Namibia Macroeconometric Model (NAMEX)

Tjiveze Tjipe
Hannah Nielsen
Ebson Uanguta

December 2004

Bank of Namibia
Research Department
Macroeconomic Modelling and Forecasting Division

Abstract*

A macroeconometric model (NAMEX) is estimated for the Namibian economy. Based on previous experience and a sound understanding of the functioning of the different sectors of the economy, a theoretical framework is set up that incorporates all essential features. The model is estimated with state-of-the-art econometric techniques. The single equations are specified and their forecasting performance is assessed. Then, the model is constructed and shock simulations are performed and different scenarios are developed to give further insight in the future path of the main economic variables.

*We have to thank Mihe Gaomab II and Dr. Silvanus Ikhide for helpful comments and suggestions that improved the paper considerably.

Contents

1. Introduction

The primary task of most central banks is to operate monetary policy to secure price stability. To assist them in formulating policy, there is a need to devise various types of models and usage of economic relationships and econometric techniques to assist in determining the structure and parameters of a particular economy.

The central banks worldwide have therefore embarked on building econometric models since the late 1980's to understand, quantify and monitor the economy as well as to produce short and long term projections for policy analysis and formulation purposes.

It is within this context that Namibia has begun to develop a macroeconometric model for Namibia. This study presents the theoretical and practical aspects of the Namibian macroeconometric model (NAMEX). It is a complex model, which consists of the main sectors of the economy, namely the real, fiscal, monetary and price sector. The objective was to formulate a model that can give a good explanation of the Namibian economy, can serve for forecasting purposes and can be used in the context of policy simulations.

The study is set out as follows. Before the introduction of the model, historical information on the Namibian economy is outlined briefly. In the following section, a review of existing models on the Namibian economy is presented to justify the need for the development of NAMEX. Section 4 presents the theoretical framework of the model, followed by the data sources and estimation techniques. Section 6 covers the detailed assessment of the different sectors of the economy and the respective single-equation estimations, and in section 7 the results of the model are given, including in-sample forecasts and policy simulations. It is closed with concluding remarks and the identification of future areas for improvement of the model.

2. Overview of the Namibian economic situation

The Namibian economy is very open and heavily dependent on primary commodities with a small manufacturing base. The economy is sensitive to developments in South Africa and the world economy. It is particularly influenced by the external demand of its three most important exports (diamonds, fish and meat products) and by the situation of the South African economy. Namibia is a member of the Southern African Customs Union (SACU) and the Common Monetary Area (CMA). It has therefore ceded monetary, exchange rate and trade policy formulation to South Africa. This means that fiscal policy, particularly on expenditures, is the main instrument available to influence macroeconomic outcomes.

The Namibian economy faced low growth performance during the 1980's. This poor performance was mainly attributed to the war situation in Namibia, the international sanctions and the uncertainties surrounding Namibia's future. However, the economy recorded favorable growth rates shortly after independence of above 7 percent in 1991 and 1992. These high growth rates in those two years were mainly attributed to high growth rates in the diamond-mining and fisheries sectors. On average, Namibia experienced a continuing decline in its economic growth from a high of 5.0 percent during the 1991-1995 period to around 3.3 percent in 1996-2001. The continuing lower economic growth is mainly caused by external influences, ranging from unfavorable climatic and marine conditions to international and regional economic situations and their effects on the production and exports of primary sector minerals (diamonds, uranium, copper etc.) and manufactured products (beef, fish etc.). Namibia's overall macroeconomic performance has been broadly satisfactory since independence compared to the pre-independence period.

Namibia experienced also an expansion of production activities in areas less vulnerable to some of the external influences. Since independence, Namibia's balance of payment has been mostly in surplus, due to a positive current account balance. This has largely been offset by a deficit on the capital and financial account, reflecting chronic excess of savings over investment in the economy. The deficit on the capital and financial account has been driven mainly by the outflow of insurance and pension fund money to South Africa. This situation (of excess savings over investment) is rather atypical for a developing country where the opposite situation is normally the case.

A highly significant event of the post-independence years was the introduction of the Namibia Dollar in October 1993, at par with and fully convertible to the South African Rand, which remains legal tender in Namibia. Movements of the latter currency are, therefore, fully reflected in the external value of the Namibia dollar. The Rand, and therefore as well the Namibia dollar, were relatively stable during the first five years of independence. For example, between 1994 and 1995 the Namibia Dollar weakened only by about 2.2 percent against the US Dollar. During the second half of the decade, especially after the Asian financial crisis in 1997/1998, this situation changed dramatically. In 1996, the Namibia Dollar started to depreciate strongly, initially due to factors such as uncertainty in South Africa regarding political stability. In 2001 it depreciated strongly as well, due the general slowdown of the world economy, perceptions about emerging markets and the perceived political instability in the SADC (Southern African Development Community) region. In 2002, the Namibia Dollar appreciated and made a comeback to earlier levels recorded in 2000.

3. Critical review of the Namibian models

Macroeconomic modelling is relatively new activity in Namibia. Work to create a consistent framework for macroeconomic modelling started after independence and resulted in the creation of Namibia's first macroeconomic model, the Namibian Macroeconomic Framework (NAMAF) in 1993. Essentially, NAMAF was developed for medium term planning in order to be used for the Public Expenditure Review (PER) of the Government of Namibia and for the first National Development Plan (NDP1). The purpose of the PER was to assist in defining a sustainable levels of government spending and to detail the methods by which this should be achieved, taking into account current social and economic trends and policy directions.

NAMAF proved to be a useful tool for developing forecasted path of the Namibian economy for a while. It was also extensively used for recommending measures for expenditures restraint in the wages and salaries commission (WASCOM) report as well as a key input into the drafting of the macroeconomic framework for NDP1. The model was abandoned in earlier 1995 due to problems of scarce technical resources at domestic level, lack of institutional capacity in model development, limited data and difficulties encountered at the level of policy co-ordination between relevant institutions.

During 1996, National Planning Commission, Bank of Namibia, Ministry of Finance and the Namibian Economic Policy Research Unit formed a Macroeconomic Modelling Working Group (MEMWOG) to formulate the future course of action regarding model development. The usefulness of NAMAF was reviewed and it was concluded that there may not be in-house capacity to understand the intricacies and workings of the model and instead opted for training in the Revised Minimum Standard Model-Extended (RMSM-X) of the World Bank and the IMF. Since then, this model has been in use and extensive work has been done to customize the model based on Namibian economic conditions and relationships. The adopted version of this model is called NAMMAC, shortened for the Namibia Macroeconomic Model.

NAMMAC suffers from severe limitations, such as a failure to incorporate a labour market, financing aspects related to fiscal deficits, and use of inflexible production on the supply side. Whilst there are different closure rules that solve for NAMMAC thus ensuring its versatility, it has a general weakness in that it is usually solved recursively, ignoring the simultaneous nature of key macroeconomic variables. The recursive solution as well does not allow for explicit consideration of the relationships among variables.

It is the objective of this paper to construct a model that will fit and explain best the Namibian economy. The new model will have sound theoretical foundation and will be based on past experiences with explicit quantification of the relationships between the macroeconomic variables and the linkages of these relationships. It should be useful for research, forecasting and policy analysis, hence, the theory upon which this model is based needs to be sound and evident from a Namibian economic point of view.

4. Theoretical Framework of the Model

This macroeconometric model of the Namibian economy is build to provide a theoretical structure for understanding the linkages between the key macroeconomic variables. The following four sectors of the Namibian economy are modelled:

The **real sector**, including the external sector, estimates private consumption and investment, total government expenditure, exports and imports to determine an aggregate demand function for the economy.

The **fiscal sector** consists of two components, government revenue and government expenditure. The budget deficit is determined as the difference between government expenditure and government revenue.

The **monetary sector** deals with the estimation of the main monetary variables, namely the broad monetary aggregate M2, domestic credit and net foreign assets.

The **price sector** estimates equations, which try to capture the influencing factors on the domestic price level.

The **labour sector** could not be estimated due to unavailability of data. The model formulation for the single sectors as well as the data and estimation techniques used are explained in the following in detail.

4.1. Real sector

The national identity from the national accounts is the starting point for specifying the real sector of a comprehensive macroeconometric model for any economy. The national identity or aggregate demand for domestic consumption is the sum of consumption, investment, government expenditure, and the trade balance:

$$Y_t = C_t^p + I_t^p + G_t + (X_t - M_t). \tag{1}$$

The variables in equation (1) are defined as follows: Y_t is the real GDP, C_t^p the real private consumption expenditure, I_t^p the real private investment expenditure and G_t the real government expenditure. X_t denotes real exports and M_t real imports.[1]

If the national output is equal to consumption, investment and government spending a closed economy is represented. If no trading with foreign economies takes place, it is implied that the domestic economy satisfies its own demand and supply. The economy becomes opened when the last term in equation (1), the trade balance, is added, which represents exports and imports of goods and services.

In the following, the specification of the underlying equations is presented, starting with private consumption.

Private consumption (C_t^p) is a function of the following variables

$$C_t^p = f(Y_t^d, rir_t, \pi_t), \tag{2}$$

where y_t^d is the total disposable income, which is defined as the difference between the gross domestic product (Y_t) as proxy for the national income and total domestic taxes (TT_t), i.e.

$$Y_t^d = Y_t - TT_t. \tag{3}$$

According to the Keynesian absolute-income hypothesis, the disposable income is

[1] A description of the variables used for the empirical application is given in Appendix A.

assumed to have a positive influence on private consumption.[2] Later theories, such as the life-cycle or the permanent-income hypothesis introduced other explanatory factors like the real interest rate (rir_t) or the inflation rate (π_t), whose impact is not clear a priori. As the real interest rate is composed of the nominal interest rate and the inflation rate, rir_t and π_t should not be considered simultaneously, but rather separate or the inflation rate together with a nominal interest rate.

Private investment can be influenced by the following factors

$$I_t^p = f(Y_t^d, \Delta K_{t-1}, rir_t, CPI_t^w), \tag{4}$$

where ΔK_t is the change in the capital stock and CPI_t^w the world price index, defined as weighted consumer price index of the five major trading partners.[3] The world price index is included, since most of the goods produced through investment will be exported. Y_t^d as well as CPI_t^w are supposed to have a positive impact on investment, while a high real interest rate should lead to the reduction of private investment.

Total **government expenditure** is assumed to be an exogenous variable and is determined as the sum of public consumption (C_t^g) and public investment (I_t^g), i.e.

$$G_t = C_t^g + I_t^g. \tag{5}$$

The specification of the **export** function is based on the assumption that Namibia is a small country, which implies that exports by Namibia will have little effect on prices in the world market. A small country can sell as much as it likes (assuming it has the capacity to produce such quantities) without depressing the price on

[2]For a comprehensive analysis of this and other theories of the consumption function as well as an application for the Namibian economy see Odada et al. (2000).

[3]Those major trading partners are the United Kingdom, the USA, Japan, Spain and Germany.

the world market. Hence, the demand for exports of goods and services is determined by the world demand and the country's competitiveness. That leads to the following functional form

$$X_t = f(Y_t^w, rer_t). \tag{6}$$

Exports of goods and services are denoted by X_t, the world income by Y_t^w and the real exchange rate by rer_t, which is used as proxy for the competitiveness of the country.[4] These variables are assumed to yield a positive and negative impact, respectively. An increase in the real exchange rate, i.e. a real appreciation, will affect the demand for exports of goods and services negatively.

Imports of goods and services in Namibia, denoted by M_t, are assumed to be determined by domestic demand that is proxied by gross domestic expenditure (GDE_t) and the relative price level, which is given by the ratio of the import price index (MPI_t) to the consumer price index (CPI_t). Since the vast majority of imports come from South Africa and the Namibian Dollar is at par with the South African Rand, the nominal exchange rate does not have to be taken into account. Therefore, only the relative price level serves as proxy for competitiveness, yielding the following functional form

$$M_t = f(GDE_t, \frac{MPI_t}{CPI_t}). \tag{7}$$

Gross domestic expenditure is expected to influence the total amount of imports positively, whereas an increase in the relative price level should lead to a decrease of imports. This specification is in line with that given by Khan (1974) for several developing countries.

[4] The real exchange rate is defined as the product of the nominal exchange rate and the ratio of domestic to foreign prices. It is a weighted sum of six exchange rates, namely those concerning the five major trading partners given above plus South Africa. For further explanation see Bank of Namibia - *Exchange Rate Methodology.* The world income is the weighted sum of the GDP of the five major trading partners.

4.2. Fiscal sector

The fiscal sector constitutes government revenue and government spending. The budget deficit results as the excess of government expenditure over government revenue and is usually financed from both domestic and external sources. Hence, the gross fiscal budget deficit ($BUDEFN_t$) is defined as follows:[5]

$$BUDEFN_t = TGEN_t - TGRN_t, \tag{8}$$

where $TGEN_t$ is total government expenditure and $TGRN_t$ total government revenue.[6]

The specifications of the equations in the fiscal sector are chosen to emphasize the link between the fiscal and the real, monetary, and price sectors. The public sector borrowing requirement is determined by this sector through the gross fiscal deficit, which in turn influences the other sectors. In addition, the fiscal and the real sector are connected via nominal output, which is used as scale variable in many fiscal sector equations, and through various tax rates.

Total government revenue is the sum of total direct taxes ($TDXN_t$), total indirect tax ($TNDXN_t$) and non-tax revenue of the government ($NTRN_t$), i.e.

$$TGRN_t = TDXN_t + TNDXN_t + NTRN_t. \tag{9}$$

Total direct and indirect taxes will be modelled as endogenous variables, whereas the non-tax revenue of the government is taken as exogenous.

Total direct tax may be influenced by the nominal output, the average direct tax rate ($tdxr_t^{avg}$), which is defined as the ratio of total direct taxes to nominal

[5]The equations for the fiscal sector are specified in nominal terms, which is indicated by an additional N concerning the notation of the variables.

[6]Due to data availability problems, grants are not included in the model at this stage.

output and the inflation rate, yielding

$$TDXN_t = f(YN_t, tdxr_t^{avg}, \pi_t). \tag{10}$$

An increase in nominal output is expected to raise revenues from direct taxes. Given a progressive structure of direct taxation, economic agents will have to pay a higher proportion of their income in the form of taxes as their income increases. Likewise, total direct tax revenue will go up as the average direct tax rate rises. The assumed positive relationship between total direct taxes and the inflation rate can be explained by the fact that each year public and private sector employees compensations are adjusted for cost of living allowance and those additional compensations are taxed.

Total indirect tax can as well be influenced by the nominal output, the average indirect tax rate ($tndxr_t^{avg}$), defined as the ratio of total indirect taxes to nominal output, and the inflation rate, i.e.

$$TNDXN_t = f(YN_t, tndxr_t^{avg}, \pi_t). \tag{11}$$

The largest proportion of indirect taxes is raised in form of the VAT (which replaced the Sales Tax in 2000), therefore, a higher price level will contribute to a higher indirect tax revenue. Because of the high share of the VAT, the nominal output has been chosen as scale variable instead of the consumption, because production and not only consumption is influenced by the VAT. A higher nominal output is proposed to lead to an increase in total indirect taxes due to higher spending. The positive relationship between total indirect tax and the average tax rate is straightforward.

Total government expenditure can be subdivided into current expenditure and capital expenditure. Government current expenditure comprises wages and salaries (WSN_t), expenditure on goods and services ($GEGSN_t$), interest payments on (internal and external) debt ($IPDBTN_t$) and subsidies and transfers (STN_t). The total government expenditure is therefore given by

$$TGEN_t = WSN_t + GEGSN_t + IPDBTN_t + STN_t + GECN_t, \qquad (12)$$

where $GECN_t$ is government capital expenditure. Except government expenditure on goods and services, all other variables are taken as exogenous variables within the model.

Government expenditure on goods and services is a function of nominal GDP and the inflation rate. As nominal GDP increases, expenditure of goods and services is also expected to increase. A rise in the prices would lead to increased government spending, as the same volume of goods and services has become more expensive. The following functional form results

$$GEGSN_t = f(YN_t, \pi_t). \qquad (13)$$

4.3. Monetary sector

The **demand for real broad money** (M2) is assumed to be positively related to the level of income. If the level of income increases, economic agents are likely to hold more money. Since M2 is the broadest monetary aggregate in Namibia and it is therefore not likely that economic agents shift their money holdings out of M2, not the opportunity costs of holding money are introduced, but the own rate of that aggregate instead. The own rate is defined as the return of the components of that aggregate itself and it is assumed to have a positive influence on the money demand. Moreover, the inflation rate has a decisive influence on the demand for money. If the inflation rate is high, people will rather invest in real assets than hold money. The functional form is therefore

$$M2_t = f(Y_t, i_t^o, \pi_t), \qquad (14)$$

where i_t^o is the own rate of money.

4.4. Price sector

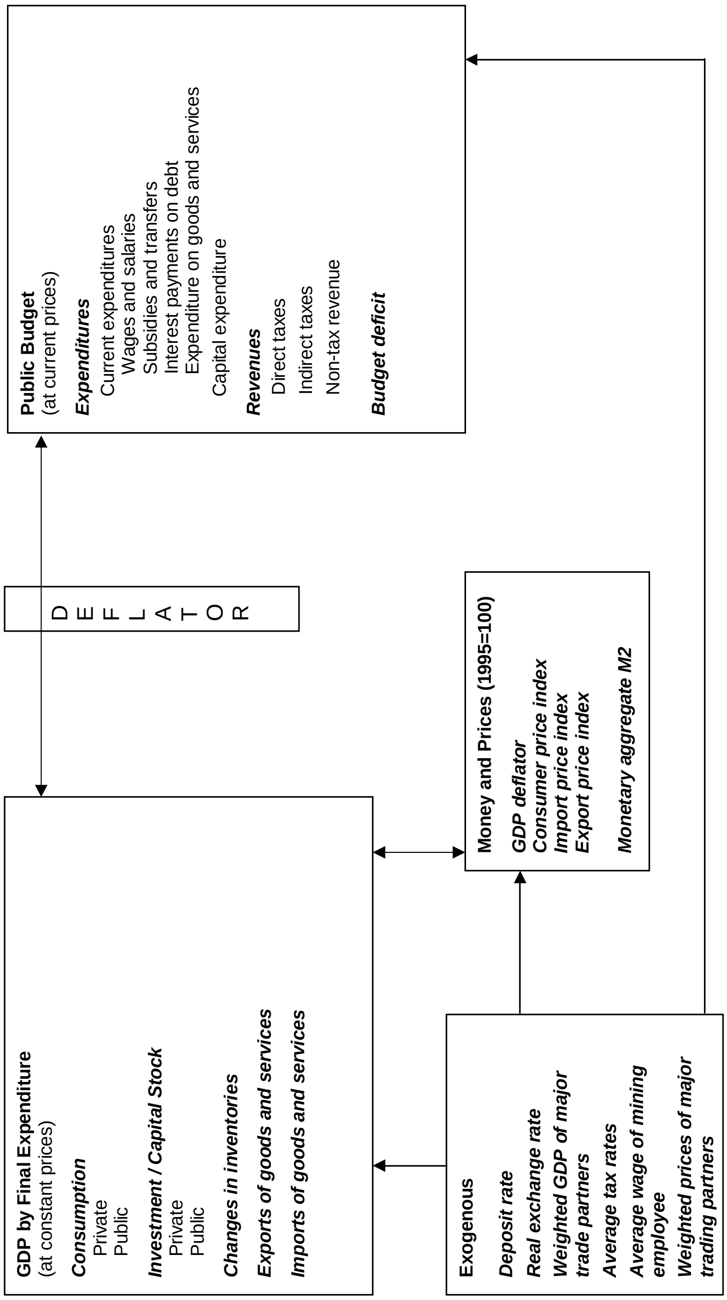
A key assumption for the development of the domestic **consumer price index** (CPI_t) is that it is strongly influenced by import prices. This is due to the fact that Namibia imports about 80 percent of the goods from South Africa. This influence can be captured by the import price index (MPI_t). Furthermore, there is assumed to be a long-run relationship between prices and nominal wages (WN_t). The functional form for the consumer price index is therefore as follows:

$$CPI_t = f(MPI_t, WN_t). \tag{15}$$

Both variables are expected to have a positive effect on the Namibian consumer price index.

The structure of the Namibian economy, as it is constructed in this model is shown in Figure 1.

Figure 1: Structure of the Namibian macroeconometric model



5. Data and estimation technique

5.1. The data

The data is obtained from different sources, mainly the national accounts of the Central Bureau of Statistics, various bulletins of the Bank of Namibia and the International Financial Statistics of the IMF. The frequency of all data is annual. Fiscal data had to be converted from the fiscal year to the calendar year.

Annual data for the period 1983-2002 is used for the estimation. All variables, except interest rates are in logarithms, which is indicated by small letters, in contrast to the capital letters in section 4. Unless otherwise stated, real data is used. All series are shown in Appendix A. Computation has been carried out using the econometric software EViews 4.1. A documentation of the necessary procedures and their practical implementation can be found in Tjipe and Nielsen (2003).

5.2. Estimation technique

5.2.1. Single-equation analysis

The applicability of the estimation techniques always has to be seen in the light of the available data. Due to the short time span, structural breaks and data with high frequencies, the number of feasible methods is limited. Whenever possible, error correction models will be estimated, which base on stable long-run relations. If this concept is not applicable, a standard OLS regression in levels is undertaken.

All the single-equation estimations have to be seen in the light of the objective of building a model for the whole Namibian economy. Since the model has to perform well, slight misspecifications of the single equations will be tolerated if the respective specification contributes significantly to the overall forecast.

Cointegration Since macroeconomic variables often display nonstationary behaviour, the cointegration methodology will be used to analyze the data. If two series follow unit root processes, but are not cointegrated, the problem of spurious regression can occur, i.e. the estimated relationship is statistically highly significant due to incorrect inference, but is not reasonably interpretable.[7] Instead, cointegration implies that there exists a linear combination of the respective variables which is stationary. Such a stationary linear combination can then be interpreted as long-run relation.

A widely used method to test for cointegration is the so called Engle-Granger two-step procedure. Engle and Granger (1987) suggested to estimate the cointegration relationship in the first step with a static OLS regression. The resulting residuals are then tested for the presence of a unit root. If they are found to be stationary, they are, in a second step, included as regressor in an error correction model as long-run equilibrium relation.

Following the representation theorem by Granger (1986) each existing linear cointegration relationship can be represented as error correction model (ECM). The advantage thereof is that long-run and short-run properties can be estimated jointly and it is possible to make statements about the direction of the causality, again for the long- and the short run. Furthermore, if cointegration exists, the variables included in the ECM are all stationary, which allows the application of standard test theory.

A bivariate ECM for the two variables x_t and y_t, which both are integrated of order 1, I(1),[8] and form the following cointegration relation

$$y_t - \gamma x_t = \epsilon_t, \tag{16}$$

where ϵ_t is I(0), can be can be represented as structural form model, i.e. that contemporaneous variables are included as regressors, in the following way:

$$\Delta y_t = c + \rho\epsilon_{t-1} + \sum_{i=1}^{n_1} \alpha_i \Delta y_{t-i} + \sum_{i=0}^{n_2} \beta_i \Delta x_{t-i} + u_t. \tag{17}$$

[7] See Granger and Newbold (1974) or Phillips (1986).

[8] A time series is said to be integrated of order d, I(d), if it is stationary after differencing d times while it is nonstationary after differencing $d-1$ times.

The lag lengths n_1 and n_2 are chosen as to make the error term u_t empirically white noise. If the error correction mechanism is working, the parameter ρ has to be statistically significant smaller than zero, assuming $\gamma > 0$, otherwise a deviation from the equilibrium path will not be corrected.

Cointegration can also be tested for in a multivariate framework. This allows the simultaneous cointegration analysis of more than two nonstationary variable and the formulation of the respective multivariate ECM.[9]

Since we deal with a very limited number of observations at high frequencies as well as structural breaks, this multivariate approach is difficult to apply. By using a structural single-equation approach, the characteristics of the time series can be modelled more directly. Hence, whenever possible, the Engle-Granger two-step procedure will be used for the following empirical application.

Unit root tests Prior to the cointegration analysis, the time series have to be tested for their order of integration. Therefore, standard Augmented-Dickey-Fuller (ADF) tests have been applied.[10] Nevertheless, the limitations of the data always have to be reminded. According to that, some series will be treated as integrated of order one, if it is reasonable for further analysis even if a certain significance level cannot be reached.

Diagnostic tests Unless indicated otherwise, estimation results will always be given with the corresponding t-statistics beneath. To assess the appropriateness of the specification of the regression, several diagnostic statistics will be employed. To test the assumption of normally distributed residuals, the Jarque-Bera (JB) statistic is employed. The hypothesis of no serial correlation of at most order one and two can be checked by means of the Ljung-Box Q-statistic. Also the Lagrange multiplier test against autoregressive conditional heteroscedasticity (ARCH) of at most order one is applied as well as a test against nonlinearity (RESET).

[9]See Johansen (1991, 1995) or Banerjee et al. (1993).
[10]See Dickey and Fuller (1979). The results are available on request.

Forecast evaluation Before the model can be build, the forecasting performance of the single equations has to be assessed. The in-sample forecast based on the final equation, either error correction model or regression in levels is computed and the forecast is evaluated by means of the mean absolute percentage error (MAPE) and Theil's inequality coefficient. These two measures are scale invariant and can therefore be used to assess the forecasting performance directly. Theil's inequality coefficient compares the forecast with a random walk and always lies between zero, where zero indicates a perfect fit and one that the forecast is not better than that of a random walk. The MAPE is not normalized, but it should as well be as small as possible. If the MAPE is zero, there has no error been made while forecasting.[11]

5.2.2. Model building

Once the equations for the single sectors of the economy have been estimated and their forecasting performance is satisfactory, the model can be built, based on those equations. Before policy simulations are carried out, the in-sample performance of the model is assessed. The static as well as the dynamic in-sample forecasts produced by the model are compared to the actual series to evaluate their accuracy. If those results are good, the out-of-sample forecast can be computed.

In order to do so, values for the exogenous variables have to be available for the whole forecasting period. Whenever possible, projections of the official sources are taken. If those projections are either not existent or not accessible, the forecasts can be based on different assumptions. Since it is questionable how precise point estimates of such a complex system are, rather different scenarios are developed, which are supposed to capture the upper and lower bound of the evolution of the endogenous variables.

[11] For a detailed description of these measures see e.g. Greene (2003).

6. Estimation results - single equations

6.1. Real sector

The considered time series of the real sector are nonstationary, therefore the cointegration methodology has to be applied.

6.1.1. Private consumption

Private consumption has been estimated according to the functional form that has been proposed in equation (2). The following long-run equation has been estimated for private consumption (c_t^p) and disposable income (y_t^d), which is defined as the difference between real GDP and total taxes:

$$c_t^p = \underset{(-1.27)}{-1.219} + \underset{(10.52)}{1.132} y_t^d - \underset{(-2.26)}{0.134} dum_t^c - \underset{(-4.30)}{0.170} dum_t^{ind} + \hat{\epsilon}_t^c, \qquad (18)$$

$$\bar{R}^2{=}0.89 \quad \text{S.E.}{=}0.05 \quad \text{DW} = 1.04 \quad \text{T} = 20 \text{ (1983-2002)}$$

where dum_t^c is an impulse dummy, which is one for 1985, because of a sharp depreciation of the South African Rand in that year, zero otherwise and dum_t^{ind} is a shift dummy, which is zero before independence, i.e. from 1983 to 1989 and one beginning with 1990. As assumed by theory, disposable income has a positive effect on private consumption. The real interest rate and the inflation rate, which have been proposed as possible influencing factors in section 4.1, do not contribute significantly to the development of private consumption and are therefore not included in the final equation. This is consistent with the results of Odada et al. (2000), who also cannot find a significant influence of the interest and inflation rates.

The t-statistic of the corresponding ADF-test regression for the residual term ϵ_t^c amounts to -2.22. Due to the fact that a shift dummy should be treated as additional regressor, the 10% critical value of -3.45 for two stochastic regressors cannot be reached.[12] Nevertheless, a cointegration relation is assumed for these variables, since the limited time span distorts the results. The estimated error correction model is given below with the corresponding diagnostic tests:[13]

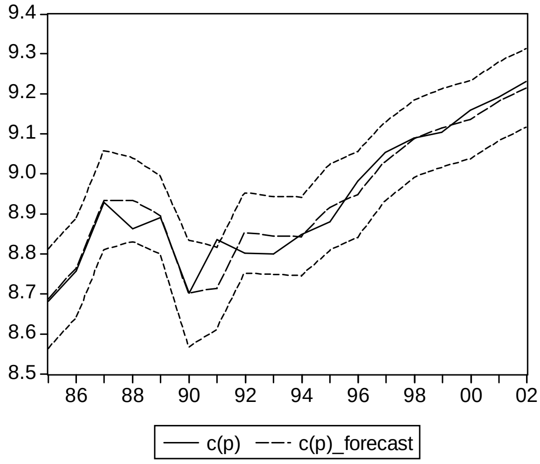
$$\Delta c_t^p = \underset{(3.07)}{0.035} - \underset{(-1.43)}{0.348} \hat{\epsilon}_{t-1}^c - \underset{(-4.50)}{0.175} \Delta dum_t^c - \underset{(-3.25)}{0.128} \Delta dum_t^c - \underset{(-4.43)}{0.217} \Delta dum_t^{ind} + \hat{u}_t. \quad (19)$$

$\bar{R}^2$=0.72	S.E.=0.05	DW = 2.25
JB = 8.77 [0.01]	Q(1) = 0.35 [0.56]	Q(2) = 0.96 [0.62]
ARCH(1)=0.004 [0.95]	RESET(1)=0.07 [0.80]	T = 20 (1983-2002)

The diagnostic tests indicate no misspecification, except for a possible problem concerning linearity as the RESET(1)-test indicates. The negative coefficient of $\hat{\epsilon}_{t-1}$, although it is only significant at the 20%-level, confirms that the error-correction mechanism is working correctly, i.e. deviations from the long-run equilibrium will be corrected. As next, the in-sample forecast is calculated to assess the forecasting ability of this equation. The actual and the forecasted series as well as the standard error bands of that forecast are given in Figure 2. The forecast evaluation measures are displayed next to the figure.[14]

[12] Here and in the following, critical values are taken from MacKinnon (1991).
[13] For an overview of the diagnostic tests see section 5.2.1.
[14] The MAPE is given as percentage already and does not have to be multiplied with 100 any more. For an description of the single measures, see section 5.2.1.

Figure 2: Forecast of private consumption



Forecast evaluation:

MAPE	0.2970
Theil	0.0022

From 1992 on the forecasting performance of the estimated ECM is good. Before, especially around the years 1986/1987 and 1990/1991, there are obvious structural breaks, which cannot be captured by the model perfectly, but the overall forecasting ability, measured also by the evaluation measures is satisfactory.

6.1.2. Private investment

According to the specification of the private investment function in section 4.1 the following equation is estimated:

$$i_t^p = \underset{(-3.16)}{-7.354} + \underset{(1.83)}{0.766} y_t^d + \underset{(4.55)}{1.713} cpi_t^w - \underset{(-2.96)}{0.282} dum_t^i + \hat{\epsilon}_t^i, \tag{20}$$

$\bar{R}^2$=0.93 S.E.=0.13 DW = 1.17 T = 20 (1983-2002)

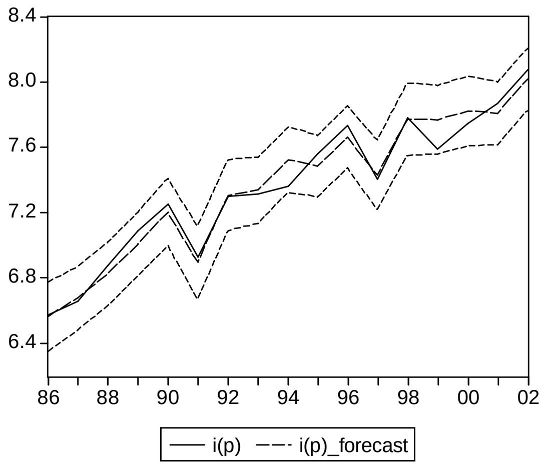
where dum_t^i is an impulse dummy, which is one for 1991, because of the consequences of independence and for 1997, zero otherwise. The real interest rate has not been significant, but the disposable income as well as the world prices have, as assumed by theory, a positive influence on private investment.

The corresponding t-statistic of the ADF-test for the residual term ϵ_t^i is -4.42, which yields significance on the 5% level. Based on this long-run equation, the following error correction model has been estimated (diagnostic tests given below):

$$\Delta i_t^p = \underset{(0.86)}{0.028} - \underset{(-2.65)}{0.665}\hat{\epsilon}_t^i + \underset{(1.82)}{0.353}\Delta i_{t-1}^p + \underset{(2.72)}{0.406}\Delta i_{t-2}^p - \underset{(-6.12)}{0.391}\Delta dum_t^i + \hat{u}_t. \quad (21)$$

$\bar{R}^2$=0.81	S.E.=0.09	DW = 1.69
JB = 4.20 [0.12]	Q(1) = 0.39 [0.53]	Q(2) = 1.55 [0.46]
ARCH(1)=0.10 [0.76]	RESET(1)=0.15 [0.70]	T = 20 (1983-2002)

Figure 3: Forecast of private investment



Forecast evaluation:

MAPE	0.7790
Theil	0.0051

The model is well specified. The significant negative coefficient of the error correction term assures the existence of a cointegration relation. The forecast of private investment, resulting from this model, as well as the actual series is given in Figure 3.

The overall development of private investment is captured quite well. For the outliers in the years 1992 and 1997 it could be accounted with the inclusion of the impulse dummy.

6.1.3. Exports

Total exports of goods and services are assumed to depend on the world income and the real exchange rate, rer_t. Relying on that functional form, the long-run equation of exports has been estimated:

$$x_t = \underset{(6.19)}{6.093} + \underset{(2.36)}{0.523} y_t^w - \underset{(-2.88)}{0.457} rer_t - \underset{(-5.09)}{0.377} dum_t^x + \underset{(2.89)}{0.171} dum_t^{ind} + \hat{\epsilon}_t^x. \qquad (22)$$

$\bar{R}^2$=0.91 S.E.=0.07 DW = 1.27 T = 20 (1983-2002)

The impulse dummy dum_t^x is one for 1990, the year Namibia became independent, and zero otherwise and dum_t^{ind} accounts once more for the long-run changes due to independence. The coefficient of world income has, as expected by theory, a positive sign, while the real exchange rate has a negative influence.

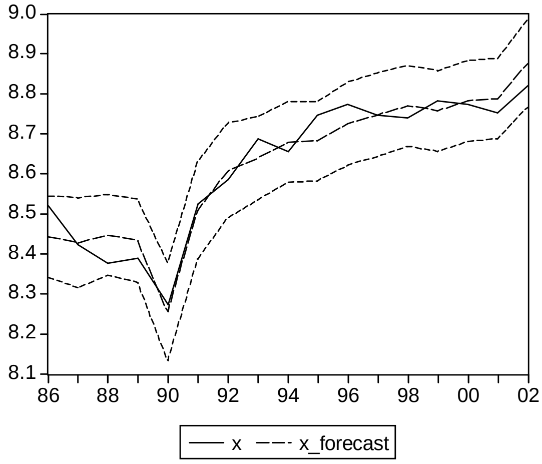
The ADF test-statistic of ϵ_t^x amounts to -3.72, which is close to the 10% critical value of -3.81, therefore the existence of a long-run relation is assumed. Hence, the following error correction model has been estimated:

$$\Delta x_t = \underset{(1.78)}{0.021} - \underset{(-2.95)}{0.598} \hat{\epsilon}_{t-1}^x - \underset{(-3.41)}{0.449} \Delta rer_t - \underset{(-5.90)}{0.206} \Delta dum_t^x + \hat{u}_t. \qquad (23)$$

$\bar{R}^2$=0.74	S.E.=0.05	DW = 1.61
JB = 1.07 [0.59]	Q(1) = 0.23 [0.63]	Q(2) = 2.38 [0.30]
ARCH(1)=0.004 [0.95]	RESET(1)=0.51 [0.49]	T = 20 (1983-2002)

The diagnostic tests indicate that the model is well specified. The coefficient of $\hat{\epsilon}_{t-1}$ is negative and highly significant, which implies that deviations from the equilibrium path are corrected in the following period. The corresponding forecast is shown in Figure 4.

Figure 4: Forecast of exports



Forecast evaluation:

MAPE	0.4319
Theil	0.0025

Again, the overall forecasting performance is good for almost the whole observation period, which is confirmed by a quite low MAPE and Theil statistic. Only at the beginning of the sample some larger discrepancies are visible.

6.1.4. Imports

Total imports of goods and services rely on the gross domestic expenditure, gde_t, as proxy for the domestic demand and on the relative price level. The long-run relation estimated with these series as explanatory variables is the following:

$$m_t = -\underset{(-0.17)}{0.143} - \underset{(-1.80)}{0.275}(mpi_t - cpi_t) + \underset{(11.00)}{0.945} gde_t + \hat{\epsilon}_t^m. \tag{24}$$

$$\bar{R}^2{=}0.97 \quad \text{S.E.}{=}0.04 \quad \text{DW} = 0.86 \quad \text{T} = 20 \text{ (1983-2002)}$$

As expected, the sign of the gross domestic expenditure is positive, whereas the effect of the relative price level is negative. The ADF test for the residual series ϵ_t^m yields a t-statistic of -3.33, which is again close to the 10% critical value

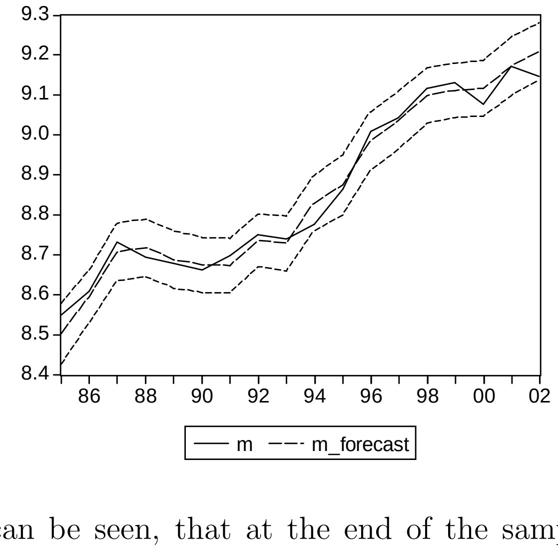
(-3.45), confirming the existence of a long-run relation. Therefore, the resulting error correction model is given below:

$$\Delta m_t = \underset{(-0.03)}{-0.0004} - \underset{(-3.65)}{0.960}\hat{\epsilon}^m_{t-1} + \underset{(2.03)}{0.333}\Delta m_{t-1} + \underset{(5.99)}{0.970}\Delta gde_t + \hat{u}_t. \quad (25)$$

$\bar{R}^2$=0.67	S.E.=0.03	DW = 1.51
JB = 1.52 [0.47]	Q(1) = 0.03 [0.86]	Q(2) = 0.10 [0.95]
ARCH(1)= 2.21 [0.16]	RESET(1)=0.29 [0.60]	T = 20 (1983-2002)

The error correction term is once more correctly signed and significant, confirming thereby that a cointegration relation exists. The rather high value of 0.960 indicates that the adjustment to the equilibrium takes place fast. No misspecifications are detected by the diagnostic tests, so it can be proceeded with the forecast, which is given in Figure 5, together with the forecast evaluation statistics.

Figure 5: Forecast of imports



Forecast evaluation:

MAPE	0.2605
Theil	0.0016

It can be seen, that at the end of the sample, in the year 2000, a small gap between the actual and the forecasted series occurs, but otherwise the forecasting performance is very good, which is confirmed by the low forecast evaluation measures.

6.2. Fiscal sector

Both direct and indirect taxes as well as the respective average tax rates are stationary, therefore the cointegration methodology does not have to be applied. Instead, standard OLS regressions in levels are carried out and nonstationary explanatory variables are included in first differences. This is in contrast to the government expenditure, which exhibits nonstationary behaviour.

All series exhibit structural breaks around the time of independence, which have to be taken into account.

6.2.1. Total direct tax revenue

The following equation for the total direct taxes ($tdxn_t$) has been estimated according to the functional form proposed in section 4.2

$$tdxn_t = \underset{(56.69)}{4.550} + \underset{(15.06)}{0.081} tdxr_t^{avg} + \underset{(0.95)}{0.222} \Delta yn_t + \underset{(21.73)}{0.155} t - \underset{(-2.19)}{0.013} dum_t^{ind} \cdot t + \hat{u}_t, \quad (26)$$

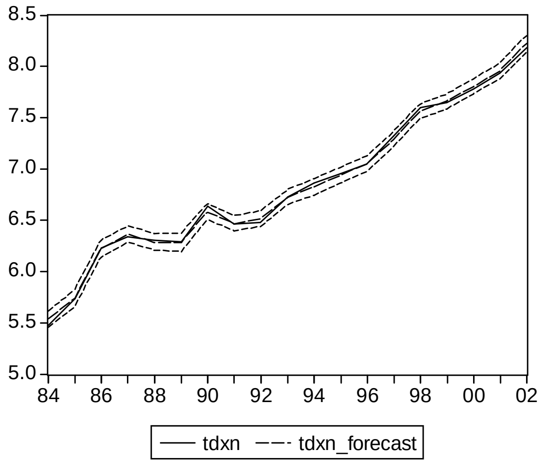
$\bar{R}^2$=0.998	S.E.=0.03	DW = 1.27
JB = 0.17 [0.92]	Q(1) = 1.01 [0.32]	Q(2) = 1.38 [0.50]
ARCH(1)= 2.56 [0.13]	RESET(1)=11.45 [0.01]	T = 20 (1983-2002)

where $tdxr_t^{avg}$ is the average direct tax rate, yn_t nominal GDP, dum_t^{ind} a shift dummy, which is defined above and t a linear time trend. The nominal GDP and the average direct tax rate contribute positively to the development of the total direct tax revenue, as assumed by theory.[15] Although the coefficient of nominal GDP is only significantly different from zero on the 30% significance level it has

[15] To establish a parsimonious model this equation has also been estimated neglecting the average direct tax rate, but that yields a deteriorated equation, measured by the information criteria and the forecasting performance.

been included in the equation due to its presumed importance for explaining direct tax revenues. The inflation rate, however, could not even be found significant on the 50% level and is therefore not taken into account. Diagnostic tests indicate that there might be a problem concerning linearity, but otherwise the model is well specified. The resulting forecast is shown below in Figure 6, accompanied by the forecast evaluation statistics.

Figure 6: Forecast of total direct tax revenue



Forecast evaluation:

MAPE	0.3485
Theil	0.0022

In Figure 6 no large deviations of the forecasted from the actual series can be seen. Only around 1990 a small gap between the two series can be detected. The evaluation measures as well confirm the good forecasting performance of the estimated equation.

6.2.2. Total indirect tax revenue

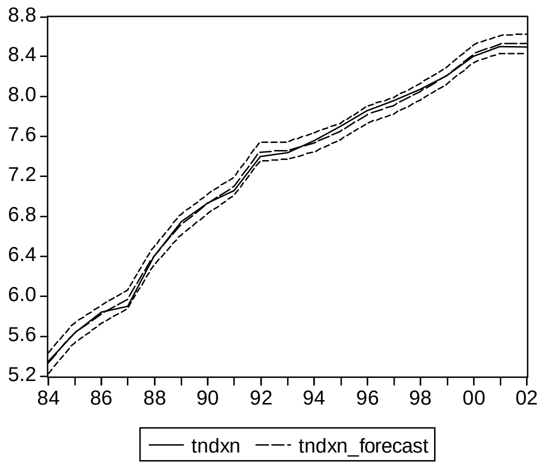
Similar to the direct tax revenue, the total indirect tax revenue is assumed to depend on the nominal GDP, the average indirect tax rate ($tndxr_t^{avg}$) and the inflation rate. This specification yields the following estimates

$$tndxn_t = \underset{(62.21)}{4.573} + \underset{(6.22)}{0.056} tndxr_t^{avg} + \underset{(2.57)}{0.615} \Delta yn_t + \\ + \underset{(3.62)}{0.420} dum_t^{ind} + \underset{(14.33)}{0.201} t - \underset{(-4.51)}{0.066} dum_t^{ind} \cdot t + \hat{u}_t. \quad (27)$$

$\bar{R}^2$=0.998	S.E.=0.04	DW = 1.15
JB = 0.73 [0.69]	Q(1) = 3.36 [0.07]	Q(2) = 3.36 [0.19]
ARCH(1)=0.32 [0.58]	RESET(1)=9.07 [0.01]	T = 20 (1983-2002)

Similar to the result of the direct tax estimation, nominal GDP and the average tax rate have a positive impact on the indirect tax rate, whereas the inflation rate does not contribute significantly to the development of indirect tax revenues.[16] Again, there is a possible problem with linearity, but the other diagnostic tests reveal no further problems. The forecasted and the actual indirect tax series are given in Figure 7.

Figure 7: Forecast of total indirect tax revenue



Forecast evaluation:

MAPE	0.3838
Theil	0.0023

[16] If the average indirect tax rate is not included, the performance of the estimated equation is worse, similar to the results concerning the direct tax rate.

Only for the years 1987 and 1991-1992 the actual series is close to the standard error bands, otherwise the results of the forecast evaluation are satisfactory.

6.2.3. Government expenditure on goods and services

According to theory, government expenditure on goods and services ($gegsn_t$) depends on the nominal GDP and the price level. Hence, the following equation has been estimated

$$\begin{aligned} gegsn_t = & \underset{(-2.78)}{-1.252} + \underset{(17.56)}{0.813} yn_t + \underset{(3.04)}{2.358} \pi_{t-1} \\ & - \underset{(-6.10)}{0.330} dum_t^{gegsn} + \underset{(4.16)}{0.244} dum_t^{ind} + \hat{\epsilon}_t^{gegsn}. \end{aligned} \tag{28}$$

$\bar{R}^2$=0.99 S.E.=0.06 DW = 1.94 T = 20 (1983-2002)

The shift dummy dum_t^{gegsn} has been included to account for the effects of the sharp depreciation of the Rand in 1985 and for independence in 1990. As expected, the nominal GDP and the inflation rate contribute positively to government expenditure on goods and services. The 10% critical value for the corresponding unit root test of the residual series is lower (in absolute terms) than the resulting t-statistic of -4.06, which confirms the existence of a stationary long-run relation.

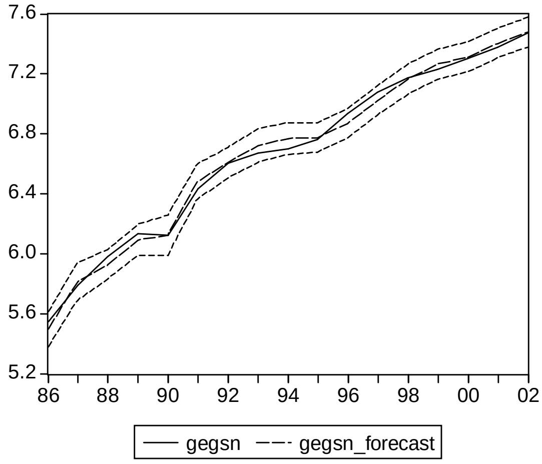
Based on that long-run relationship, an error correction model has been estimated, which is given below

$$\begin{aligned} \Delta gegsn_t = & \underset{(2.20)}{0.048} - \underset{(-1.32)}{0.307} \hat{\epsilon}_{t-1}^{gegsn} + \underset{(3.71)}{0.412} \Delta gegsn_{t-1} \\ & - \underset{(-8.45)}{0.412} \Delta dum_t^{gegsn} + \underset{(3.39)}{0.231} \Delta dum_t^{ind} + \hat{u}_t. \end{aligned} \tag{29}$$

$\bar{R}^2$=0.83	S.E.=0.05	DW = 1.35
JB = 0.91 [0.63]	Q(1) = 1.54 [0.22]	Q(2) = 1.83 [0.40]
ARCH(1)=0.45 [0.51]	RESET(1)=0.91 [0.36]	T = 20 (1983-2002)

The equation is well specified and the coefficient of the error correction term is once more negative and significant. The corresponding forecast together with the actual series is given in Figure 8.

Figure 8: Forecast of government expenditure on goods and services



Forecast evaluation:

MAPE	0.4973
Theil	0.0030

The overall forecasting performance is good, although the development of the actual series is not captured very well in 1990 and 1994, but the forecast stays within the standard error bands.

6.3. Monetary sector

6.3.1. Money demand

The money demand for the broad monetary aggregate M2 is supposed to be influenced by the GDP as a scale variable, the own rate of money and the inflation rate. The deposit rate (dr_t) has been taken as proxy for the return on the components of M2.[17] The assumption of Ikhide and Fajingbesi (1998) to consider the rate on

[17]Since official figures for the Namibian monetary aggregate M2 are only available starting with 1990, the series has been extended backwards using the growth rates of the corresponding South African monetary aggregate. Concerning the deposit rate, which is available from 1992

savings and time deposit multiplied with the respective share of that deposits in M2 has been followed as well, but has not been proven to contribute significantly to the estimation result. The estimated long-run relation is given below

$$m2_t = \underset{(-5.59)}{-10.940} + \underset{(10.17)}{2.059}y_t + \underset{(0.43)}{0.003}dr_t - \underset{(-2.33)}{0.021}\pi_t + \underset{(2.34)}{0.154}dum_t^{ind} + \epsilon_t^{m2}. \tag{30}$$

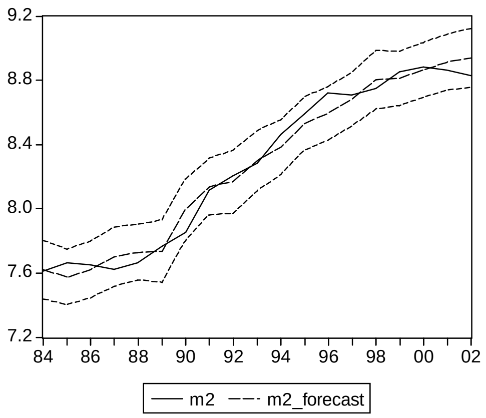
$$\bar{R}^2\text{=0.98} \quad \text{S.E.=0.08} \quad \text{DW = 1.50} \quad \text{T = 20 (1983-2002)}$$

The positive sign of the GDP is consistent with theory, which is also the case for the negative influence of the inflation rate. The deposit rate is positive, but not significant. Nevertheless, it will be included in the model, due to the undeniable importance of the interest rate in the economy. The term dum_t^{ind} has been included once more to account for the consequences due to independence. The t-statistic resulting from the unit root test of the residuals is -3.10, which is smaller (in absolute values) than the 5% critical value. Due to that and to the general difficulty in estimating a money demand function for Namibia it will not be attempted to estimate an error correction model and the long-run relationship will be used in the model.

The corresponding forecast and the actual series are given in Figure 9. At the end of the sample a deviation of the forecasted from the actual series is visible, which could not be fully explained, but otherwise the forecasting performance is good, which is confirmed by a low MAPE and Theil statistic.

on, the South African deposit rate has been taken as proxy for 1983-1991.

Figure 9: Forecast of monetary aggregate M2



Forecast evaluation:

MAPE	0.6945
Theil	0.0041

6.4. Price sector

6.4.1. Consumer price index

It is assumed that, due to the dependence from Namibia on imports, the import price index (mpi_t) influences the consumer price index of Namibia (cpi_t) significantly. Wages as well are an important explanatory factors for the price development. Since official wage figures for the whole Namibian economy are not accessible, the nominal average annual wage of a mining employee (wn_t^{mine}), provided by the *Chamber of Mines in Namibia* (CM, 2002), is taken as proxy. Consequently, the following long-run equation has been estimated.

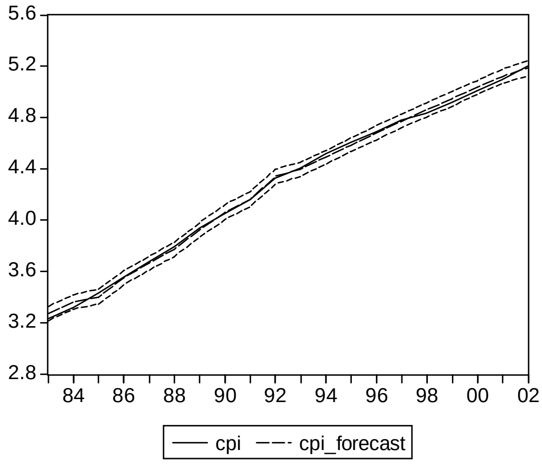
$$cpi_t = \underset{(2.14)}{1.298} + \underset{(4.18)}{0.391}mpi_t + \underset{(0.761)}{0.070}wn_t^{mine} + \underset{(3.52)}{0.080}dum_{t-2}^{ind} \cdot t + \underset{(6.67)}{0.055}t + \hat{\epsilon}_t^{cpi}. \quad (31)$$

$$\bar{R}^2{=}0.998 \quad \text{S.E.}{=}0.03 \quad \text{DW} = 1.11 \quad \text{T} = 20 \text{ (1983-2002)}$$

The shift dummy dum_{t-2}^{ind} has been included to account for a shift in the trend of the price level in 1992, leading to a inflation rate of over 16% in that year. As expected, wages as well as the import price index have a positive influence on the consumer price index. Although the wages are not highly significant they have been included in the estimation due to their presumed importance for prices. The low significance might also be due to data problems, since they only represent the mining industry.

Since the direction of causality runs from prices to wages and not vice versa, i.e. prices do not adjust to wages, but wages to prices and the objective is to incorporate an equation, which explains the movements of prices, no error correction model, but the long-run relationship, given in equation (31) is included in the model. Incorporating an error correction model would distort the results since the adjustment process runs in the wrong direction.

Figure 10: Forecast of consumer price index



Forecast evaluation:

MAPE	0.4600
Theil	0.0025

The actual and forecasted series, resulting from the long-run equation, are displayed in Figure 10. Figure 10 and the forecast evaluation measures indicate a very good fit of the forecast. Also the years around independence are captured very well.

7. Model estimation results

7.1. In-sample performance

After having specified all single equations and assured that their forecasting performance is good, the model is build, based on these stochastic equations. To do so, several identities have to be added to the model. The central identity for the real sector is the national income identity, i.e.

$$y_t = c_t^p + i_t^p + g_t + x_t - m_t + \Delta invent_t, \tag{32}$$

where g_t is the total expenditure of the government, which is taken as exogenous and is the sum of public consumption and public investment. $\Delta invent_t$ accounts for changes in inventories, which are defined as the difference between the total value of all goods that enter the inventories of producers and the total value of all goods that are withdrawn from them.[18] Other identities are those for gross domestic expenditure, the discrepancies, changes in inventories, the budget deficit, total government expenditure and total government revenue.

The number of equations for the different sectors is comprised in Table 1. A summary of the equations is given in Table B.1 in Appendix B.

Overall, 38 variables are included in the model, 16 endogenous and 22 exogenous (including 5 dummy variables). The linkages of the single variables resulting from the estimation of the sectoral equations are given in Figure 11.

At first, the model is solved for the period 1983 to 2002, to assess its in-sample forecasting properties. Therefore, a static solution is chosen, i.e. the one-period-ahead forecasts are computed, using actual values for both the exogenous and the

[18] The GDP can be computed according to the production, income and expenditure approach. As the production approach is considered to be the most reliable, the GDP is calculated according to it. Due to imperfections and gaps in data sources, discrepancies occur between that series and the GDP series calculated following the expenditure approach. These discrepancy have to be taken into account by building the model. For further explanations see e.g. CBS/NPC (2001).

Table 1: Number of equations

sector	stochastic equations	identities	total
real	4	4	8
fiscal	3	3	6
monetary	1	-	1
price	1	-	1
all sectors	9	7	16

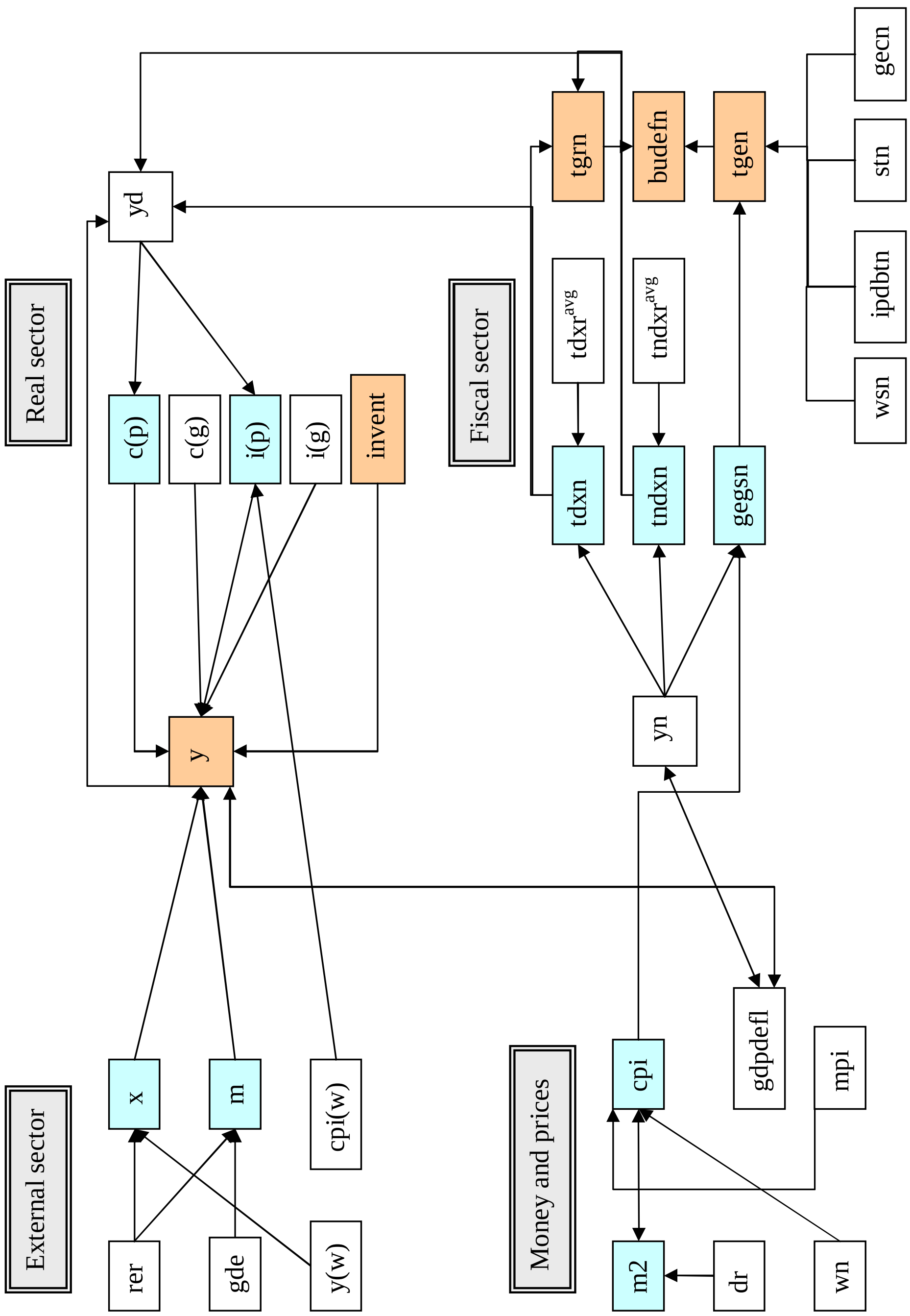
lagged endogenous variables. The resulting paths for the endogenous variables are depicted in Figure C.1 in Appendix C together with the actual series.[19]

Since the result of the static in-sample forecast is quite satisfactory, the next step is the dynamic in-sample forecast, i.e. examining the forecasting performance of the model, when forecasting not only one period, but many periods ahead. This dynamic forecast displays no large differences, when compared to the static in-sample forecast and is therefore not shown here.

For all exogenous variables, shock simulations have been carried out. The respective variable has been shocked five years prior to the end of the sample, i.e. a very high growth rate compared to the average growth rate perceived before has been assumed. Then, the model has been solved and the reaction of the endogenous variables to that development has been examined. It turns out that the responses of the endogenous variables to these simulations are in line with the expected signs and coefficients and the assumed interrelationships between the series.[20]

[19] In the context of forecasting, the series are given in levels and not in logarithms, as the development of the levels is of interest.
[20] The detailed results are not presented here, but are available on request.

Figure 11: Detailed structure of the Namibian macroeconometric model



7.2. Policy simulations

The crucial part in solving the model is the specification of the future paths of the exogenous variables. Whenever possible, projections of official sources are taken into account. This has been the case for the years 2003-2005 for the following variables: $gecn_t, ntrn_t, intdbtn_t, stn_t$ and wsn_t, where the official projections have been provided by the Ministry of Finance in the context of the medium-term expenditure framework.[21] The average tax rate forecasts have been computed using the official projections of $tdxn_t$ and $tndxn_t$. For the world income (y_t^w), world prices (cpi_t^w) and the real exchange rate (rer_t), projections of various other sources, such as the IMF World Economic Outlook or the OECD Economic Outlook, have been used.

For the remaining exogenous variables different scenarios will be constructed. In a model like the one implemented here, where complex econometric methodology is involved, it is very difficult to establish precise point estimates of the endogenous variables. Hence, for the purpose of this paper, two scenarios are created to provide insight into the behaviour and reaction of the endogenous variables. The two scenarios are characterized by the following developments:

Scenario 1: High government spending (consumption and investment), weak Namibia Dollar and high interest rates;

Scenario 2: Low government spending (consumption and investment), strong Namibia Dollar and low interest rates.

The assumptions about prices and wages will be the same for both scenarios.

As benchmark for the development of the exogenous variables, their average growth rate during the years following independence has been taken. The EViews-programmes for the two scenarios are given in Appendix D. The resulting paths of the endogenous variables for the two different scenarios is given in Figure E.1 and E.2 in Appendix E.

[21] MTEF 2003-2005 and MTEF 2004-2006.

The projected development of selected endogenous variables for the years 2003-2005 and for the respective scenario is summarized in Table 2.

Table 2: Future paths of selected endogenous variables

	Scenario 1			Scenario 2		
year	2003	2004	2005	2003	2004	2005
c_t^p	0.5	0.8	2.6	0.5	0.4	0.5
i_t^p	12.2	8.2	7.9	12.3	9.0	8.4
x_t	-3.1	4.9	-1.4	-3.1	-2.8	0.3
m_t	0.04	1.3	2.2	-0.2	0.8	1.6
cpi_t	7.8	7.7	8.1	7.8	7.7	8.1
y_t	3.7	5.1	3.6	2.6	1.2	2.1

For all variables the annual percentage change is given.

In scenario 1, the growth rate of GDP is projected to equal 5.1 percent in 2004, mainly due to the weak Namibia Dollar assumed in Scenario 1, which contributes to a large increase in exports. This is not the case in scenario 2 in 2004, yielding a forecasted GDP growth rate of 1.2 percent. The growth rates of exports are reversed in 2005, which is due to the performance of the export sector in the respective scenario, which is the reference period for the annual growth rate. In Scenario 1, GDP is projected to grow by 3.6 percent, compared to 2.1 percent in Scenario 2. The inflation rate is projected to remain a single-digit-figure and is the same for both scenarios, since the assumptions on the price developments are the same.

These two scenarios should be seen as a band, within which the most likely forecast is supposed to lie and can therefore be considered as a pessimistic an optimistic outlook. It has to be emphasized once more that these forecasts depend crucially on the assumptions on the future development of the exogenous variables, hence, it is advisable to consider different possible scenarios instead of one point forecast.

8. Conclusion and way forward

A macro-econometric model for the Namibian economy has been constructed that incorporates the essential features of the economy while making extensive use of economic theory. The model identifies the activities of the real sector, the external sector, the fiscal sector, and the monetary and the price sector. Behavioural equations are specified according to economic theory and estimated within the Keynesian framework using recent econometric techniques. The linkages of these four sectors are identified and the model solved simultaneously to incorporate those linkages.

Stochastic equations for all of the endogenous variables in the model have been set up inspired by the list of potential economic explanatory variables. Dummy variables have been included where necessary in order to correct for outliers, policy changes or other events that affect the Namibian economy. Generally, the single-equation analysis shows that the behavioural equations are well specified and the forecasting performance is good. Different paths for the exogenous variable have been assumed to proceed to the out-of sample forecast of the model.

The results of the dynamic simulation fit the actual data well, reproducing most of the turning points of the time series. Further, the dynamic simulation of the model produces satisfactory results, as they show that the economic aggregates behave according to a priori expectations. However, it is worth mentioning that the results need to be interpreted with considerable caution, because this is a simple aggregated model and further work to disaggregate the model needs to be done. The model provides GDP by expenditure as an output and further disaggregation of the model needs to be done to provide disaggregated output, i.e. GDP by sector. Currently, different major production sectors of the Namibian economy are analyzed separately to complement the overall aggregated GDP forecasts. The main sectors, which will be focussed on are the mining, agricultural, fishing, tourism and manufacturing sectors. Each sector will be modelled and forecasted individually and the projections can support the overall outlook derived from NAMEX.

Furthermore, the nominal average annual wage of a mining employee was used as a proxy for the wage of the whole Namibian economy and further work is necessary in this regard. The labour sector should be modelled separately and linked to the overall model. At the moment, no reliable time series for unemployment and wages is available, which complicates the model building. So far, the labour force and population and household surveys data have been used in combination with the employment elasticity of output to create different scenarios of the development of the unemployment rate, based on the GDP projections of the NAMEX. Nevertheless, a thorough investigation of further possibilities to model the labour sector and link it to the overall model are necessary.

A. Variables used for estimation

The frequency of all data is annual. All variables, except the interest rates, are in logarithms, indicated by small letters. Variables with an additional n are nominal variables, all others real. $ex/en/id$ resembles if the variable is modelled endogenously, taken as exogenous or given by an identity.

A.1. List of variables

Table A.1: List of variables included in the model

variable	description	sample	ex/en/id
$budefn_t$	budget deficit	1983-2002	id
c_t^g	public consumption expenditure	1983-2002	ex
c_t^p	private consumption expenditure	1983-2002	en
cpi_t	consumer price index	1983-2002	en
cpi_t^w	weighted cpi of five major trading partners	1983-2002	ex
$discrep_t$	discrepancies	1983-2002	id
dr_t	deposit rate	1983-2002	ex
dum_t^c	impulse dummy (1=1985)	1983-2002	ex
dum_t^{gegsn}	impulse dummy (1=1985 and 1990)	1983-2002	ex
dum_t^i	impulse dummy (1=1991 and 1997)	1983-2002	ex
dum_t^{ind}	shift dummy (1 from 1990)	1983-2002	ex
dum_t^x	impulse dummy (1=1990)	1983-2002	ex
g_t	total government expenditure ($=c_t^g + i_t^g$)	1983-2002	ex
gde_t	gross domestic expenditure	1983-2002	id
$gecn_t$	government capital expenditure	1983-2002	ex
$gegsn_t$	government expenditure on goods and services	1983-2002	en

Table A.1: *(continued)*

variable	description	sample	ex/en
i_t^g	public investment	1983-2002	ex
i_t^p	private investment	1983-2002	en
$\Delta invent_t$	change in inventories	1983-2002	id
$ipdbtn_t$	interest payment on debt (internal and external)	1983-2002	ex
m_t	imports of goods and services	1983-2002	en
$m2_t$	broad monetary aggregate M2	1983-2002	en
mpi_t	import price index	1983-2002	ex
$ntrn_t$	non-tax revenue of government	1983-2002	ex
rer_t	real exchange rate	1983-2002	ex
stn_t	subsidies and transfers	1983-2002	ex
$tdxn_t$	total direct taxes	1983-2002	en
$tdxr_t^{avg}$	average direct tax rate	1983-2002	ex
$tgen_t$	total government expenditure	1983-2002	id
$tgrn_t$	total government revenue	1983-2002	id
$tndxn_t$	total indirect taxes	1983-2002	en
$tndxr_t^{avg}$	average indirect tax rate	1983-2002	ex
tt_t	total taxes ($=tdx_t + tndx_t$)	1983-2002	ex
wn_t^{mine}	annual wage for mining employee	1983-2002	ex
wsn_t	wages and salaries	1983-2002	ex
x_t	exports of goods and services	1983-2002	en
y_t	gross domestic product	1983-2002	id
y_t^d	disposable income ($=y_t - tt_t$)	1983-2002	ex
y_t^w	weighted world income of 5 major trading partners	1983-2002	ex
yp_t	GDP deflator	1983-2002	ex
π_t	inflation (based on cpi_t)	1984-2002	en

A.2. Graphs of analyzed variables

Figure A.1: Analyzed time series

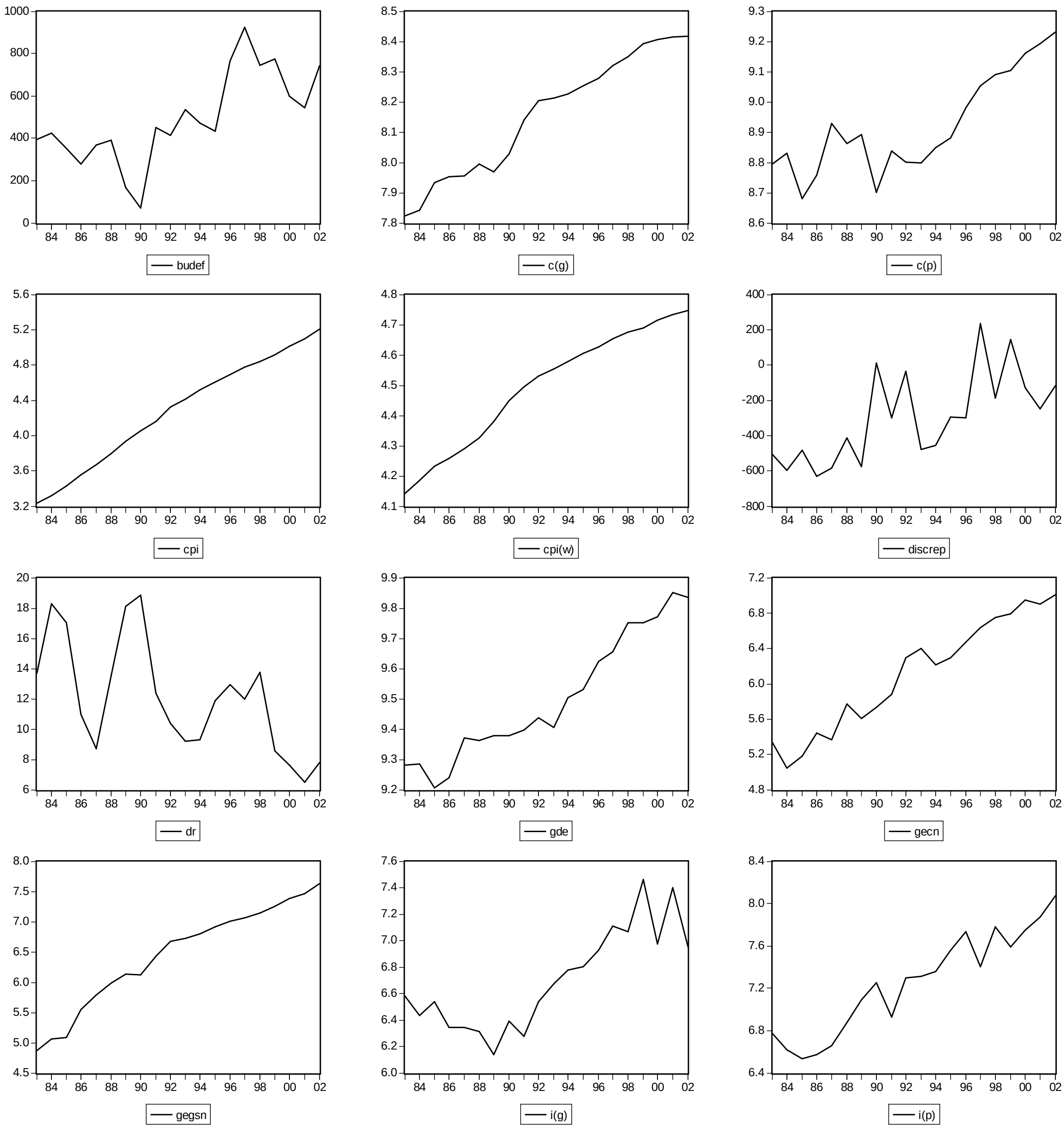


Figure A.1: Analyzed time series *(continued)*

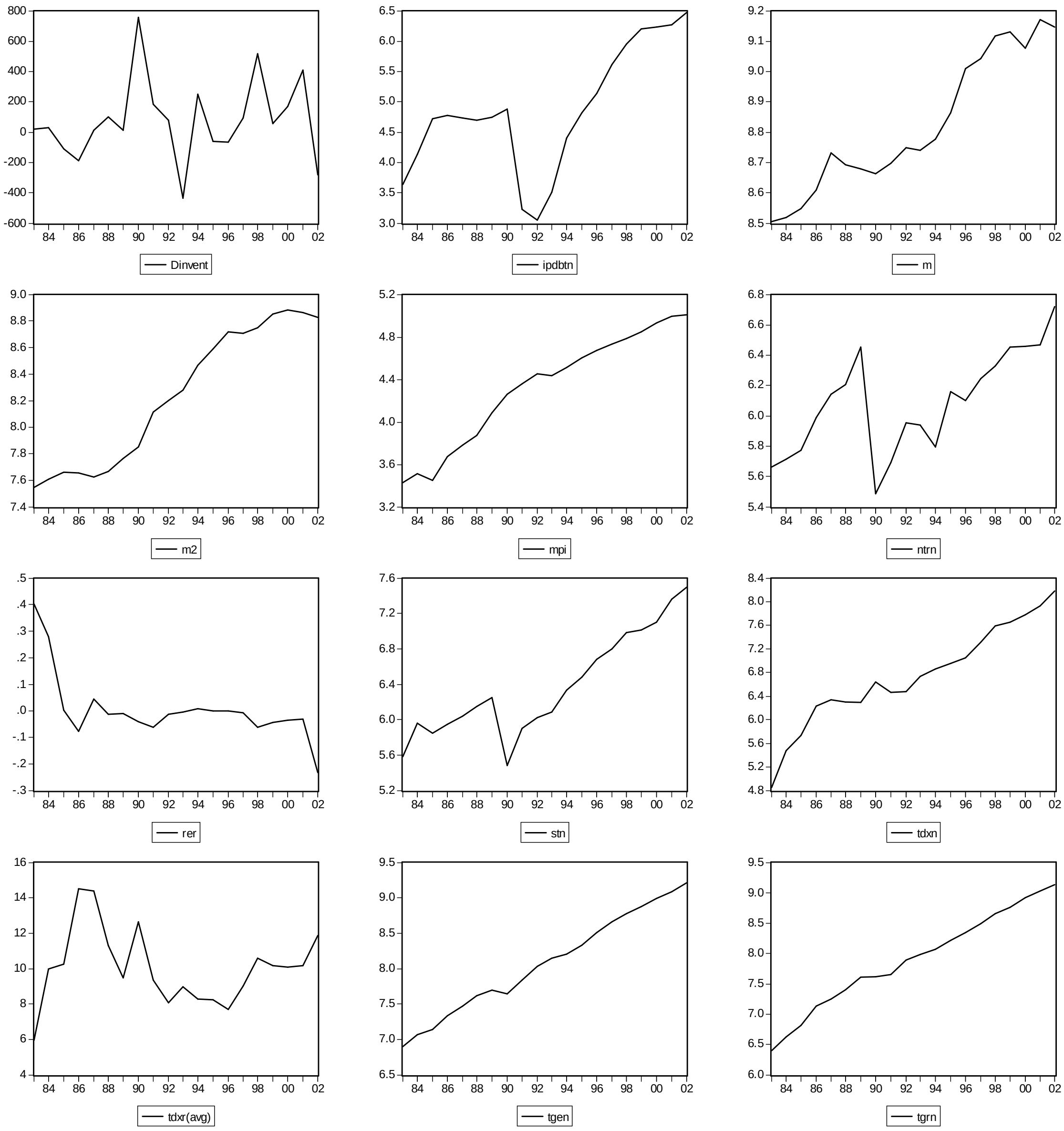
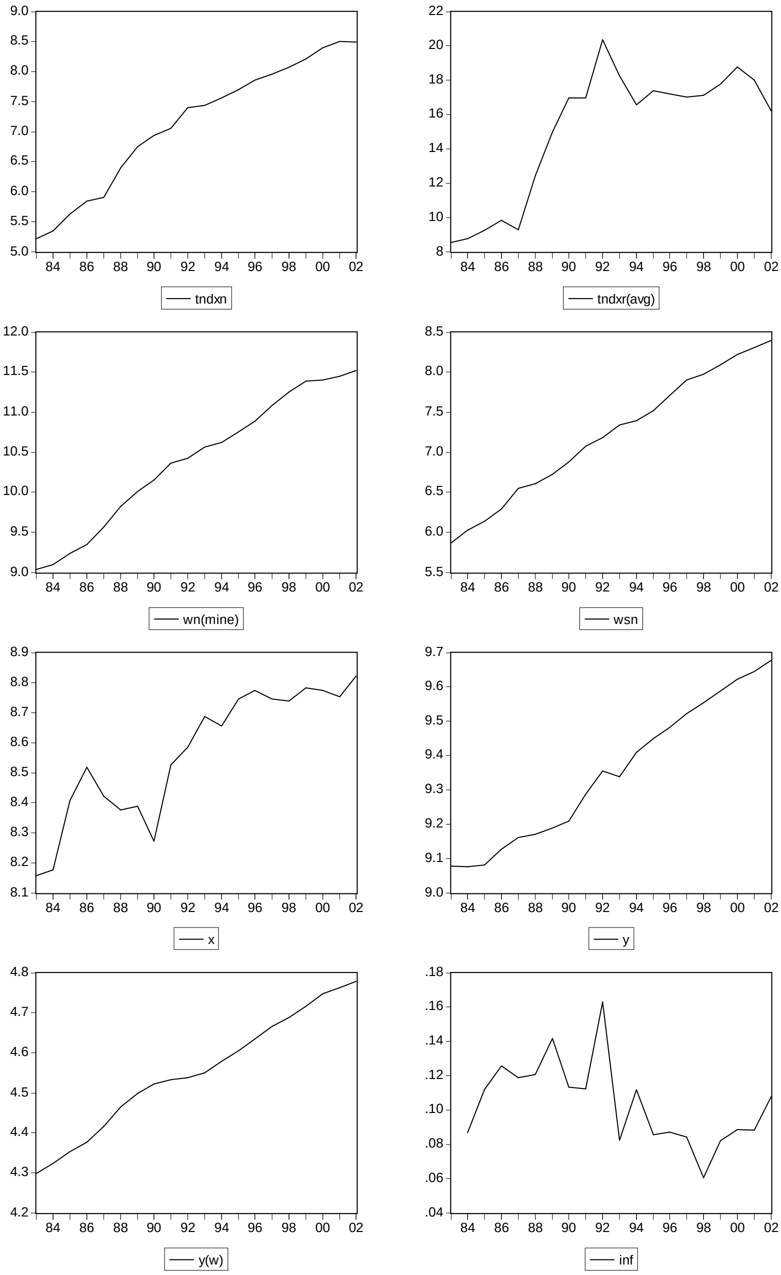


Figure A.1: Analyzed time series *(continued)*



B. Summary of equations included in the model

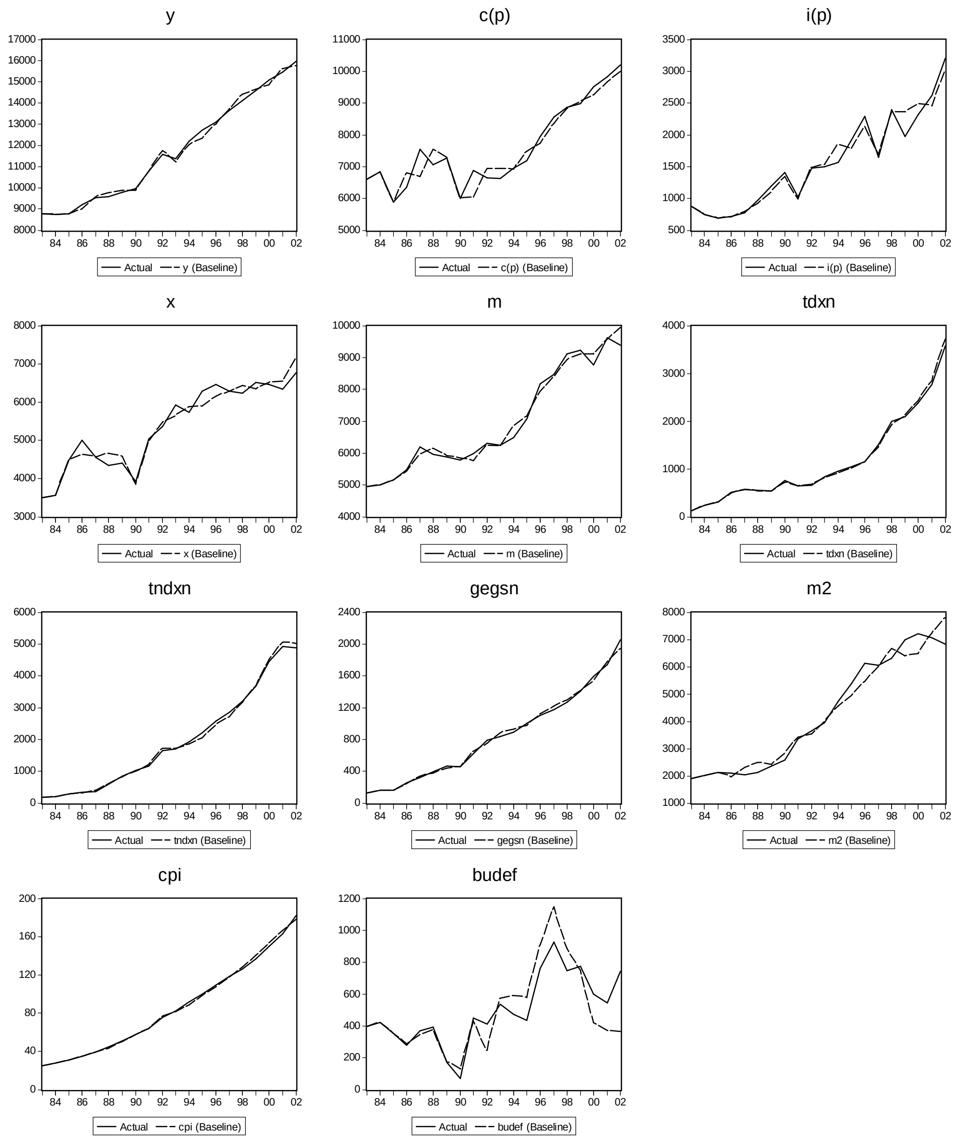
In Table the equations, stochastic and identities, are summarized for the single sectors. Only the functional dependencies are given, not the specific coefficients.

Table B.1: List of equations included in the model

Real sector	
Stochastic equations	$c_t^p = f(y_t^d, dum_t^c, dum_t^{ind})$
	$i_t^p = f(y_t^d, cpi_t^w, dum_t^i)$
	$x_t = f(y_t^w, rer_t, dum_t^x)$
	$m_t = f(gde_t, rer_t)$
Identities	$y_t \equiv c_t^g + c_t^p + i_t^g + i_t^p + \Delta invent_t + x_t - m_t + discrep_t$
	$\Delta invent_t \equiv gde_t - c_t^g - c_t^p - i_t^g - i_t^p$
	$discrep_t \equiv y_t - gde_t - x_t + m_t$
	$gde \equiv c_t^g + c_t^p + i_t^g + i_t^p + \Delta invent$
Fiscal sector	
Stochastic equations	$tdxn_t = f(yn_t, dum_t^{ind}, tdxr_t^{avg})$
	$tndxn_t = f(yn_t, dum_t^{ind}, tndxr_t^{avg})$
	$gegsn_t = f(yn_t, \pi_{t-1}, dum_t^{gegsn})$
Identities	$budefn_t \equiv tgen_t - tgrn_t$
	$tgen_t \equiv wsn_t + gegsn_t + ipdbtn_t + stn_t + gecn_t$
	$tgrn \equiv tdxn_t + tndxn_t + ntrn_t$
Monetary sector	
Stochastic equations	$m2_t = f(y_t, \pi_t, dr, dum_t^{ind})$
Price sector	
Stochastic equations	$cpi_t = f(mpi_t, wn_t^{mine}, dum_{t-2}^{ind})$

C. In-sample forecast of the model

Figure C.1: Static in-sample forecast



D. EViews-Programmes for creating upper and lower bound scenarios

D.1. Scenario 1

'Scenario 1 for 2003-2005 'high government spending, weak N$, high interest rates
'workfile modelworkfile
'$gecn, intdbtn, ntrn, stn$ and wsn do not have to be forecasted, official projections are used; for wcpi and wy projections from different sources are used as well; dr and rer available for 2003
'$avgtdx$ and $avgtndx$ are forecasted using the official projections for $tdxn$ and $tndxn$ and the model forecast for gdp and $gdpdefl$
'the other exogenous variables have to be forecasted [22]

smpl 1983 2002
genr $consg\_3 = consg$
genr $dr\_3 = dr$
genr $gdpdefl\_3 = gdpdefl$
genr $invg\_3 = invg$
genr $mpi\_3 = mpi$
genr $rer\_3 = rer$
genr $unitwage\_3 = unitwage$

smpl 2003 2003
genr $consg\_3 = consg\_3(-1) * 1.06$
genr $dr\_3 = dr$
genr $gdpdefl\_3 = gdpdefl\_3(-1) * 1.04$
genr $invg\_3 = invg\_(-1) * 1.20$
genr $mpi\_3 = mpi\_3(-1) * 1.04$
genr $rer\_3 = rer$
genr $unitwage\_3 = unitwage\_3(-1) * 1.07$

smpl 2004 2004
genr $consg\_3 = consg\_3(-1) * 1.07$

[22] Since this is the original EViews programming code, the notation of the variables may differ from that used in the text. The differences are the following: $invg = i_t^g$, $consg = c_t^g$, $gdpdefl = yp_t$, $intdbtn = ipdbtn_t$, $unitwage = wn_t^{mine}$. This applies as well for Scenario 2.

genr $dr\_3 = 10.0$
genr $gdpdefl\_3 = gdpdefl\_3(-1) * 1.08$
genr $invg\_3 = invg\_3(-1) * 1.05$
genr $mpi\_3 = mpi\_3(-1) * 1.04$
genr $rer\_3 = 0.80$
genr $unitwage\_3 = unitwage\_3(-1) * 1.06$

smpl 2005 2005
genr $consg\_3 = consg\_3(-1) * 1.06$
genr $dr\_3 = 11.0$
genr $gdpdefl\_3 = gdpdefl\_3(-1) * 1.07$
genr $invg\_3 = invg\_3(-1) * 1.17$
genr $mpi\_3 = mpi\_3(-1) * 1.05$
genr $rer\_3 = 0.85$
genr $unitwage\_3 = unitwage\_3(-1) * 1.06$

smpl 1983 2005

D.2. Scenario 2

'Scenario 2 for 2003-2005 'low government spending, strong N$, low interest rates
'workfile modelworkfile
'$gecn, intdbtn, ntrn, stn$ and wsn do not have to be forecasted, official projections are used; for wcpi and wy projections from different sources are used as well; dr and rer available for 2003
'$avgtdx$ and $avgtndx$ are forecasted using the official projections for $tdxn$ and $tndxn$ and the model forecast for gdp and $gdpdefl$
'the other exogenous variables have to be forecasted

smpl 1983 2002
genr $consg\_4 = consg$
genr $dr\_4 = dr$
genr $gdpdefl\_4 = gdpdefl$
genr $invg\_4 = invg$
genr $mpi\_4 = mpi$
genr $rer\_4 = rer$
genr $unitwage\_4 = unitwage$

smpl 2003 2003

genr $consg\_4 = consg\_4(-1) * 1.03$
genr $dr\_4 = dr$
genr $gdpdefl\_4 = gdpdefl\_3(-1) * 1.05$
genr $invg\_4 = invg\_4(-1) * 1.10$
genr $mpi\_4 = mpi\_4(-1) * 1.04$
genr $rer\_4 = rer$
genr $unitwage\_4 = unitwage\_4(-1) * 1.07$

smpl 2004 2004
genr $consg\_4 = consg\_4(-1) * 1.04$
genr $dr\_4 = 7.5$
genr $gdpdefl\_4 = gdpdefl\_4(-1) * 1.08$
genr $invg\_4 = invg\_4(-1) * 0.95$
genr $mpi\_4 = mpi\_4(-1) * 1.04$
genr $rer\_4 = 0.95$
genr $unitwage\_4 = unitwage\_4(-1) * 1.06$

smpl 2005 2005
genr $consg\_4 = consg\_4(-1) * 1.03$
genr $dr\_4 = 7.0$
genr $gdpdefl\_4 = gdpdefl\_4(-1) * 1.07$
genr $invg\_4 = invg\_4(-1) * 1.05$
genr $mpi\_4 = mpi\_4(-1) * 1.05$
genr $rer\_4 = 0.97$
genr $unitwage\_4 = unitwage\_4(-1) * 1.06$

smpl 1983 2005

E. Out-of-sample forecasts of the model

Figure E.1: Dynamic out-of-sample forecast: Scenario 1

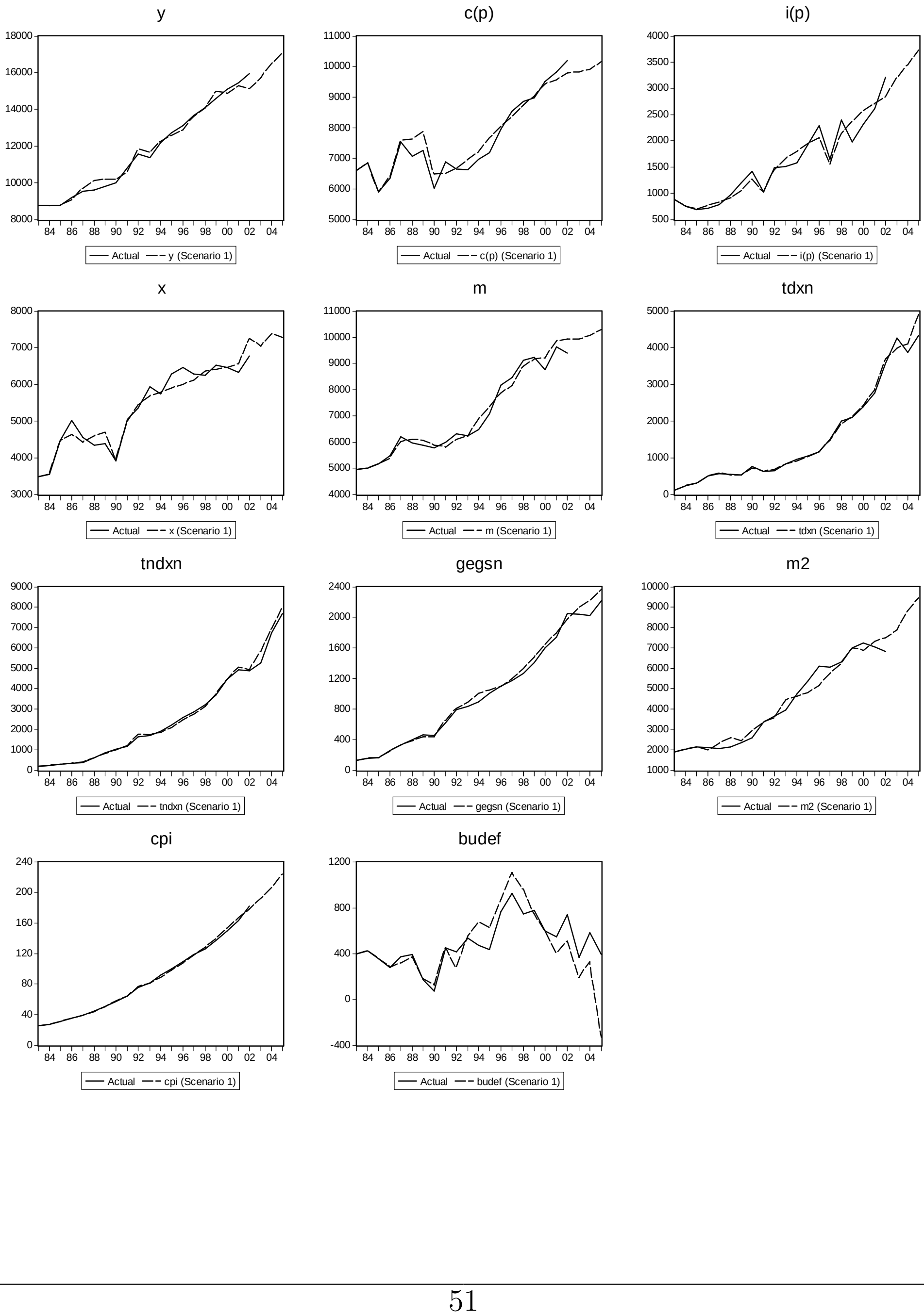
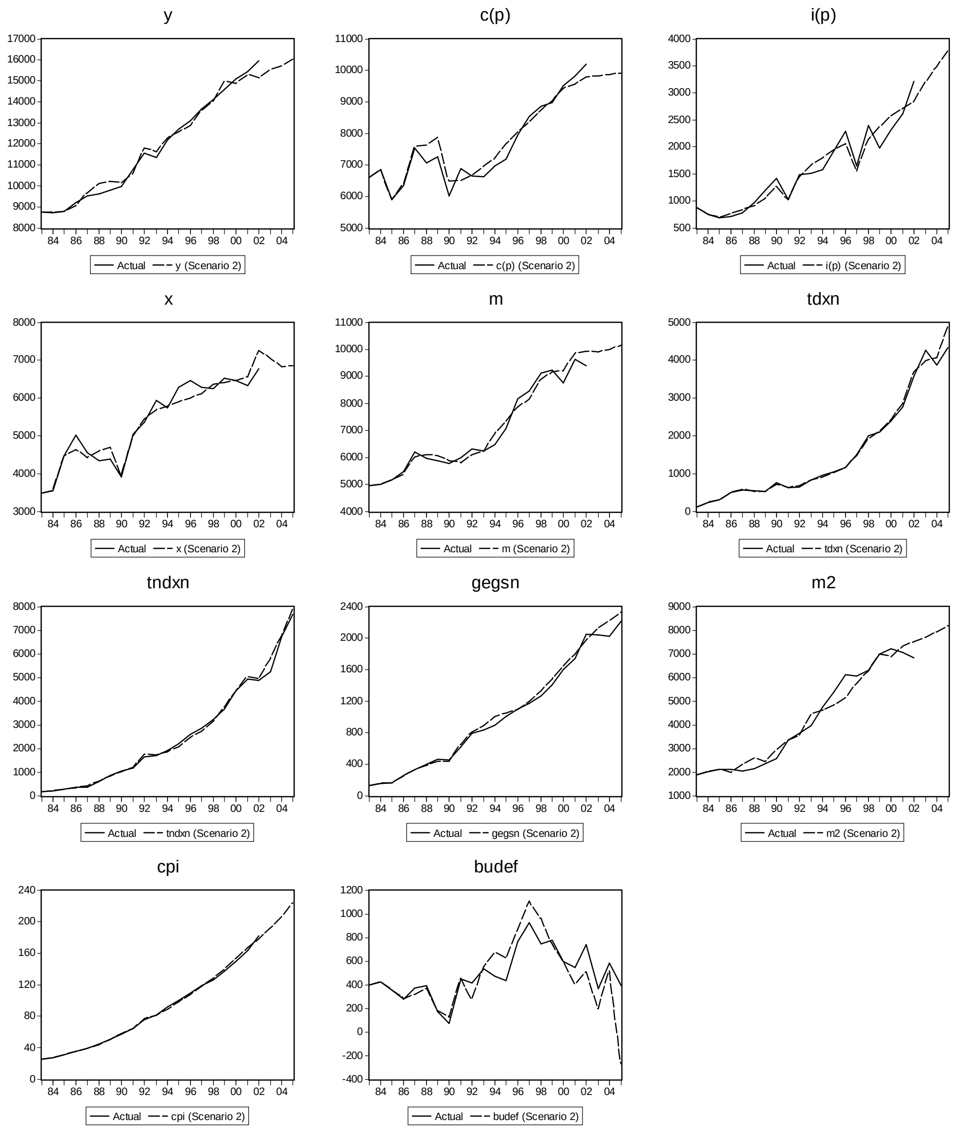


Figure E.2: Dynamic out-of-sample forecast: Scenario 2



References

Banerjee, A., J. Dolado, J. Galbraith and D. Hendry (1993), *Co-integration, error correction, and the econometric analysis of non-stationary data*, Oxford University Press, Oxford.

Bank of Namibia, *Exchange Rate Methodology - Nominal and Real Effective Rate Index for Namibia*, mimeo.

CBS/NPC (2001), *National Accounts 1993-2000*, Central Bureau of Statistics, Windhoek.

CM (2002), *Annual Report*, The Chamber of Mines of Namibia.

Dickey, D. and W. Fuller (1979), Distribution of the Estimators for Autoregressive Time Series with a Unit Root, *Journal of the American Statistical Association*, 74, 427–431.

Engle, R. and C. Granger (1987), Co-Integration and Error Correction: Representation, Estimation, and Testing, *Econometrica*, 55, 251–276.

Granger, C. (1986), Developments in the Study of Cointegrated Economic Variables, *Oxford Bulletin of Economics and Statistics*, 48, 213–228.

Granger, C. and P. Newbold (1974), Spurious Regressions in Econometrics, *Journal of Econometrics*, 2, 111–120.

Greene, W. (2003), *Econometric Analysis*, 5th ed., Prentice Hall, New Jersey.

Ikhide, S. and A. Fajingbesi (1998), Interest Rate Deregulation and the Demand for Money Function: Evidence from Selected African Countries, *RISEC*, 45 (4), 785–804.

Johansen, S. (1991), Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models, *Econometrica*, 59, 1551–1580.

— (1995), *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*, Oxford University Press, Oxford.

Khan, M. (1974), Import and Export Demand in Developing Countries, *IMF Staff Papers*, 678–693.

MacKinnon, J. (1991), *Critical Values for Cointegration Tests*, In: R. Engle and C. Granger (eds.) Long-Run Economic Relationships, Oxford University Press, Oxford, 267-276.

Odada, J., J. Eita and O. Nhuleipo (2000), *An Aggregate Consumption Function for Namibia: An Empirical Appraisal*, Multi-Disciplinary Research & Consultancy Centre, University of Namibia, SSD RR #40.

Phillips, P. (1986), Understanding Spurious Regression in Econometrics, *Journal of Econometrics*, 33, 311–340.

Tjipe, T. and H. Nielsen (2003), *Namibia Macroeconometric Model (NAMEX) - Manual*, Bank of Namibia, Research Department, Macroeconomic Modelling and Forecasting Division, Preliminary Draft.