorn (1992) 'Import Compression, Investment Determination and Macroeconomic Adjustment: A Macroeconomic Model Relevant for Sub-Saharan Africa', *Development Economics Seminar Paper NR. 92-1/4a*. The Hague: Institute of Social Studies.
- Rattso, Jorn (1994) 'Medium-run Adjustment under Import Compression: Macroeconomic Analysis Relevant for Sub-Saharan Africa' *Journal of Development Economics*, 45: 35-54.
- Ramos, Francisco Fernando Ribeiro. 2003. "Forecasts of Market Shares from VAR and BVAR Models: A Comparison of Their Accuracy." *International Journal of Forecasting*, 19, pp. 95-110.
- Reifschneider, David L., Stockton, David J. and Wilcox, David W. 1997. "Econometric Models and the Monetary Policy Process." *Carnegie-Rochester Conference Series on Public Policy*, 47, pp. 1-37.
- Robalino, David A., Voetberg, Albertus, and Picazo, Oscar. 2002. "The Macroeconomic Impact of AIDS in Kenya Estimating Optimal Reduction Targets for the HIV/AIDS Incidence Rate." *Journal of Policy Modeling*, 24, pp. 195-218.
- Salvatore, D. (1989) "The Prototype Model," *In African Development Prospects: A Policy Modelling Approach* (Salvatore, D., Ed.) New York: Taylor and Francis.
- Tarp, Finn (1993). ***Stabilization and Structural Adjustment: Macroeconomic Frameworks For Analysing The Crisis in Sub-Saharan Africa***. London: Routledge.
- Taylor, Lance (1989) 'Stabilization and Growth in Developing Countries: A Structuralist Approach', *Fundamentals of Pure and Applied Economics - Economic Development Section*, Chur, Harwood Academic Publisher.
- Taylor, Lance (1991). *Income Distribution, Inflation and Growth: Lectures on Structuralist Macroeconomic Theory*. Cambridge, Mass: The MIT Press.
- Van Frausum, Yves and D.E.Sahn (1993) 'An Econometric Model for Malawi: Measuring the Effects of External Shocks and Policies', *Journal of Policy Modelling*, 15(3): 313-327.

Appendix 1: Exercises

Exercise 1:

I. Using the EVIEWS data “Exercise 1 Ghana Data”,

1. Fit a trend model for GDP in the form of $\ln y_t = \ln \beta_0 + \beta_1 T + \varepsilon_t$ for the period of 1967 – 2001. Forecast the level of output for 2002.
2. Fit AR(p) and MA(q) model of GDP. Determine the appropriate lag length using AIC and SIC.
3. Forecast the level of output for 2002 using both the AR and MA models.
4. Fit an ARIMA (p, 1, q) model of GDP and determine the appropriate lag length for the AR and MA.
5. Forecast the level of output for 2002.
6. Compare the forecasting performance of the AR, MA and ARIMA models. Which one performs better? (*Hint: Use Theil's inequality coefficient along with its disaggregation*)

II. Using the same data

1. Estimate a VAR (P) model using GDP, price, investment and export. Determine the lag length using the AIC and SIC. (*Note: as the data are nonstationary, use first difference of all the variables*).
2. Estimate the VAR from 1967 – 1998 withholding data for 3 years. Forecast the growth rate of GDP, price, investment and export for the period of 1999 to 2001 and compare the forecast with the actual observations. Does the model forecast well? Comment.
3. Forecast the growth rate of GDP, price, investment and export for 2002.
4. Using the estimated VAR model, examine the impact of an increase in the price level on GDP and investment (*Hint: Use impulse response analysis*). Comment on the results.
5. What is the impact of an increase in the growth rate of investment on GDP growth?

Data Source: African Development Indicators CD-ROM 2003

Exercise 2:

- 1) *What will be the effects on the economy and government finance if wages get an additional impulse of 2 per cent each year?*
- 2) *What will be the effects on government finance and the economy of the 3 percentage points (from 15 to 18 per cent) increase of the VAT on local goods?*
- 3) *What will be the effects on government finance and the economy of 10 per cent increase in corporate income tax rate?*
- 4) *What will be the effects on government finance and the economy of 10 per cent point increase of the marginal wage tax rates?*