

## EXPLAINING LONG-TERM GROWTH IN NAMIBIA

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### Abstract

Supply-side economics stresses the importance of analysing and modelling the long-term properties of an economy's production structures in order to investigate each factor of production's impact on final output. This helps to determine how much should be produced, how much is available for consumption and, eventually, how an economy can improve its long-term economic growth path. This study applied the neoclassical growth model to Namibia's growth over the period from 1971 to 2005 in order to identify and develop the main supply-side components of long-term economic growth in the country. Along with a production function, behavioural equations were estimated for the factors of production labour demand and capital investment, as well as for the links between prices and wages.

**Keywords:** Economic growth, neoclassical growth model, supply-side, cointegration, Cobb–Douglas production function.

JEL C5, C51, C52

### 1

## Introduction

Once the core principle of economic policy, the Keynesian approach has now been largely discredited because of its inability to solve the problems of unemployment and inflation. As Du Toit, Koekemoer and Ground (2004: 3) note, the inadequacy of demand-oriented theories to account for and deal with the problem of stagnation, lagging productivity, double digit inflation, high interest rates and depreciating currencies has led to the emergence of supply-side economics.

Supply-side economics emphasises the importance of understanding the structure of the production process and the effect of each production factor on the level of output. This approach to economics stresses the importance of analysing and modelling the cost-minimising and profit-maximising behaviour of firms involved in production activities, as well as the long-term properties of an economy's production

structures, in order to investigate the impact of each factor of production on final output. Once the production structure of an economy has been deciphered, the productive capacity of the economy can be used to determine how much should be produced, how much is available for consumption and, more importantly, how the economy concerned can improve its long-term economic growth path.

In this context, the objective of this study was to model the supply side of the Namibian economy, using the neoclassical growth model. The estimated model can be used to understand long-term economic growth in Namibia, the determinants of such growth and the constraints that limit such growth. Section 2 of this study provides an economic overview of Namibia's GDP and employment growth in recent times. Section 3 discusses the theoretical framework of the neoclassical growth model employed in the study. Section 4 outlines the empirical methodology used in the estimation of the growth model, and Section 5 provides the

model's final behavioural results. The model is closed in Section 6. A conclusion incorporating policy recommendations is presented in Section 7.

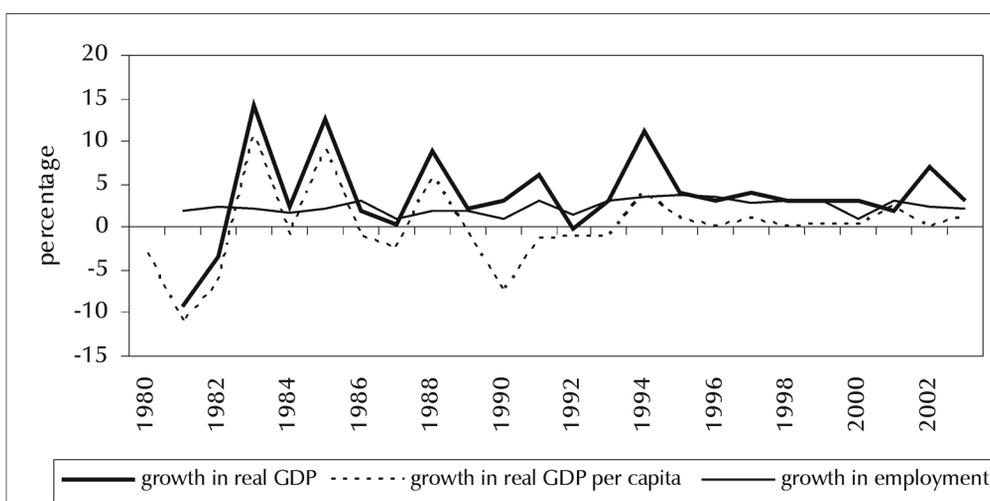
## 2

### The Namibian economy's growth performance

Since Namibia gained independence in 1990, the Namibian government has taken great strides towards reviving an economy which had

previously performed very poorly. Diversifying the economy and developing the manufacturing and agricultural sectors are two important parts of the government's strategy to create employment opportunities and address the socio-economic imbalances inherited from colonial times. Real GDP growth for the period from 1980 to 2003 is plotted in Figure 1. Growth in the 1980s was sluggish, at times even negative. However, since independence, GDP growth has improved to an average of 3.9 per cent for the period from 1990 to 2003.

**Figure 1**  
Growth rates of real GDP, GDP per capita and employment



Source: Data for the construction of the graph are obtained from Bank of Namibia (1991; 1999; 2004; 2005); Hartman (1988).

Employment growth, shown in Figure 1, remained constant in the 1980s, but picked up to a steady yet slow average growth of 3 per cent between 1990 and 2003. Despite positive growth rates in employment and the real GDP since 1990, unemployment rose steadily over the entire period, reaching a peak of 22 per cent in

2003 (see Figure 2). It is important to note that a narrow definition of unemployment is used here (people who are not actively looking for jobs in the period under review are excluded from the figure). If discouraged job-seekers are counted, the unemployment rate rises to 34.5 per cent (Bank of Namibia, 2001:4).

**Figure 2**  
Unemployment rate



Source: Compiled using the data from Hartman (1988) and Ministry of Labour and Social Welfare (1997; 2000; 2004)

Unemployment jumped suddenly in 1997 and increased gradually. Unemployment is brought about by structural problems that make it impossible for the Namibian economy to generate enough jobs to keep up with the number of people entering the labour force. The manufacturing sector is still small and employs only about 25 000 people. The mining sector, which accounted for 12 per cent of the GDP in 2004 employs about 5 000 people; and employment in this sector has been declining because of greater efficiencies brought about by technology. The closure of the Tsumeb Corporation Limited (TCL) copper mine in the period from 1997 to 1998 also contributed to a rise in unemployment. TCL employed, on average, 7 200 people between 1990 and 1997 (Bank of Namibia, 2001).

Namibia imports most of its consumer goods and exports its products in unprocessed form. Exporting unprocessed products does not contribute much to the generation of much-needed employment.

As Figure 1 reveals, the growth in employment has been relatively stable, which suggests that unemployment is driven by supply factors. These factors include an increase in the number of secondary school leavers. The Namibia Labour Force Survey of 1997, 2000 and 2004 indicate that most unemployed people are the youth (Ministry of Labour and Social Welfare, 1997; 2000; 2004). The entry of increasing numbers of women into the labour

force has also contributed to the increase in unemployment.

The poor education system inherited from the pre-independence era is also to blame for Namibia's unemployment woes. The Ministry of Labour and Social Welfare (2000) indicates that unemployment is most prevalent in the unskilled worker category. By contrast, at the other end of the educational ladder, the unemployment rate for people with qualifications beyond secondary school level is less than 1 per cent (Bank of Namibia, 2001:8). This is an indication that the Namibian labour market has a stronger preference for people with an advanced education. This preference, coupled with an acute shortage of skilled human resources, has led to a severe mismatch. This situation is not unique to Namibia, but is evident in all countries.

Another factor hampering the growth of employment in Namibia is that the private sector's absorption of the unemployed is limited by the fact that most modern industries are capital intensive, the mining sector in particular.

## 2.1 Sources of economic growth: growth accounting

In order to identify the supply-side structural changes that may have occurred in the Namibian economy, it is important to identify the various sources of the country's growth performance. An

economy's output of goods and services depends on the quantities of available inputs, such as capital and labour, as well as on the productivity of those inputs. The relationship between output and inputs is described in the production function. A production function such as  $Y = AF(K, L)$  relates total output to the economy's use of the inputs of capital  $K$ , labour  $L$ , and productivity or technology  $A$  (Abel & Bernanke, 2001: 206-209). If inputs and productivity are constant, output will also be constant and there will be no economic growth – the quantity of

inputs must grow for output to grow. According to the growth accounting equation, output is equal to the weighted sum of growth in capital, labour and productivity or technology,

$$\frac{\Delta Y}{Y} = [(1 - \theta) * \frac{\Delta N}{N}] + (\theta * \frac{\Delta K}{K}) + \frac{\Delta A}{A}.$$

For the purposes of this study, the contribution to growth of each input was derived by dividing the sample into two periods, namely from 1971 to 1989 and from 1990 to 2005. The results are presented in Table 1.

**Table 1**  
Sources of economic growth

	1971–1989	1990–2005
Sources of growth		
Capital growth	2.74%	0.40%
Labour growth	0.42%	1.93%
Total input growth	3.16%	2.33%
Total factor productivity	0.34%	1.80%
Total output growth	3.50 %	4.13 %

Source: Calculations performed on data from Cornwell *et al* (1991) National Planning Commission (1999; 2006) and Bank of Namibia (2001; 2006)

Table 1 shows that during the period from 1971 to 1989, economic growth was led by growth in labour and capital inputs, whilst productivity's contribution was low. Between 1990 and 2005, growth in capital contributed little to economic growth, and growth in output was led by labour growth and total productivity growth.

While in the period from 1971 to 1989 output growth in the economy was driven mainly by growth in factor inputs, the period from 1990 to 2005 saw growth dependent on factor inputs as well as technological improvements and efficiency gains in the economy. The low contribution to growth by total factor productivity during the period from 1971 to 1989 may partly be due to political uncertainties, resulting in a reluctance by the mining sector – a significant contributor to Namibia's GDP (9 per cent in 2003) and exports (37 per cent in 2003) – to invest in new technology and exploration (Bank of Namibia, 1991:6). The implication

of these low levels of investment in machinery and equipment is a shortage of opportunities in which workers can “learn by doing” and hence build a set of skills, which are in turn essential for productivity and output growth (Amavilah, 1999:5). Since independence (from 1990 to 2005), prospecting for new minerals has been resumed. The long-term prospects of the mining industry look brighter due to increased investment in new technologies and exploration (Bank of Namibia, 2001:6). This in turn contributed to an increase in productivity. Hence, the contribution to growth by productivity increased from 0.34 per cent in the period from 1971 to 1989 to 1.80 per cent in the period from 1990 to 2005.

Financial deepening and widening is a potential reason for increased productivity between 1990 and 2005. Growth in the financial sector is measured as the ratio of money supply to GDP, which gives an indication of financial deepening and the size of the banking industry

in relation to the economy. Broadly defined, money supply (M2) as a ratio of GDP in Namibia increased from below 30 per cent in 1991 to 45 per cent in 2003. This increase indicates that the financial sector has been progressively more able to raise capital for growth and that there has been a diversification of risk in the economy. The improvement in productivity may also be attributed to an increase in the contribution of services such as tourism, telecommunications and transport to the Namibian GDP in the late 1990s and early 2000s. Increased openness of the Namibian economy, as reflected in lower Southern African Customs Union (SACU) tariffs may also have been a source of increased productivity.

### 3

## Theoretical framework

### 3.1 Model specification

This study used Solow's (1956) neoclassical growth model, which is the most influential of the early neoclassical growth models. The model focuses on output ( $Y$ ), capital ( $K$ ), labour ( $L$ ) and knowledge or effectiveness of labour ( $A$ ). At any given time, an economy has some amounts of capital, labour and knowledge that are combined to produce output. The evolution of the three inputs into production over time is the central assumption of the Solow model concerning the properties of the production function (Romer, 2006:9). The model is built around a standard production function with constant returns to scale of capital and labour. This implies that doubling the quantity of capital and labour should double the amount of output.

As Romer (2006: 10) notes, the assumption of constant returns can be thought of as a combination of two separate assumptions. First, it is assumed that the economy is big enough for the gains from specialisation to be exhausted. In small economies, there are possibilities for further specialisation, so that if the amounts of capital and labour are doubled, output should more than double. Solow's model assumes that the economy is large enough for a doubling of capital and labour to be used in the same way as existing inputs, and hence output will double.

In the second assumption, inputs other than capital, labour and knowledge are relatively unimportant. Solow's model neglects land and other natural resources. According to Romer, if natural resources are relevant, doubling capital and labour could result in less than a doubling of output. However, Romer notes that the availability of natural resources does not appear to be a significant constraint on growth and, under the assumption of constant returns to scale capital and labour alone, appear to be a reasonable approximation of inputs. However, this is not relevant to Namibia, because the country's economy is based on its natural resources.

The Cobb-Douglas (Cobb & Douglas, 1928) function is a specific format of a production function. It appears to be a good first approximation to actual production functions. The Cobb-Douglas production function showing a constant return to scale can be written as follows:

$$Y_t = A(t)K(t)^\alpha L(t)^{1-\alpha} \quad 0 < \alpha < 1 \quad (1)$$

where

$Y$  = output;

$K$  = capital stock;

$L$  = labour employed; and

$A$  = the level of technology.

$K$  and  $L$  have positive but diminishing marginal products.

### 3.2 Equations in the neoclassical growth model

#### 3.2.1 Labour and wages

The demand for labour is specified as

$$L(t) = f\left(\frac{w}{p}, Y\right) \quad (2)$$

The growth rate of  $L$  depends on the real wage ( $\frac{w}{p}$ ) and GDP or output. The nominal wage rate is estimated as

$$w = f(p^e, \text{productivity}) \quad (3)$$

where

$w$  = the nominal wage rate;

$p^e$  = expected consumer prices; and

productivity = labour productivity.

The expected consumer price index influences the nominal wage rate. As Du Toit (1999:113) commented, workers are concerned with and base their utility decisions on the nominal value of wage remuneration. This is due to the nature of the tax structure of their remuneration packages. Both the expected consumer price index and labour productivity have positive influences on nominal wages.

The real wage ( $\frac{w}{p}$ ) equation is specified as suggested by Allen and Nixon (1997:147) – a typical wage equation can be written as

$$w = \varphi(cp, u, z, t), \quad (4)$$

$$\varphi_1 > 0, \varphi_2 < 0, \varphi_3 > 0, \varphi_4 > 0$$

where

$cp$  = the consumer price index;

$u$  = the rate of unemployment;

$z$  = a wage shift factor which includes inflation accelerations; and

$t$  = increasing wage aspirations.

Assuming that wages are homogenous of degree one in consumer prices, the exact consumer index as a linearly homogenous combination of domestic prices ( $p$ ) and imported prices ( $p^*$ ) can be written as

$$cp = h(p, p^*) \quad (5)$$

If Equation (6) is substituted into Equation (5) and homogeneity constraints are used, the following equation for real wages can be derived:

$$\frac{w}{p} = \varphi \left( h \left( 1, \frac{p^*}{p} \right), u, z, t \right) \quad (6)$$

### 3.2.2 Capital (Investment)

Assuming depreciation ( $\delta$ ), aggregate capital stock ( $K$ ) at the end of time  $t$  is referred to as the net capital stock, defined as

$$K_t = (1 - \delta)K_{t-1} + I_t \quad (7)$$

Equation 8 shows that the replacement investment is  $\delta K_{t-1}$ . Net investment (defined as the net increment in the capital stock since the previous time period,  $K_t - K_{t-1}$ ) equals total investment minus replacement investment,  $I_t - \delta K_{t-1}$  (Du Toit, 1999: 81; Du Toit & Moolman, 2004: 649). Gross investment, replacement investment and

net investment are explained by the following identity:

$$\text{Gross investment} = \text{replacement investment} + \text{net investment}$$

Du Toit (1999) argues that most theories of investment behaviour relate the demand for new plants and equipment to the gap between the desired or optimal amount of capital stock ( $K^*$ ) and the actual amount of capital  $K$ . There are two main problems with this. The first concerns factors affecting ( $K^*$ ) and how such factors can be modelled and measured. The second problem concerns the inequality of  $K$  and  $K^*$ , as well as the adjustment of  $K$  towards  $K^*$  and the factors affecting the speed of this adjustment.

According to Du Toit (1999), these two problems with investment behaviour can be combined as such: if net capital stock at the end of period  $t-1$  is  $K_{t-1}$ , and  $K_t^*$  is the desired capital stock at the end of the current time period, the speed of adjustment between  $K_t^*$  and  $K_{t-1}$  will be  $\lambda_t$ . If  $\lambda_t$  is zero,  $K$  will be fixed and there will be no net investment reducing the gap between  $K_t^*$  and  $K$ . If  $\lambda_t$  is 1, the gap will close within one time period, which implies that the adjustment will happen immediately. Net investment during time  $t$  by definition equals  $\lambda_t(K_t^* - K_{t-1})$  and replacement investment equals  $\delta K_{t-1}$ . Because gross investment is the summation of the net and replacement investment, it can be expressed as

$$I_t = \lambda_t(K_t^* - K_{t-1}) + \delta K_{t-1} = \lambda_t K_t^* + (\delta - \lambda_t) K_{t-1} \quad (8)$$

Investment can be modelled using the Keynesian approach, which is based on a fixed capital output ratio, the cash flow model and the neoclassical model (Jorgenson approach). The neoclassical model is considered to be the most suitable approach for estimating the domestic fixed investment function. It incorporates all cost minimising and profit maximising decision-making by firms. It is based on the explicit model of optimisation behaviour, which relates the desired capital stock to interest rates, output, capital prices and tax prices.

The Jorgenson approach was used in this study. A detailed description of this approach

can be found in Jorgenson (1963), Hall and Jorgenson (1967), Coen (1968), Du Toit and Moolman (2004) and Pretorius (1998).

### 3.2.3 Prices

According to a neoclassical profit maximising framework, firms set prices as a mark-up on the marginal cost of production. The marginal cost of production is proxied by average or unit costs, as Layard and Nickell (1986:142) suggest. This is illustrated as follows:

$$p^p = m \cdot AC \text{ and } m = \frac{1}{1 - \frac{1}{\eta}} > ; \quad m \geq 0 \quad (9)$$

where

$p^p$  = production prices;

$m$  = the price mark-up;

$AC$  = the average or unit cost of production;  
and

$\eta$  = the price elasticity of demand.

The mark-up depends on the price elasticity of demand and the short-term demand position; it can therefore be specified in terms of a demand pressure variable such as expected demand relative to actual output (Du Toit, 1999:150).

$$m = m \left( \frac{Y^{ed}}{Y^*} \right) \quad (10)$$

where  $Y^{ed}$  and  $Y^*$  are expected demand and actual output. Going a step further by expanding the price equation to incorporate expected competitors' prices yields the following result:

$$\frac{p^p}{W} = h \left( \frac{p^p}{p^e} \right) m \left( \frac{Y^{ed}}{Y^*} \right) g \left( \frac{Y^*}{\alpha L} \right) \quad (11)$$

where

$W$  = nominal wages inclusive of employers' labour taxes;

$\frac{p^p}{p^e}$  = production prices relative to expected prices; and

$\frac{Y^*}{\alpha L}$  = labour productivity.

Consumer prices ( $p^c$ ) are directly related to production prices and can be specified as:

$$p^c = f(p^p, t^i, p^m) \quad (12)$$

where

$p^c$  = consumer prices;

$t^i$  = indirect taxes; and

$p^m$  = import prices.

## 4

### Empirical framework

#### 4.1 The data

This study covers the period from 1971 to 2005 (annual data). The data were obtained from Hartman (1988), National Planning Commission (1999; 2006), Bank of Namibia (1991; 1999; 2004; 2005; 2006) and Ministry of Labour and Social Welfare (1997; 2000; 2004), Chamber of Mines of Namibia (2003, 2005), and Cornwell, Leistner and Esterhuysen (1991). Detailed descriptions of the data are provided in Table 2 in the Appendix.

#### 4.2 Estimation technique

The appropriateness of the estimation techniques has to be based on the availability of the data. Since this study uses a limited data set (few observations), the number of methods that would be feasible was limited. Cointegration methodology was used to analyse the data, because most economic variables are non-stationary. The Engle–Granger two-step estimation technique was chosen, despite its potential defects. This technique entails the determination of the long-term cointegration relationship through testing for stationarity of the residuals using Augmented Dickey–Fuller (ADF) tests. Any non-stationarity is then corrected for by means of a short-term error correction model (ECM). The Engle–Granger two-step estimation technique has potential defects in the sense that it assumes that there is one cointegrating vector. The other problem with this technique is that if there is an error in the first step, it is carried over to the second step of the estimation.

Multivariate cointegration techniques (such as Johansen's) are more powerful than the Engle–Granger two steps, but they require more data. The ADF test statistics also have some defects because they have low power and tend to under reject the null of unit root. Other tests for unit root, such as Kwiatkowski–Phillips–Schmidt–Shin (KPSS) and Ng–Perron (NP), are more powerful than the ADF. However, these tests also require more observations.

Four behavioural equations were estimated individually and brought together by linking them with identities and definitions to form a neoclassical supply model for the Namibian economy.

## 5

### Estimation results

#### 5.1 Production function for the Namibian economy

An aggregate production function based on the Cobb–Douglas function was estimated for the Namibian economy. The empirical production

$$\ln Y_t = -2.929 + 0.357 \ln K_t + (1 - 0.357) \ln L_t + 0.012 T_t$$

(-15.998) (4.257) (11.978) (15)

*Adjusted R*<sup>2</sup> : 0.967

The results above show that increases in capital and labour by one per cent increased GDP by 0.357 and 0.643 per cent respectively. The estimated coefficient of labour was higher than that of capital, consistent with the results of growth accounting in Table 1, which showed that labour became the main driver of economic growth in Namibia during the period from 1990 to 2005. The coefficient of technology was also

$$\Delta \ln Y_t = -0.841 \text{residual}_{t-1} + 0.310 \Delta \ln K_t + 0.511 \Delta \ln Y_{t-1}$$

(-4.880) (1.983) (3.281) (16)

*Adjusted R*<sup>2</sup> : 0.512

The coefficient of the lagged residuals was negative and significant. This shows that the dynamics of the equation adjusted towards the long-term equilibrium path instead of moving away from it. It shows that 84 per cent of disequilibrium was corrected for every year. Diagnostic tests show that the equation was well specified and there was no violation of the Gaussian assumption or classical linear regression assumptions at a 5 per cent level of significance.

#### 5.2 Investment

As already mentioned, the neoclassical approach is the most suitable to estimating the

function for the Namibian economy used in this study is the following:

$$Y = f(K^+, L^+, T^+) \quad (13)$$

An increase in capital and labour input was expected to lead to an increase in output. Technology (*T*) approximated by a linear time trend was also included to test the impact of technical progress in driving economic growth. Constant returns to scale were enforced and the equation was estimated as follows:

$$\ln Y_t = c + \alpha \ln K_t + (1 - \alpha) \ln L_t + \beta_1 T_t \quad (14)$$

The long-term results are as follows (t-statistics in parentheses):

positive but low. As has already been discussed under growth accounting, the contribution of technology was low from 1971 to 1989 and increased thereafter.

The residuals from this regression were tested for stationarity and the null hypothesis of no cointegration was rejected.

The next step was the ECM. The results are as follows (t-statistics in parentheses):

investment function, as it incorporates the cost-minimising and profit maximising decisions of firms. According to the neoclassical theory of investment, firms maximise profits by finding the optimal level of capital stock associated with the level of interest rates, capital prices and tax policies (Du Toit, 1999: 90). The relation between *I*<sub>*t*</sub> and *K*<sub>*t*</sub> is captured by the following:

$$K_t = (1 - \delta)K_t + I_t \quad \text{or} \quad I_t = K_t + \delta K_t. \quad (17)$$

There are thus two potential approaches in the empirical estimation of investment. The first approach is the estimation of *K*<sub>*t*</sub> and the subsequent derivation of *I*<sub>*t*</sub>. The second approach is the empirical determination of *I*<sub>*t*</sub>

followed by the derivation of  $K_t$ . In this study, the estimation of  $I_t$  and the subsequent derivation of  $K_t$  was regarded as the appropriate approach.

Gross domestic investment in Namibia was modelled as a function of income, the real user cost of capital, lagged values of capital and savings. A dummy variable for Namibia's

independence was included to explain variation in the investment. It was modelled as follows:

$$I_t = f(Y_t^+, uccreal_t^-, sav_t^+, k_{t-1}, du \text{ min } d) \quad (18)$$

The long-term results were (t-statistics in parentheses) the following:

$$\ln I_t = 0.991 \ln Y_t - 0.468 \ln uccreal_t + 0.149 \ln sav_t + 0.572 \ln k_{t-1} + 0.736 du \text{ min } d - 7.762$$

(2.794)      (-3.589)      (2.909)      (1.235)      (3.771)      (-1.654)      (19)

*Adjusted R - squared*: 0.610

The results show that increases in income, gross domestic savings and lagged values of capital were associated with an increase in investment, whereas increases in the user cost of capital caused investment to decrease. These results are consistent with the *a priori* expectations.

The residuals from this regression were tested for stationarity and the null hypothesis of no cointegration was rejected.

The next step was the ECM. The results were the following (t-statistics in parentheses):

$$\Delta \ln I_t = -0.462 residual_{t-1} + 3.52 \Delta \ln k_{t-1} - 0.076 \Delta \ln sav_{t-1} + \Delta \ln sav_{t-2} + 0.145 dum2002$$

(-3.839)      (4.952)      (-2.375)      (2.043)      (2.202)

$$+ 0.184 du \text{ min } d - 0.152$$

(3.720)      (-3.862)      (20)

*Adjusted R<sup>2</sup>*: 0.637

Apart from the long-term explanatory variables, the dummy variable for independence (*dumind*) and for significant investment that took place in 2002 (*dum2002*) were included in the ECM to explain fully the short-term dynamics of the investment function. The coefficient of the lagged residuals was negative and significant. This shows that the dynamics adjusted towards the long-term equilibrium path instead of moving away from it. It shows that 46 per cent of any disequilibrium was corrected for every year. Diagnostic tests showed that the equation was well specified and did not violate the Gaussian assumption or classical linear regression assumptions.

### 5.3 Labour demand

Labour demand was modelled as a function of real GDP and real wages. It was specified as

$$L = f(Y_t^+, rw_t^-) \quad (21)$$

A dummy variable for independence was included as an additional explanatory variable. The long-term results were (t-statistics in parentheses):

$$\ln L_t = 1.584 \ln Y_t - 0.254 \ln rw_t + 0.109 DUMIND$$

(64.191)      (-7.510)      (1.432)      (22)

*Adjusted R<sup>2</sup>*: 0.703

An increase in real wages caused a decrease in the demand for labour, while an increase in economic activity had a positive impact on the demand for labour. A one per cent increase in economic activity led to an increase in the labour demand by 1.584 per cent, while an increase in real wages by one per cent caused the labour demand to decrease by 0.25 per cent. The dummy variable showed that Namibia's independence had a positive impact on the demand for labour, but it was not statistically significant. The residuals from this regression were tested for stationarity and the null hypothesis of no cointegration was rejected.

The next step was to estimate the ECM.

The results were as follows (t-statistics in parentheses):

$$\Delta \ln L_t = -0.249 \text{residual}_{t-1} + 0.021 \text{DUMIND}_t + 0.048 \Delta \ln r w_{t-1} - 0.036 \Delta \ln r w_{t-3} + 0.294 \Delta \ln L_{t-3}$$

$$\begin{array}{ccccc} (-3.770) & (5.134) & (2.345) & (-1.978) & (1.970) \end{array} \quad (23)$$

Adjusted R<sup>2</sup>: 0.604

The coefficient of the lagged residuals was negative and significant. This shows that the dynamics adjusted towards the long-term equilibrium path instead of moving away from it. It shows that 25 per cent of any disequilibrium was corrected for every year. Diagnostic tests showed that the equation was well specified and did not violate the Gaussian assumption or classical linear regression assumptions.

#### 5.4 Wages

Nominal wages are estimated as a function of the consumer price index, labour productivity and unemployment. Productivity is derived as the ratio of GDP to total employment. Unemployment is computed as the difference between the economically active population and the total number of employed people. The nominal wage equation is estimated as

$$w = f(cpi, prod, u) \quad (24)$$

where

*cpi* = the consumer price index;

*prod* = labour productivity; and

*u* = unemployment.

$$\Delta \ln w_t = -0.631 \text{residual}_{t-1} + 0.258 \Delta \ln u_t + 0.578 \Delta \ln w_{t-1} + 0.255 \ln w_{t-2} + 0.226 \Delta \ln prod_{t-1}$$

$$\begin{array}{ccccc} (-4.269) & (2.942) & (4.746) & (2.086) & (2.146) \\ + 0.381 \ln prod_{t-3} & & & & \end{array}$$

$$(3.769) \quad (26)$$

Adjusted R<sup>2</sup>: 0.544

The coefficient of the lagged residuals was negative and significant. This shows that the dynamics adjusted towards the long-term equilibrium path instead of moving away from it. It shows that 63 per cent of any disequilibrium was corrected for every year. Diagnostic tests showed that the equation was well specified

The long-term results are (t-statistics in parentheses):

$$\ln w_t = 0.128 \ln prod_t - 0.281 \ln u_t + 1.098 \ln cpi_t$$

$$(1.865) \quad (-9.688) \quad (11.345) \quad (25)$$

Adjusted R<sup>2</sup>: 0.980

The results show that increases in consumer prices and productivity caused wages to increase. An increase in labour productivity by one per cent caused nominal wages to increase by 0.128 per cent, and an increase in prices by one per cent caused nominal wages to increase by 1.09 per cent. Unemployment was negatively related to nominal wages. An increase in unemployment by one per cent caused wages to decrease by 0.281 per cent. The results are consistent with theoretical expectations. The residuals from this regression were tested for stationarity and the null hypothesis of no cointegration was rejected.

The next step was the ECM. The results are as follows (t-statistics in parenthesis):

and did not violate the Gaussian assumption or classical linear regression assumptions.

#### 5.5 Prices

The Namibian consumer price index was expected to be influenced by import prices, which are captured by the import price index. It

was also assumed that consumer prices would be influenced by nominal wages, the nominal user cost of capital and the nominal exchange rate

(Namibian dollar per US dollar). Prices were modelled as follows:

$$CPI = f(uccnom, w, exch, imp) \quad (27)$$

The long-term results are (t-statistics in parentheses):

$$\ln CPI_t = 0.096 \ln uccnom_t + 0.244 \ln w_t + 0.314 \ln exch_t + 0.357 \ln imp_t$$

(1.934)                      (6.665)                      (6.339)                      (3.807)                      (28)

Adjusted R<sup>2</sup>: 0.984

The results above show that increases in the user cost of capital, nominal wages and import prices, and a depreciation of the Namibian dollar caused consumer prices to increase. A one per cent increase in the nominal user cost of capital and wages caused prices to increase by 0.096 and 0.244 per cent respectively. If the Namibian dollar depreciated by 1 per cent it led to a 0.314

per cent increase in consumer prices, while a one per cent increase in the price of imports was associated with a 0.357 per cent increase in consumer prices. The residuals from this regression were tested for stationarity and the null hypothesis of no cointegration was rejected.

The next step was the ECM, which is as follows (t-statistics in parentheses):

$$\begin{aligned} \Delta \ln CPI_t = & -0.228 residuals_{t-1} + 0.484 \Delta \ln CPI_{t-1} + 0.293 \Delta \ln CPI_{t-2} + 0.332 \Delta \ln CPI_{t-3} \\ & (-4.438) \quad (3.176) \quad (2.055) \quad (2.569) \\ & -0.061 \Delta \ln uccnom_{t-1} - 0.057 \Delta \ln uccnom_{t-3} + 0.317 \Delta \ln w_{t-1} + 0.061 \Delta \ln imp_{t-1} \\ & (-3.54) \quad (-3.241) \quad (4.344) \quad (2.10) \\ & -0.048 \\ & (-2.382) \end{aligned} \quad (29)$$

Adjusted R<sup>2</sup>: 0.663

The coefficient of the lagged residual was negative and significant. This shows that the dynamics adjusted towards the long-term equilibrium path instead of moving away from it. Diagnostic tests showed that the equation was well specified and did not violate the Gaussian assumption or classical linear regression assumptions.

## 6

### Closing the model

#### 6.1 Closing the model

The production function, investment function, labour demand function, wage model and the price equation were combined into a neoclassical growth model for the Namibian economy.

A number of identities and definitions were introduced in order to link all the endogenous variables in the model to ensure a fully dynamic system. The model is closed, as presented, from Equations 30 to 40:

#### BEHAVIOURAL EQUATIONS

$$Y_t = a + \alpha K_t + (1 - \alpha)L_t + T \quad (30)$$

$$I_t = f(Y_t, uccreal, sav, K_{t-1}, DUMIND) \quad (31)$$

$$L_t = f(Y_t, rw, DUMIND) \quad (32)$$

$$W = f(CPI, productivity, u) \quad (33)$$

$$CPI = f(uccnom, W, exch, imp) \quad (34)$$

#### IDENTITIES AND DEFINITIONS

$$K_t = (1 - \delta)K_{t-1} + I_t \quad (35)$$

$$u = EAP_t - L_t \quad (36)$$

$$prod_t = \frac{Y_t}{L_t} \quad (37)$$

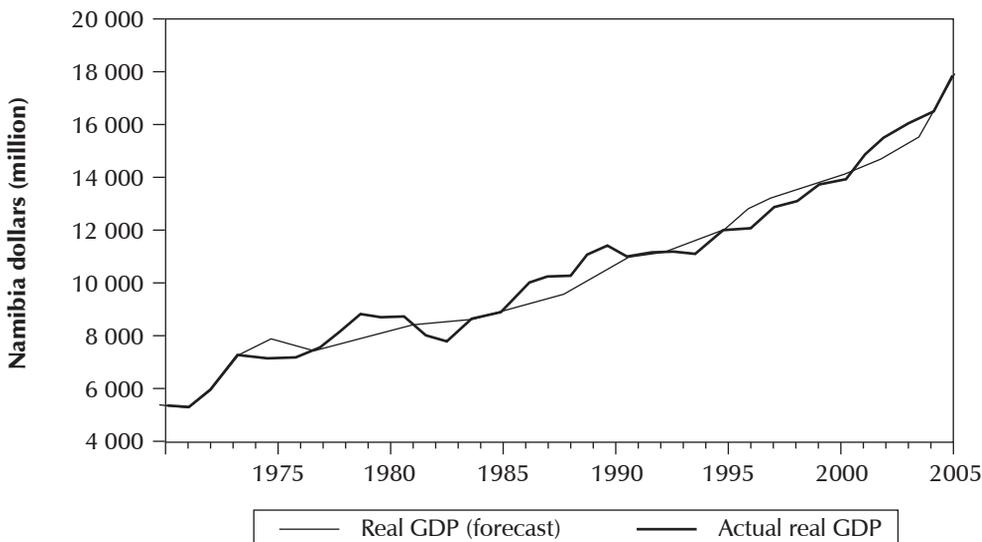
$$uccreal = \text{price of capital} \left[ \frac{\text{real interest rate} + \text{depreciation rate}}{1 - \text{tax rate}} \right] \quad (38)$$

$$uccnom = \text{price of capital} \left[ \frac{\text{nominal interest rate} + \text{depreciation rate}}{1 - \text{tax rate}} \right] \quad (39)$$

$$RW = \frac{W}{CPI} \quad (40)$$

The model was then simulated and the results revealed that it is a good fit, as presented in Figure 3.

**Figure 3**  
Actual and forecasted real GDP



## 7 Conclusion

A simple neoclassical growth model was developed and applied to the Namibian economy using annual data for the period from 1971 to 2005. The model consisted of five behavioural equations, namely the Cobb-Douglas production function, and investment, labour, wage and price equations. A number of identities and definitions were introduced to link every endogenous variable in the model in order to ensure a fully dynamic system. GDP was modelled as a function of capital, labour and technology. Investment was modelled as a function of income, gross domestic savings, lagged values of capital and the real user cost of capital. Labour demand was explained by real

wages and income (GDP), while nominal wages were determined by the unemployment rate, consumer prices and productivity. Consumer prices were determined by import prices, the nominal user cost of capital, nominal wages, and the exchange rate of the Namibian dollar. The results of all estimated behavioural equations were consistent with the theoretical expectations.

After the estimation of the individual equations, the model was closed by bringing the individual behavioural equations, identities and definitions together into a neoclassical model of the Namibian economy. The full model was simulated and the results of the dynamic simulation showed that the estimated values approximated actual values, proving that the model is a good fit.

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## Appendix

**Table 2**  
List of variables

Series	Natural logarithm	Variable name
eap		Economically active population
cpi	Ln cpi	Consumer price index
dum88		Dummy variable representing political uncertainty in 1988
dum92		Dummy variable for the drought in 1992
dumind		Dummy variable for independence in 1990
exd	Ln exd	Excess demand
exch	Ln exch	Exchange rate – Namibia dollar (N\$) per US dollar
finainve	Ln finainve	Financing of investment or capital formation
imp	Ln imp	Import price index at 1995 prices
I	Ln I	Gross domestic investment
k	Ln k	Fixed capital stock
prod	Ln prod	Labour productivity
rw	Ln rw	Real wages
sav	Ln sav	Gross domestic savings
taxrate		Company tax rate
u	Ln u	Unemployment
uccnom	Ln uccnom	User cost of capital (nominal)
uccreal	Ln uccreal	User cost of capital (real)
w	Ln w	Total wages paid by the mining sector as a proxy for wages of the Namibian economy
y	Ln y	Real GDP at 1995 prices

**Table 3**  
Unit root test results

Variable	Model specification	ADF-statistic	Joint test (F-statistic)	Conclusion
Ln cpi	Intercept & trend Intercept	-0.475 -3.841***	$\Phi_3 = 1.005$	I(0), no unit root
Ln exch	Intercept & trend	-3.271*		I(0), no unit root
Ln exd	Intercept & trend Intercept	-2.273 -2.516	$\Phi_3 = 4.249$ $\Phi_1 = 6.335^{**}$	I(0), no unit root
Ln finainve	Intercept & trend Intercept None	-2.807 0.267 1.884	$\Phi_3 = 0.668$ $\Phi_1 = 0.781$	I(1), has a unit root

lnimp	Intercept & trend Intercept None	-1.764 -1.174 1.337	$\Phi_3=1.318$ $\Phi_1=2.689$	I(1), has a unit root
lninve	Intercept & trend	-4.062**		I(0), no unit root
lnk	Intercept & trend Intercept None	-2.361 -2.709*	$\Phi_3=0.191$	I(0), no unit root
lni	Intercept & trend Intercept None	-1.831 -0.052 1.822	$\Phi_3=3.202$ $\Phi_1=1.561$	I(1), has unit root
lnprod	Intercept & trend Intercept None	-2.092 -2.578 -0.727	$\Phi_3=4.685$ $\Phi_1=3.656$	I(1), has a unit root
lnrw	Intercept & trend Intercept None	-2.011 -0.022 -1.752*	$\Phi_3=4.184$ $\Phi_1=0.548$	I(0), no unit root
lnsav	Intercept & trend Intercept None	-2.838 -1.072 0.578	$\Phi_3=2.448$ $\Phi_1=0.141$	I(1), has a unit root
lnsavgdp	Intercept & trend Intercept None	-2.714 -1.588 -0.219	$\Phi_3=2.433$ $\Phi_1=1.272$	I(1), has a unit root
lnu	Intercept & trend Intercept None	-2.291 -0.334 1.520	$\Phi_3=2.083$ $\Phi_1=1.159$	I(1), has a unit root
lnuccnom	Intercept & trend Intercept None	-2.193 -0.724 2.168	$\Phi_3=0.337$ $\Phi_1=1.954$	I(1), has a unit root
lnuccreal	Intercept & trend Intercept None	-2.863 -2.289 -0.260	$\Phi_3=0.033$ $\Phi_1=0.305$	I(1), has a unit root
lnw	Intercept & trend Intercept None	-1.173 -1.992 1.488	$\Phi_3=2.719$ $\Phi_1=3.440$	I(1), has a unit root
lny	Intercept & trend Intercept None	-2.696 -0.437 1.731	$\Phi_3=3.266$ $\Phi_1=1.547$	I(1), has a unit root

**Notes:**

- \*/\*\*/\*\* Significant at a 10% or 5% or 1% level
- Critical values for  $\Phi_3$  and  $\Phi_1$  are from Dickey and Fuller (1981: 1063)
- The "general to specific" iterative procedure in Enders (2004: 213) was used