CHAPTER 5

ESTIMATING POTENTIAL OUTPUT AND CAPACITY UTILISATION FOR THE SOUTH AFRICAN ECONOMY

5.1 INTRODUCTION

An aspect that deserves considerable attention in supply-side modelling is the development of some measure for potential output. Measuring productive potential and the deviation between actual and potential output (i.e. the output gap) provides a number of key insights into macroeconomic performance.

Output in general is determined by the quantity and quality of the various factors of production and their productivity. Potential output is an indication of the aggregate supply capabilities of the economy and embodies information about developments in the stock of capital, the labour force and technical change. The actual level of output on the other hand, is also influenced by the demand for goods and services. Deviations between the potential and actual levels of output, designated as the output gap, thus provide a measure of the capacity utilisation of the economy and to the extent that demand factors are incorporated, a measure of relative supply and demand in the economy at a particular time. As such, it contains useful short-term information for the formulation of economic policy, particularly policies aimed at controlling inflation. Over the medium term, the growth rate of potential output provides a useful guide for the assessment of sustainable non-inflationary growth in output and employment. Therefore, in macro-econometric context, capacity utilisation (or the output gap) serves as a determinant of the behaviour of prices and wages and influences all key macroeconomic variables through a well-developed supply system.

However, modelling the output gap or capacity utilisation is a complicated matter for a number of reasons. First, different concepts of potential output have been proposed in the literature and are used in different models. Second, a wide variety of empirical methods are used to measure potential output, ranging from time-series and trend-type analyses to production function-based methodologies, with the precise results sensitive to the method chosen. Finally, actual output could be determined directly from Keynesian demand or by using a production function (supply) approach.

The aim of this chapter is three-fold:

(i) to give a brief review of the different concepts and methodologies of potential output and output gaps;
(ii) to identify and explain two measures for potential output; and
(iii) to explain the methodology and to present the analytical framework and estimates for potential output and capacity utilisation for the South African economy.

5.2 DIFFERENT CONCEPTS AND METHODOLOGIES

The concept of "potential output" is not well defined in literature and has seen different applications in production analyses. Does "potential" refer to the maximum attainable level of production such as has been demonstrated at peak periods in the past, or does it refer to a sustainable level of production in the sense that production can continue at this level without major constraints developing?

It appears from the literature (Laxton and Tetlow 1992) that the concept of potential output has evolved from one that focussed on the maximum possible output to the currently preferred definition of "...the level of goods and services that an economy can supply without putting pressure on the rate of inflation" (Conway and Hunt 1997: 2). This development coincided with a change from the view that the supply of goods (and thus potential output) is an essentially deterministic process to one that regards supply as a stochastic phenomenon.

In a recent review of the concepts of potential output, Scacciavillani and Swagel (1999) summarise the literature as follows:

> *Broadly speaking the literature distinguishes between two definitions. In the first, more along the Keynesian tradition, the business cycle results primarily from movements in aggregate demand in relation to a slow moving level of aggregate supply. In business cycle downswings, there exist factors of production that are not fully employed... In the second approach – more along the neoclassical tradition – potential output is driven by exogenous productivity shocks to aggregate supply that determine both the long-run growth trend and, to a large extent, short-term fluctuations in output over the business cycle.... Unlike the Keynesian framework where the economy might reach potential only after an extended period, potential output in the neoclassical framework is synonymous with the trend growth rate of actual output. The key measurement problem is thus to distinguish between permanent movements in potential output and transitory movements around potential.*

The methodologies employed in measuring potential output and its deviation from actual output (i.e. the output gap) are not necessarily divided neatly into the above two intellectual frameworks. In early applications, potential output was treated as a deterministic process. The essence of this approach is that "potential" refers to the maximum attainable level of output without taking the sustainability of growth in production into account (Burrows and Smit 1999). An example is the trends-through-peaks method developed by Lawrence Klein at the Wharton School.

The stochastic or economic approach is based on the use of a production function to determine potential output. This approach has been widely used, also by institutions such as the OECD (Giosno *et al.* 1995 and Turner *et al.* 1996). The production function approach can be implemented with varying degrees of sophistication and detail. Examples are the relatively simple Cobb-Douglas function estimated on the basis of factor income shares (Scacciavillani and

Swage 1999), CES production functions estimated for the OECD Interlink country model (Torres and Martin 1993; Giosno *et al.* 1995 and Turner *et al.* 1996), and the Hickman-Coen annual growth model of the U.S. economy endogenising the natural rate of unemployment, potential labour force and potential average hours of work (1995).

A distinction between "potential" and "normal" output needs to be made within the stochastic production function-based framework. Modelling potential output as opposed to normal output requires the estimation of potential levels of factor inputs. "Normal" output, defined as the production level with the current quantities of factor inputs and operating at a "normal" or trend rate of utilisation, is usually obtained by smoothing the various components of the production function (Turner *et al.* 1996).

The statistical or time-series approach to determine potential output as an exogenous trend variable, developed when economists started to question the notion that potential output changed deterministically over time. The supply shocks of the 1970s and the publication of the influential paper by Nelson and Plosser (1982) suggesting that output series are best characterised as integrated series, led to a change in focus on stochastic trends. This implied that determining potential output requires techniques that could distinguish between permanent and temporary movements in total output. A number of techniques were developed for this purpose (Burrows and Smit 1999).

Two important and commonly-used measures can therefore be identified. First, measures of potential output that are structural and depend on a production function framework, incorporating information concerning the capital stock, working population, trend participation rates, structural unemployment and factor productivity developments. Specific attention may also be given to the sustainability of non-inflationary growth associated with the labour market, in which case information about both actual rates and underlying natural rates of unemployment is utilised (i.e. the non-accelerating wage rate of unemployment, or NAWRU).

A second set of measures are derived by applying time-series analysis and methods to actual developments in real GDP. Though parsimonious in the use of information, these methods are mechanical and have difficulty in dealing with frequent structural changes. They therefore require *ad hoc* judgements about the current cycle in order to keep the results within reasonable bounds.

5.3 ESTIMATING POTENTIAL OUTPUT AND OUTPUT GAPS

A variety of methods[1] can be used to determine trend or potential output and a corresponding output gap. They can be divided into two broad groups, i.e. time-series (mostly smoothing) techniques and structural production function-techniques. The techniques most commonly used in empirical analysis are firstly the Hodrick-Prescott filter, a time-series method, and secondly the estimation of potential output, a structural approach based on a production function-relationship. The latter approach requires more data inputs and more assumptions about economic inter-

1 See Canova (1993) for a number of other possible approaches

relationships, but is less mechanical and more directly relevant to macroeconomic assessment. These two approaches will now be discussed.

5.3.1 A time-series approach: smoothing actual output using a Hodrick-Prescott filter

The gross domestic output (GDP) smoothing approach using a Hodrick-Prescott (HP) filter fits a trend through all the observations of real GDP, regardless of any structural breaks that might have occurred, by allowing the regression coefficients themselves to vary over time. This is done by finding a trend output that simultaneously minimises a weighted average of the gap between output and trend output, at any given time, and the rate of change in trend output at that point in time. The HP filter is a two-side linear filter that estimates the trend Y* for t = 1, 2, ...T to minimise

$$\sum_{t=1}^{T}(\ln Y_t - \ln Y_t^*)^2 + \lambda\sum_{t=2}^{T-1}[(\ln Y_{t+1}^* - \ln Y_t^*) - (\ln Y_t^* - \ln Y_{t-1}^*)]^2$$

where λ is the weighting factor that controls the smoothness of the resulting trend line. A low value of λ will produce a trend that follows actual output more closely, whereas a high value of λ reduces sensitivity of the trend to short-term fluctuations in the actual series and, in the limit, the trend tends to the mean growth rate for the whole estimation period.

The mechanical nature of a filter such as the HP filter, requiring only actual values for GDP, has the advantage of being a fairly straightforward and simple technique to perform. However, some points of criticism have been raised against the HP filter.

(i) A major point of criticism is the arbitrary choice of λ which determines the variance of the trend output estimate. Specifically, the variance of trend output falls as λ increases, whilst the amplitude of the corresponding output gap increases with λ (increasing). From a statistical point of view, λ must be arbitrarily chosen. The reason is that any non-stationary series (integrated of order 1) can be decomposed into non-stationary trend and stationary cycle combinations. Thus far, no satisfactory statistical criterion has been developed for the optimal choice of trend/cycle decompositions.

However, Hodrick and Prescott proposed setting λ equal to 100, 1600 and 14400 for annual, quarterly and monthly data respectively. These values seem to have become the standard for many applications in literature.[2]

Since the choice of λ remains arbitrary, Giorno *et al.* (1995) identified the following possible criteria. The first approach would be to follow Hodrick and Prescott's approach and choose a constant ratio of the variance of trend and actual output, i.e. choose a λ consistent with the degree of fluctuation in the actual GDP time series. This means that λ would be chosen to generate greater variance (fluctuation) in trend for an actual GDP that is fluctuating more. A second approach is to choose a value for λ that generates a pattern

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2 Canova (1993) discusses the problems arising from the indiscriminate use of these values for λ for GDP and other data series.

of cycles that is broadly consistent with *a priori* information about past cycles in the GDP. This approach is both judgmental and less transparent than the first criterion.

(ii) Another criticism is that the accuracy of the HP filter deteriorates near the end of the sample – referred to as an end-point problem. The reason for this is that a trend line is fitted symmetrically through the data. If the beginning and the end of the data set do not reflect similar points in the cycle, then the trend will be pulled upwards or downwards towards the path of actual output for the first few and the last few observations. For example, for a country that is slower to emerge from a recession, a HP filter will tend to under-estimate trend output growth for the current period. Using projections, which go beyond the short-term to the end of the current cycle, can reduce this problem and give more stability to estimates for the current and short-term projections period. Again this is arbitrary in the sense that specific weight is assigned to judgements about potential and output gaps embodied in the projection. The HP filter estimates will tend towards potential, providing the output gap is closed by the end of the extended sample period.

(iii) A further weakness of the method is the treatment of structural breaks, which are typically smoothed over by the HP filter. The break is moderated when it occurs and its effects are spread out over several years, depending on the value of λ. This is especially problematic in the case where the break results in large discrete changes in output levels.

5.3.2 Structural production function approach: estimating potential output

From the point of view of macroeconomic analysis, the most important limitation of any smoothing method is that it is largely mechanistic and ignores all structural properties associated with production. Aspects such as the availability and quality of factors of production, their productivity, the production technology and technical progress, and all other exogenous influences are not taken into account. The trend output growth projected by time-series methods may be inconsistent (too high or too low) with what is known or being assumed about the growth in capital, labour supply or factor productivity. The trend growth may also be unsustainable because of the ignored inflationary pressures.

A structural production function approach therefore has the advantages of overcoming the above-mentioned shortcomings, incorporating the role of demand pressure on employment and inflation and allows for consistent judgement on some of the key elements.

The production function approach explicitly models a production technology in terms of factor inputs, factor technology and to some extent the role of technical progress. Potential output is then determined as the level of output that results when the factors of production and total factor productivity are at their "potential" levels. The output gap (capacity utilisation) is calculated as the ratio[3] between the potential and actual levels of output.

3 Capacity utilisation or output gap is determined as the difference between potential and actual output if the logarithmic forms of the variables are used.

The production function may be represented by:

$$Y_t = A_t * F(K_t, L_t)$$

with

Y_t	=	output
A_t	=	technical progress (including factor productivity)
K_t	=	capital stock
L_t	=	employment
F	=	the assumed production technology, e.g. Cobb-Douglas, CES, etc.

The technical progress (A_t) may be Hicks-neutral, Harrod-neutral or even endogenous in nature incorporating factor productivity (Appendix 12).

Potential output Y_t^* is then generated by:

$$Y_t^* = A_t^* * F(K_t^*, L_t^*)$$

with

A_t^*	=	"potential" technical progress
K_t^*	=	"potential" capital stock
L_t^*	=	"potential" employment

The potential levels of A, K and L may be determined in different ways. If "potential" is to designate the maximum output levels, then some measure of the maximum attainable levels of A, K and L must be provided. Depending on the purpose of estimation and the definition applied, variations on these potential levels may occur. For example, if potential output is defined as the maximum level of output consistent with stable inflation, a measure such as the non-accelerating wage rate of unemployment (NAWRU) needs to be included in the specification of potential employment (L_t^*).[4]

Should potential be defined as the "trend" or "normal" levels of factor utilisation, a time-series measure such as the Hodrick-Prescott filter may be used.[5]

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4 This technique was utilised by the OECD in the measuring of potential output and output gaps in the seven major OECD countries (Torres *et al.* 1989 and Giorno *et al.* 1995)

5 This technique was employed by the OECD in the modelling of the supply-side of the seven major OECD economies (Turner *et al.* 1996)

5.4 ESTIMATES OF POTENTIAL OUTPUT AND CAPACITY UTILISATION FOR THE SOUTH AFRICAN ECONOMY

5.4.1 The methodology

There are many alternative definitions of potential output and many methods have been used to quantify these concepts. The particular concept of potential output selected for the purpose of modelling the supply-side of the South African economy, refers to the maximum level of output that is consistent with stable inflation.

Capacity utilisation is therefore defined as the ratio between actual production (production function-based) and potential, not normal output, incorporating the role of the non-accelerating wage rate of unemployment (NAWRU).

This particular concept was chosen in line with the emphasis on control of inflation as a key medium-term priority. In addition, its use ensures consistency between labour market equilibrium and product market equilibrium in the supply-side model.

5.4.2 The analytical framework

The estimation of potential output for South Africa is based on a structural production-function relationship, with the maximum level of output consistent with stable inflation. The level of unemployment and its associated non-accelerating wage rate are incorporated in the estimation of potential employment. This approach was adopted from the OECD.[6]

The estimated production function for South Africa has proven to be of Cobb-Douglas technology[7] and is represented by the following expression:

$$Y = A_0 e^{\delta T} K^{\alpha} N^{\beta}$$

In logarithmic form:

$$y = a_0 + \delta T + \alpha k + \beta n$$

with

Y = actual gross domestic product at factor cost
A_0 = Hicks-neutral technology component
N = actual employment

[6] This approach was specifically followed on two occasions: "Measuring potential output in the seven major OECD countries" (Torres *et al.* 1989) and "Estimating potential output, output gaps and structural budget balances" (Giorno *et al.* 1995).

[7] See chapter 4 for the results of the estimation of a neo-classical production function for the South African economy.

K = actual capital stock
T = endogenous technical progress or technology (including factor productivity)
α = labour share parameter
β = capital share parameter
δ = technical progress (technology) parameter
$(\alpha + \beta) < 1$; exhibiting decreasing returns to scale technology

Potential output is determined by substituting trend technology (T^*), actual capital stock[8] (k) and potential employment (n^*) back into the estimated production function:

$$y^* = a_0 + \delta T^* + \alpha k + \beta n^*$$

where T^* is determined by smoothing technology using a Hodrick-Prescott filter ($\lambda = 100$).

The measure of potential employment is defined as the level of labour resources that might be employed without resulting in additional inflation. This amounts to adjusting the actual labour input used in the estimated production function for the gap between actual unemployment and the estimated non-accelerating wage rate of unemployment (NAWRU).

The level of potential employment (N^*) is calculated as:

$$N^* = \text{LFS}\ (1 - \text{NAWRU})$$

where: LFS = the smoothed labour force (the product of the working age population and the trend participation rate);
NAWRU = the estimated non-accelerating wage rate of unemployment

The method adopted to measure the NAWRU[9] essentially assumes that the change in wage inflation is proportional to the gap between actual unemployment and the NAWRU.[10] Assuming also that the NAWRU changes only gradually over time,[11] successive observations of the changes in inflation and actual unemployment rates can then be used to calculate a time series corresponding to the implicit value of the NAWRU. More specifically, it is assumed that the rate

8 Capacity utilisation, a short-run variable in nature, acts as a supply-side constraint via its effect on prices. In estimating potential output with the primary purpose of determining the associated output gap for one reason, it is necessary to use the actual level of capital since it represents a relative binding physical constraint on supply in the short to medium term.

9 See Pichelmann and Schuh (1997) for an exposition on the basic theory and empirical estimation of the NAWRU.

10 This method is described by Elmeskov and MacFarlan (1993).

11 This is based on the assumption of partial hysteresis: actual unemployment feeds only partly into future equilibrium unemployment. In this case unemployment evolves only slowly towards its steady-state level. In such a situation, the short-run NAWRU – meaning the level of unemployment at which there is no current upwards or downwards pressure on inflation – always lies between steady-state equilibrium unemployment and last period's actual unemployment. This carries the implication that high unemployment can only be slowly reduced to its long-run equilibrium level ("speed limits") if temporary increases in inflationary pressures are to be avoided (Pichelmann and Schuh 1997: 8).

of change of wage inflation is proportional to the gap between actual unemployment and the NAWRU, thus:

$$D^2 \log W = -a(U - NAWRU), \qquad a > 0$$

where D is the first-difference operator and W and U are the real wage and unemployment rates, respectively. Assuming the NAWRU to be constant between any two consecutive time periods, an estimate of a can be calculated as:

$$a = -(D^3 \log W) / DU$$

which, in turn, is used to give the estimated NAWRU as:

$$NAWRU = U - (DU / D^3 \log W) D^2 \log W$$

The resulting NAWRU series is then smoothed, again using a Hodrick-Prescott filter to eliminate erratic movements.[12] The information utilised in the above expression for the NAWRU is endogenised. Both the unemployment and the real wage rates result from a consistent neoclassical labour model, which in turn forms part of a supply-side model for South Africa where prices are also endogenously determined by the system as a whole. This measure for the NAWRU can therefore be classified as a wage-price model approach (Appendix 13).

5.4.3 The estimation results

(i) Estimation of the South African NAWRU

The estimate for the NAWRU of the South African economy is given by figure 5.1. It is increasing at a steady rate, suggesting severe structural problems in the economy as a whole and the labour market in particular.

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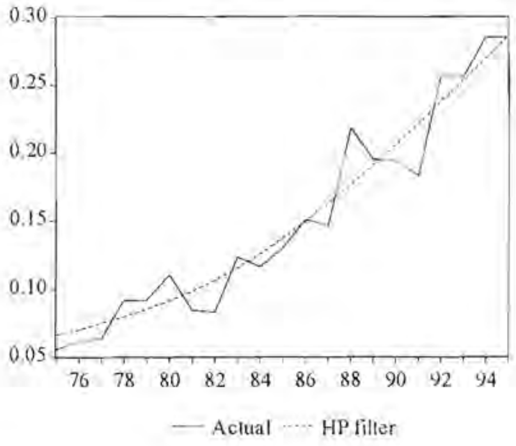
12 Surveys of the empirical literature on the NAWRU by Rose (1988) and Setterfield *et al.* (1992) suggest that robust structural estimates of the NAWRU have proven elusive. Both studies find that estimates vary considerably depending on the methodology used, the variables in the estimation, and the sample period. Two fundamental types of uncertainty exist which may contribute to the imprecise measurement of the equilibrium unemployment rate. The first source of uncertainty arises from the fact that the NAWRU is an unobserved variable, which leaves room for a number of plausible empirical models for measurement. Different specifications lead in general to different point-estimates of the level of the NAWRU. The second source of uncertainty stems from the fact that it is impossible to determine the exact values of the parameters using statistical methods. According to all empirical specifications the NAWRU represents a combination of stochastic variables and parameters, leading to imprecision in measurement. Computing confidence intervals for the point estimates of the equilibrium unemployment rates gives an idea of the magnitude of imprecision of conventional methods for the calculation of the NAWRU. Since the NAWRU is an important input into the measurement of potential output, this fragility of structural estimates poses a problem – uncertainty about the NAWRU translates into uncertainty about potential output (Butler 1996: 35).

In principle a wide range of evidence could be included. The NAWRU can be estimated by drawing on a structural estimate of the trend unemployment rate that is based on the work of Côté and Hostland (1996); a price-unemployment rate Phillips curve based on the work of Laxton, Rose and Tetlow (1993); the previous quarter's estimate of the NAWRU; a growth-rate restriction that is applied in the final quarters of the sample; and a smoothness constraint.

Figure 5.1 South African NAWRU



The results imply that an "equilibrium" rate of unemployment and therefore a unique long-run NAWRU to which the unemployment reverts in the long run does not exist. This is in line with a growing number of empirical studies (Pichelmann and Schuh 1997) that suggest that the equilibrium unemployment rate may be described by a non-stationary time-series, incorporating both a deterministic and stochastic trend component.

This increasing rate is attributed to the hysteresis[13] nature of unemployment in South Africa, which in turn is based on the behaviour of labour market participants, changes in their productive capacity caused by unemployment and the resulting consequences for wage bargaining and the matching process between workers and jobs. The general idea is that a distinction be drawn between insiders and outsiders in the labour market and that they carry different weights in the wage bargaining process. When unemployment by itself tends to reinforce the outsider status of those affected, then the moderating impact of higher unemployment on wages will vanish over time. The same result will emerge when the (employed) insiders have sufficient market power, probably fostered by employment protection regulations, to safeguard their income claims and employment status against outside labour market conditions. Finally, a growing number of unemployed outsiders may create information distortions in the labour market, thereby making it more difficult to form suitable matches between workers' characteristics and the skill requirements of potentially available jobs.

A number of hysteresis-mechanisms,[14] which could lead to permanent shifts of equilibrium unemployment over time, have been identified. The most suitable mechanism to explain the South African situation, operates through changes in human capital. According to this view, prolonged periods of unemployment may lead to a deterioration of skills and important attitudinal aspects of the work ethics and motivation of individual job seekers. And, when out of work, there are no opportunities for learning-

13 Unemployment is strongly dependent on its own history (Pichelmann and Schuh, 1997: 7).

14 Pichelmann and Schuh (1997) present a theoretical model in explaining the occurrence and effects (supply- and demand-side effects) of hysteresis on the equilibrium level of unemployment.

by doing and on-the-job training. The loss of skills during unemployment may also lead to duration dependence in the probability of leaving unemployment, i.e. the likelihood that unemployed workers move to employment is likely to fall as the duration of unemployment increases. Furthermore, discouragement effects may over time loosen the attachment to the work force resulting in reduced job search intensities.

Even when the quantitative importance of human capital depreciation is considered to be fairly small, the mere fact of being out of work for a long time may convey a negative signal about workers' productivity to potential employers. Consequently, the long-term unemployed may over time receive fewer and fewer job offers and may, finally, even be regarded as "unemployable". The resulting detachment from the labour market implies that the long-term unemployed may exert little or no downward pressure on wage increases. Moreover, a growing number of unsuccessful job seekers in the pool of the unemployed may reduce the speed by which vacant jobs can be filled by suitable candidates.

When specific skills are an important aspect of the employment relation, involuntary separation from a job may imply long waiting periods for re-employment; and when the loss of specific skills and the associated wage premium eventually has to be accepted, specific capital no longer provides a buffer between productivity and the value of employment elsewhere or non-employment, so turnover from new jobs, probably associated with recurrent unemployment, may be rapid.

Another strand of reasoning emphasises the wage-bargaining behaviour of the employed insiders and the role of adjustment costs. For example, when unions bargain mainly on behalf of the incumbent workforce, a temporary adverse shock to employment will tend to perpetuate itself, because real wage demand is adapted to the now smaller number of employed insiders. Generally speaking, shifts in the employment composition in favour of groups facing little risk of unemployment may affect the overall bargaining stance of unions and thus reduce the wage-moderating impact of a given rate of unemployment.

For insider effects to persist, the employed insiders must command some degree of market power. This could stem from several sources such as training costs or statutory seniority systems, but also from various forms of job security legislation. While the resulting reduction in turnover may well be in the interest of both the firm and the workers, the crucial point with regard to the persistence issue is that turnover costs render it difficult for outsiders to effectively compete for jobs.

In addition to the supply-side mechanisms described above there may also be a number of important demand-side effects which could lead to an adjustment in equilibrium unemployment. In addition, a number of possible "price push" factors may cause product demand changes to impact on equilibrium unemployment. Some of these are wage-price stickiness (the traditional Keynesian argument), changes in the marginal product of inputs, competitive interaction between firms, changes in the real user-cost-of-capital and changes in the composition of demand (Pichelmann and Schuh 1997).

(ii) Potential output and output gap (capacity utilisation) for South Africa

A comparison of growth rates and output gaps of estimated potential output and HP trend estimates are provided in figures 5.2 and 5.3 and table 5.1.

Figure 5.2 Output growth

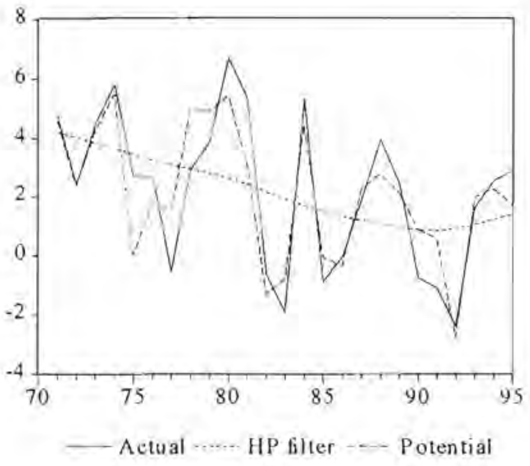
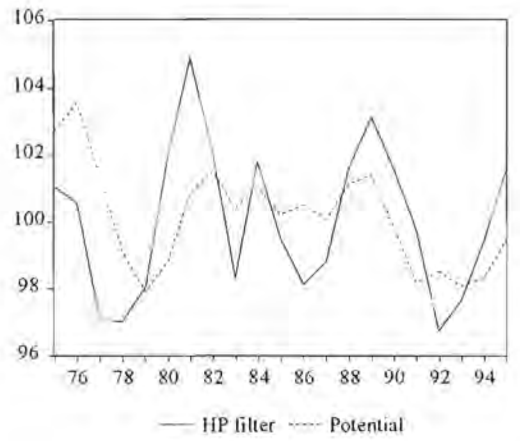


Figure 5.3 Output gap (capacity utilisation)



Potential output is defined here as the maximum level of output consistent with stable inflation. A structural approach, based on the estimated production function for South Africa, is used to estimate potential output. Potential output is therefore dependent on the actual level of capital stock (serving as a short-run supply constraint), potential employment and the trend in technical progress. Potential employment is estimated by taking into account the relationship between unemployment and wage/price inflation as embodied in wage-price blocks in the supply-side model of the South African economy. Consistency between labour market equilibrium and product market equilibrium is ensured by incorporating the NAWRU in the definition of potential output.

An important feature of the estimation results is that potential output growth rates fluctuate from year to year, more so than trend growth rates derived from output smoothing (using the Hodrick-Prescott filter). The three obvious reasons for this higher degree of variance are variations in the NAWRU, the growth in capital stock and in working-age population.

Table 5.1 Growth rates and output gaps under different methods

	Growth rates			Output gaps	
	Actual	*Hodrick-Prescott*	*Potential*	*Hodrick-Prescott*	*Potential*
1975	2.70	3.42	0.00	101	103
1976	2.64	3.23	1.76	101	104
1977	-0.57	3.07	1.55	97	101
1978	2.86	2.93	4.95	97	99
1979	3.83	2.79	4.88	98	98
1980	6.68	2.61	5.41	102	99
1981	5.34	2.38	3.08	105	101
1982	-0.65	2.12	-1.32	102	102
1983	-1.93	1.86	-0.83	98	100
1984	5.29	1.64	4.44	102	101
1985	-0.92	1.44	-0.11	99	100
1986	-0.06	1.28	-0.37	98	100
1987	1.83	1.15	2.23	99	100
1988	3.94	1.03	2.78	102	101
1989	2.45	0.93	2.09	103	101
1990	-0.75	0.85	0.84	102	100
1991	-1.12	0.82	0.53	100	98
1992	-2.39	0.88	-2.78	97	98
1993	1.58	1.02	1.97	98	98
1994	2.51	1.19	2.24	99	98
1995	2.89	1.39	1.67	102	99

The results obtained for potential output based on the structural production function approach indicate that the South African potential to grow is deteriorating (see figure 5.2). This seems plausible due to the huge constraint posed by rising labour cost (see figure 5.4) and the resulting continuous increase in unemployment (see figure 5.5). This declining rate of employment is of a both structural and cyclical nature. A significant part (the major portion) of the South African labour force is unskilled (see figure 5.6) and relatively expensive (see figure 5.7), while the global tendency towards capital-intensive production acquiring more capital, skilled labour and less unskilled workers, has further contributed to the greater degree of capital-intensive production in South Africa (see figure 5.8). Apart from the fact that a significant component of unemployment in South Africa is structural in nature, the growth in GDP (see figure 5.2) has been inadequate to create sufficient job opportunities to alleviate the unemployment problem. The period of economic sanctions and disinvestment, resulting in the outflow of skilled labour (referred to as the "brain-drain") and other consequences, has only intensified the problem.

Figure 5.4 Real wage rate

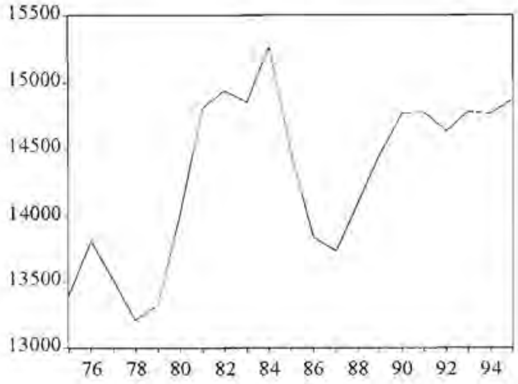


Figure 5.5 Unemployment rate

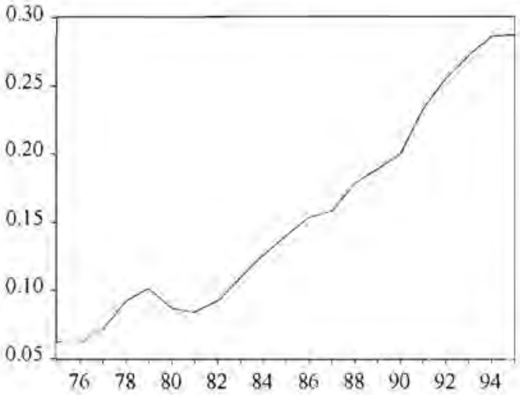


Figure 5.6 Total, skilled and unskilled labour supply

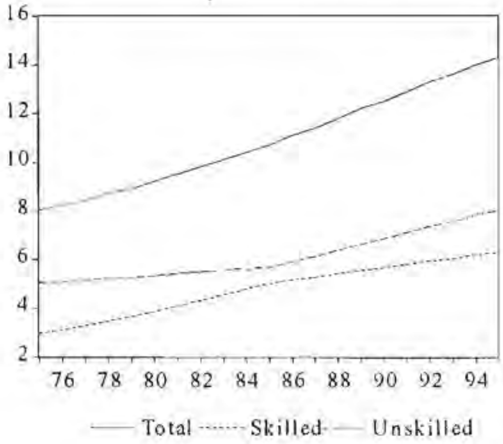


Figure 5.7 Skilled/Unskilled wage rate

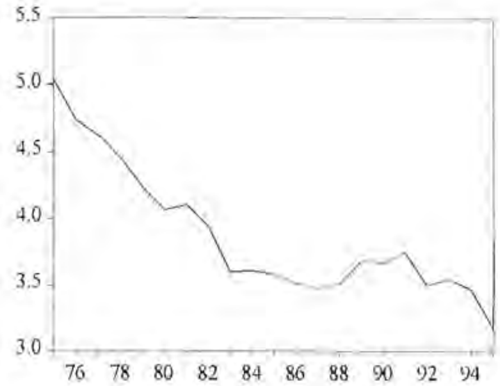
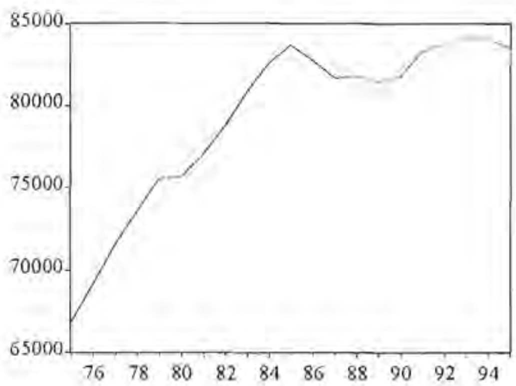


Figure 5.8 Capital-labour ratio



The time-series approach where output is smoothed by using the Hodrick-Prescott filter is clearly not taking the effect of these severe structural deficiencies in the South African economy into account. The advantage though of the HP-smoothed GDP is that it provides a check on the level and trend of the NAWRU. Although the structural estimation of potential output is sensitive to the specification of the NAWRU, which in turn is subjected to a range of possible measurement problems, the preferred approach is still to use the potential measure, provided that its plausibility is checked against a suitable time-series estimate of trend GDP.

5.5 CONCLUSION

In this chapter a measure for potential output and an associated output gap (capacity utilisation) were determined with the objective of incorporating them in an extended supply-side model of the South African economy.

Two measures for potential output and their associated output gaps are determined. First, normal or trend output is obtained by smoothing actual GDP, using the Hodrick-Prescott filter. Second, potential output is estimated by using an estimated production function for the South African economy. Potential output is estimated by substituting trend technology, actual capital stock and potential employment into the Cobb-Douglas estimated production function (Chapter 4).

Trend technology is obtained by smoothing the endogenously determined technical progress variable (technology index) by applying the Hodrick-Prescott filter. Potential employment is estimated by adjusting the actual labour input in the estimated production function for the gap between actual unemployment and the estimated non-accelerating wage rate of unemployment (NAWRU). The method adopted to measure the NAWRU is based on the assumption that the change in wage inflation is proportional to the gap between actual unemployment and the NAWRU.

The estimation results obtained for the potential output and associated output gap seem plausible given the structural properties and history of the South African economy. The Hodrick-Prescott filter smoothed GDP serves as a check for the level and trend in the potential output, but cannot be used in the structural supply-side model due to its mechanic nature. Therefore, based on the structural nature of the analysis, the preferred measure identified is one based on a production function approach which takes explicit account of structural information, in particular with respect to the NAWRU.

The obtained results for potential output revealed the essence of the impediments on the South African economy - the South African potential to grow is deteriorating. This is due to the sizeable constraint posed by rising labour cost and the resulting continuous increase in unemployment. This declining rate of employment is of a both structural and cyclical nature. A significant part of the South African labour force is unskilled and relatively expensive, while the international tendency towards capital-intensive production acquiring more capital, skilled labour and less unskilled workers, has further contributed to the greater degree of capital-intensive production observed in South Africa. Apart from the structural component of unemployment, the growth in GDP has been inadequate to create sufficient job opportunities to cure the unemployment problem. The period of economic sanctions and disinvestment, resulting in the outflow of skilled labour and other consequences, has aggravated the problem.

CHAPTER 6

A NEOCLASSICAL INVESTMENT MODEL OF THE SOUTH AFRICAN ECONOMY: THEORY AND EVIDENCE

6.1 INTRODUCTION

In this chapter, a model of aggregate fixed investment is proposed, derived and estimated. Investment plays an important role in the gross domestic product of the economy for a number of reasons. First, investment increases a country's productive capacity to the extent that investment outlays (plant and equipment) are long-lived, durable goods and embody the most recent technical advances. Second, investment expenditure induces shifts in the aggregate levels of employment and personal income by affecting the demand for capital goods. Third, the sensitivity of aggregate supply and demand to changes in investment is important empirically, since investment is a severely volatile component of the GDP. Given this volatility and the fact that investment movements have important consequences for productive capacity, the demand for labour, personal income and the balance of payments make it is important to understand the fundamental causes of variations in aggregate investment.

Gross domestic fixed investment in South Africa has deteriorated significantly with the imposition of economic sanctions and the resulting disinvestment and outflow of foreign capital since 1985. The situation has not improved with the abolition of sanctions or when disinvestment in South Africa came to a halt in 1994. Instead, the greater degree of openness of the economy further exposed South Africa's vulnerability to international financial market instability, as was experienced with the East Asian and Russian crises of 1998.

Therefore, in modelling gross domestic fixed investment for South Africa, it is necessary to incorporate the significant role of financial constraints (internal and external) on investment. In this regard, it is also necessary to estimate a model of corporate savings – an important source of internal funding.

Investment and corporate savings are estimated to be consistent with a neoclassical supply-side model for the South African economy. In the neoclassical tradition, the model has to allow for profit-maximising or cost-minimising decision-making processes by firms, where supply-side factors such as taxes, interest rates and funding in the broader sense play a significant role.

6.2 THEORETICAL FRAMEWORK

6.2.1 Definitions and general framework

Aggregate capital stock at the end of time period t, assuming a constant exponential depreciation (δ), is referred to as the net capital stock and is defined by:

$$K_t = (1-\delta)K_{t-1} + I_t \,. \qquad (6.1)$$

From equation (6.1) follows that replacement investment equals δK_{t-1} and net investment, defined as the net increment to the capital stock since the previous time period, $K_t - K_{t-1}$, equals total investment minus replacement investment, i.e. $I_t - \delta K_{t-1}$. Finally, gross investment, replacement investment and net investment are related by the identity:

$$gross\ investment \equiv replacement\ investment + net\ investment\,.$$

Most theories of investment behaviour relate the demand for new plant and equipment to the gap between the desired or optimal amount of capital stock, denoted as K^*, and the actual amount of capital, K. Two aspects of K and K^* are of concern: (1) What are the factors affecting K^*, and how can such factors be modelled and measured? (2) Why is $K \neq K^*$, how does K adjust towards K^* and which factors affect the speed of adjustment?

These two aspects of investment behaviour can be combined as follows. Let the net capital stock at the end of period $t-1$ be K_{t-1}, let K_t^* be the desired capital stock at the end of the current time period, and let the speed of adjustment between K_t^* and K_{t-1} be λ_t. If λ_t was zero, K would be fixed and there would be no net investment reducing the gap between K^* and K, while if λ_t was 1, this gap would be closed within one time period, that is, adjustment would be instantaneous. By definition, net investment during time period t equals $\lambda_t(K_t^* - K_{t-1})$, and replacement investment equals δK_{t-1}. Since gross investment I_t is the sum of net and replacement investment, gross investment can be written as:

$$I_t = \lambda_t(K_t^* - K_{t-1}) + \delta K_{t-1} = \lambda_t K_t^* + (\delta - \lambda_t)K_{t-1}\,. \qquad (6.2)$$

6.2.2 Modelling investment: a survey

6.2.2.1 *Accelerator model (Keynesian approach)*

One of the early empirical models of aggregate investment behaviour is the accelerator model, which was put forward by J.M. Clark in 1917 as an explanation of the volatility of investment expenditures. The distinguishing feature of the accelerator model is that it is based on the assumption of a fixed capital/output ratio. This implies that prices, wages, taxes and interest rates have no direct impact on capital spending but may have indirect impacts.

The naive accelerator model defines optimal capital stock K_t^* as a fixed proportion to output (Y_t):

$$K_t^* = \mu \cdot Y_t \qquad (6.3)$$

with μ denoting the fixed capital/output ratio. Furthermore, since the capital stock is always optimally adjusted in each time period, implying $K_t^* = K_t$, net investment I_{nt} equals:

$$I_{nt} = K_t - K_{t-1} = \mu(Y_t - Y_{t-1}) . \tag{6.4}$$

A generalised version of the naive accelerator model is called the flexible accelerator and was introduced by Leendert M. Koyck (1954). In this specification, the adjustment of capital stock to its optimal level is no longer instantaneous, but instead is assumed to be a constant proportion λ of the gap between K^* and K. Let the partial adjustment coefficient be λ_t, set $\lambda_t = \lambda$ for all t and specify net investment as:

$$I_{nt} = \lambda(K_t^* - K_{t-1}) . \tag{6.5}$$

Substitution of equation (6.3) into equation (6.5) yields:

$$I_{nt} = K_t - K_{t-1} = \lambda\mu(Y_t - Y_{t-1}) \tag{6.6}$$

or

$$K_t = \lambda\mu Y_t + (1-\lambda)K_{t-1} . \qquad (6.7)^1$$

Assuming a constant rate of depreciation (δ), gross investment is defined by:

$$I_t = K_t - (1-\delta)K_{t-1} = \lambda\mu Y_t + (\delta - \lambda)K_{t-1} . \qquad (6.8)^2$$

Equation (6.8) does not have an intercept term (although in practice this equation is typically estimated with a constant term included) and, provided the value of δ is known (needed to construct the K_t series), estimation by least squares would then yield implicit estimates of μ and λ.

6.2.2.2 *Cash-flow model*

The emphasis on capital market imperfections and the significance of financial constraints on investment behaviour are not novel in empirical studies of investment decisions. Three main sources of funds have been identified in various applied research

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1 Equation (6.7) can be extended to yield a distributed lag formulation with geometrically declining weights:
$K_t = \mu[\lambda Y_t + \lambda(1-\lambda)Y_{t-1} + \lambda(1-\lambda)^2 Y_{t-2} + \cdots]$
or
$K_t - K_{t-1} = \mu[\lambda(Y_t - Y_{t-1}) + \lambda(1-\lambda)(Y_{t-1} - Y_{t-2}) + \lambda(1-\lambda)^2(Y_{t-2} - Y_{t-3}) + \cdots]$
(Berndt 1991: 234-235).

2 Because of the difficulties in obtaining reliable capital stock measures, this equation is frequently estimated in an alternative form: the Koyck transformation, where equation (6.8) is lagged one period, multiplied on both sides by (1 - δ) and the product then subtracted from (6.8), yielding:
$I_t - (1-\delta)I_{t-1} = \lambda\mu Y_t - (1-\delta)\mu\lambda Y_{t-1} + (\delta-\lambda)K_{t-1} - (1-\delta)(\delta-)K_{t-2}$ which can be rewritten as
$I_t - (1-\delta)I_{t-1} = \lambda\mu Y_t - (1-\delta)\mu\lambda Y_{t-1} + (\delta-\lambda)I_{t-1}$ since $I_{t-1} = K_{t-1} - (1-\delta)K_{t-2}$. Collecting terms, gross investment can finally be written as: $I_t = \lambda\mu Y_t - (1-\delta)\mu\lambda Y_{t-1} + (\delta-\lambda)I_{t-1} + (1-\delta)I_{t-1}$ (Berndt 1991).

studies of investment: internal cash flow, availability of external debt and equity financing (sales). It has however, been argued that internal cash flow is the pre-eminent source of funds.

The cash-flow model posits investment spending as a variable proportion of internal cash flow. Since the supply of internal funds is obviously affected by the current level of profits, it has been suggested that the optimal capital stock K^* should be made dependent not on the level of output, as in the accelerator framework, but instead on variables capturing the level of profits or expected profits.

Consider the specification by Grunfeld (1960), who assumed that the optimal capital stock is a linear function of expected profits, as proxied by the market value of the firm, V_t:

$$K_t^* = \alpha + \beta V_t \, . \qquad (6.9)$$

With equation (6.9) substituted into equation (6.2), Grunfeld obtained an investment equation with an intercept term. The intercept and V_t may then be used to replace Y_t in the accelerator model (6.8):

$$I_t = \lambda\alpha + \lambda\beta V_t + (\delta - \lambda)K_{t-1} \, . \qquad (6.10)$$

Equation (6.10) suggests that investment is severely affected by the external market value (net worth) of the firm.[3]

Among others, Meyer and Kuh (1957) and Duesenberry (1958) have argued that there are imperfections in capital markets. There are basically two main concerns (one on a macro and one on a micro-level), based on the links between internal funds and investment decisions.

First, from a macroeconomic perspective, the concern is that cyclical movements in investment appear too large to be explained by market indicators of expected future profitability of the user-cost-of-capital. This has led some macroeconomists to identify financial factors in propagating relatively small shocks, which factors correspond with accelerator models. The term *financial accelerator* has been used to refer to the magnification of initial shocks by financial market imperfections (see, e.g., Bernanke, Gertler and Gilchrist 1996). This fashion actually has a long history among macroeconomists, with contributions by Irving Fisher (1933), John Gurley and Edward Shaw (1955, 1960) and Albert Wojnilower (1980). Some econometric forecasting models have also focused on financial factors (see, e.g., the description for the DRI model in Otto Eckstein and Allen Sinai, 1986).

3 Hubbard (1998) presents a graphical analysis to illustrate the link between net worth (internal funds) of a firm and capital investment in models of informational imperfections.

Second, the microeconomic concern relates to consequences of informational imperfections in insurance and credit markets. In this line of inquiry, problems of asymmetric information between borrowers and lenders lead to a gap between the cost of external financing and internal financing. This notion of costly external financing stands in contrast to the more complete markets approach underlying conventional models of investment emphasising expected future profitability and the user-cost-of-capital as key determinants of investment.

If the risks associated with firms' increasing the ratio of their debt to their earnings should lead them to have strong preferences for the internal cash flow financing of investment, then V_t in equation (6.9) needs to be replaced with a liquidity-type variable such as profits or retained earnings after taxes.

A common variable used to measure available funds is cash flow, defined as profits after taxes plus depreciation allowances less dividend payments to shareholders. Cash flow has historically accounted for a substantial portion of firms' sources of funding for fixed investment.

Cash flow is not, however, the sole source of available funds. The second principal source of funds for investors, is debt financing. Although debt financing may allow a firm to expand its capital budget, such financing becomes considerably more expensive than its yield would suggest. For example, debt obligations may place constraints on capital budgeting options, they may increase the risk that is inherent in owning shares of the firm and they may even eventually increase the risk that managers and shareholders forfeit control of their investments. Most empirical analysts also believe that the cost of debt financing exceeds its yield by an increasing margin as the firm's reliance on borrowed funds increases.[4]

A third source of funds for firms, is the issuing of shares. This type of financing is particularly important for firms whose current or prospective investment opportunities far exceed their cash flow. New equity financing can be expensive for firms, however, since new equity-holders are entitled to their share of any dividends paid by the firm and also because, tax laws frequently disallows tax-deductions of dividend payments for firms. This cost premium can be substantial.

Therefore, according to the cash-flow model, firms tend to commit their retained earnings firstly to finance their capital budgets. Only after internal cash flow is exhausted does the firm seek external debt or equity financing. Since internal cash flow serves as a measure of profitability and as an index of the firm's capacity to attract external financing, the magnitude of the firm's investment is postulated to depend on its available cash flow.

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4 Since the mid-1960s, however, most applied work isolated real firm decisions from purely financial factors. The intellectual justification for this shift in approach drew on the seminal work by Franco Modigliani and Merton Miller (1958), who demonstrated the irrelevance of financial structure and financial policy for real fixed investment decisions. As a result, investment decisions by firms, motivated by the maximisation of shareholders' claims, are independent of financial factors such as liquidity, leverage, or dividend payments.

In summary: a common theme amongst existing theoretical models of market imperfections is that imperfect information about the quality or risky nature of the borrowers' investment projects, leads to a gap between the cost of external financing and internally generated funds. Second, in the presence of incentive problems and costly monitoring of managerial actions, external suppliers of funds to firms require a higher return to compensate them for these monitoring costs and the potential moral hazard associated with managers' control over the allocation of investment funds. Theoretical models of imperfections in capital markets therefore imply that external financing is more costly than internal financing for many firms.

Recently, Hubbard (1998) conducted empirical tests and found that (1) all else being equal, investment correlates significantly with proxies for change in net worth or internal funds; and (2) that correlation is most important for firms likely to face information related capital-market imperfections.

One ambiguity that emerges from the above interpretation of the importance of cash flow, is whether cash flow affects the desired capital stock K^*, or whether it instead operates by affecting the speed of adjustment λ from K to K^*. The literature is not clear on the matter, but it is plausible to argue that both channels are potentially significant. Note, however, that if cash flow affects the speed of adjustment, then λ is time-varying and endogenous, rather than fixed and exogenous as in equations (6.8) and (6.10).

The cash-flow model has been implemented in a variety of ways by a large number of researchers. Two examples, both based on the Tobin's q-model[5], are empirical studies done by Kopcke (1977, 1982, 1985) and Fazzari, Hubbard and Petersen (1988).

Kopcke estimated a cash-flow model of the general form:

$$I_t = a + \sum_{i=0}^{m-1} b_i (F/J)_{t-1} + cK_{t-1} + u_t \qquad (6.11)$$

where the b_i, a and c are unknown parameters to be estimated, F is internal cash flow in current prices and J is a price index for new capital. In his 1982 study, however, Kopcke estimated a somewhat different equation in which I_t / K_{t-1} was the dependent variable and a market value variable was added as a regressor.

Kopcke's later approach is similar to the Fabazzi, Hubbard and Peterson framework where cash flow is used to measure the change in net worth of the firm:

$$\left(\frac{I}{K}\right)_t = a + bQ_t + c\left(\frac{F}{K}\right)_t + u_t \qquad (6.12)$$

with Q the tax-adjusted value of Tobin's q.[6]

5 See discussion on Tobin's q-models.

6.2.2.3 *The neoclassical model: Jorgenson's approach*

The accelerator model, assuming the capital/labour ratio to be fixed, is highly restrictive in implying that substitution possibilities among capital, labour and other inputs are constrained to zero. Similarly, in the cash-flow model, only internal cash flow affects the optimal capital stock, and again no role for substitution is allowed. By contrast, neoclassical theory emphasised the role of input substitution as a critical element in the economic theory of cost and production. While it has undergone some cosmetic refinements and generalisations,[7] Jorgenson's model still remains the standard reference in the field of neoclassical theory of domestic investment.

The distinguishing feature of the neoclassical model is that it is based on an explicit model of optimisation behaviour, which relates the desired capital stock to interest rates, output, capital prices and tax policies.

To illustrate Jorgenson's model, consider a firm that produces one output, Q, by using two inputs, K and L. Unlike the Keynesian (accelerator) model, which only considers one input in which the capital/labour ratio is assumed to be fixed, the neoclassical model presupposes substitution between its multiple inputs.

In his seminal work on domestic investment behaviour, Jorgenson (1963) postulated the maximisation of the net worth of the firm as its ultimate objective. The net worth (often labelled cash flow) is the amount that a purchaser would be willing to pay for the firm, which again equals the sum of the net present value of the future stream of profits from time zero, subject to a neoclassical production function constraint: $Y_t = f(K_t, L_t)$.

The optimisation problem is therefore defined as:

$$\max_{K,L,I} V = \int_0^{\infty} \exp(-R_t)[p_t \cdot f(K_t, L_t) - w_t L_t - q_t I_t]dt \ \ (with\ R_t = \int_0^t i_s ds) \quad (6.13)$$

where i_s is the rate of interest at time s, I_t is gross investment or net purchase of capital stock at time t. The output is sold at p_t and the inputs for period t is bought at w_t and q_t respectively. Since Jorgenson assumes a perfectly competitive market, it implies that the firm is a price-taker.

In this particular specification, the firm must choose L_t, K_t and I_t at each point in time to maximise the net present value of the firm.[8] The linkage between I_t and K_t is captured by the perpetual inventory relation:

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6 See Hubbard (1998).

7 See Berndt (1991: 250-256).

8 The net present value (net worth) of a firm is often depicted by its cash flow. However, cash is, strictly speaking, profits after taxes and depreciation allowances less dividends to shareholders (Berndt 1991). This concept is therefore more limited than profit, and should be used with care.

$$K_t = (1-\delta)K_t + I_t \qquad \text{or} \qquad I_t = K_t' + \delta K_t \tag{6.14}$$

where K_t' is the change in the level of capital stock at time t and δ is the rate of depreciation in the capital stock. K_t' is positive if new capital is purchased, negative if it is sold and zero if there are no purchases or sales of capital stock.

Under the assumption of certainty with regard to all the exogenous variables (output and input prices), it can be shown that this model reduces to its static equivalent and thus encounters the one-period-optimisation problem (Nickell 1978). The static approach considers each period in isolation and postulates that the firm aims to maximise its instantaneous profit at each point in time. The optimisation problem can then be defined as:

$$\max_{K,L} \pi_t = \pi_t(Y_t, K_t, L_t; p_t, r_t, w_t) = p_t \cdot Y_t - [w_t L_t + r_t K_t] \tag{6.15}$$

where $\{Y_t, K_t, L_t; p_t, r_t, w_t\} \in R_+$, $\pi \in R$, $\pi()$ is at least twice differentiable and r_t is the user-cost-of-capital in period t. Therefore, by postulating that the firm chooses optimal values for K_t, L_t and Y_t so as to maximise one-period profits subject to the production function constraint defined as $Y_t = f(K_t; L_t)$, the optimisation problem (objective function) becomes:

$$\max_{K,L} \pi_t = p_t \cdot f(K_t, L_t) - [w_t L_t + r_t K_t]\,. \tag{6.16}$$

Under the above profit-maximisation conditions, use of the traditional Lagrangian multiplier procedure yields the necessary conditions for optimality, namely, for capital:

$$p_t \cdot \frac{\partial Y_t}{\partial K_t} = r_t \rightarrow \frac{\partial Y_t}{\partial K_t} \equiv MPP_{K,t} = \frac{r_t}{p_t} \tag{6.17}$$

and for labour:

$$p_t \cdot \frac{\partial Y_t}{\partial L_t} = w_t \rightarrow \frac{\partial Y_t}{\partial L_t} \equiv MPP_{L,t} = \frac{w_t}{p_t} \tag{6.18}$$

where $MPP_{K,t}$ and $MPP_{L,t}$ denote the marginal physical products of K and L, respectively. These equations confirm the theoretical conditions for profit maximisation, namely, that firms will choose a set of inputs such that for each input, the marginal benefit of employing another unit of the input (additional real output) equals the marginal cost of employing another unit of the input (the additional real wage or real user-cost-of-capital).

In order to estimate equation (6.17), which forms the basis of the neoclassical investment model, it is necessary to assume an explicit form of the production function. The marginal physical product is then obtained by taking the partial derivative with respect to capital and solve the expression for the level of K^* such that the marginal physical product of capital equals the real user-cost-of-capital (Appendix 14).

Hall and Jorgenson originally assumed a Cobb-Douglas technology in their investment studies, i.e. a production structure exhibiting unitary elasticity of substitution:

$$Y_t = A \cdot K_t^{\alpha} \cdot L_t^{\beta} \qquad (6.19)$$

with $\alpha + \beta = 1$ under the assumption of constant returns to scale. Solving equation (6.19) with respect to K_t and its marginal physical product (6.17), yields:

$$\alpha(Y_t / K_t) = r_t / p_t . \qquad (6.20)$$

Optimal capital stock K^* is then defined as:

$$K_t^* = \alpha \cdot (p_t / r_t) \cdot Y_t . \qquad (6.21)$$

Jorgenson expanded on this original version of his model by specifying partial adjustment in the form of a distributed lag specification (assuming orders for new net investment) and incorporating replacement investment as proportional to the capital stock (Berndt 1991: 249). The estimation equation for gross fixed investment can therefore be specified as:

$$I_t = \sum_{i=0}^{\infty} \alpha \phi_i (p \cdot Y / r)_{t-i} + \delta \cdot K_{t-1} \qquad (6.22)$$

with ϕ_i representing the proportion of all orders that take i periods to be delivered.

6.2.2.4 *Tobin's q-model*

In the cash-flow model framework, optimal capital stock was postulated to be a function of expected profits, which in turn may be measured by the market value (net worth) of the firm. James Tobin (1969) has generalised the cash-flow model and has provided a rigorous framework for an investment model in which net investment depends on the ratio of the market value of business capital assets to their replacement value, a ratio known as q. The theory underlying Tobin's q is closely related to the neoclassical investment model considered in the previous section.

Managers determine the price they are willing to pay for an investment project (the demand price for an asset) on the basis of the expected profitability. The demand price for an entire firm is the market value of all its securities, that is, the market value of all its debt and equity in securities markets. The cost of producing all new capital goods is the supply price and is typically measured by assessing the replacement cost of a firm's assets. In equilibrium, the demand and supply prices for fixed investment must be equal.

If the ratio of the market value of the firm to the replacement value of its assets were unity, then there would be no incentive for the firm to invest.

The naive form of the Tobin's q-model of investment, implying that whenever marginal q is greater (less) than unity, there are incentives for net investment (disinvestment) in capital goods, is specified by:

$$I_t = a + \sum_{i=0}^{m-1} b_i \cdot (q-1)_{t-i} K_{t-i-1} + b_K \cdot K_{t-1} + u_t \qquad (6.23)$$

with b_i expected to be positive.

Note that in equation (6.23), $q_t \cdot K_t$ represents the market value of the firm. In this sense, equation (6.23) is similar to Grunfeld's cash-flow model (6.10).

In practice, there are serious problems in empirically implementing the q-model. Measurement problems, such as measuring the replacement value of the firm's assets (the denominator of q), valuation of the outstanding debt obligations (the nominator of q) and determining a marginal rather than an average value for q, have contributed to the poor performance of *q-models* (Berndt 1991). Further, since the underlying theory is vague on the functional form, the q investment equation is often estimated in variants of equation (6.23), including, for example, regressing I_t / K_{t-1} rather than I_t on the left-hand side of the equation.

Abel (1979, 1980), Yoshikawa (1980) and Hayashi (1982) have indicated that Tobin's *q-model* of investment can be related to the neoclassical framework in defining an amended q as:

$$q_t \equiv \pi_t / r_t \qquad (6.24)$$

with π_t the additional profits expected in time period t (representing the one-period shadow price of capital) and r_t the user-cost-of-capital (representing the one-period tax-adjusted price of uninstalled capital goods). The definition of q in terms of one-period prices (flow prices) rather than the previous version where q was defined in asset prices, has the advantage of highlighting the expectational and marginal (not average) nature of q.

Although the *q-model* is relatively attractive because of its theoretical foundations and its ability to distinguish order, delivery, and gestation from expectational lags, its empirical performance has been less than impressive to date.[9] A number of studies have regressed investment on q and a common finding is that the variations in q fail to explain a large part of the variation in investment; further, as with other empirical investment models,

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9 Only recently has Allen (1997) successfully modelled forward-looking investment by linking it to Tobin's q-model and applying a flexible functional form.

the residuals or unexplained movements in investment tend to be highly correlated, suggesting that important explanatory variables are omitted (Berndt 1991).

6.2.2.5 *Time-series (Autoregressive) models*

In contrast to the theories of investment discussed in the previous sections, the time-series/autoregressive approach does not directly use output, cash flow, market value, prices, or taxes as determinants of investment expenditure. Rather, in its simplest form, investment is merely regressed on a series of previous investment expenditures:

$$I_t = a + \sum_{i=1}^{m} b_i I_{t-i} + u_t \qquad (6.25)$$

with m lagged investment terms. This is therefore following an autoregressive process of degree m.

Due to the lack of explaining the structural properties of investment, this approach is unsuitable for estimating investment consistent with a supply-side model and is not explored any further.

6.3 AN EMPIRICAL INVESTMENT FUNCTION FOR THE SOUTH AFRICAN ECONOMY: A NEOCLASSICAL APPROACH

In this section an aggregate gross domestic fixed investment function, based on Jorgenson's neoclassical model is estimated. The Engle-Yoo (1991) three-step cointegration estimation procedure is employed. The resulting investment function is subjected to comprehensive evaluation and testing to ensure that the function complies with the "full ideal principles" of model selection.

6.3.2 The theoretical model

The neoclassical (Jorgenson) approach is the most suitable in estimating a domestic fixed investment function as it has to be consistent with a supply-side model for the South African economy, incorporating all cost-minimising and profit-maximising decision-making processes by firms.

Based on earlier reasoning, it is necessary to model the significant role of financial constraints (internal and external) on investment in South Africa. An attempt is therefore made to extend the neoclassical specification by incorporating the financial constraints as specified by cash-flow models[10] – only on an aggregate level.

The neoclassical theory of investment states that firms will maximise their profits by finding the optimal level of capital stock associated with the levels of interest rates, output, capital prices and tax policies. Taking into account a constant depreciation in capital stock, the linkage between I_t

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[10] See Hubbard (1998).

and K_t is captured by: $K_t = (1-\delta)K_t + I_t$ or $I_t = K'_t + \delta K_t$. Empirical estimation therefore allows for two parallel approaches: (i) the estimation of K_t and subsequent derivation of I_t; or (ii) the empirical determination of I_t followed by the derivation of K_t applying the perpetual inventory relation.

In applying the Jorgenson neoclassical model for the South African case it is possible to specify the underlying technology to be of Cobb-Douglas nature. This ensures consistency in the supply system as it was proven in chapter 4 that a Cobb-Douglas production specification, taking endogenous technical progress into account, is valid and representative of the South African economy.

For the purpose of accommodating the principles of the cash-flow model, an aggregate financial constraint variable is constructed, incorporating both internal (domestic) and external (foreign) sources of funding. In accordance with the exposition of the national accounts, domestic financial constraints consist of savings by households (*sp*), corporate enterprises (*sc*), the government (*sg*), as well as replacement investment or depreciation in real capital stock (*depr*). External financial constraints consist of net foreign capital flow (*capflow*) and the value of the change in gold and other foreign reserves (*reserv*). Assuming the behaviour of all role-players, except business corporations (firms) as exogenous, it is necessary to estimate an empirical equation for corporate savings – an important source of internal funding

The following empirical approaches were explored in order to obtain a cointegration relationship for investment:

(i) estimating K_t and deriving I_t;
(ii) estimating I_t and deriving K_t ; and
(iii) estimating I_t / K_{t-1}, normalising on either K_t or I_t and deriving the other.

A direct estimation of I_t and subsequent derivation of K_t turned out to be an appropriate approach in obtaining an equilibrium or cointegration relationship, consistent with *a priori* information on the magnitudes and signs of the long-run explanatory variables. This can be portrayed as follows:

Gross domestic investment in South Africa is therefore modelled by a system of equations: a stochastic function for gross domestic fixed investment (*if*), identities for the real capital stock (*k*) and aggregate financial constraints in nominal terms (*fc*), and a stochastic function for nominal corporate savings (*sc*).

$$if = f(\overset{+}{real\ capital\ stock},\ \overset{+}{financial\ constraint},\ \overset{+}{gdp\ @\ factor\ cost},\ \overset{-}{user\text{-}cost\text{-}of\text{-}capital})$$

$$\uparrow$$

$$k_t = (1-\delta)k_{t-1} + if_t$$

$$\uparrow$$

$$fc = sp + sg + depr + sc + capflow + reserv$$

$$\uparrow$$

$$sc = f(profits\ of\ companies)$$

6.3.2 The data

Appendix 7 presents an exposition of the data (sources, derivation and univariate characteristics) utilised in both the long-run cointegration and short-run dynamics of the model. Appendices 8 and 9 present an associated variable list and graphical illustration of the data series respectively.

6.3.3 The estimation results of the cointegration equation

The first step of the Engle and Yoo (1991) three-step estimation technique (Appendix 1) was employed to test whether the set of variables specified in the empirical model is cointegrated, i.e. whether the particular combination of variables is consistent with the long-run equilibrium relationship. The cointegration results are reported in table 6.1.

Table 6.1 Cointegration equation: Real fixed investment

Dependent Variable: ln_if
Method: Least Squares
Sample(adjusted): 1971 1995
Included observations: 25 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
ln_bbpfact_90p	0.329617	0.114466	2.879613	0.0090
ln_ucc2_90p	-0.141681	0.050808	-2.788546	0.0110
ln_fincond_ppi	0.552063	0.131118	4.210414	0.0004
kap_r	7.33E-07	3.69E-07	1.985826	0.0603
R-squared	0.728342	F-statistic		18.76772
Adjusted R-squared	0.689534	Prob(F-statistic)		0.000004

Comparing the Engle-Granger test statistic of –3.50 with the computed MacKinnon[11] and the specified cointegration augmented Dickey-Fuller critical values respectively, resulted in the rejection of the null of no-cointegration in favour of stationary residuals and cointegrated variables. Figure 6.1 represents a plot of the stationary residuals.

6.3.4 The short-run dynamics: error correction model (ECM)

After the long-run cointegration relationship has been determined, the second stage of the Engle and Yoo procedure consists of an estimation of the error correction mechanism (ECM) (Appendix 1) in order to capture the short-run or dynamic adjustment process to the long-run equilibrium. It incorporates the equilibrium error (residual terms) estimated from the long-run equilibrium relationship. The estimation results of the ECM are reported in table 6.2.

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11 Critical values for the relevant response surfaces can be found in MacKinnon (1991). The response surface for any number of regressors, excluding any constant and trend components, $1 \leq n \leq 6$, can be calculated as $C(p) = \phi_{\infty} + \phi_1 T^{-1} + \phi_2 T^{-2}$, where $C(p)$ is the p percent critical value.

Figure 6.1 Residuals: Real fixed investment (ln_if)

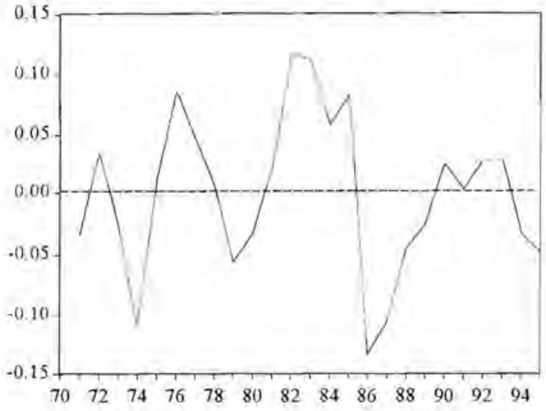


Table 6.2 Error correction model: Real fixed investment

Dependent Variable: Δ(ln_if)
Method: Least Squares
Sample(adjusted): 1973 1995
Included observations: 23 after adjusting endpoints

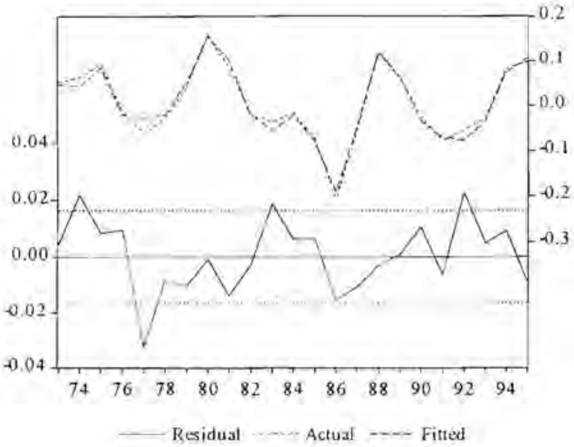
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.941250	0.105223	-8.945332	0.0000
Δ(kap_r(-1))	3.97E-06	5.12E-07	7.748606	0.0000
Δ(ln_vpi)	-0.941551	0.171373	-5.494178	0.0001
Δ(ln_vpi(-2))	0.976882	0.185696	5.260663	0.0001
Δ(ln_p_manuf(-1))	-1.037919	0.185598	-5.592299	0.0001
Δ(ln_p_manuf(-3))	0.412439	0.140326	2.939142	0.0108
Δ(ln_fincond_ppi)	0.355705	0.029531	12.04523	0.0000
Δ(ln_fincond_ppi(-1))	0.158596	0.037555	4.223015	0.0009
Δ(ln_fincond_ppi(-2))	0.162331	0.037396	4.340865	0.0007

R-squared	0.974944	F-statistic	68.09447
Adjusted R-squared	0.960627	Prob(F-statistic)	0.000000
S.E. of regression	0.016371		

Apart from the long-run explanatory variables, consumer prices and manufacturing prices were also included in the ECM to fully explain the short-run dynamics of investment behaviour. It is plausible to assume that both consumer and manufacturing prices, which affect the cost of capital goods, have additional short-run effects on the expenditure behaviour of corporate enterprises.

A data plot of the actual and fitted values of gross domestic fixed investment is provided in figure 6.2.

Figure 6.2 Actual, fitted and residual values of ln_if



6.3.5 Diagnostic testing

The investment function was subjected to rigorous diagnostic testing. Once again it must be noted that since all the variables in the ECM are stationary, the assumptions of classical regression analysis are fulfilled. Standard diagnostic tests can therefore be used to determine which variables should be included in the final specification of the ECM (Harris 1995: 24). The diagnostic test results reported in table 6.3 indicate that the function passes all the statistical diagnostic tests.

Table 6.3 Diagnostic tests: Real fixed investment (ln_if)

Purpose of test	*Test*	*d.f.*	*Test statistic*	*Probability*
Normality	Jarque-Bera	JB(2)	0.602397	[0.739931]
Homoscedasticity	ARCH LM	$nR^2(1)$	1.115332	[0.290926]
Homoscedasticity	White	$nR^2(18)$	14.78429	[0.676721]
Serial correlation	Breusch-Godfrey	$nR^2(2)$	0.903840	[0.636405]
Serial correlation	Lung Box Q	Q(12)	20.76200	[0.054000]
Misspecification	Ramsey Reset	LR(2)	4.815899	[0.090000]
Parameter stability	Recursive estimates	Indicative of stability		

6.3.6 Cointegration correction and adjusted coefficients

In this step, the originally estimated coefficients and *t*-statistics are adjusted by applying the Engle and Yoo technique (Appendix 1). Tables 6.4 and 6.5 summarise the third-step estimation results and the adjusted coefficients.

Table 6.4 Engle-Yoo third-step estimation: Real fixed investment (ln_if)

Dependent Variable: residual_ecm
Method: Least Squares
Sample(adjusted): 1973 1995
Included observations: 23 after adjusting endpoints

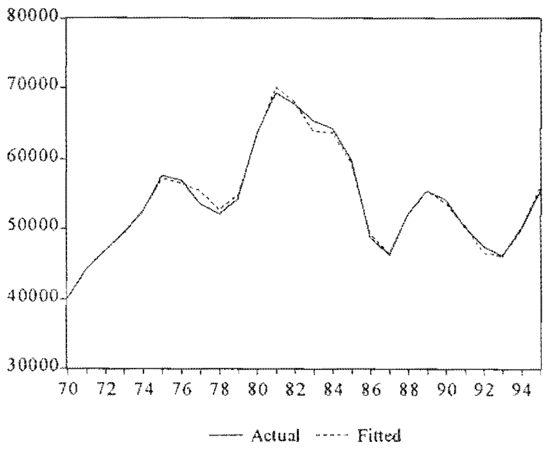
Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.94125)*ln_bbpfact_90p	0.005695	0.024834	0.229322
(0.94125)*ln_ucc2_90p	0.012817	0.013217	0.969749
(0.94125)*ln_fincond_ppi	0.003303	0.027384	0.120614
(0.94125)*kap_r	-1.02E-07	1.09E-07	-0.935943

Table 6.5 Cointegration correction: Real fixed investment (ln_if)

Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_bbpfact_90p	0.335012	13.300000
ln_ucc2_90p	-0.128864	-9.750000
ln_fincond_ppi	0.555366	20.280000
kap_r	6.31E-07	5.790000

Dynamic simulation of the final model yields the overall fit as depicted in figure 6.3.

Figure 6.3 Actual and fitted values of ln_if



The fit of the estimated equation is evaluated in an *ex post* simulation context by means of a number of quantitative measures. From the simulation error statistics (Appendix 2) reported in table 6.6 can be concluded that the estimated equation represents a good fit of the actual corresponding data series.

Table 6.6 Simulation error statistics of real fixed investment

Actual v Fitted : ln_if	
Root Mean Squared Error	0.012773
Mean Absolute Error	0.010296
Mean Absolute Percentage Error	0.094450
Theil Inequality Coefficient	0.000585
Bias Proportion	0.001078
Variance Proportion	0.000867
Covariance Proportion	0.998055

The estimation results comply with what was expected and are in line with *a priori* theoretical assumptions. It is significant that financial constraints play the biggest role in long-run investment decisions. This is plausible, given the degree of openness and subsequent vulnerability of the South African economy and has important consequences for economic policy aimed at stimulating sustainable growth and employment.

6.3.7 Dynamic simulation: response properties of the model

Next, the model's dynamic simulation properties are investigated and tested for stability and robustness simultaneously (Appendix 10). In all instances, the adjustment process is completed within the sample range.

The results of the adjustment process towards a new long-run equilibrium are both tabled and graphed below.

Table 6.7 below indicates the level of convergence of the dependent variable, gross domestic fixed investment. All responses of real fixed investment were consistent with what was expected.

Table 6.7 Difference between the baseline forecast and forecasts with shocked variables, dependent variable: ln_if

Variable	*Coefficient*	*Expected change (10% of coefficient)*	*Convergence level (% difference)*
ln_bbpfact_90p	0.3350120	0.0335012	0.0330000
ln_ucc2_90p	- 0.128864	- 0.012886	- 0.012000
ln_fincond_ppi	0.5553660	0.0555366	0.0540000
kap_r	6.31E-07	0.0418675[12]	0.0550000

The results of the sensitivity tests documented in table 6.7 are portrayed in figures 6.4, 6.5, 6.6 and 6.7.

12 Since the relationship between ln_if and kap_r is of semi-log form, the elasticity of ln_if with respect to kap_r is not given by the coefficient of kap_r, but had to be calculated : $\varepsilon = kap\_r * \hat{a}$ (Studemund 1997: 228).

Figure 6.4 Dynamic adjustment (percentage change) in real fixed investment (ln_if) with a 10 percent increase in real gross domestic product at factor cost (ln_bbpfact_90p)

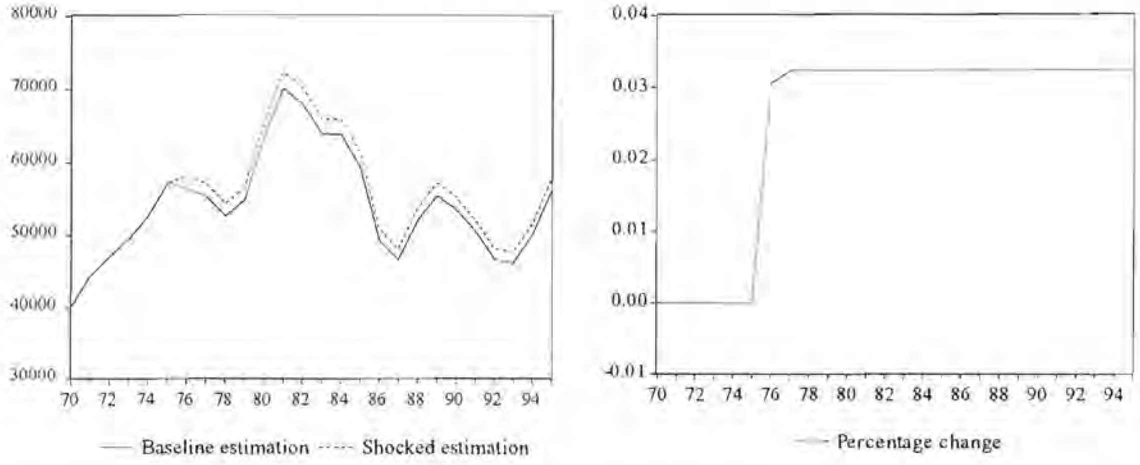


Figure 6.5 Dynamic adjustment (percentage change) in real fixed investment (ln_if) with a 10 percent increase in real user cost of capital (ln_ucc2_90p)

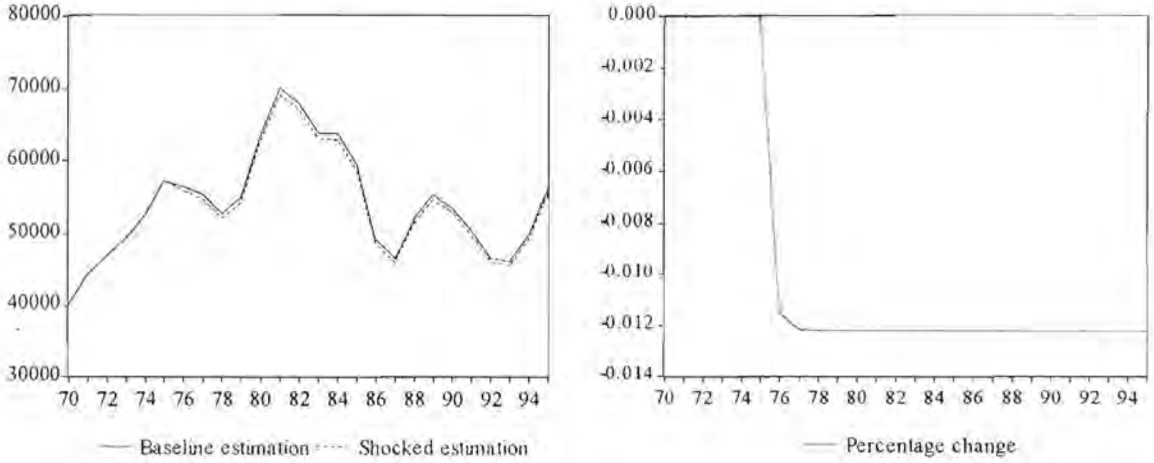


Figure 6.6 Dynamic adjustment (percentage change) in real fixed investment (ln_if) with a 10 percent increase in real financing of gross domestic investment (ln_fincond_ppi)

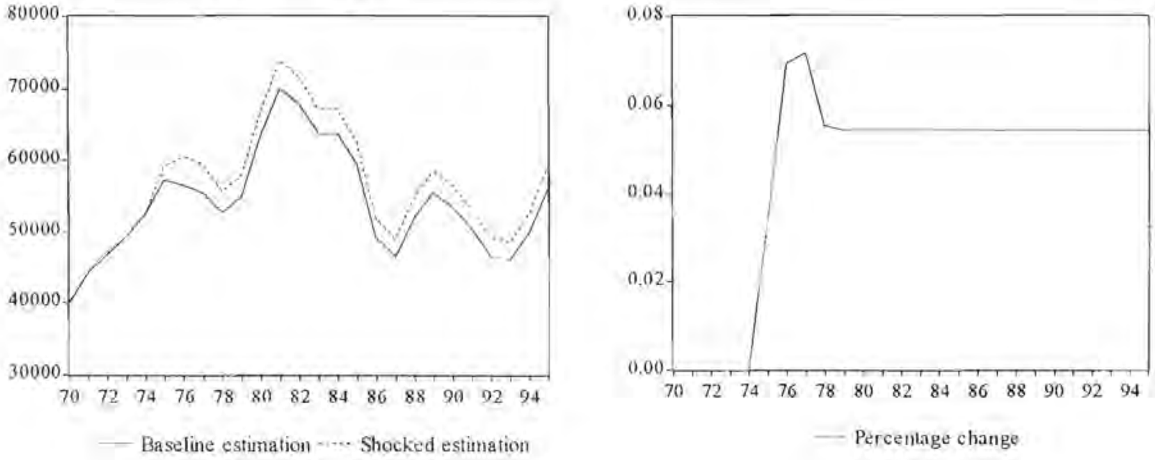
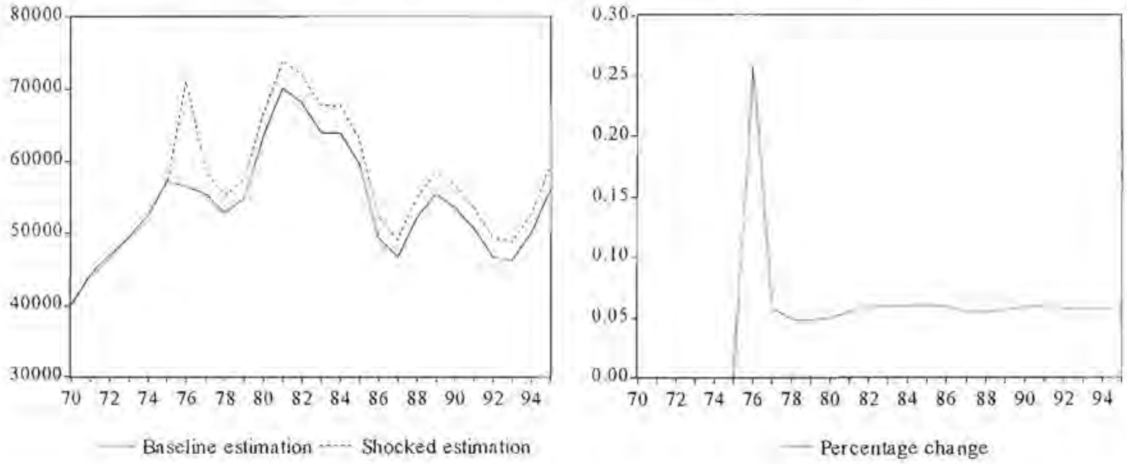


Figure 6.7 Dynamic adjustment (percentage change) in real fixed investment (ln_if) with a 10 percent increase in real capital stock (kap_r)



6.4 AN EMPIRICAL FUNCTION FOR CORPORATE SAVINGS IN SOUTH AFRICA: A NEOCLASSICAL APPROACH

6.4.1 The theoretical model

Corporate savings, representing an internal source of investment financing, enter the investment model as an important component of the identity for financial constraints.

Theory suggests that corporate savings depend on a firm's capacity utilisation (an activity variable), cost of production in terms of wages and some specification of the user-cost-of-capital (cost/price variables) and additional factors such as taxes, subsidies and depreciation rates. These factors constitute the pre-taxed gross operating surplus (*gos*) of the firm, i.e. the pre-taxed level of profits.

Nominal corporate savings can therefore be specified in terms of gross operating surplus (*gos*) and direct taxes on corporate business enterprises (*tc*):

$$sc = f(gos,\ direct\ company\ taxes)\ .$$

However, the specification can be further simplified by adjusting gross operating surplus for direct taxes on corporate business enterprises (*tc*), yielding an after-taxed gross operating surplus (*gos_tc*):

$$sc = f(gos\_tc)\ .$$

6.4.2 The data

An exposition on the data (sources, derivation and univariate characteristics) utilised in both the long-run cointegration and short-run dynamics of the model, is presented by Appendix 7. This should be viewed in conjunction with appendices 8 and 9, which present a variable list and graphical illustration of the data series respectively.

6.4.3 The estimation results of the cointegration equation

The first step of the Engle and Yoo (1991) three-step estimation technique (Appendix 1) was employed to test whether the set of variables specified in the empirical model is cointegrated, i.e. whether the particular combination of variables is consistent with the long-run equilibrium relationship. The cointegration results are reported in table 6.8.

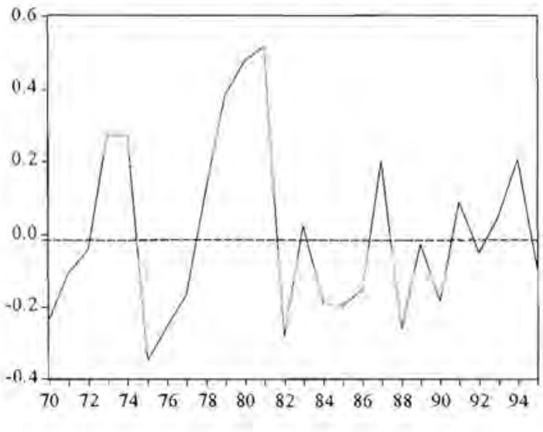
Table 6.8 Cointegration equation: Nominal corporate savings

Dependent Variable: ln_sc_cp
Method: Least Squares
Sample(adjusted): 1970 1995
Included observations: 26 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
ln_gostc_cp	0.814213	0.013015	62.55731	0.0000
R-squared	0.764176			
Adjusted R-squared	0.764176			

Comparing the Engle-Granger test statistic of –2.54 with the computed MacKinnon[13] and the specified cointegration augmented Dickey-Fuller critical values respectively, resulted in the rejection of the null of no-cointegration in favour of stationary residuals and cointegrated variables. Figure 6.8 represents a plot of the stationary residuals.

Figure 6.8 Residuals: Nominal corporate savings (ln_sc_cp)



13 Critical values for the relevant response surfaces can be found in MacKinnon (1991). The response surface for any number of regressors, excluding any constant and trend components, $1 \le n \le 6$, can be calculated as $C(p) = \phi_\infty + \phi_1 T^{-1} + \phi_2 T^{-2}$, where $C(p)$ is the p percent critical value.

6.4.4 The short-run dynamics: error correction model (ECM)

After the long-run cointegration relationship has been determined, the second stage of the Engle and Yoo procedure consists of an estimation of the error correction mechanism (ECM) (Appendix 1) in order to capture the short-run or dynamic adjustment process to the long-run equilibrium. It incorporates the equilibrium error (residual terms) estimated from the long-run equilibrium relationship. The estimation results of the ECM are reported in table 6.9.

Table 6.9 Error correction model: Nominal corporate savings

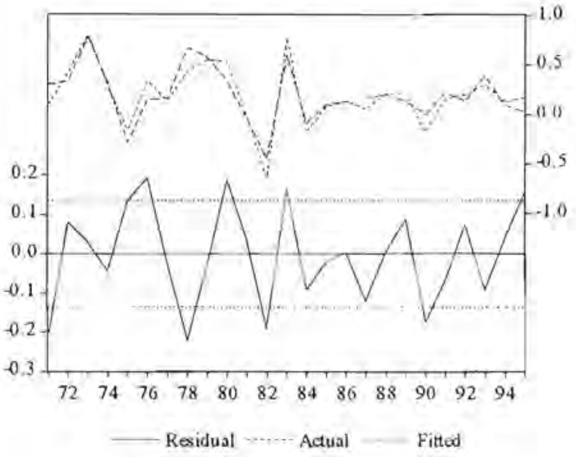
Dependent Variable: Δ(ln_sc_cp)
Method: Least Squares
Sample(adjusted): 1971 1995
Included observations: 25 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.122745	0.042240	-2.905897	0.0087
Δ(ln_gostc_cp)	1.312995	0.213453	6.151199	0.0000
opec_dum	0.323139	0.109153	2.960419	0.0077
Δ(imf_dum)	-0.400409	0.069414	-5.768391	0.0000
Δ(sanction_dum)	-0.243745	0.095932	-2.540809	0.0195

R-squared	0.840163	F-statistic	26.28195
Adjusted R-squared	0.808196	Prob(F-statistic)	0.000000
S.E. of regression	0.135357		

Appendix 7 presents an explanation of the included dummy variables. A data plot of the actual and fitted values of nominal corporate savings is provided in figure 4.9.

Figure 6.9 Actual, fitted and residual values of ln_sc_cp



6.4.5 Diagnostic testing

The savings function was submitted to rigorous diagnostic testing. Once again it must be noted that since all the variables in the ECM are stationary, the assumptions of classical regression analysis are fulfilled. Standard diagnostic tests can therefore be used to determine which variables should be included in the final specification of the ECM (Harris 1995: 24). The diagnostic test results reported in table 6.10 indicate that the function passes all tests.

Table 6.10 Diagnostic tests: Nominal corporate savings (ln_sc_cp)

Purpose of test	*Test*	*d.f.*	*Test statistic*	*Probability*
Normality	Jarque-Bera	JB(2)	0.867169	[0.648181]
Homoscedasticity	ARCH LM	$nR^2(1)$	2.070935	[0.150129]
Homoscedasticity	White	$nR^2(9)$	14.87341	[0.094472]
Serial correlation	Breusch-Godfrey	$nR^2(2)$	3.837143	[0.040923]
Serial correlation	Lung Box Q	Q(12)	11.44700	[0.491000]
Misspecification	Ramsey Reset	LR(2)	2.366166	[0.306333]
Parameter stability	Recursive estimates	Indicative of stability		

6.4.6 Cointegration correction and adjustment coefficients

The Engle and Yoo third-step estimation results and the resultant adjusted coefficients and *t*-statistics are reported in tables 6.11 and 6.12 respectively.

Table 6.11 Engle-Yoo third-step estimation: Nominal corporate savings (ln_sc_cp)

Dependent Variable: residual_ecm
Method: Least Squares
Sample(adjusted): 1971 1995
Included observations: 25 after adjusting endpoints

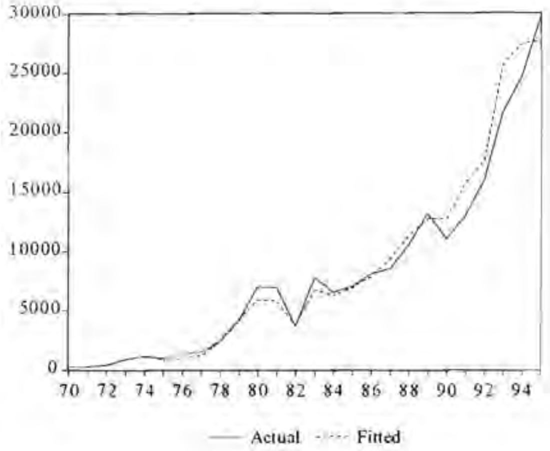
Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.122745)*ln_gostc_cp	-0.003376	0.019377	-0.174200

Table 6.12 Cointegration correction: Nominal corporate savings (ln_sc_cp)

Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_gostc_cp	0.810837	41.845332

A dynamic simulation of the finalised model, combining the long- and short-run characteristics, resulted in figure 6.10.

Figure 6.10 Actual and fitted values of ln_sc_cp



The fit of the estimated equation is evaluated in an *ex post* simulation context by means of a number of quantitative measures. The simulation error statistics (Appendix 2) reported in table 6.13 confirm that the estimated equation represents a good fit of the actual corresponding data series.

Table 6.13 Simulation error statistics of nominal corporate savings

Actual v Fitted : ln_sc_cp	
Root Mean Squared Error	0.121067
Mean Absolute Error	0.099271
Mean Absolute Percentage Error	1.238919
Theil Inequality Coefficient	0.007094
Bias Proportion	0.001560
Variance Proportion	0.005345
Covariance Proportion	0.993095

The economic results were consistent with the theoretical conditions and *a priori* information concerning the sign and magnitude of the explanatory variable in the long-run or cointegration relationship. More than 80 percent of the variation in corporate savings is attributed to after-taxed profits or gross operating surplus.

6.4.7 Dynamic simulation: response properties of the model

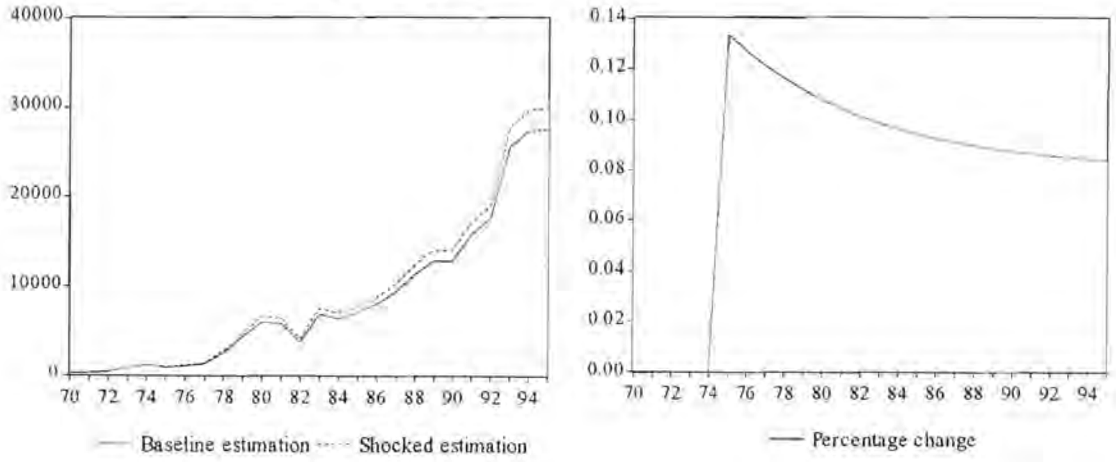
Table 6.14 reports the level of convergence of corporate savings and verifies the model's stability and robustness.

Table 6.14 Difference between the baseline forecast and forecasts with shocked variables, dependent variable: ln_sc_cp

Variable	*Coefficient*	*Expected change (10% of coefficient)*	*Convergence level (% difference)*
ln_gostc_cp	0.810837	0.0810837	0.0841198

The results of the sensitivity tests documented in table 6.14 are portrayed in figure 6.11.

Figure 6.11 Dynamic adjustment (percentage change) in nominal corporate savings (ln_sc_cp) with a 10 percent increase in nominal after-taxed gross operating surplus (ln_gostc_cp)



6.5 CONCLUSION

This chapter aimed to secure a theoretical approach to model aggregate domestic fixed investment. The neoclassical (Jorgenson) approach was selected as the most suitable in estimating fixed investment, as it is consistent with a supply-side model for the South African economy, incorporating all cost-minimising and profit-maximising decision-making processes by firms.

The South African economy's vulnerability to international financial market instability has serious implications for domestic fixed investment. It is therefore necessary to incorporate the significant role of financial constraints (internal and external) on investment. An attempt was therefore made to extend the neoclassical specification by incorporating the financial constraints as specified by cash-flow models – only on an aggregate level. Gross domestic investment in South Africa is therefore modelled by a system of equations: a stochastic function for gross domestic fixed investment, identities for the real capital stock and aggregate financial constraints in nominal terms, and a stochastic function for nominal corporate savings.

Corporate savings were specified and estimated as a function of after-taxed gross operating surplus, i.e. as a function of gross operating surplus adjusted for direct taxes on corporate business enterprises. This is based on the notion that a firm's ability to save is influenced by the utilisation of capacity (activity or production), cost of production in terms of wages and some specification of the user-cost-of-capital (cost/price factors) and additional factors such as taxes, subsidies and depreciation rates. These factors constitute the pre-taxed gross operating surplus of the firm, i.e. the pre-taxed level of profits.

The dynamic response properties were investigated by applying exogenous shocks to each of the long-run variables separately. In each case, the adjustment path after the initial shock was smooth and the deviation of the new long-run variable from the baseline converged to the expected value as indicated by the magnitude of the estimated elasticity. The performance of the estimated model confirms that it is a robust representation of the investment behaviour of South African firms.

CHAPTER 7

A LABOUR MODEL OF THE SOUTH AFRICAN ECONOMY

7.1 INTRODUCTION

The ultimate purpose of this study is to proposed policy measures that will address the severe unemployment problem the South African economy is faced with. Based on the expanded definition and survey of the latest national census of 1996, the unemployment rate in South Africa is in the region of 34 percent (BEPA 1999: 107).

The unemployment is to a large extent of a structural nature. This is confirmed by the phenomenon of *jobless-growth* witnessed in the South African economy. The state of affairs may be caused by various factors, such as the rapid growth of the work force, the use of capital or skill-intensive technology and an inflexible labour market. Other likely causes of structural unemployment in South Africa are the mismatch between the skills offered and demanded and the mismatch between the geographical locations where these skills are offered and demanded (Barker 1992: 73). It is also argued that labour union activities are responsible for a substantial degree of unemployment, since they prevent wages from declining to a market-clearing level.

The purpose of this chapter is to develop a neoclassical labour model of the South African economy. The resultant wage and employment levels will influence economic activity through the supply side of the macroeconometric model. For empirical purposes, the South African labour market is divided into two parts: a skilled and an unskilled labour market (see Appendix 8 for an explanation of the definitions). The distinction is based on differences in the wage determination processes and differences in the demand for skilled and unskilled labour, which is the result of different levels of productivity and the role of labour unions.

An attempt is also made to model the labour participants in the informal sector separately from the formal labour market activities. There is no contemporaneous feedback from the informal sector to the supply-side model in general and the formal labour market in particular.[1] The reason for this is that informal activities are inadequately incorporated in the production sector time series over the sample period under consideration. The contribution of the informal sector has only more comprehensively been recorded in the national accounts after 1995. An equation for the informal labour activities is valuable in the sense that it gives an indication of the magnitude of the informal sector and the unexplored potential for the formal economy.

The modelling of wages and employment, essentially according to a systems approach to ensure consistency in a neoclassical framework, is based on the work of Layard and Nickell (1985, 1986) and Nickell (1988). They use a framework of wage bargaining under imperfect competition, emphasising labour market interactions. Their approach also includes the role of labour unions and labour taxes on employers. A slight deviation in the approach followed in this study, is the ultimate inclusion of a production function and not a cost function in the complete

1 The contribution of the informal sector to the formal economy will be dealt with in further research.

supply-side system. It was decided to include a production rather than a cost function in the neoclassical supply-side model, as this approach enables the derivation of an estimate for capacity utilisation – a key component in the price mechanism (structure) of the economy.

Although a production function is included in the model, it was not estimated directly, but derived from an estimated cost function for the South African economy on the basis of Shephard's duality. This approach is only possible for restricted functional forms such as the Cobb-Douglas and CES production/cost functions. It was proven in chapter 4 that the Cobb-Douglas technology is a valid and representative estimation of the South African production structure. The direct estimation of a cost function and subsequent derivation of factor demand and price functions, ensure consistency with profit-maximising or cost-minimising decision-making processes of firms.

7.2 THE THEORETICAL FRAMEWORK

7.2.1 The labour market

In modelling the labour market, a labour demand equation, a labour supply equation and a wage adjustment equation are defined and estimated. The labour market framework utilised in this study is based on the Layard-Nickell approach and is adopted from Whitley (1994). A significant distinction of this labour market framework is the incorporation of market imperfections, i.e. imperfect competition in goods markets and the role of unions in wage setting, thereby relaxing the issue of whether the market clears or not. The framework acknowledges the existence of an equilibrium rate of unemployment or the NAIRU, i.e. a non-accelerating inflation rate of unemployment.[2]

Demand for labour is specified as:

$$N_t^d = f(w_t^p, Z_t^d) \qquad (7.1)$$

where w^p is the real wage rate defined in terms of production prices, and Z^d is a set of exogenous variables affecting the demand for labour. These might include the real prices of other factors of production, the capital stock and output.

Labour supply is defined as:

$$N_t^s = f(w_t^c, Z_t^s) \qquad (7.2)$$

where w^c is the real wage rate defined in terms of consumer prices, and Z^s is a set of exogenous determinants of labour supply such as the labour force, unemployment benefits and real interest rates.

[2] See Whitley (1994: 101-102) for an exposition on the NAIRU concept and how it is related to wage and price setting in an imperfectly competitive environment.

Under market-clearing, the real wage rate (w^*) is obtained by solving the demand and supply equations, by setting demand equal to supply:

$$w^* = f(T, Z^d, Z^s) \tag{7.3}$$

where T is a set of tax variables causing a wedge between the real product wage and the real consumption wage.

Market-clearing employment (N^*) is given by:

$$N^* = f(T, Z^d, Z^s). \tag{7.4}$$

In a disequilibrium framework, actual employment is typically determined as the minimum of demand and supply ($N_t = \min(N_t^s - N_t^d)$), and a wage adjustment mechanism is specified as:

$$w_t - w_{t-1} = f[(N_t^s - N_t^d), Z_t^w] \tag{7.5}$$

where Z_t^w is a set of factors causing wages to deviate from their equilibrium values.

A reduced-form for the non-market-clearing model is:

$$w_t = f(Z_t^s, Z_t^d, Z_t^w, T, w_{t-1}]. \tag{7.6}$$

This is different from the market-clearing case (7.3) due to the inclusion of Z^w and w_{t-1}.

The reduced-form representation of employment in the non-market-clearing case is:

$$N_t = f(Z_t^s, Z_t^d, Z_t^w, T, w_{t-1}]. \tag{7.7}$$

The labour force (L) may be treated as exogenous or explained by a participation equation. Both instances allow changes in employment to be directly associated with changes in unemployment:

$$U_t = L_t - N_t. \tag{7.8}$$

In practice, the excess demand for labour is proxied by the level of unemployment (U), giving:

$$w_t - w_{t-1} = f(U_t, Z_t^w) \tag{7.9}$$

which closely resembles the augmented Phillips curve:

$$w_t - w_{t-1} = f(U_t, P_t^e / P_{t-1}, Z_t^w) \tag{7.10}$$

where P^e is the expected price level. The Phillips curve, i.e. the relationship between inflation and unemployment, is therefore embodied in the dynamic adjustment mechanism to equilibrium.

7.2.2 The demand for labour

For purposes of consistency between factor demands and price setting, these equations and every decision about the supply of output ought to be derived jointly. Nickell (1988) argues that if this consistency is not present, the equilibrium level of employment consistent with the NAIRU may not correspond with that given by the labour demand function conditioned on equilibrium real wages. For this reason, Layard and Nickell (*op. cit.*) suggest the cost function approach opposed to the production function approach to derive factor demands.

For the purpose of generating a measure for capacity utilisation, this study opted for an approach where the cost function was directly estimated and then utilised to derive a consistent production function based on the principles of Shephard's duality. This approach ensures consistency between factor demands and the price setting mechanisms. The factor demands are now derived from a production function that is consistent with the underlying cost structures of the economy.

The approach can be summarised as follows:

Assume a production function of the general form:

$$y = y(n, k, t) \tag{7.11}$$

where y is output, n is employment, k capital stock and t technology. The labour demand function can be derived by rearranging the marginal productivity condition for labour under profit maximisation. A firm ensures profit maximisation by employing workers up to the point where the real wage equals the marginal product of labour:

$$w / p = y_n(n, k, t) . \tag{7.12}$$

Rearranging and substituting capital with the production function yields:

$$n^d = n^d(w / p, y, t) . \tag{7.13}$$

Assuming a Cobb-Douglas technology then gives:

$$n^d = \alpha y \cdot (w / p)^{-1} \tag{7.14}$$

with α the labour elasticity of production.

7.2.3 Labour supply

In order to derive a consistent model for unemployment, the supply of labour is specified as:

$$N_t^s = EAP * LFP \tag{7.15}$$

where *EAP* is the economically active population, defined as that part of the population between the age of 15 and 65 that is eligible to work and *LFP* represents the labour force participation rate.

The rate of labour force participation is defined as:

$$LFP_t = f(w_t^c, Z_t^s) \tag{7.16}$$

where w^c is the real wage rate defined in terms of consumer prices, and Z^s is a set of exogenous determinants of labour supply such as unemployment benefits, the role of labour unions and real interest rates.

7.2.4 Wage determination

For purposes of closing the labour model, it is necessary to specify a model for wage determination, consistent with the rest of the supply side.

As Nickell (*op. cit.*) pointed out, a wage function has to be sufficiently general to encompass every possible mechanism of wage determination: (1) supply and demand factors; (2) firms' profit-maximising and cost-minimising behaviour; (3) the role of unions and (4) processes of collective bargaining.

The wage determination model that is proposed and utilised in this study, is based on a union bargaining framework and therefore assumes imperfect competition in goods markets. The framework is extended to incorporate the role of taxes that create a wedge between the real product and the real consumption wage.

Firms are assumed to bargain about wages in order to maximise their expected real profits π_i^*:

$$\pi_i^* = \frac{P_i}{P^e} Y_i - \frac{W}{P^e} N_i \tag{7.17}$$

where P_i is the mark-up price the firm sets, P^e is the expected aggregate production price level, Y_i is the firm's output, W the nominal wage and N_i the labour demanded by the firm.

Expected real profits can be written as a function with the form:[3]

[3] See Nickell (1985) for an exposition and derivation of the equation.

$$\pi_i^* = \pi_i(\underset{-}{W/P^e}, \underset{+}{Y^*/\alpha L})K_i \qquad (7.18)$$

where Y^* denotes expected demand and K_i capital stock.

A union, representing the labour force associated with a certain firm (L_i), is assumed to bargain about wages in order to maximise its utility (U_i):

$$U_i = N_i v + (L_i - N_i)\bar{v} \qquad (7.19)$$

where v is a union member's utility if he is employed within the firm, $\bar{v}$ is his utility if not.

The union member's utility functions may be written as:

$$v = v(W_c / P_c^e) \qquad (7.20)$$

and

$$\bar{v} = \bar{v}(W_c / P_c^e, N/L, z_2) \qquad (7.21)$$

where W_c is the consumption after-tax wage and P_c^e is the consumer price index, denoting W_c / P_c^e as the real consumption after-tax wage. z_2 denotes those variables that improve the worker's welfare while unemployed, e.g. the replacement ratio (or unemployment benefit relative to income).

The real consumption wage (W_c / P_c^e) is dependent on the real product wage (W / P^e) and the wedge between the two. These wedge elements consist of (1) taxes changing product wage relative to consumption wage, e.g. employers' labour taxes, employees' income taxes and taxes on consumption goods, and (2) the real price of imports ($P_m / \bar{P}$)[4]. Equations (7.20) and (7.21) can therefore be written as:

$$v = v(W / P^e, z_1, P_m / \bar{P}) \qquad (7.22)$$

and

$$\bar{v} = \bar{v}(W / P^e, z_1, P_m / \bar{P}, z_2, N/L) \qquad (7.23)$$

where z_1 is the taxation element of the wedge.

[4] $\bar{P}$ denotes the price of domestic output (not value added).

Since employment (N_i) can be written as a function of the form:[5]

$$N_i = N_i(W / P^e, Y^* / \alpha L)K_i \tag{7.24}$$

the union's utility function can be written as:

$$U_i = (v - \bar{v})N_i(W / P^e, Y^* / \alpha L)K_i + \bar{v}L_i \tag{7.25}$$

The wage function, resulting from a union-firm wage bargaining model such as that proposed by Nash (1950) is of the form:

$$W / P^e = w(\underset{+}{Y^* / \alpha L}, \underset{+}{N / L}, \underset{+}{z_1}, \underset{+}{z_2}, \underset{+}{P_m / \bar{P}}) \tag{7.26}$$

Nickell (1985) proposes a separation between exogenous and endogenous elements. It is therefore useful to rewrite $P_m / \bar{P}$ as $(P_m / P^*)(P^* / \bar{P})$, where P_m / P^* can be said to be the exogenous international terms of trade and $P^* / \bar{P}$ the endogenous level of competitiveness.

Including a measure for union power (U_p), which is positively related to real wages, the wage equation can finally be written as:

$$W / P = w(Y^* / \alpha L, N / L, P^* / \bar{P}, z)P^e / P \tag{7.27}$$

with z the complete set of exogenous wage pressure variables:

$$z = (z_1, z_2, P_m / P^*, U_p) \tag{7.28}$$

7.3 ESTIMATION RESULTS

In this section a labour market model, based on a framework of market imperfections, is proposed and estimated. Again the Engle and Yoo estimation technique is employed and the model is subjected to a number of validation tests.

7.3.1 The theoretical model

For purposes of consistency between the factor demands and price setting mechanisms within a neoclassical framework where firms' decision-making processes are aimed at profit-making, these equations and each of the other supply-side decisions are jointly estimated. Imperfect competition in the goods markets and the role of labour unions in the price setting process are modelled.

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5 See Nickell (1985) for an exposition and derivation of the equation.

A Cobb-Douglas cost function was estimated and validated as representative of the South African production structure and utilised to derive a consistent production function based on Shephard's duality principles.[6] The production function is now used to derive the demand for labour within a framework of profit maximising. A distinction is made between the demand for skilled and unskilled labour. Based on the theoretical exposition in the previous section, the demand for skilled labour (N_s^d) is specified and estimated as:

$$N_s^d = f(\underset{+}{y}, \underset{-}{(w_s / w_u)}, \underset{-}{(\cos t_n^p / r)})$$

where y is the real output, (w_s / w_u) denotes the skilled relative to the unskilled wage rate and $(\cos t_n^p / r)$ specifies the total real product cost of skilled labour for a firm, relative to the real user-cost-of-capital. The real cost of labour takes into account income taxes payable by the firm, as well as pension and medical contributions made by the firm – each of these can be quite substantial where skilled labour is concerned. With the inclusion of $(\cos t_n^p / r)$ the Manning (1992: 5) assumption of super-neutrality is relaxed to some extend. The notion of super-neutrality is that equilibrium unemployment is independent of capital accumulation and productivity (Hall and Nixon 1997).

The demand for unskilled labour (N_u^d) is specified and estimated as:

$$N_u^d = f(\underset{+}{y}, \underset{-}{w_u^p})$$

where w_u^p is the real product unskilled wage rate.

A model for the labour activities in the informal sector (N_{inf}), separate from the formal labour market activities, is specified in order to capture the unutilised potential of the informal sector:

$$N_{inf} = f(\underset{+}{y}, \underset{-}{w^c})$$

where w^c is the total consumption wage rate.

Labour supply is also divided into skilled and unskilled workers. Based on the availability of reliable data, total and skilled labour supply are estimated and used to derive the supply of unskilled labour.

Although total labour supply (N^s) is specified as: $N^s = EAP * LFP$ with $LFP = f(w^c, Z^s)$, it is estimated in the form:

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6 See chapter 4.

$$N^s = f(w^c, EAP, Z^s)$$
$$\quad + \quad + \quad +$$

where EAP is the economically active population. The set of exogenous determinants of labour supply (Z^s) such as unemployment benefits, the role of labour unions and real interest rates, are mainly included in the short-run estimation of the model.

The supply of skilled labour (N_s^s) may be defined as $N_s^s = N^s * share_s$, with $share_s = f(w^c, educ)$ where $share_s$ denotes the share of skilled labour in the total labour supply and $educ$ refers to the level of education.

Skilled labour supply (N_s^s) is estimated by:

$$N_s^s = f(w^c, educ, N^s)$$
$$\quad + \quad + \quad +$$

with N^s only included in the short-run dynamics of the model.

Wage functions, consistent with the neoclassical cost-minimising approach and based on the Layard-Nickell framework discussed in section 7.2.4, were specified for both the skilled and unskilled labour markets.

The skilled wage rate (W_s) is specified and estimated as:

$$W_s = f(P^e, product_n)$$
$$\quad + \quad +$$

where W_s denotes the nominal skilled wage rate, P^e is the expected consumer prices and $product_n$ signifies labour productivity. Note that the skilled wage rate is estimated in nominal terms. The notion is that skilled labour, due to the tax-structured nature of their remuneration packages, are primarily concerned with and therefore base their utility maximising decisions on the nominal value of the wage remuneration. The other explanatory variables specified in the Nickell-Layard framework are included in the short-run dynamics of the wage model.

The unskilled wage rate (w_u^c) is specified and estimated as:

$$w_u^c = f(P^e, product_n, x_{gold})$$
$$\quad + \quad + \quad +$$

where w_u^c is the real consumption unskilled wage rate and x_{gold} is real gold exports, included to adjust unskilled wages for the structural break caused by the mining industry in the early 1980s. The real value South African gold exports slumped dramatically due to a declining international interest in gold and a sharp decrease in the gold price. Similarly to the model of skilled wages, the other explanatory variables included in the short-run dynamics of the wage function are those specified in the Nickell-Layard framework.

7.3.2 The data

Appendix 7 describes the data and related processes utilised in the empirical estimation of the labour model. Appendices 8 and 9 present an explanatory list and graphical representation for each of the variables encountered in both the long-run cointegration and short-run error correction model.

7.3.3 Demand for labour

7.3.3.1 Demand for skilled labour

(i) *The estimation results of the cointegration equation*

The cointegration results, based on the empirical specification presented in the previous section, are reported in table 7.1

Table 7.1 Cointegration equation: Demand for skilled labour

Dependent Variable: ln_ns
Method: Least Squares
Sample(adjusted): 1971 1995
Included observations: 25 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
ln_bbp_90p	0.310367	0.006050	51.30205	0.0000
ln_rel_wsu_rat	-0.628338	0.064917	-9.679053	0.0000
ln_rel_wscost_u	-0.135828	0.012351	-10.99734	0.0000
R-squared	0.991987	F-statistic		1361.835
Adjusted R-squared	0.991259	Prob(F-statistic)		0.000000

The Engle-Granger test statistic of –5.03 is compared with the computed MacKinnon[7] and the specified cointegration augmented Dickey-Fuller critical values respectively. The results rejected the null of no-cointegration in favour of stationary residuals and cointegrated variables. Figure 7.1 represents a plot of the stationary residuals.

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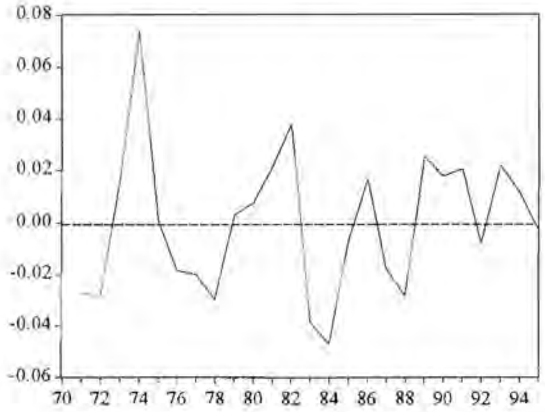
7 Critical values for the relevant response surfaces can be found in MacKinnon (1991). The response surface for any number of regressors, excluding any constant and trend components, $1 \leq n \leq 6$, can be calculated as $C(p) = \phi_\infty + \phi_1 T^{-1} + \phi_2 T^{-2}$, where $C(p)$ is the p percent critical value.

Figure 7.1 Residuals: Demand for skilled labour (ln_ns)



(ii) *The short-run dynamics: error correction model (ECM)*

The short-run dynamics of skilled labour demand are reported in table 7.2.

Table 7.2 Error correction model: Demand for skilled labour

Dependent Variable: Δ(ln_ns)
Method: Least Squares
Sample(adjusted): 1974 1995
Included observations: 22 after adjusting endpoints

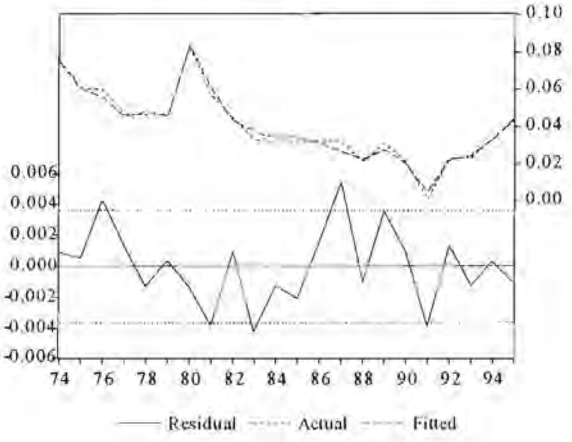
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.294219	0.076298	-3.856204	0.0032
Δ(ln_bbp_90p)	0.329872	0.039923	8.262628	0.0000
Δ(ln_bbp_90p(-1))	0.496150	0.050496	9.825513	0.0000
Δ(ln_bbp_90p(-2))	0.415129	0.068378	6.071130	0.0001
Δ(ln_rel_wsu_rat)	-0.162451	0.040032	-4.058061	0.0023
Δ(ln_rel_wsu_rat(-3))	0.132016	0.036567	3.610220	0.0048
Δ(ln_interposind(-2))	0.078446	0.011656	6.729955	0.0001
Δ(sanction_dum)	-0.023055	0.003449	-6.684743	0.0001
Δ(ln_kap_lab_rat(-1))	0.250117	0.087685	2.852459	0.0172
Δ(ln_rel_wscost_u)	-0.037895	0.007122	-5.320492	0.0003
Δ(ln_uniopresind(-2))	-0.022202	0.011078	-2.004104	0.0729
c	0.018879	0.001828	10.32710	0.0000

R-squared	0.982973	F-statistic	52.48300
Adjusted R-squared	0.964244	Prob(F-statistic)	0.000000
S.E. of regression	0.003594		

Apart from the cointegration variables also contributing to the dynamics of the model, it is plausible to assume that the demand for skilled labour is influenced by the capital-intensive nature of the economy's production structure, denoted by the capital-labour ratio (*ln_kap_rat*). The demand for skilled labour is also affected by union activities (*ln_uniopresind*) such as lobbying for affirmative action policies. The effect of economic sanctions (Appendix 7) is also accounted for on the short run.

The data plot of the actual and fitted values of the demand for skilled labour is provided in figure 7.2.

Figure 7.2 Actual, fitted and residual values of ln_ns



(iii) *Diagnostic testing*

The estimated function passed the full battery of diagnostic tests as reported in table 7.3.

Table 7.3 Diagnostic tests: Demand for skilled labour (ln_ns)

Purpose of test	*Test*	*d.f.*	*Test statistic*	*Probability*
Normality	Jarque-Bera	JB(2)	0.294514	[0.863073]
Homoscedasticity	ARCH LM	$nR^2(1)$	2.554611	[0.109973]
Homoscedasticity	White	Insufficient number of observations		
Serial correlation	Breusch-Godfrey	$nR^2(2)$	1.279385	[0.527455]
Serial correlation	Lung Box Q	Q(12)	18.80600	[0.093000]
Misspecification	Ramsey Reset	LR(2)	4.165195	[0.124606]
Parameter stability	Recursive estimates	Indicative of stability		

(iv) *Cointegration correction and adjusted coefficients*

The Engle and Yoo third-step cointegration correction and subsequent adjusted coefficients and *t*-values are reported in tables 7.4 and 7.5 respectively.

Table 7.4 Engle-Yoo third-step estimation: Demand for skilled labour (ln_ns)

Dependent Variable: residual_ecm
Method: Least Squares
Sample(adjusted): 1974 1995
Included observations: 22 after adjusting endpoints

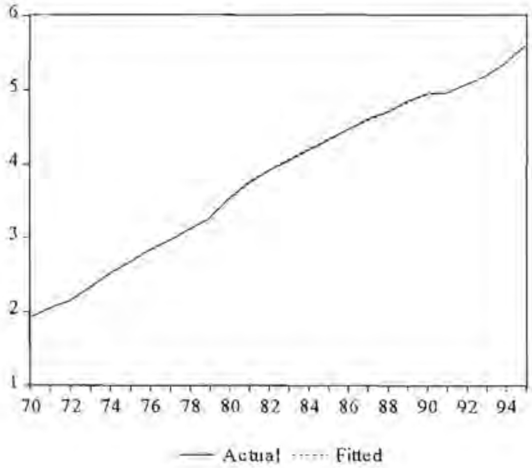
Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.294219)*ln_bbp_90p	-0.000534	0.001891	-0.282242
(0.294219)*ln_rel_wsu_rat	0.015958	0.031994	0.498787
(0.294219)*ln_rel_wscost_u	-0.001277	0.004775	-0.267475

Table 7.5 Cointegration correction: Demand for skilled labour (ln_ns)

Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_bbp_90p	0.309833	163.85000
ln_rel_wsu_rat	-0.612380	-19.14000
ln_rel_wscost_u	-0.137105	-28.71000

A dynamic simulation by combining the long and short-run characteristics of the model resulted in the overall fit depicted in figure 7.3.

Figure 7.3 Actual and fitted values of ln_ns



The goodness-of-fit of the model is proven by the simulation error statistics (Appendix 2) presented in table 7.6.

Table 7.6 Simulation error statistics of demand for skilled labour

Actual v Fitted : ln_ns	
Root Mean Squared Error	0.002423
Mean Absolute Error	0.001925
Mean Absolute Percentage Error	0.140424
Theil Inequality Coefficient	0.000858
Bias Proportion	0.000000
Variance Proportion	0.016409
Covariance Proportion	0.983591

In addition to the fact that the estimated function is statistically well-behaved and stable, the estimated function for skilled labour demand is consistent with the *a priori* theoretical and empirical specifications made in the preceding sections.

7.3.3.2 Demand for unskilled labour

(i) *The estimation results of the cointegration equation*

The equilibrium estimation results are reported in table 7.7, with the associated Engle-Granger test statistic of –2.80, indicative of a cointegrated long-run relationship.

Table 7.7 Cointegration equation: Demand for unskilled labour

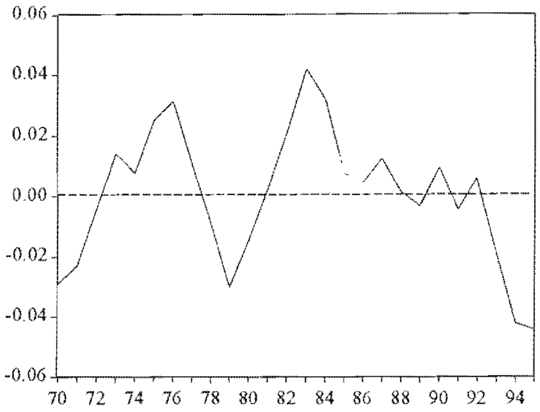
Dependent Variable: ln_nu
Method: Least Squares
Sample(adjusted): 1970 1995
Included observations: 26 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
ln_bbp_90p	0.353382	0.060253	5.864983	0.0000
ln_wuppi_rat	-0.321770	0.085706	-3.754329	0.0010

R-squared	0.582432	F-statistic	33.47565
Adjusted R-squared	0.565033	Prob(F-statistic)	0.000006

A plot of the stationary residuals are presented in figure7.4.

Figure 7.4 Residuals: Demand for unskilled labour (ln_nu)



(ii) *The short-run dynamics: error correction model (ECM)*

The estimation results of the short-run adjustment path in the long-run equilibrium are reported in table 7.8.

Table 7.8 Error correction model: Demand for unskilled labour

Dependent Variable: Δ(ln_nu)
Method: Least Squares
Sample(adjusted): 1974 1995
Included observations: 22 after adjusting endpoints

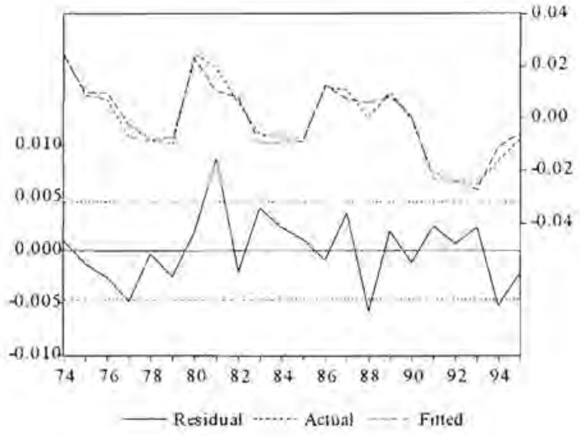
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.130607	0.064762	-2.016733	0.0688
Δ(ln_socind)	-0.083803	0.019051	-4.398812	0.0011
Δ(ln_socind(-1))	0.059588	0.018826	3.165141	0.0090
Δ(ln_interposind)	-0.074636	0.009589	-7.783107	0.0000
Δ(ln_interposind(-3))	-0.019511	0.008591	-2.271173	0.0442
Δ(ln_gprys_r(-2))	0.068958	0.008773	7.859921	0.0000
Δ(sanction_dum)	0.022791	0.004274	5.332887	0.0002
Δ(ln_uniopresind(-1))	-0.030357	0.014388	-2.109857	0.0586
Δ(ln_uniopresind(-3))	0.046513	0.016109	2.887461	0.0148
Δ(ln_bbp_90p(-1))	-0.101683	0.067336	-1.510081	0.1592
c	-0.022128	0.002792	-7.926049	0.0000

R-squared	0.946229	F-statistic	19.35697
Adjusted R-squared	0.897345	Prob(F-statistic)	0.000014
S.E. of regression	0.004663		

Socio-economic factors (*ln_socind*) such as the level of education, provision of housing and basic services such as electricity, the crime rate, levels of disposable income, unemployment benefits and other government transfers, have a significant effect on the efficiency of labour in South Africa. The demand for particularly unskilled labour is affected by these factors. Given the large degree of openness of the South African economy, international factors (*ln_interposind*) such as the exchange rate, foreign investment, level of domestic competitiveness relative to the rest of the world, share in world trade and the gold price (*ln_gprys*), contribute to a large extent to the availability of job opportunities and subsequently the demand for labour. These international factors, as well as the role of labour unions (*ln_uniopresind*), are consistent with the framework suggested by Nickell (1985). Economic sanctions against South Africa (Appendix 7) contributed to the structural break in the demand for unskilled labour during the mid-1980s.

A plot of the estimation results is provided in figure 7.5.

Figure 7.5 Actual, fitted and residual values of ln_nu



(iii) *Diagnostic testing*

The estimated demand for unskilled labour was subjected to diagnostic testing and the results reported in table 7.9 were obtained.

Table 7.9 Diagnostic tests: Demand for unskilled labour (ln_nu)

Purpose of test	*Test*	*d.f.*	*Test statistic*	*Probability*
Normality	Jarque-Bera	JB(2)	0.730901	[0.693884]
Homoscedasticity	ARCH LM	$nR^2(1)$	0.480817	[0.488053]
Homoscedasticity	White	$nR^2(20)$	19.94371	[0.461456]
Serial correlation	Breusch-Godfrey	$nR^2(2)$	2.316336	[0.314061]
Serial correlation	Lung Box Q	Q(12)	9.482200	[0.661000]
Misspecification	Ramsey Reset	LR(2)	5.796962	[0.055107]
Parameter stability	Recursive estimates	Indicative of stability		

(iv) *Cointegration correction and adjusted coefficients*

After the estimation of the short-run dynamics, the third-step cointegration correction was carried out (table 7.10) to determine the adjusted coefficients and *t*-values (table 7.11).

Table 7.10 Engle-Yoo third step: Demand for unskilled labour (ln_nu)

Dependent Variable: residual_ecm
Method: Least Squares
Sample(adjusted): 1974 1995
Included observations: 22 after adjusting endpoints

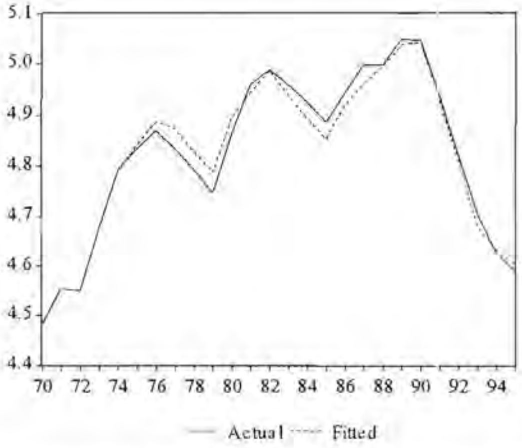
Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.130607)*ln_bbp_90p	0.022273	0.074260	0.299932
(0.130607)*ln_wuppi_rat	-0.031699	0.105696	-0.299909

Table 7.11 Cointegration correction: Demand for unskilled labour (ln_nu)

Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_bbp_90p	0.375655	5.0586453
ln_wuppi_rat	- 0.353469	-3.3442041

A dynamic simulation of the estimated model resulted in figure 7.6.

Figure 7.6 Actual and fitted values of ln_nu



The associated simulation error statistics, indicative of a good fit, are reported in table 7.12.

Table 7.12 Simulation error statistics of demand for unskilled labour

Actual v Fitted : ln_nu	
Root Mean Squared Error	0.003297
Mean Absolute Error	0.002639
Mean Absolute Percentage Error	0.166585
Theil Inequality Coefficient	0.001041
Bias Proportion	0.000000
Variance Proportion	0.072664
Covariance Proportion	0.927336

7.3.3.3 Labour participants in the informal sector

(i) *The estimation results of the cointegration equation*

In estimating the long-run relationship empirically specified in the previous section for the labour participants in the informal sector, the cointegration equation in table 7.13 was obtained, with a Engle-Granger test statistic of –4.65.

Table 7.13 Cointegration equation: Labour participants in informal sector

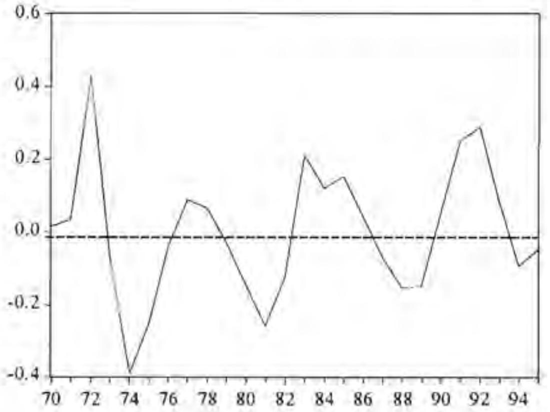
Dependent Variable: ln_n_informal
Method: Least Squares
Sample(adjusted): 1970 1995
Included observations: 26 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
ln_bbp_90p	6.335701	0.560104	11.31166	0.0000
ln_wtot_vpi_rat	-4.147632	1.161653	-3.570456	0.0016
c	-25.03542	5.665373	-4.419024	0.0002

R-squared	0.941156	F-statistic	183.9331
Adjusted R-squared	0.936040	Prob(F-statistic)	0.000000

A plot of the stationary residuals are presented by figure 7.7.

Figure 7.7 Residuals: Labour participants in informal sector (ln_n_informal)



(ii) *The short-run dynamics: error correction model (ECM)*

The estimation results for the error correction model are reported in table 7.14.

Table 7.14 Error correction model: Labour participants in informal sector

Dependent Variable: Δ(ln_n_informal)
Method: Least Squares
Sample(adjusted): 1973 1995
Included observations: 23 after adjusting endpoints

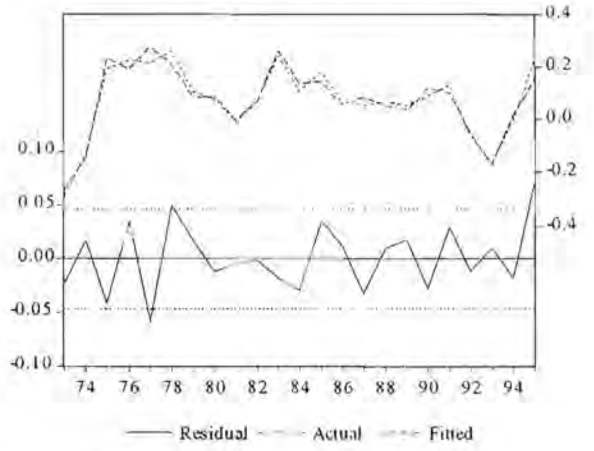
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.516895	0.095506	-5.412184	0.0003
Δ(ln_n_informal(-1))	0.291756	0.088837	3.284163	0.0082
Δ(ln_n_informal(-2))	-0.439398	0.152038	-2.890060	0.0161
Δ(ln_socind(-2))	-0.689871	0.220594	-3.127335	0.0107
Δ(ln_bbp_min_90p(-1))	1.128687	0.530795	2.126410	0.0594
Δ(ln_interposind)	0.318244	0.123585	2.575100	0.0276
Δ(ln_r$(-1))	0.496072	0.150376	3.298869	0.0080
Δ(ln_r$(-2))	0.774041	0.167916	4.609693	0.0010
Δ(ln_gprys_$(-1))	0.293102	0.086653	3.382492	0.0070
Δ(ln_gprys_$(-2))	0.360206	0.131247	2.744485	0.0207
Δ(ln_xgoud_ppi)	0.181036	0.089353	2.026086	0.0703
Δ(ln_xgoud_ppi(-2))	-0.521724	0.160481	-3.251000	0.0087
Δ(ln_unempl_rat)	0.410871	0.110798	3.708273	0.0041

R-squared	0.948481	F-statistic	15.34196
Adjusted R-squared	0.886658	Prob(F-statistic)	0.000073
S.E. of regression	0.046791		

The short-run dynamics of the informal sector are explained by basically the same set of variables as the demand for unskilled labour, i.e. socio-economic factors (*ln_socind*), a set of international factors (*ln_interposind*) and factors specifically relating to the slowdown in the real activities of the mining industry (*ln_bbp_min_90p*). A declining gold price (*ln_gprys*), a slump in gold exports (*ln_xgoud_ppi*) and higher production costs due to increasing import costs on the back of a depreciating rand (*ln_r$*) have resulted in the inadequate performance of the mining industry and subsequently a large number of retrenchments. These jobless unskilled workers, in an economy with an already low labour absorption capacity or high unemployment rate (*ln_unemplrat*), have no other option than to resort to informal activities. The longer these labourers participate in informal activities, the smaller the possibility that they will re-enter the formal labour market. There are a number of reasons for this phenomenon (e.g. a deterioration in skills, motivation, etc.), which is modelled by lagging the dependent variable in the equation (*ln_n_informal*).

The estimated function is illustrated in figure 7.8.

Figure 7.8 Actual, fitted and residual values of ln_n_informal



(iii) *Diagnostic testing*

The estimated function is statistically well-behaved and passed the diagnostic tests presented in table 7.15.

Table 7.15 Diagnostic tests: Labour participants in informal sector (ln_n_informal)

Purpose of test	*Test*	*d.f.*	*Test statistic*	*Probability*
Normality	Jarque-Bera	JB(2)	0.395898	[0.820412]
Homoscedasticity	ARCH LM	$nR^2(1)$	1.032531	[0.309565]
Homoscedasticity	White	Insufficient number of observations		
Serial correlation	Breusch-Godfrey	$nR^2(2)$	4.633882	[0.046070]
Serial correlation	Lung Box Q	Q(12)	17.11000	[0.145000]
Misspecification	Ramsey Reset	LR(2)	4.483972	[0.106247]
Parameter stability	Recursive estimates	Indicative of stability		

(iv) *Cointegration correction and adjusted coefficients*

The results of the subsequent cointegration correction estimation and adjusted coefficients and t-values are reported in tables 7.16 and 7.17 respectively.

Table 7.16 Engle-Yoo third-step estimation: Labour participants in informal sector (ln_n_informal)

Dependent Variable: residual_ecm
Method: Least Squares
Sample(adjusted): 1973 1995
Included observations: 23 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.516895)*ln_bbp_90p	0.194355	0.163623	1.187819
(0.516895)*ln_wtot_vpi_rat	-0.252055	0.212369	-1.186874

Table 7.17 Cointegration correction: Labour participants in informal sector (ln_n_informal)

Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_bbp_90p	6.530056	39.909157
ln_wtot_vpi_rat	-4.399687	-20.717181

Figure 7.9 illustrates the dynamic simulation results of the function, while table 7.18 confirms a good fit in terms of the relevant error statistics.

Figure 7.9 Actual and fitted values of ln_n_informal

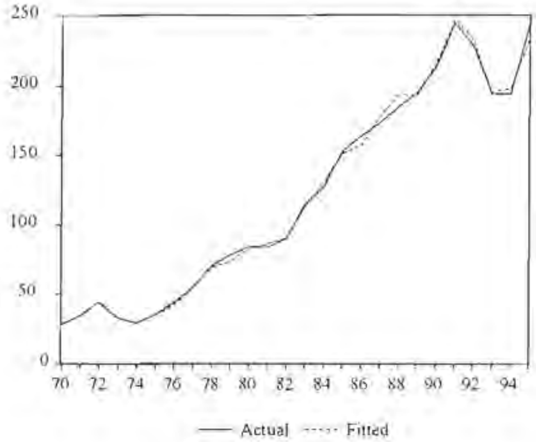


Table 7.18 Simulation error statistics of labour participants in informal sector

Actual v Fitted : ln_n_informal	
Root Mean Squared Error	0.030853
Mean Absolute Error	0.025663
Mean Absolute Percentage Error	0.185701
Theil Inequality Coefficient	0.001109
Bias Proportion	0.000960
Variance Proportion	0.036203
Covariance Proportion	0.962837

7.3.4 Supply of labour

7.3.4.1 Total labour supply

(i) *The estimation results of the cointegration equation*

Estimating the long-run theoretical specification for total labour supply, set out in the previous section, resulted in a cointegration relationship with an Engle-Granger test statistic of –2.94. The results are documented in table 7.19.

Table 7.19 Cointegration equation: Total labour supply

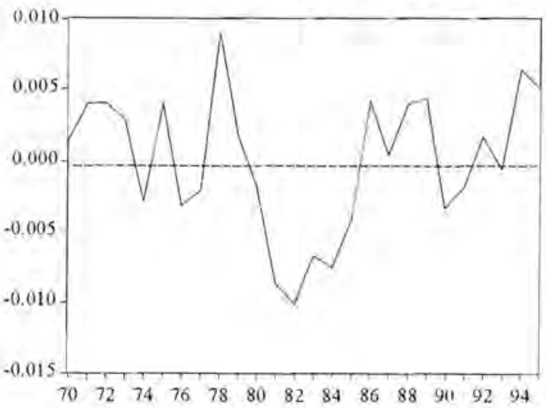
Dependent Variable: ln_s
Method: Least Squares
Sample(adjusted): 1970 1995
Included observations: 26 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
ln_total_pop	0.481162	0.095507	5.037988	0.0000
ln_wtot_rate	0.135614	0.017582	7.713210	0.0000
c	-3.834824	0.837194	-4.580571	0.0001

R-squared	0.999541	F-statistic	25054.99
Adjusted R-squared	0.999501	Prob(F-statistic)	0.000000

Figure 7.10 represents a plot of the stationary residuals.

Figure 7.10 Residual: Total labour supply (ln_s)



(ii) *The short-run dynamics: error correction model (ECM)*

The short-run adjustment to the long-run equilibrium is explained by results of the ECM in table 7.20.

Table 7.20 Error correction model: Total labour supply (ln_s)

Dependent Variable: Δ(ln_s)
Method: Least Squares
Sample(adjusted): 1973 1995
Included observations: 23 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.897759	0.122497	-7.328823	0.0000
Δ(ln_s(-1))	-0.552752	0.120961	-4.569677	0.0004
Δ(ln_s(-2))	-0.347900	0.123343	-2.820584	0.0136

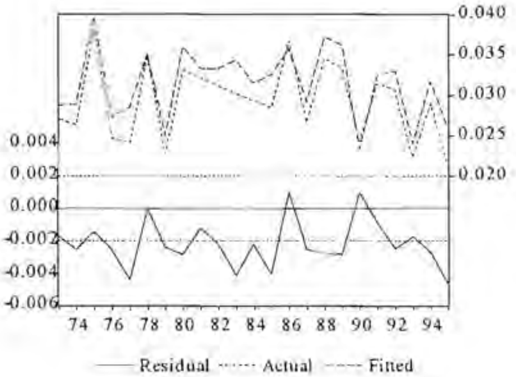
Table 7.20 (*cont.*)

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
Δ(ln_empl_rat(-1))	-0.201420	0.042537	-4.735126	0.0003
Δ(ln_empl_rat(-2))	0.101256	0.039938	2.535333	0.0238
ln_cu(-1)	0.010675	0.001234	8.652970	0.0000
Δ(ln_interposind)	-0.021152	0.004185	-5.053829	0.0002
Δ(ln_interposind(-1))	-0.020555	0.003853	-5.334710	0.0001
Δ(ln_interposind(-2))	-0.010088	0.004143	-2.435013	0.0289
R-squared	0.891956	F-statistic		14.44717
Adjusted R-squared	0.830217	Prob(F-statistic)		0.000015
S.E. of regression	0.001958			

The supply of labour in the short-run is influenced by those variables determining the potential of the economy to increase the labour absorption capacity, i.e. the availability of job opportunities. In this respect, it is plausible to assume that total labour supply in the short run is dependent on the current level of employment (*ln_empl_rat*), the capacity utilisation of the economy (*ln_cu*) and a set of international factors (*ln_interposind*) contributing to production activities and therefore employment opportunities in the economy.

Figure 7.11 illustrates the estimated function.

Figure 7.11 Actual, fitted and residual values of ln_s



(iii) *Diagnostic testing*

The estimated function for total labour supply passed the battery of diagnostic tests. These results are reported in table 7.21.

Table 7.21 Diagnostic tests: Total labour supply (ln_s)

Purpose of test	*Test*	*d.f.*	*Test statistic*	*Probability*
Normality	Jarque-Bera	JB(2)	0.979403	[0.612809]
Homoscedasticity	ARCH LM	$nR^2(1)$	0.888627	[0.345850]
Homoscedasticity	White	$nR^2(18)$	22.22722	[0.222053]
Serial correlation	Breusch-Godfrey	$nR^2(2)$	1.692369	[0.429049]
Serial correlation	Lung Box Q	Q(12)	8.301100	[0.761000]
Misspecification	Ramsey Reset	LR(2)	2.904753	[0.093579]
Parameter stability	Recursive estimates	Indicative of stability		

(iv) *Cointegration correction and adjusted coefficients*

Subjecting the original estimated long-run coefficients to cointegration correction (table 7.22) resulted in the set of adjusted coefficients and *t*-values reported in table 7.23.

Table 7.22 Engle-Yoo third-step estimation: Total labour supply (ln_s)

Dependent Variable: residual_ecm
Method: Least Squares
Sample(adjusted): 1973 1995
Included observations: 23 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.897759)*ln_total_pop	5.81E-05	0.000415	0.139860
(0.897759)*ln_wtot_rate	-6.86E-05	0.000490	-0.139985

Table 7.23 Cointegration correction: Total labour supply (ln_s)

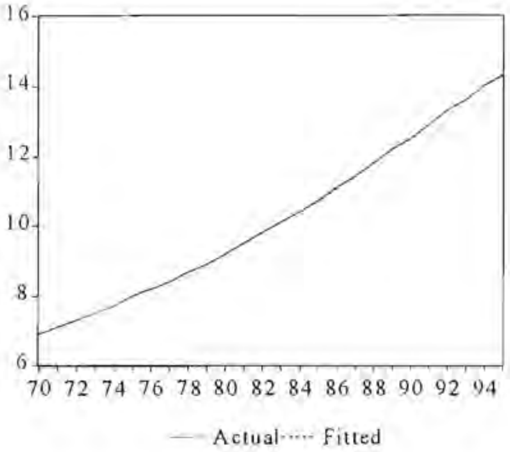
Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_total_pop	0.4812201	1159.5665
ln_wtot_rate	0.1355454	276.62327

Dynamic simulation of the adjusted function yields a good fit as presented by figure 7.12. This result is confirmed by the simulation measures depicted in table 7.24.

Table 7.24 Simulation error statistics of total labour supply

Actual v Fitted : ln_s	
Root Mean Squared Error	0.002628
Mean Absolute Error	0.002359
Mean Absolute Percentage Error	0.101019
Theil Inequality Coefficient	0.000559
Bias Proportion	0.695235
Variance Proportion	0.000055
Covariance Proportion	0.304710

Figure 7.12 **Actual and fitted values of ln_s**



7.3.4.2 Skilled labour supply

(i) *The estimation results of the cointegration equation*

The estimated long-run coefficients for skilled labour supply are reported in table 7.25. The Engle-Granger test statistic of –2.84 is indicative of a cointegration relationship among the long-run explanatory variables.

Table 7.25 Cointegration equation: Skilled labour supply

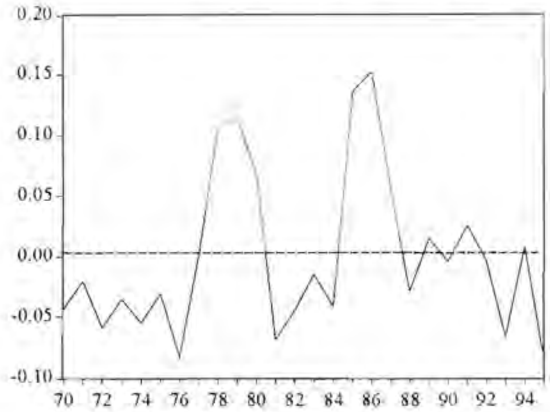
Dependent Variable: ln_ss
Method: Least Squares
Sample(adjusted): 1970 1995
Included observations: 26 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
ln_educind	0.567973	0.050449	11.25842	0.0000
ln_wtot_vpi_rat	1.676947	0.263586	6.362042	0.0000
c	-14.59531	2.512955	-5.808026	0.0000

R-squared	0.959622	F-statistic	273.3067
Adjusted R-squared	0.956111	Prob(F-statistic)	0.000000

The stationarity of the residuals is confirmed by the residual plot in figure 7.13.

Figure 7.13 Residuals: Skilled labour supply (ln_ss)



(ii) *The short-run dynamics: error correction model (ECM)*

An estimation of the short-run dynamics yielded the results of table 7.26.

Table 7.26 Error correction model: Skilled labour supply (ln_ss)

Dependent Variable: Δ(ln_ss)
Method: Least Squares
Sample(adjusted): 1972 1995
Included observations: 24 after adjusting endpoints

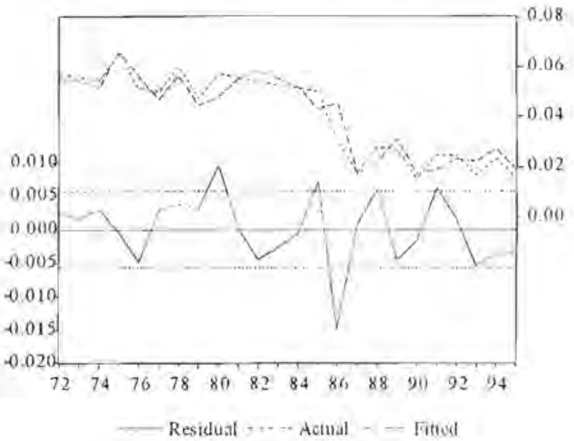
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.040049	0.019057	-2.101557	0.0492
Δ(ln_s)	1.268536	0.269037	4.715099	0.0002
Δ(ln_ss(-1))	0.739383	0.088745	8.331577	0.0000
braindrain_dum	-0.008025	0.003288	-2.440369	0.0246
c	-0.024742	0.008157	-3.033187	0.0068

R-squared	0.906154	F-statistic	45.86465
Adjusted R-squared	0.886397	Prob(F-statistic)	0.000000
S.E. of regression	0.005708		

Apart from the explanatory variables that are included with the same motivation as Nickell (1985), a dummy for the emigration or outflow of skilled labour (*braindrain_dum*) is introduced. International sanctions and disinvestment during the mid-1980s and early 1990s, together with a new political dispensation endorsing labour legislation enforcing affirmative action, created an unstable and unprofitable environment in particular for skilled labour in South Africa. This led to a substantial outflow of highly qualified and professional labour, which labour was seriously needed domestically.

A data plot of the actual and fitted values of skilled labour supply is provided in figure 7.14.

Figure 7.14 Actual, fitted and residual values of ln_ss



(iii) *Diagnostic testing*

The estimated function turned out to be well-behaved in the face of rigorous diagnostic testing, of which the results are reported in table 7.27.

Table 7.27 Diagnostic tests: Skilled labour supply (ln_ss)

Purpose of test	*Test*	*d.f.*	*Test statistic*	*Probability*
Normality	Jarque-Bera	JB(2)	3.257484	[0.196176]
Homoscedasticity	ARCH LM	$nR^2(1)$	0.025794	[0.872404]
Homoscedasticity	White	$nR^2(7)$	10.57651	[0.158188]
Serial correlation	Breusch-Godfrey	$nR^2(2)$	3.013318	[0.221649]
Serial correlation	Lung Box Q	Q(12)	8.834200	[0.717000]
Misspecification	Ramsey Reset	LR(2)	0.889318	[0.641043]
Parameter stability	Recursive estimates	Indicative of stability		

(iv) *Cointegration correction and adjusted coefficients*

The function is once again subjected to cointegration correction (table 7.28) to obtain the adjusted coefficients and their associated *t*-statistics (table 7.29).

Table 7.28 Enlge-Yoo third-step estimation: Skilled labour supply (ln_ss)

Dependent Variable: residual_ecm
Method: Least Squares
Sample(adjusted): 1972 1995
Included observations: 24 after adjusting endpoints

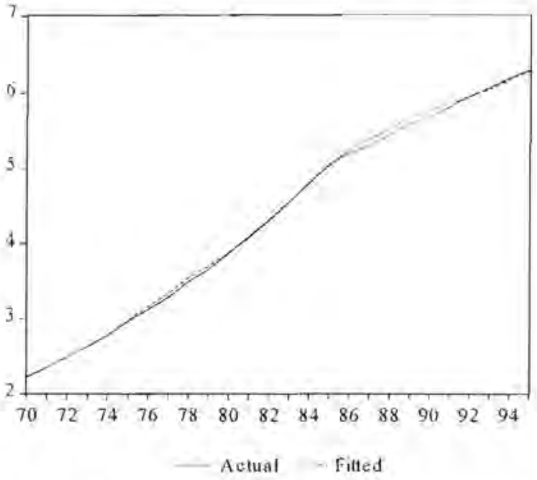
Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.040049)*ln_educind	-0.091983	0.068304	-1.346667
(0.040049)*ln_wtot_vpi_rat	0.000679	0.002769	0.245113

Table 7.29 Cointegration correction: Skilled labour supply (ln_ss)

Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_educind	0.475990	6.9686988
ln_wtot_vpi_rat	1.677626	605.85955

The dynamic simulation results of the adjusted function are illustrated by figure 7.15.

Figure 7.15 Actual and fitted values of ln_ss



The goodness of fit of the estimated relationship is confirmed by the simulation error statistics reported in table 7.30.

Table 7.30 Simulation error statistics of skilled labour supply

Actual v Fitted : ln_ss	
Root Mean Squared Error	0.005079
Mean Absolute Error	0.003947
Mean Absolute Percentage Error	0.268691
Theil Inequality Coefficient	0.001697
Bias Proportion	0.000000
Variance Proportion	0.067727
Covariance Proportion	0.932273

7.3.5 Wage determination

7.3.5.1 Skilled wage rate

(i) *The estimation results of the cointegration equation*

A cointegrated equation was obtained, consistent with the theoretical specification of the skilled wage rate in the previous section. The Engle-Granger test statistic is –4.05 and the estimated long-run coefficients are presented in table 7.31.

Table 7.31 Cointegration equation: Nominal skilled wage rate

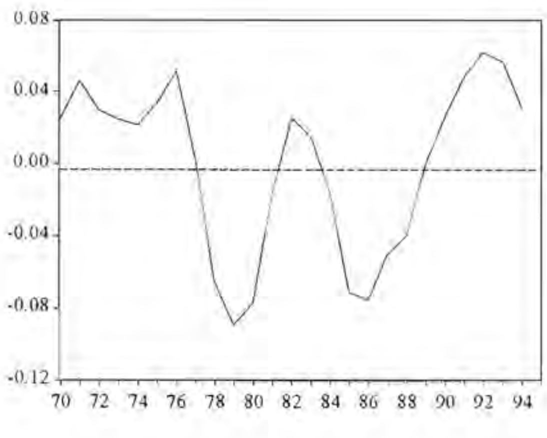
Dependent Variable: ln_ws_rate
Method: Least Squares
Sample(adjusted): 1970 1994
Included observations: 25 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
ln_vpi(1)	0.868357	0.024210	35.86725	0.0000
ln_product	0.673244	0.525963	1.280020	0.2139
c	6.807242	2.423993	2.808277	0.0102

R-squared	0.996778	F-statistic	3402.726
Adjusted R-squared	0.996485	Prob(F-statistic)	0.000000

Figure 7.16 provides a plot of the stationary residuals.

Figure 7.16 Nominal skilled wage rate (ln_ws_rate)



(ii) *The short-run dynamics: error correction model (ECM)*

The estimation results of the ECM associated with the long-run equilibrium are reported in table 7.32.

The inclusion of the skilled employment rate (*ln_emplrat_s*) and a set of international factors (ln_*interposind*) ensures consistency between the estimated equation and the Layard-Nickell framework discussed in the previous section. The dummy for the emigration of skilled labour (*braindrain_dum*) also plays a significant role in the short-run dynamics of the skilled wages, emigration of skilled labour, i.e. a decrease in the supply of skilled labour, increases the equilibrium wage rate (Appendix 7).

Table 7.32 Error correction model: Nominal skilled wage rate

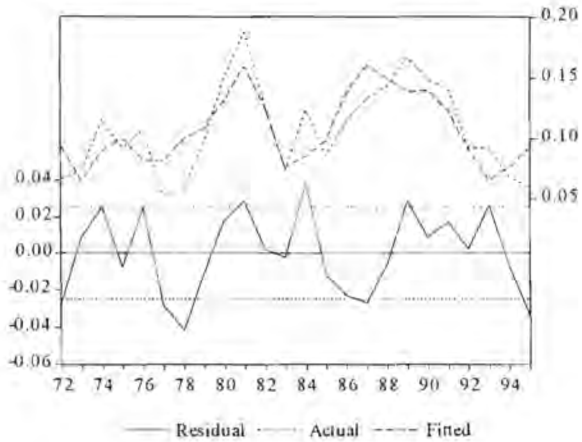
Dependent Variable: Δ(ln_ws_rate)
Method: Least Squares
Sample(adjusted): 1972 1995
Included observations: 24 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.546388	0.137577	-3.971494	0.0008
Δ(ln_emplrat_s(-1))	0.857995	0.408059	2.102622	0.0491
Δ(ln_interposind)	0.075203	0.049190	1.528814	0.1428
braindrain_dum	0.029546	0.012000	2.462171	0.0235
c	0.107963	0.008717	12.38562	0.0000

R-squared	0.625019	F-statistic	7.917323
Adjusted R-squared	0.546076	Prob(F-statistic)	0.000623
S.E. of regression	0.025130		

A graphical illustration of the estimated function for the nominal skilled wage rate is presented in figure 7.17.

Figure 7.17 Actual, fitted and residual values of ln_ws_rat



(iii) *Diagnostic testing*

The estimated equation was subjected to the full battery of diagnostic tests. The results, indicative of a statistically well-behaved function, are reported in table 7.33.

Table 7.33 Diagnostic tests: Nominal skilled wage rate (ln_ws_rate)

Purpose of test	*Test*	*d.f.*	*Test statistic*	*Probability*
Normality	Jarque-Bera	JB(2)	1.263065	[0.531776]
Homoscedasticity	ARCH LM	$nR^2(1)$	2.652358	[0.103396]
Homoscedasticity	White	$nR^2(7)$	2.680042	[0.912941]
Serial correlation	Breusch-Godfrey	$nR^2(2)$	2.756960	[0.251961]
Serial correlation	Lung Box Q	Q(12)	19.74400	[0.072000]
Misspecification	Ramsey Reset	LR(2)	3.428850	[0.180067]
Parameter stability	Recursive estimates	Indicative of stability		

(iv) *Cointegration correction and adjusted coefficients*

The estimation results of the Engle and Yoo cointegration correction, as well as the resulting adjusted coefficients and *t*-values, are reported in tables 7.34 and 7.35 respectively.

Table 7.34 Engle-Yoo third-step estimation: Nominal skilled wage rate (ln_ws_rate)

Dependent Variable: residual_ecm
Method: Least Squares
Sample(adjusted): 1972 1994
Included observations: 23 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.546388)*ln_vpi(1)	0.007864	0.009888	0.795313
(0.546388)*ln_product	0.001995	0.002551	0.782171

Table 7.35 Cointegration correction: Nominal skilled wage rate (ln_ws_rate)

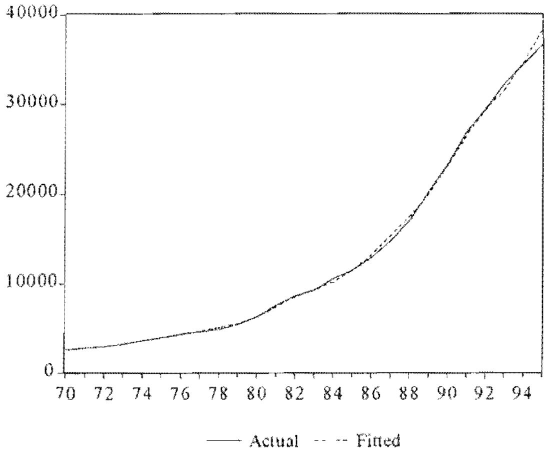
Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_vpi(1)	0.876221	88.614583
ln_product	0.675239	264.69581

The dynamic simulation results as well as the statistical confirmation of the goodness-of-fit of the model are presented by figure 7.18 and table 7.36 respectively.

Table 7.36 Simulation error statistics of nominal skilled wage rate

Actual v Fitted : ln_ws	
Root Mean Squared Error	0.022359
Mean Absolute Error	0.019130
Mean Absolute Percentage Error	0.210106
Theil Inequality Coefficient	0.001206
Bias Proportion	0.000000
Variance Proportion	0.003345
Covariance Proportion	0.996655

Figure 7.18 Actual and fitted values of ln_ws_rat



7.3.5.2 Unskilled wage rate

(i) *The estimation results of the cointegration equation*

The Engle-Granger test statistic of –3.78 confirms that the set of variables specified in the empirical model is cointegrated. The long-run coefficients of the cointegration equation are reported in table 7.37.

Table 7.37 Cointegration equation: Real unskilled wage rate

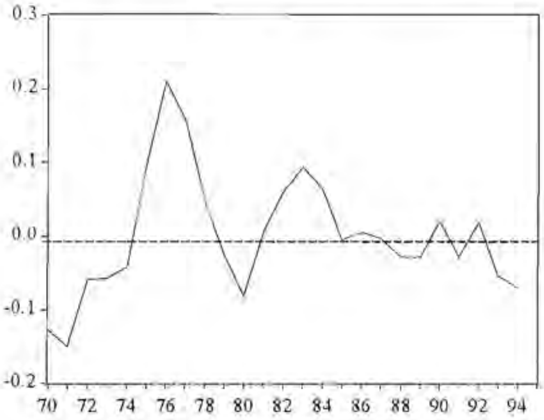
Dependent Variable: ln_wuvpi_rat
Method: Least Squares
Sample(adjusted): 1970 1994
Included observations: 25 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
ln_vpi(1)	0.058106	0.019884	2.922283	0.0079
ln_xgoud_px	0.383017	0.115404	3.318941	0.0031
ln_product	1.079851	0.248837	4.339593	0.0003

R-squared	0.641314	F-statistic	19.66750
Adjusted R-squared	0.608706	Prob(F-statistic)	0.000013

Figure 7.19 provides a data plot of the stationary residuals.

Figure 7.19 Residuals: Real unskilled wage rate (ln_wuvpi_rat)



(ii) *The short-run dynamics: error correction model (ECM)*

Table 7.38 reports the short-run or dynamic adjustment process to the long-run equilibrium.

Table 7.38 Error correction model: Real unskilled wage rate (ln_wuvpi_rat)

Dependent Variable: Δ(ln_wuvpi_rat)
Method: Least Squares
Sample(adjusted): 1974 1995
Included observations: 22 after adjusting endpoints

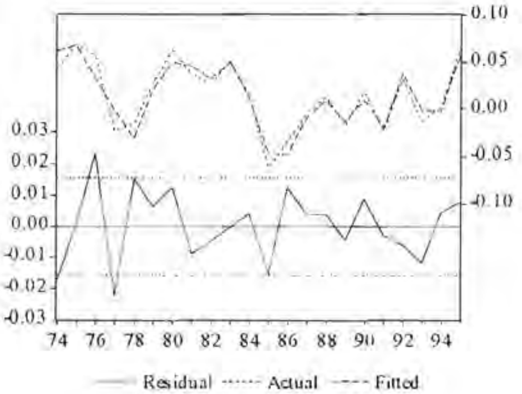
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.186843	0.070747	-2.641006	0.0230
Δ(ln_socind)	0.186627	0.058317	3.200236	0.0085
Δ(ln_socind(-2))	-0.130427	0.069680	-1.871793	0.0880
Δ(ln_socind(-3))	0.178179	0.066587	2.675901	0.0216
Δ(ln_xgoud_px(-1))	0.170801	0.047591	3.588941	0.0043
Δ(ln_xgoud_px(-2))	-0.101029	0.044692	-2.260564	0.0450
Δ(ln_xgoud_px(-3))	-0.163723	0.058452	-2.800985	0.0172
Δ(ln_xgoud_px)	-0.107496	0.058710	-1.830943	0.0943
Δ(ln_uniopresind(-1))	0.216062	0.054947	3.932188	0.0023
Δ(ln_gprys_$(-3))	0.140599	0.021866	6.430109	0.0000
sanction_dum	-0.033496	0.007245	-4.623660	0.0007

R-squared	0.899201	F-statistic	9.812778
Adjusted R-squared	0.807565	Prob(F-statistic)	0.000380
S.E. of regression	0.015731		

An improvement of socio-economic factors (*ln_socind*) enhances the efficiency of particularly unskilled labour, which in turn raises the associated real wage rate. A decline in the gold price (*ln_gprys_$*) and gold exports (*ln_xgoud_px*) have resulted in a slowdown in the real activities of the South African mining industry since the 1980s. On the other hand, the subsequent retrenchments and decrease in the demand for particularly unskilled labour, have counteracted the upward pressure on unskilled wages. However, labour unions are powerful in South Africa and by means of recurrent militant actions (strikes, etc.) effective in their efforts to inflate unskilled wages. Economic sanctions and disinvestment actions against South Africa from the mid-1980s to early 1990s (Appendix 7) slowed down domestic economic activity severely and served to contain the surge in unskilled wages.

A graphical illustration of the estimated unskilled wage rate is presented in figure 7.20.

Figure 7.20 Actual, fitted and residual values of ln_wuvpi_rat



(iii) *Diagnostic testing*

The results reported in table 7.39 indicate that the estimated function satisfied every condition specified by the diagnostic tests.

Table 7.39 Diagnostic tests: Real unskilled wage rate (ln_wuvpi_rat)

Purpose of test	*Test*	*d.f.*	*Test statistic*	*Probability*
Normality	Jarque-Bera	JB(2)	0.259343	[0.878384]
Homoscedasticity	ARCH LM	$nR^2(1)$	2.592183	[0.107392]
Homoscedasticity	White	Insufficient number of observations		
Serial correlation	Breusch-Godfrey	$nR^2(2)$	8.151354	[0.016981]
Serial correlation	Lung Box Q	Q(12)	16.45600	[0.171000]
Misspecification	Ramsey Reset	LR(2)	1.615805	[0.445792]
Parameter stability	Recursive estimates	Indicative of stability		

(iv) *Cointegration correction and adjusted coefficients*

The estimated cointegration equation and resulting long-run coefficients are now corrected and adjusted. The results are reported in tables 7.40 and 7.41 respectively.

Table 7.40 Engle-Yoo third-step estimation: Real unskilled wage rate (ln_wuvpi_rat)

Dependent Variable: residual_ecm
Method: Least Squares
Sample(adjusted): 1974 1994
Included observations: 21 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.186843)*ln_vpi(1)	-0.002531	0.020259	-0.124947
(0.196843)*ln_xgoud_px	0.010302	0.089893	0.114607
(0.186843)*ln_product2	-0.023894	0.203941	-0.117162

Table 7.41 Cointegration correction: Real unskilled wage rate (ln_wuvpi_rat)

Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_vpi	0.055575	2.7432252
ln_xgoud_px	0.393319	4.3754130
ln_product	1.055957	5.1777573

The overall fit of the model is graphically illustrated in figure 7.21 and statistically confirmed by the results of the error measures reported in table 7.42.

Figure 7.21 Actual and fitted values of ln_wuvpi_rat

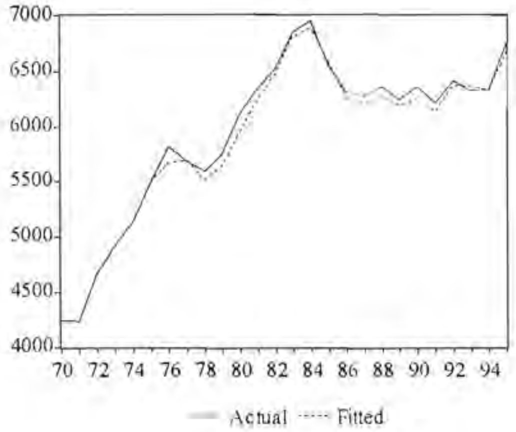


Table 7.42 Simulation error statistics of real unskilled wage rate

Actual v Fitted : ln_wuvpirat	
Root Mean Squared Error	0.011123
Mean Absolute Error	0.009102
Mean Absolute Percentage Error	0.104563
Theil Inequality Coefficient	0.000637
Bias Proportion	0.001127
Variance Proportion	0.000088
Covariance Proportion	0.998785

7.4 DYNAMIC SIMULATION: RESPONSE PROPERTIES OF THE MODEL

The dynamic simulation properties of every labour market function are now investigated and, simultaneously, tested for stability and robustness. Appendix 10 described the methodology applied.

The results of every adjustment process towards a new long-run equilibrium are both tabled and graphically illustrated. In every instance, the adjustment process is completed within the sample range and the levels of convergence of the dependent variables are consistent with the elasticities of the respective cointegration relationships.

7.4.3 Demand for labour

7.4.3.1 Demand for skilled labour

Table 7.43 Difference between the baseline forecast and forecasts with shocked variables, dependent variable: ln_ns

Variable	*Coefficient*	*Expected change (10% of coefficient)*	*Convergence level (% difference)*
ln_bbp_90p	0.3098330	0.0309833	0.0301143
ln_rel_wsu_rar	- 0.612380	- 0.061238	- 0.056627
ln_rel_wscost_u	- 0.137105	- 0.013711	- 0.012974

Figure 7.22 **Dynamic adjustment (percentage change) in demand for skilled labour (ln_ns) with a 10 percent increase in real gross domestic product at market prices (ln_bbp_90p)**

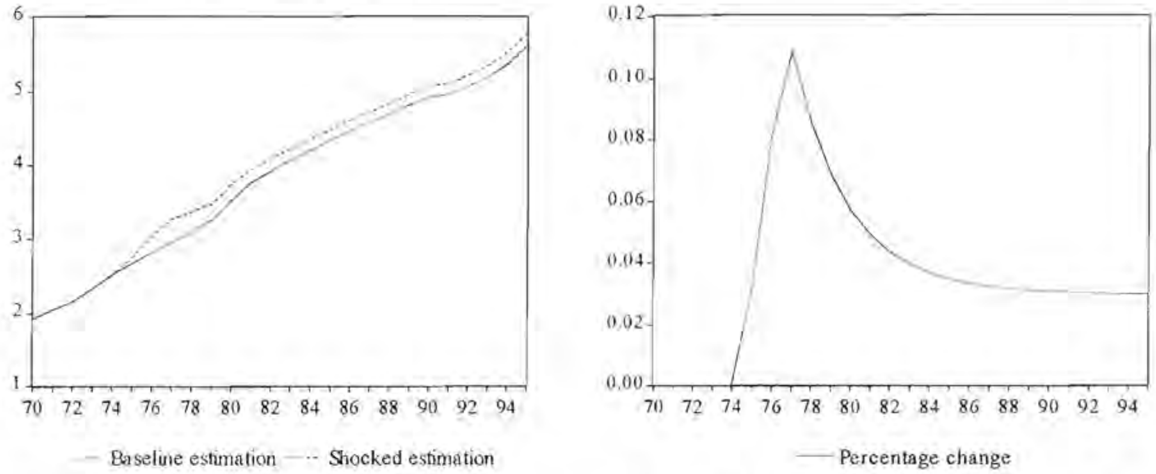


Figure 7.23 **Dynamic adjustment (percentage change) in demand for skilled labour (ln_ns) with a 10 percent increase in skilled wage rate relative to unskilled wage rate (ln_rel_wsu_rat)**

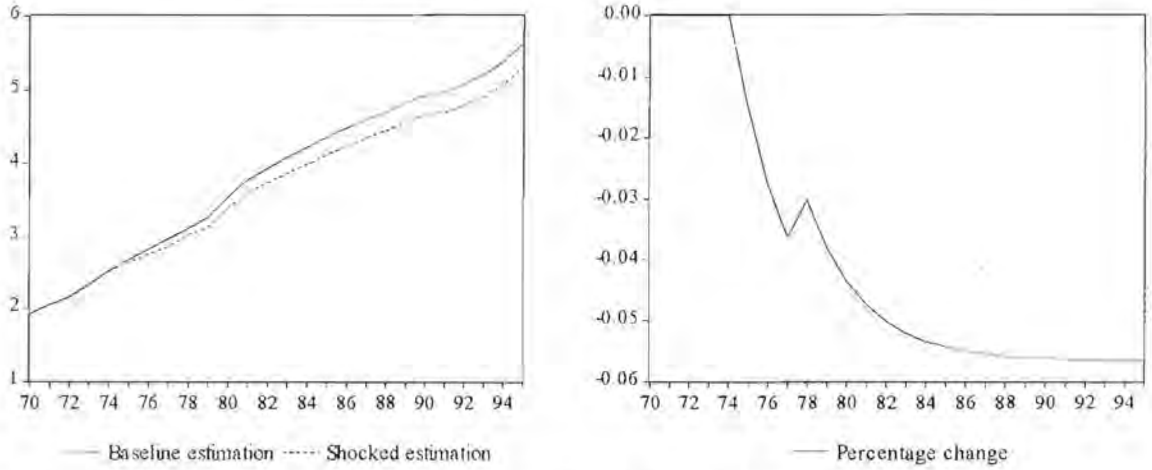
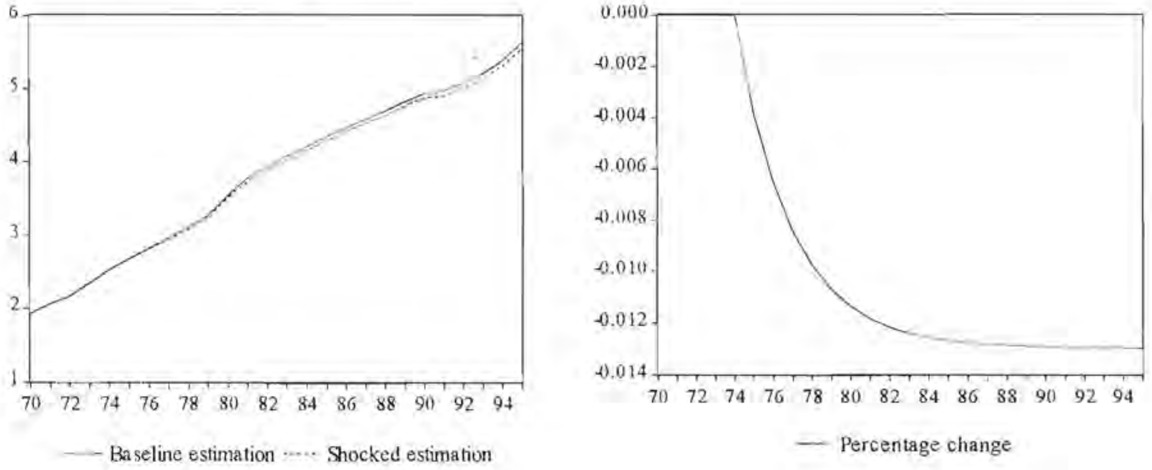


Figure 7.24 **Dynamic adjustment (percentage change) in demand for skilled labour (ln_ns) with a 10 percent increase in skilled labour cost relative to user cost of capital (ln_rel_wscost_u)**



7.4.3.2 Demand for unskilled labour

Table 7.44 Difference between the baseline forecast and forecasts with shocked variables, dependent variable: ln_nu

Variable	*Coefficient*	*Expected change (10% of coefficient)*	*Convergence level (% difference)*
ln_bbp_90p	0.3756550	0.0375655	0.0344908
ln_wuppi_rat	- 0.353469	- 0.035347	- 0.031403

Figure 7.25 Dynamic adjustment (percentage change) in demand for unskilled labour (ln_nu) with a 10 percent increase in real gross domestic product at market prices (ln_bbp_90p)

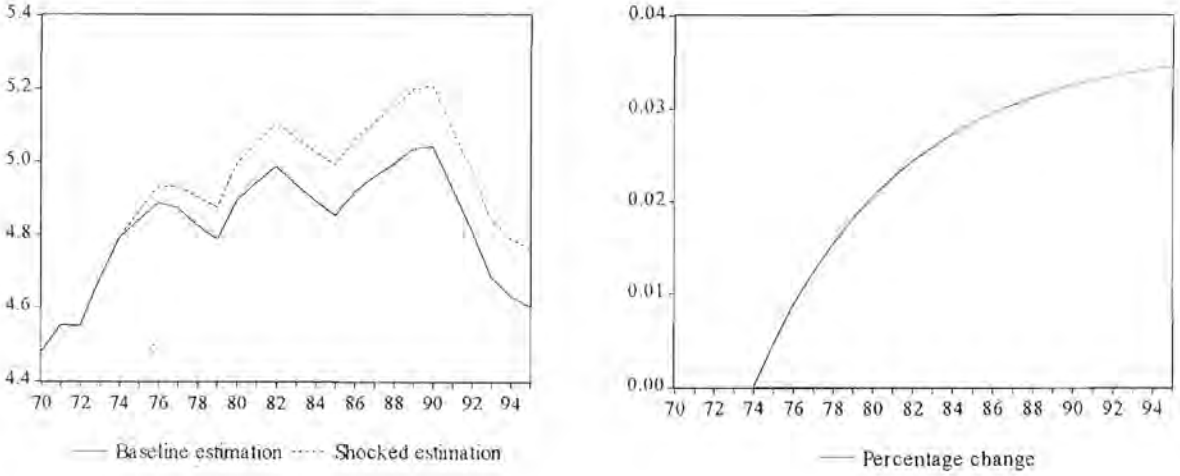
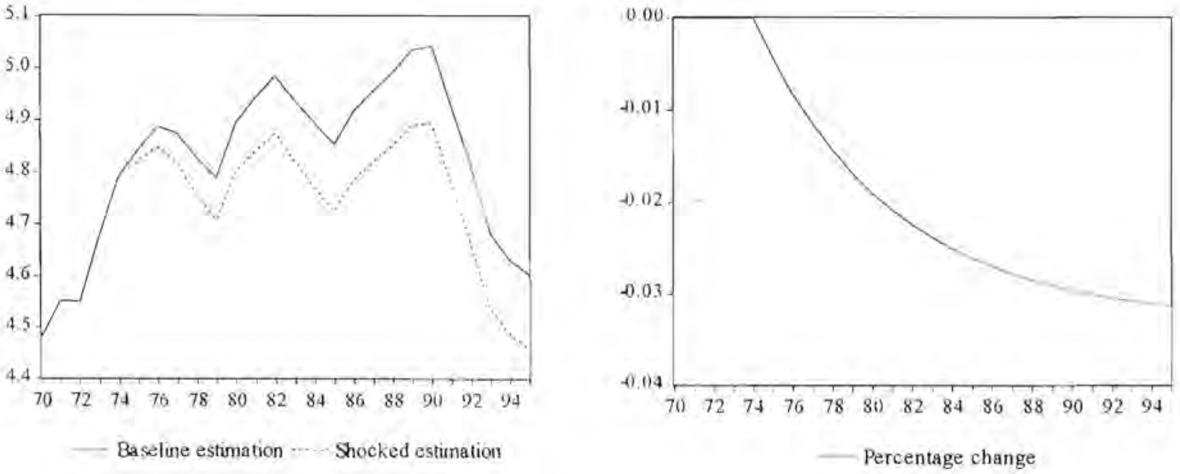


Figure 7.26 Dynamic adjustment (percentage change) in demand for unskilled labour (ln_nu) with a 10 percent increase in real unskilled wage rate (ln_wuppi_rat)



7.4.3.3 Labour participants in the informal sector

Table 7.45 Difference between the baseline forecast and forecasts with shocked variables, dependent variable: ln_n_informal

Variable	*Coefficient*	*Expected change (10% of coefficient)*	*Convergence level (% difference)*
ln_bbp_90p	6.5300560	0.6530056	0.6490558
ln_wtot_vpi_rat	- 4.399687	- 0.439969	- 0.436853

Figure 7.27 Dynamic adjustment (percentage change) in labour participants in informal sector (ln_n_informal) with a 10 percent increase in real gross domestic product at market prices (ln_bbp_90p)

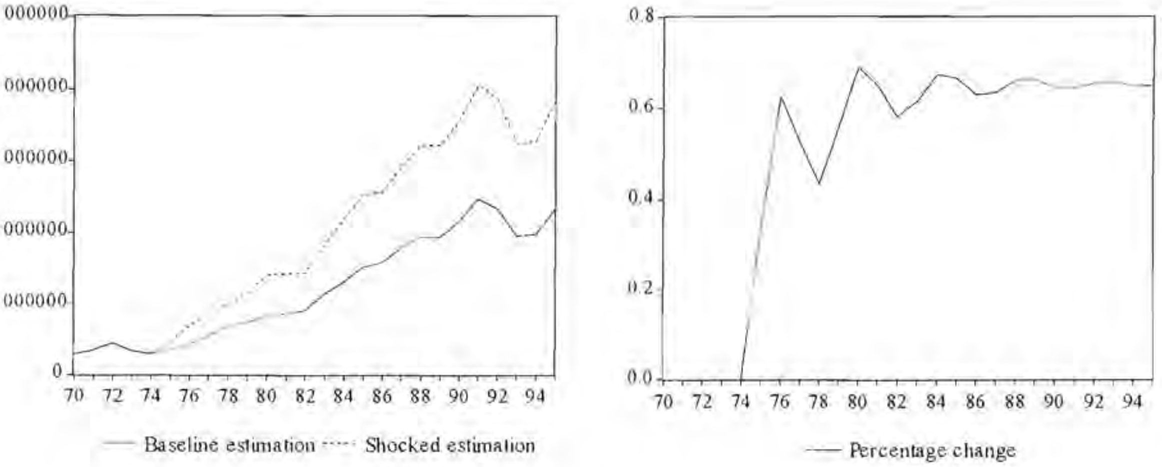
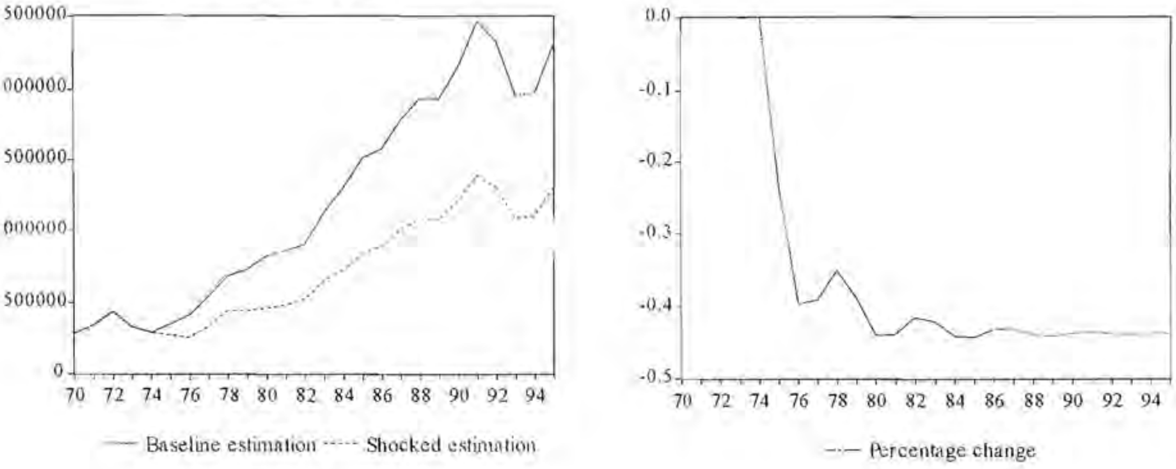


Figure 7.28 Dynamic adjustment (percentage change) in labour participants in informal sector (ln_n_informal) with a 10 percent increase in real total wage rate (ln_wtot_vpi_rat)



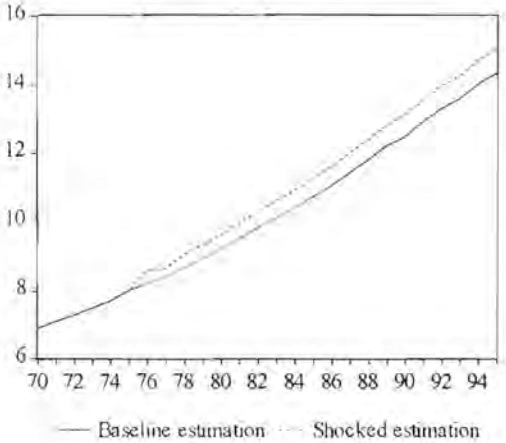
7.4.4 Labour supply

7.4.4.1 Total labour supply

Table 7.46 Difference between the baseline forecast and forecasts with shocked variables, dependent variable: ln_s

Variable	*Coefficient*	*Expected change (10% of coefficient)*	*Convergence level (% difference)*
ln_total_pop	0.4812201	0.0481220	0.0491877
ln_wtot_rate	0.1355454	0.0135545	0.0152223

Figure 7.29 Dynamic adjustment (percentage change) in total labour supply (ln_s) with a 10 percent increase in total population (ln_total_pop)



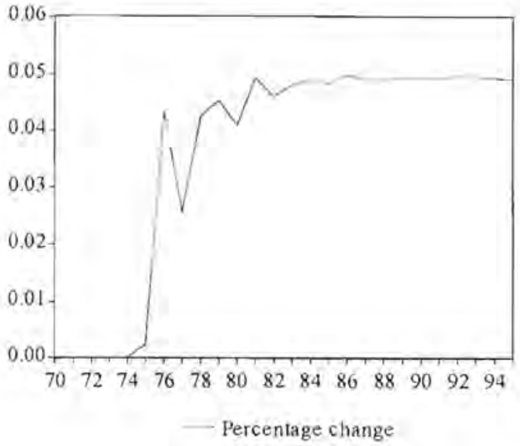
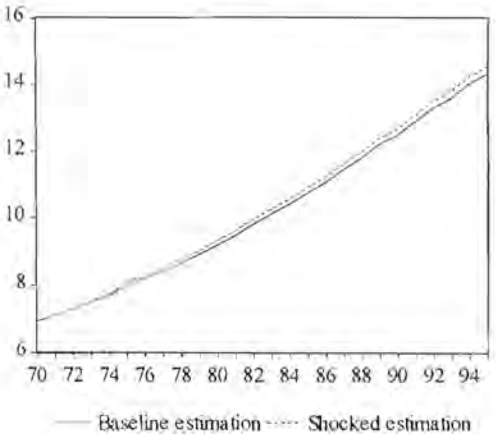
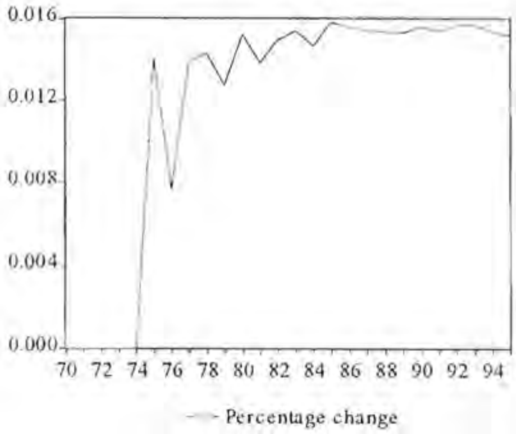


Figure 7.30 Dynamic adjustment (percentage change) in total labour supply (ln_s) with a 10 percent increase in nominal total wage rate (ln_wtot_rate)



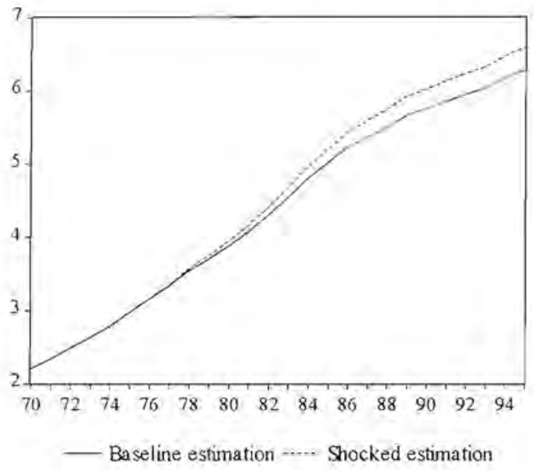


7.4.4.2 Skilled labour supply

Table 7.47 Difference between the baseline forecast and forecasts with shocked variables, dependent variable: ln_ss

Variable	*Coefficient*	*Expected change (10% of coefficient)*	*Convergence level (% difference)*
ln_educind	0.4759900	0.0475990	0.0486180
ln_wtot_vpi_rat	1.6776260	0.1677626	0.1818975

Figure 7.31 Dynamic adjustment (percentage change) in skilled labour supply (ln_ss) with a 10 percent increase in education index (ln_educind)



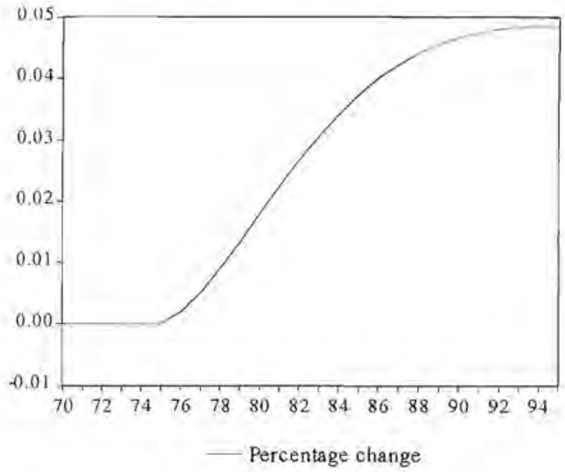
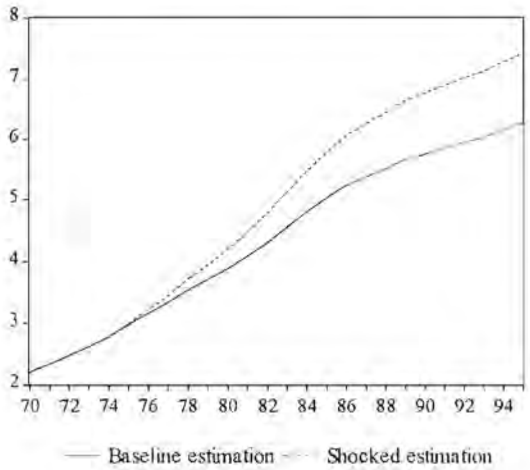
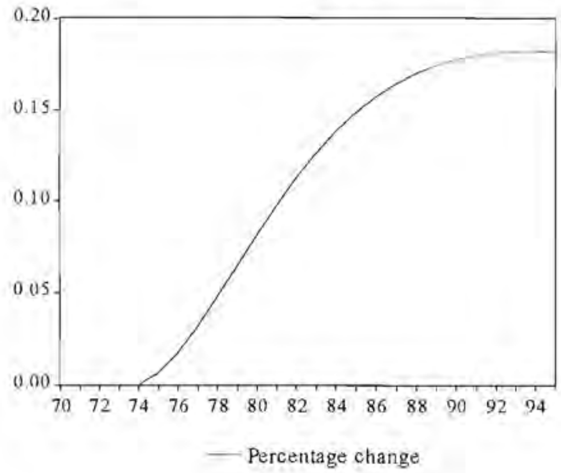


Figure 7.32 Dynamic adjustment (percentage change) in skilled labour supply (ln_ss) with a 10 percent increase in real total wage rate (ln_wtot_vpi_rat)





7.4.5 Wage determination

7.4.5.1 Skilled wage rate

Table 7.48 Difference between the baseline forecast and forecasts with shocked variables, dependent variable: ln_ws_rate

Variable	*Coefficient*	*Expected change (10% of coefficient)*	*Convergence level (% difference)*
ln_vpi(1)	0.876221	0.087622	0.087099
ln_product	0.675239	0.067524	0.066473

Figure 7.33 Dynamic adjustment (percentage change) in nominal skilled wage rate (ln_ws_rate) with a 10 percent increase in consumer price index (ln_vpi)

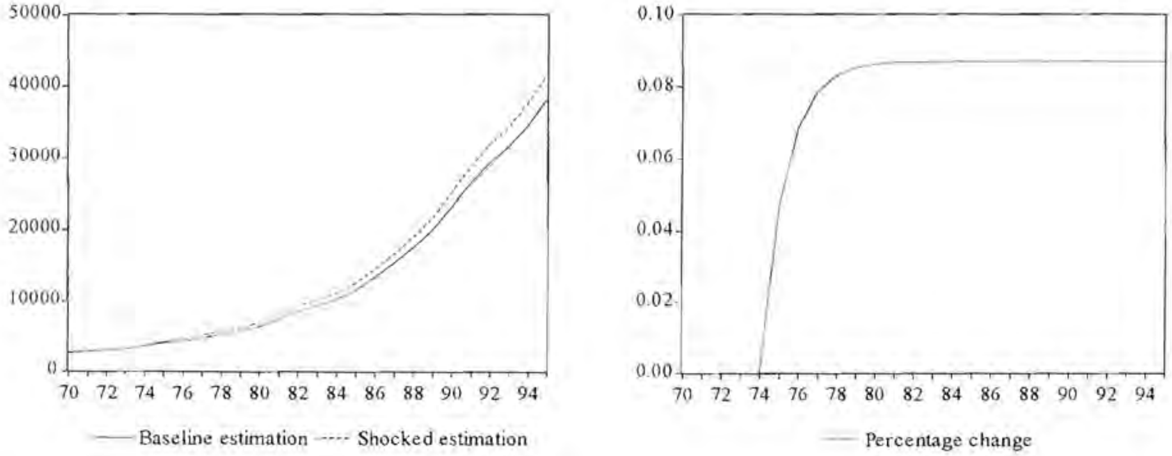
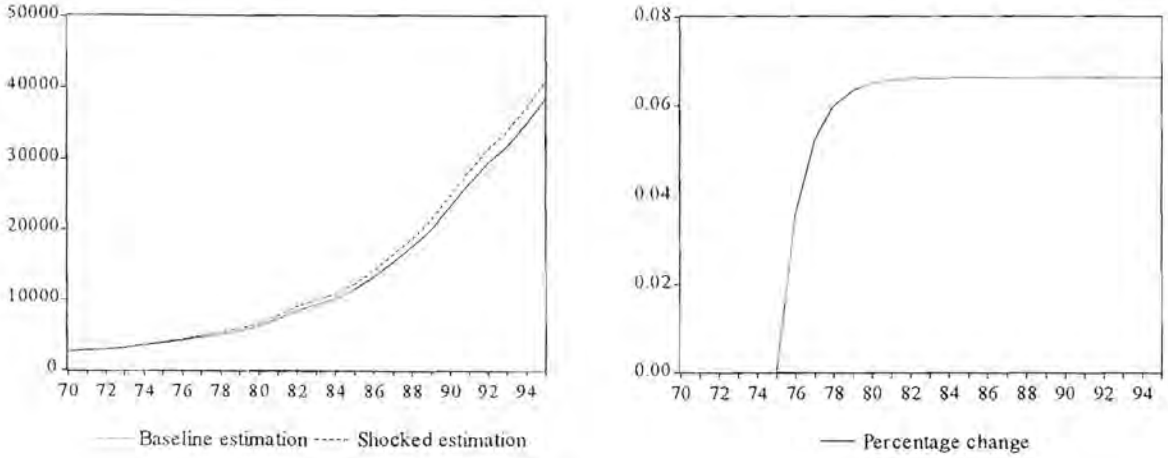


Figure 7.34 Dynamic adjustment (percentage change) in nominal skilled wage rate (ln_ws_rate) with a 10 percent increase in productivity (ln_product)



7.4.5.2 Unskilled wage rate

Table 7.49 Difference between the baseline forecast and forecasts with shocked variables, dependent variable: ln_wuvpi_rat

Variable	*Coefficient*	*Expected change (10% of coefficient)*	*Convergence level (% difference)*
ln_vpi	0.055575	0.005558	0.005242
ln_xgoud_px	0.393319	0.039332	0.037017
ln_product	1.055957	0.105596	0.104106

Figure 7.35 Dynamic adjustment (percentage change) in real unskilled wage rate (ln_wuvpi_rat) with a 10 percent increase in consumer price index (ln_vpi)

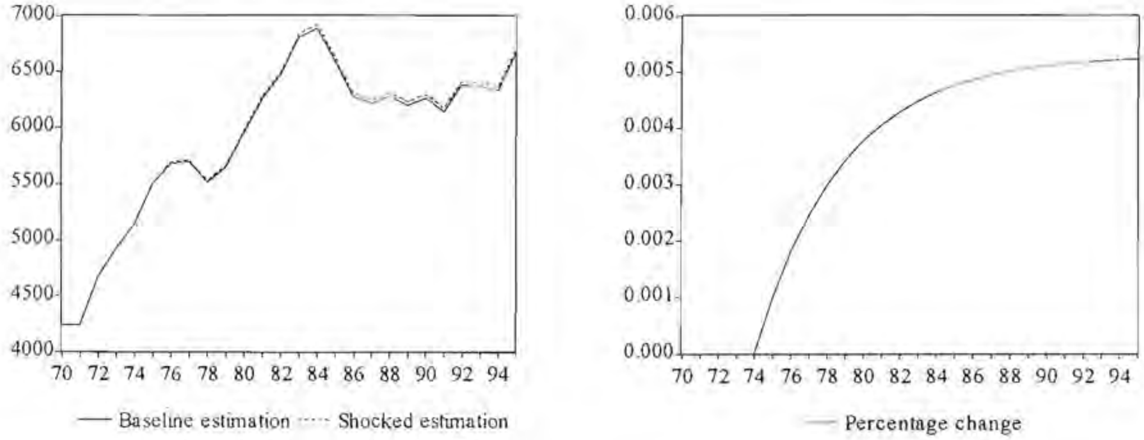


Figure 7.36 Dynamic adjustment (percentage change) in real unskilled wage rate (ln_wuvpi_rat) with a 10 percent increase in real net gold exports (ln_xgoud_px)

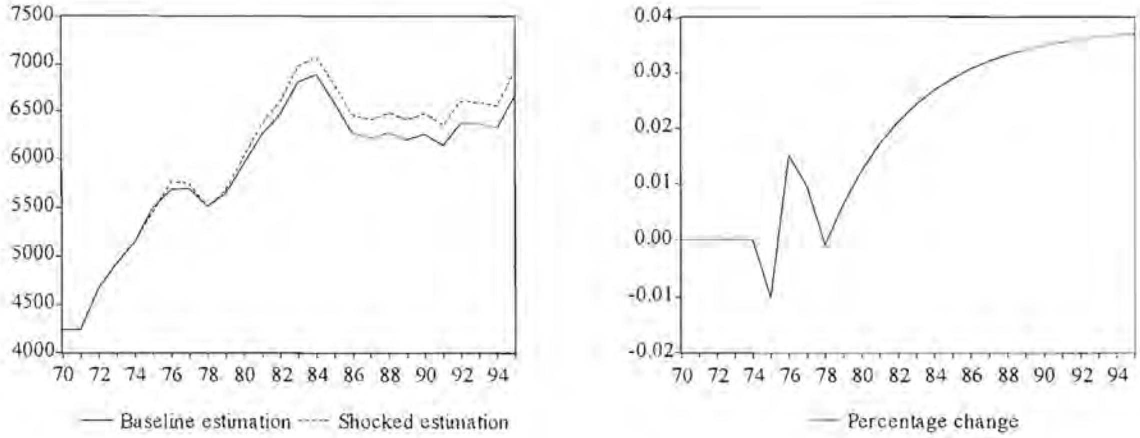
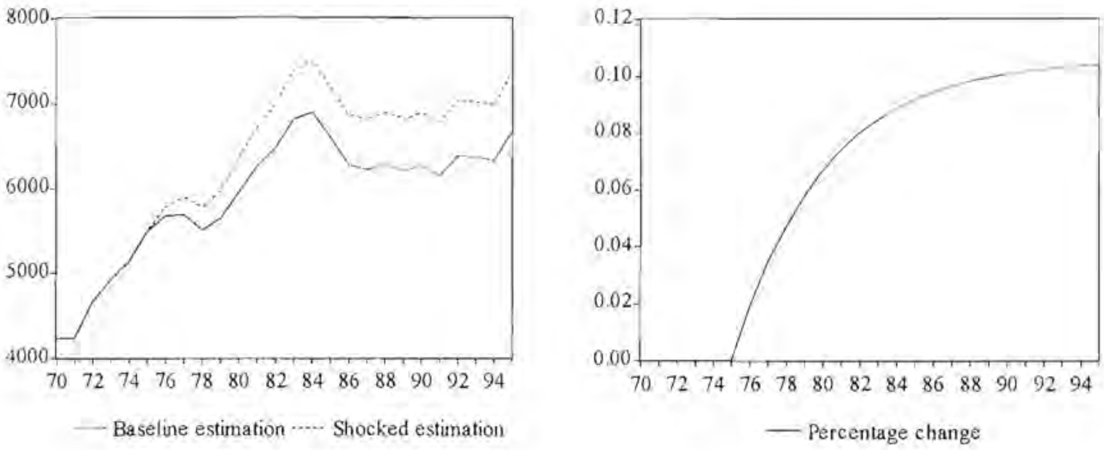


Figure 7.37 Dynamic adjustment (percentage change) in real unskilled wage rate (ln_wuvpi_rat) with a 10 percent increase in productivity (ln_product)



7.5 CONCLUSION

The purpose of this chapter is to develop a labour model of the South African economy as part of a neoclassical supply-side of the macroeconometric model. For empirical purposes, a distinction is made between skilled and unskilled labour. At the same time, an attempt is made to model the labour participants in the informal sector, separate from, but with no contemporaneous feedback to formal labour market activities.

Wages and employment are modelled essentially according to a systems approach to ensure consistency in a neoclassical framework. The Layard-Nickell framework of wage bargaining under imperfect competition, emphasising labour market interactions, is utilised. The approach also incorporates the role of labour unions and labour taxes on employers. Although the Layard-Nickell framework is based upon a cost-function approach, the decision was made in this study to include a production rather than a cost function in the neoclassical supply-side model. The main reason is to derive an estimate for capacity utilisation – a key component in the price mechanism (structure) of the economy.

Although a Cobb-Douglas production function is included in the model, it was not estimated directly, but derived from an estimated cost function for the South African economy on the basis of Shephard's duality. The direct estimation of a cost function and subsequent derivation of factor demand and price functions ensure consistency in the profit maximising or cost minimising decision-making processes of firms.

Each of the estimated components of the labour model proved to comply with both economic and statistical *a priori* conditions. The labour model is therefore established as a robust mechanism to explain wages and unemployment in the South African economy.