A SUPPLY-SIDE MODEL OF THE SOUTH AFRICAN ECONOMY: CRITICAL POLICY IMPLICATIONS

by

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Charlotte du Toit

SUMMARY

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Supply-side theory, policy and modelling have become imperative in economic analysis. This is due to the deficiencies of demand-oriented theory, policy and models to satisfactory address unemployment and inflation. For many decades the Keynesian foundation for conducting economic policy was undisputed, but its failure to explain and solve the problems of stagnation, lagging productivity, double-digit inflation, high interest rates and depreciating currencies, led to the emergence of supply-side economics.

Macroeconomic models were criticised for theoretical inconsistency, forecasting failures and inadequate policy analysis and had to adapt to supply-side modelling in the 1970s. Specific consideration was given to the long-run equilibrium properties and stability of models with respect to output, employment and inflation, which in turn crucially depend on the consistency and structure of supply-side specifications.

This study attempts to develop a neoclassical supply-side model of the South African economy, based on the requirements for theoretical consistency, forecasting and policy analysis. The model specification, estimation and validation, as well as the derivation and estimation of the individual equations are done consistently with leading developments in the field of supply-side policy and macroeconomic modelling.

Although a cost-minimising approach is followed to guarantee consistency between cost, prices and factor demands, a Cobb-Douglas production function is derived on Shephard's duality and included in the model. This enables the estimation of potential output and subsequent derivation of a measure for capacity utilisation. The Cobb-Douglas technology is only included on validation against the more flexible Translog functional form. A further attempt is made to endogenise technical progress in the production relationship. A Jorgenson neoclassical investment function is estimated but extended to incorporate the financial constraint principles which are of particular relevance to the South African economy. Consistency is maintained with the estimation of a neoclassical labour model, wage determination and price-setting within a framework of market imperfections and collective bargaining.

The supply-side model is finally validated and subjected to a series of policy scenario simulations to propose an optimal set of policy measures that will alleviate the labour market inefficiencies and related unemployment problem of the South African economy.

A SUPPLY-SIDE MODEL OF THE SOUTH AFRICAN ECONOMY: CRITICAL POLICY IMPLICATIONS[*]

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
BEPA	Bureau of Economic Policy and Analysis
CES	Constant elasticity of substitution
ECM	Error correction model
DBSA	Development Bank of Southern Africa
DGP	Data generating process
DF	Dickey-Fuller
EAP	Economically active population
FIML	Full information maximum likelihood
GDE	Gross domestic expenditure
GDP	Gross domestic product
GNP	Gross national product
HP	Hodrick-Prescott
IID	Independently identically distributed
IFS	International Financial Statistics
IMF	International Monetary Fund
LBS	London Business School
LFP	Labour force participation rate
LN	Layard-Nickell
MAE	Mean absolute error
MAPE	Mean absolute percentage error
MP	Marginal product
MPP	Marginal physical product
MRS	Marginal rate of substitution
NAIRU	Non-accelerating inflation rate of unemployment
NAWRU	Non-accelerating wage rate of unemployment
NICs	Newly industrialised countries
OECD	Organisation for Economic Co-operation and Development
RMSE	Root mean square simulation error
RMSPE	Root mean square percentage error
SA Statistics	South African Statistics
SAMEM	South African macroeconomic model of the University of Pretoria
SARB	South African Reserve Bank
SE	Standard error
SMEs	Small and medium enterprises
Translog	Transcendental logarithmic
UK	United Kingdom
USA	United States of America
VES	Variable elasticity of substitution

CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

During the two decades following the second world war, the objective of full employment was the first priority in the market economies and the Keynesian tenet set the (then) undisputed foundations for conducting economic policy. The nature of the unemployment problem was mostly cyclical and limited attention was devoted to the role and functioning of labour markets in the economy and specifically to their allocative, distributional and informational functions and capacities. Demand-management policies, coupled with relatively high economic growth rates, were deemed adequate to deal with unemployment. This, however, also meant an uninterrupted period of rising prices, as a result of which inflation came to be seen as a typical condition of the economy.

As a result of the inflationary pressure exerted by the international oil crisis at the time, unemployment once more became a serious problem during the 1970s. Unemployment in most countries became, to a greater or lesser degree, a non-cyclical phenomenon, i.e. unemployment rates tended to increase steadily despite periods of relatively high economic growth. Unemployment increasingly displayed structural characteristics and labour markets showed larger imbalances and rigidities. Rising unemployment, especially since the early 1980s, caused the labour market and its relationship with the rest of the economy to become the primary focus of policymakers and researchers.

This study shows that the South African labour market has lost its capacity to perform its allocative, distributional and informational functions efficiently and thus also became relatively inflexible in adapting to internal and external shocks to the economy. South Africa as a developing country is also experiencing a high and growing level of unemployment and since the late 1980s the capacity of the formal economy to provide sufficient employment opportunities for its growing labour force, has steadily been eroded to the present position where it is virtually non-existent. Apart from the immense economic cost to society, this structural problem also has a direct impact on the socio-economic conditions and political developments in the country.

Structural unemployment will only be permanently alleviated by addressing the structural impediments of the labour market and by accomplishing sustainable long-term economic growth and stability. Long-run economic growth will in turn be enhanced by supply-side policies in general and labour market policies in particular focusing on the improvement and quality of human capital. This notion is according to the growth theory pioneered by Paul Romer (Romer 1986: 1002-37), stating that knowledge, resultant from investment in human capital, is just as important a component of economic growth as raw labour and physical capital.

1.2 OBJECTIVE AND RESEARCH METHODOLOGY

Supply-side theory, policy and modelling have become imperative in economic analysis. This is due to the deficiencies of demand-oriented theory, policy and models to satisfactory address unemployment and inflation. For many decades the Keynesian foundation for conducting economic policy was undisputed, but its failure to explain and solve the problems of stagnation, lagging productivity, double-digit inflation, high interest rates and depreciating currencies, led to the emergence of supply-side economics and the formulation of supply-side propositions

Macroeconomic modellers have consequently taken up the challenge to coincide with the supply-side notion of long-run growth in an economy with stable employment, productivity, wages and prices and thereby acknowledged the cost-minimising or profit-maximising decision-making processes of the firms which are responsible for production activities in the economy. For a macro-econometric model to be instrumental in policy analysis that goes beyond short-term forecasting requirements, distinct consideration must be given to its long-run equilibrium properties and stability with respect to output, employment and inflation. These, in turn, depend crucially on the consistency and structure of its supply-side specification.

The purpose of the study is to develop a theoretically consistent supply-side model of the South African economy. Ultimately, the objective is to integrate the supply-side model with a full-sector macroeconomic model of South Africa. The macroeconomic model developed by the econometric research team of the University of Pretoria (SAMEM) and which is primarily demand-driven, is used for this purpose.

The methodology of this study comprises:

(i) A thorough investigation of the theoretical principles of supply-side economics and the developments in macroeconomic modelling to ensure compliance with the requirements for theoretical consistency, forecasting and policy analysis in particular. These results are used to evaluate and restructure the demand-driven SAMEM.

(ii) The specification, estimation and validation of a neoclassical supply-side model of the South African economy, encompassing the recent, leading developments in the field such as cost-minimising behaviour, market imperfections and collective bargaining. This involves the derivation and estimation of single equations for production (actual and potential), capacity utilisation, fixed investment, corporate savings, demand for labour (skilled and unskilled), labour supply (total and skilled), wage rates (skilled and unskilled), unemployment (NAWRU) and prices (production and consumption prices).

(iii) Finally, the system of supply-side equations is subjected to a series of policy-scenario simulations for the purpose of proposing an optimal set of policy measures that will resolve or at least alleviate the severe labour market inefficiencies and related unemployment problem of the South African economy

1.3 OUTLINE OF THE STUDY

Based on the above-mentioned methodology, the study is divided into three sections: (1) the theory and background of supply-side modelling; (2) estimation of a neoclassical supply-side model of the South African economy and (3) critical policy implications. The first section is covered in chapters 2 and 3. Chapters 4 to 9 deal with the estimation and validation of the model and chapter 10 presents the policy analysis and critical policy implications for South Africa.

In chapter 2 the theoretical principles of supply-side economics are explored, as they need to form the basis of a supply-side macro-econometric model of the South African economy. Supply-side effects and particularly the role of taxation, which is the main supply-side instrument, are modelled within a neoclassical framework of profit-maximising or cost-minimising behaviour of firms. These neoclassical principles are adopted in several, different ways by macro-economic modellers. The structural properties of the existing (mainstream) supply-side models are investigated to establish how they compare in modelling the neoclassical and associated supply-side principles.

Chapter 3 presents a brief outline of the current structure and shortcomings of SAMEM, along with a proposed restructured framework, incorporating a neoclassical supply-side model of the South African economy. The properties and objectives of the supply-side model are identified and an outline of the proposed methodology for the development of the supply-side model is presented.

The purpose of chapter 4, is to estimate an aggregate neoclassical production function for the South African economy as the key component of the supply-side model. The production function is used to derive a measure for capacity utilisation in the model, a property which a cost function does not exhibit. The resulting production function identifies the technology and properties of the South African production structure. Two aspects are considered in the estimation of a production function: (1) the functional form; and (2) whether to estimate the production function directly or to estimate a cost function and derive a consistent production function based on duality principles. The cost-function approach has the advantage of allowing for consistency between costs, prices and factor demands in a neoclassical framework.

Duality principles, however, according to which unique relationships exist between the coefficients of cost and production functions, only apply to restricted functional forms such as the Cobb-Douglas and the Constant Elasticity of Substitution (CES) functions. The Transcendental logarithmic (Translog) form on the other hand, for which duality principles do not apply, is more flexible and may therefore be considered preferable. As a result, two different approaches are followed: (1) the direct estimation of a Cobb-Douglas cost function, used for the derivation of a consistent production function based on Shephard's duality principles; and (2) the estimation of a non-homothetic Translog cost function, tested for the validity of imposed restrictions that will result in a Cobb-Douglas cost function. If the Translog cost function cannot reduce to a Cobb-Douglas cost function, an equivalent Translog production function has to be estimated by imposing restrictions, similar to those validly imposed when estimating a cost function. This, however, will imply theoretical inconsistency in the derivation and estimation of the price and factor demand equations.

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. In macro-econometric context, capacity utilisation 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 answers sensitive to the method selected. Finally, actual output could be determined directly from Keynesian demand or from a production-function (supply) approach may be used. In chapter 5, (1) a brief review is presented of the different concepts and methodologies of potential output and output gaps; (2) two measures for potential output are identified and explained; and (3) the analytical framework, methodology and estimates for potential output and capacity utilisation for the South African economy are presented.

A model of aggregate fixed investment is proposed, derived and estimated in chapter 6. 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, increasing potential capacity output supply and to the extent that new investment goods 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. This volatility and the fact that investment movements have important consequences for productive capacity, employment demand, personal income and the balance of payments, make 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 resulting disinvestment since 1985. The situation has not improved with the abolition of sanctions and the end of disinvestment in South Africa in 1994. Instead, the greater degree of openness of the economy serve to expose South Africa's vulnerability to international financial market instability, as was only too apparent during the East Asian and Russian crises of 1998.

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. A further advantage of the Jorgenson approach, is the fact that supply-side policy instruments such as taxes, interest rates and funding play an integral role.

However, 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.

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. Domestic financial constraints consist, in accordance with the exposition of the national accounts, of savings by households, corporate enterprises and the government, as well as replacement investment or depreciation in real capital stock. External financial constraints consist of net foreign capital flow and the value of the change in gold and other foreign reserves. 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.

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.

The purpose of chapter 7 is to develop a neoclassical labour model of the South African economy. The resulting 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. The reason for this is assumed differences in both the wage determination processes and firms' employment behaviour concerning differences in the levels of productivity and the role of labour unions applicable to skilled and unskilled workers.

Although an attempt is made to model the labour participants in the informal sector separately from the formal labour market activities, it is done without any contemporaneous feedback from the informal sector to the supply-side model in general and the formal labour market in particular. The reason for this is that informal activities are inadequately recorded in the production sector time series over the sample period under consideration. The contribution of the informal sector has been presented more comprehensively in the system of national accounting after 1995. The value of an equation for the informal labour activities, is 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; 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. This study deviates slightly from this approach by ultimately including a production function and not a cost function in the complete supply-side system, as this approach allows 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 wasn't estimated directly, but derived from an estimated cost function for the South African economy on the basis of Shephard's duality principles. The direct estimation of a cost function and subsequent derivation of factor demand and price functions, ensure consistency with the profit-maximising or cost-minimising decision-making processes of firms.

In chapter 8 a pricing structure for the neoclassical supply-side model is developed. The estimated price-setting equations may also be used as tools to explain the high inflation levels the South African economy has been plagued with since 1970. For purposes of consistency, the Layard-Nickell approach of cost minimisation, utilised in chapter 7 to model wages and employment, is again employed.

The estimations for production, fixed investment, corporate savings, the labour model and the pricing system are combined into a neoclassical supply-side model of the South African economy in chapter 9. The system is closed by introducing a number of identities and definitions, linking every endogenous variable in the model and thereby ensuring a fully dynamic system. The model is subsequently evaluated along the full ideal principles of model selection.

First, the theoretical structure of the estimated model (empirical specification) is evaluated to determine if the model complies with (1) the *a priori* objectives of neoclassical supply-side modelling, (2) economic theory – for the model in general and the individual equations in particular, (3) rival models, i.e. the extent to which the model encompasses the characteristics of rival models and (4) policy analysis, i.e. the relevancy of the specified model for policy analysis.

Second, a simulation (i.e. *ex-post* forecast) of the full system of equations is conducted. These dynamic simulation properties of the model are evaluated in terms of (1) the statistical significance (*ex-post* forecast ability) and (2) the stability of the model over the simulated sample range. The statistical significance (goodness-of-fit) of the full system is measured in terms of simulation/forecast error statistics and confirmed by the graphical representations of the simulations.

Third, a series of dynamic, *ex-post* simulations are conducted by shocking every stochastic variable in the system. The simulation results are used to (1) determine the long-run (steady-state) multipliers and elasticities of the system and once again, (2) to evaluate the statistical significance and sensitivity of the model in terms of the degree, speed and stability of convergence. The robust (stable) nature of the model serves as an indication of the forecasting ability of the model.

The level of unemployment, associated with a consistent level of output, can be explained in terms of the structural, long-run or supply-side properties of the economy. The essence of a neoclassical supply-side model is to capture and explain the underlying production structure of the economy, associated with consistent factor demand and price relationships. The resulting levels of production and employment are forthcoming from firms' decision-making processes which, in turn, are driven by profit-maximising or cost-minimising goals.

In chapter 10, (1) a brief description of the labour conditions and unemployment problem in South Africa is given; (2) a set of policy rules (proposals) which may increase the labour absorption capacity of the economy and subsequently reduce the unemployment problem is identified; and (3) the suggested policy measures are empirically validated through a series of dynamic simulations of the estimated supply-side model.

CHAPTER 2

A REVIEW OF SUPPLY-SIDE ECONOMICS

2.1 INTRODUCTION

Given the range and nature of uses of macroeconomic models, i.e. structural analysis, forecasting and policy analysis, it is necessary to recognise the important balance between statistical goodness-of-fit, structural simplicity and theoretically plausible behaviour. For a macro-econometric model to be useful for policy analysis that goes beyond short-term forecasting requirements, particular attention must be paid to its long-run equilibrium properties and stability with respect to output, employment and inflation. These, in turn, depend crucially on the consistency and form of its supply-side specification. At the same time, appropriate econometric methods are needed to ensure that short-term dynamic properties and underlying estimated properties are data consistent and well determined.

Against this background, the theoretical principles of supply-side economics are explored, as they need to form the basis in the development of a supply-side macro-econometric model of the South African economy. Supply-side effects and particularly the role of taxes, which are the main supply-side instruments, are modelled within a neoclassical framework of profit maximising or cost minimising behaviour of firms. These neoclassical principles are adopted in several, different ways by macro-economic modellers. The structural properties of the existing (mainstream) supply-side models are investigated to see how they compare in modelling the neoclassical and associated supply-side principles.

The purpose of this chapter is therefore three-fold:

(i) to present an overview of supply-side economic theory;
(ii) to discuss the modelling of supply-side effects in a neoclassical framework and
(iii) to compare the structural properties of existing supply-side models.

2.2 THE THEORY OF SUPPLY-SIDE ECONOMICS

Although some economists believe supply-side economics to be a modern concept, its origin can be traced back to the classical doctrines of the 1800s and 1900s. Widespread unemployment and the worldwide depression of the 1930s led to demand management policies of the Keynesian Revolution, with its rejection of the classical assumptions. Keynesian analysis became the widely accepted foundation of economic policies, but its failure to address and explain problems such as stagnation, lagging productivity, double-digit inflation, high interest rates and depreciating currencies, led to the emergence of supply-side economics and the development of supply-side propositions.

This section therefore commences by discussing the classical roots of supply-side economics and contrasts it with the Keynesian approach. A discussion of the emergence of supply-side economics and the development of supply-side propositions then follows and the section is concluded by addressing different concepts associated with the theoretical principles of supply-side economics.

2.2.1 The supply-side notion

Divergent ideas and controversy reign with regard to the basic concepts and theory of supply-side economics. It is therefore important to investigate the different aspects of what is actually meant by supply-side economics. According to Hailstones, supply-side economics can be defined as a study of policies designed to stimulate economic growth and promote price stability through various measures that affect the supply of goods and services. These measures include lower taxation, increased savings, greater investment and stronger work motivation (Hailstones 1982: 3).

Lyle E. Gramley, a member of the Board of Governors of the Federal Reserve System and former member of the USA President's Council of Economic Advisers, said the following about supply-side economics:

> *What do we mean by supply-side economics? Conceivably, a wide range of things could be included - energy policy, manpower training, Federal support for higher education, and other programs that might increase the growth of supply or enhance productivity (Gramley 1980: 2).*

Professor **Arthur B. Laffer** from the University of California refers to supply-side economics as the

> *new, new economics of individual incentives (Business Week 1979: 116).*

While **Michael Evans** who developed the well-known Chase Econometric model of the USA economy states that

> *Keynesian models cannot deal with current economic ills because they concentrate on questions of demand.*

According to Evans, we need models that stress the supply-side, focusing on the stimulation of productivity (Evans 1980: 3).

Martin Feldstein, professor of Economics at Harvard and President of the National Bureau of Economic Research comments that *demand-side* economists emphasise federal budgetary and monetary policies as a means of manipulating demand for goods and services, thereby spurring on the production side of the economy. Supply-side economists emphasise the need for new tax incentives to encourage people to save and business to invest in new and more efficient factories and machinery (Golden 1980: 33).

In referring to supply-side economics, an International Monetary Fund (IMF) aide noted that the supply-side school stresses tax incentives for business and upper-bracket individuals in the hope of spurring capital investment to modernise ageing plants and equipment (Janssen 1980: 26).

According to **Norman B. Turé**, president of his own consultant firm and a pioneer in supply-side theory, this theory is based on principles developed by the classical economists:

> *Supply-side economics is shorthand for a way of analysing the effects of government policies and actions on the economy... its basic concepts predate Keynesian by a century and a half. What's new about "supply-side" economics is its application to public economic policy problems, particularly tax and fiscal policies (Raboy 1980: 18).*

Professor **Robert Mundell** of Columbia University, an ardent supply-sider, believes that high tax rates have had such a large inflationary impact on the cost of many goods and services that people have been induced to forego their purchases and perform services for themselves that could be more efficiently performed by specialists. According to Mundell, this reduces productivity and the level of economic activity. This may not be true, however, if the work was performed in the spare time of the potential purchaser.

However, Mundell's point is verified to some extent by the rapid growth in the so-called subterranean or underground economy. This non-monetary, or sometimes called invisible economy, produces increasingly larger percentages of the GNP of many economic systems. Stressing that changes in tax rates are the heart of supply-side economics, **Dr. Paul Craig Roberts**, Associate Editor of the Wall Street Journal, states that:

> *The essence of supply-side economics is to regard tax-rate changes as relative price changes affecting the supply and form of labour, savings, investment and visible economic activity (Business Week 1980).*

According to Roberts there are basically two important relative prices governing production on the supply-side. One determines the choice between additional current income and leisure; the other determines the choice between additional future income (investment) and current consumption. Both prices are affected by the marginal tax rates (Roberts 1982: 1-13). Roberts and some of his colleagues claim that higher after-tax incomes will encourage work through increased overtime, less absenteeism and shorter periods of unemployment. On the basis of their thinking, supply-siders opt for the following:

(i) large and sustained personal and corporate tax cuts to induce more work and capital investment;
(ii) keeping monetary growth in line with the long-run growth potential of the economy, including perhaps a return to some form of a gold standard and

(iii) a slowdown in the growth of government spending and a lessening of the nations' tax burden relative to the GNP, thereby freeing more financial resources for private investment.

Hailstones and many others believe that although supply-side economics is thought of as a new concept, its origin can be traced back to the classical doctrines (economics) of the 1800s and 1900s. Widespread unemployment and worldwide depression of the 1930s led to demand management policies of the Keynesian revolution, with its rejection of the classical assumptions. Keynesian analysis became the widely accepted foundations of economic policies, but its failure to address and explain new problems and issues, especially stagnation, lagging productivity, double-digit inflation, volatile interest rates and a declining external value of the national currency, led to the emergence of supply-side economics and the development of supply-side propositions.

The classical roots of supply-side economics is investigated next, followed by a look at the basic principles of and differences found in the Keynesian approach, also known as the income-expenditure analysis. A discussion of the emergence of the supply-side economics and the development of supply-side propositions follows, after which the section is concluded by highlighting key concepts associated with the theoretical principles of supply-side economics.

2.2.2 The classical roots of the supply-side

From the classical doctrine which is based on the concepts of economic freedom, self interest, competition and *laissez faire*, one of the foremost and most relevant propositions for the supply-side theory, is the fact that savings provide the funding for growth in the economy. This is based on Say's Law, which in broad context, states that production of a given level of output generates sufficient income to purchase that amount of output, and that savings are directly or indirectly converted into investment. The Keynesians, of course, take a different view and state that aggregate demand may fall short of aggregate supply.

Say's law implies that supply and demand will always be equal and any amount of goods and services can be cleared from the market. Therefore, the economy will automatically move towards a full-employment level. Furthermore, the restriction of government spending to necessities or emergencies such as war is advocated. Most classical economists advocate a balanced budget and early repayment of debt incurred. These are the most distinctive propositions of the classical doctrine, which differ significantly from those of the Keynesian approach.

2.2.3 The Keynesian view

With the global depression and sustained unemployment of the 1930s, a change in economic thinking emerged, led by John Maynard Keynes. He departed from the conditions of Say's Law, presented a thorough critique of the classical doctrine and proposed a new set of macroeconomic principles regarding production, employment and income.

These principles and relationships of the various steps of the income-expenditure analysis can be summarised as follows:

(i) Production (GNP), employment, income and prices depend on effective demand.

(ii) Effective demand is measured by the total of consumption, investment and government spending.

(iii) Consumption depends on the size of income and the average propensity to consume at that level of income.

(iv) Since the consumption function is relatively stable, and assuming government spending has a neutral effect, changes in employment and income will result primarily from changes in investment.

(v) Investment is determined by the marginal efficiency of capital relative to the interest rate.

(vi) Marginal efficiency of capital is dependent on profit expectations compared to the cost of capital assets.

(vii) The interest rate depends largely on liquidity preference compared to the quantity of money.

(viii) Liquidity preference is dependent on the strength of the precautionary, transactions and speculative motives for holding money.

(ix) Government spending is the total of national, provincial and local expenditures, which may be either or emergency spending.

(x) If consumption, investment and regular government spending are insufficient to provide a high level of economic activity, emergency government spending may be used to raise the level of GNP, income and employment.

Ceteris paribus, an increase in the size of income will, for example, bring about higher consumption, increase effective demand and raise the level of production, employment and income. If the economy is in a state of full employment, however, such a change will result in higher prices. A strengthening of liquidity preference will raise the interest rate, decrease investment, lower effective demand and result in a decrease of production, employment and income. A lowering of the interest rate will have the opposite effect. It can be seen, further, that deficit government financing will raise effective demand, while a surplus budget will have a dampening effect on the economy unless used to combat inflation. All savings are not automatically converted into private, voluntary investment.

An aspect which also needs to be highlighted as it constitutes a significant divergence between the Keynesian approach on the one side and the classical and supply-side approaches on the other, is the fact that savings, according to the Keynesians, is considered to be a leakage and therefore, depending on the propensities to consume and save, an increase in savings will lead to a decline in economic activity and growth.

2.2.4 The emergence of the supply-side economics

Although the term supply-side economics had been known as early as the mid-1960s, the concept was widely used only by the late 1970s, when it received widespread attention and became subject to more analytical scrutiny. Many different views and interpretations, and therefore also

macroeconomic problems, such as increasing inflation, lower productivity, increasing unemployment, lower potential growth rates and weakening exchange rates, was a shift in resource allocation from investment to consumption, both private and public. Fiscal and monetary policies tilted in the direction of subsidising consumption and penalising investment. When these policies lead to excess demand, monetary policy was invoked to reduce investment, causing a recession. This vicious cycle led to an ever-increasing rate of inflation. To an extent, this cycle has been fuelled by political considerations. Tax cuts for lower income individuals are easier to defend than tax cuts for businesses (Evans 1982: 253 and Hailstones 1982: 112).

These features are embedded in the large-scale econometric models, based on the principle that an increase in demand will automatically trickle down to increase aggregate supply, thus ensuring balanced non-inflationary growth. However, there is nothing magical about the balance between aggregate demand and supply. If incentives for investment are lacking, capital formation will stagnate. If incentives are lacking for employment, labour force participation will be reduced and productivity will diminish. As a result, the total productive capacity of an economy will grow more slowly than total demand, and bottlenecks, shortages and higher inflation must then be fought by causing a recession and reducing aggregate demand. It is true that the gap between aggregate demand and supply must be closed in order to diminish inflationary pressures. However, there are two ways to accomplish the same aim. One is indeed to diminish demand, thereby causing higher unemployment. The other is to increase aggregate supply, thereby raising the production possibility curve of the economy and increasing jobs and output at the same time that inflation is being lowered. This is the fundamental hypothesis underlying Evans's supply-side modelling (Evans 1982: 254).

Evans, as well as the other supply-side advocates, accuse Keynesian policies as being one-dimensional insofar as they concentrate on changing effective demand and ignoring supply. They also challenge the Keynesian tenet that a redistribution of income *via* taxation in favour of lower income groups will raise spending, output and employment because poor people spend a larger share of their income than rich people. They claim that this could cause a decline in savings and investment and have an adverse effect on production, employment and income. It is this latter possibility that is lacking in the Keynesian models (Evans 1982: 254 and Hailstones 1982: 112).

They also question the Keynesian tenet that spending stimulates demand while savings retard demand. Savings actually can be useful in providing funds for investment. Moreover, supply-siders claim that personal saving is affected by the after-tax return earned on savings. Of particular importance is the work of another supply-sider, Michael Boskin of Stanford University, whose findings reveal that a 10 percent reduction in taxes generates a 2 percent increase in personal saving. It is this saving that is not converted into investment (a part of effective demand) by the Keynesian models (Evans 1982: 254 and Hailstones 1982: 112).

Finally, the Keynesian tenet that government spending will result in a larger increase in demand and output than an equivalent reduction in taxes, is also challenged. The Keynesian reasoning states that the entire amount of government spending is reflected by additional demand. If taxes are cut, however, some of the tax remission may be channelled into saving, which do not contribute to increased demand (consumption or investment). Thus, according to Keynesian policy, the effect of a tax cut on the economy is less than that resulting from an equivalent increase in government spending. This implies, also, that a simultaneous cut in taxes and government spending will lead to a decline in economic activity (Evans 1982: 254 and Hailstones 1982: 112).

Associated with this is the Keynesian belief that a personal income tax cut has a greater impact on the economy than an equivalent corporate tax cut because individuals spend a larger portion of their income than corporations (Evans 1980). The supply-siders do not agree, since savings are not lost, but converted into investment.

From the vast body of theoretical exposition, the principles of supply-side economics may be summarised as follows:

(i) A reduction in tax rates increases the incentive of individuals to save by raising the rate of return on assets held by individuals. The higher saving leads to lower interest rates and higher investment (Evans 1982: 254; Evans 1980; Evans 1982: 108; Klein 1982: 247; Roberts 1982: 4; Roberts 1982: 49, 51; Keleher 1982: 265; Turé 1982: 35; Boskin 1982: 18,20 and Kemp 1982: 31).

(ii) Corporate tax rate cuts or similar measures, such as increasing the investment tax credit or liberalising depreciation allowances, improve investment directly by increasing the average after-tax rate of return (Evans 1982: 254-255; Evans 1980; Evans 1982: 108; Klein 1982: 247; Roberts 1982: 4; Roberts 1982: 49; Keleher 1982: 266; Boskin 1982: 21 and Kemp 1982: 31).

(iii) Increases in both personal and corporate savings lead to greater liquidity and less loan demand, thereby lowering interest rates. These effects help both capital spending and residential investment (Evans 1982: 255; Evans 1980; Roberts 1982: 49-50; Keleher 1982: 266; Turé 1982: 37, 42-47; Boskin 1982: 22 and Weidenbaum 1982: 10).

(iv) Higher investment leads to an increase in productivity, which means that more goods and services can be produced per unit of input. As a result, unit costs do not rise as fast and inflation grows more slowly (Evans 1982: 255; Evans 1980; Klein 1982: 247, 249; Roberts 1982: 4, 7; Keleher 1982: 266; Turé 1982: 37, 38, 47, 49 and Boskin 1982: 22).

(v) A reduction in personal income tax rates leads to a rise in labour force participation and work effort, increasing the quality and quantity of work and therefore the supply of labour necessary to produce more goods and services. It raises the overall growth rate in productivity and productive capacity, thereby contributing to the slowdown in the rate of inflation (Evans 1982: 255; Evans 1980; Evans 1982: 109, 189; Roberts 1982: 4; Keleher 1982: 265-256; Turé 1982: 37, 40-42, 48, 52-56 and Boskin 1982: 19-20). This proposition is, however, debated by Lawrence Klein. The sensitivity between tax changes and labour changes is based on the theoretical principles of the tax labour wedge model

(1982: 247, 250). Klein argues that according to the Wharton model, a reduction in indirect taxes lowers the real wage incentive (1982: 247, 249).

(vi) Labour supply, capital stock and productivity are all increased by lower tax rates, thereby expanding the maximum productive capacity of the economy (Evans 1982: 255; Evans 1980; Keleher 1982: 267; Klein 1982: 247 and Turé 1982: 37).

(vii) As a result of higher maximum capacity, the inflationary pressures of shortages and bottlenecks diminish, thereby reducing the rate of inflation (Evans 1982: 255; Evans 1980 and Turé 1982: 37, 38, 40).

(viii) An increase in maximum capacity also permits the production of more goods and services for export markets as well as domestic consumption. This improves the net foreign balance and strengthens the exchange unit, thus leading to lower inflation because imported goods decline rather than increase in price (Evans 1982: 255; Evans 1980; Keleher 1982: 267 and Turé 1982: 39, 47, 56-60).

(ix) Lower tax rates result in more modest demands for wage increases, since real income has risen by virtue of the tax cut and workers do not suffer a loss of real income by moving into higher tax brackets. This in turn reduces inflation further (Evans 1982: 255; Evans 1980; Evans 1982: 109; Klein 1982: 247; Roberts 1982: 49; Turé 1982: 40-42, 47-49, 52-56 and Boskin 1982: 19).

(x) Lower tax rates therefore cause a reduction in inflation through several channels. Inflationary pressures decline as the gap between actual and maximum potential GNP rises; productivity increases, thereby lowering unit labour costs; the exchange unit (currency) strengthens, causing less imported inflation and wage rates rise more slowly (Evans 1982: 255; Evans 1980; Klein 1982: 247 and Turé 1982: 37, 39, 40-49).

(xi) Lower inflation leads to an increase in real disposable income (bracket inflation is mitigated) and hence a rise in consumption, output and employment (Evans 1982: 255; Evans 1980 and Turé 1982: 46-57).

(xii) Lower inflation leads to lower interest rates, stimulating investment in both plant and equipment and in housing (Evans 1982: 255; Evans 1980 and Turé 1982: 46-52).

(xiii) The lower rate of inflation causes an increase in net exports, which strengthens the value of the monetary unit (currency). This leads to further reductions in the rate of inflation because imported goods decline rather than increase in price (Evans 1982: 255 and Evans 1980).

(xiv) The increased demand for goods and services stemming from lower inflation is matched by the rise in the maximum potential capacity of the economy to produce these goods and services, thereby resulting in balanced, non-inflationary growth (Evans 1982: 255; Evans

1980; Evans 1982: 109; Keleher 1982: 265; Turé 1982: 36, 37, 49, 50; Boskin 1982: 22 and Weidenbaum 1982: 9).

The above theoretical principles are supported by the new developments in macro-econometric modelling by economists such as Stephen Nickell (1988: 202-221), Chris Allen, Stephen Hall and James Nixon (1994; Hall 1995: 974-988)), John Helliwell (1995), Robert Coen and Bert Hickman (1995), Thomas Thomsen (1995) and others.

A main contention is that the above tax effects take place in the first instance on account of changes in relative prices and not as a result of changes in disposable income as the Keynesians suggest. According to Roberts (1982: 2, 49), Turé (1982: 36) and others, there are two important relative prices governing production. One price determines the choice between additional future income (investment) and current consumption and the other the choice between current income and leisure. Both prices are affected by the marginal tax rates. Boskin is of the opinion that supply-side economics is better described by the term incentive-oriented economics, as the basis of supply-side economics lies in the incentives to produce income and wealth. According to Keleher (1982: 264-276), the tax changes which are especially relevant to aggregate supply in the sense that they influence behaviour and incentives, are changes in marginal tax rates (the rate at which the additional increment of activity is taxed) and not tax revenues. Weidenbaum (1982: 9-15) stresses the fact that government legislation should not oppose these tax incentives.

Feldstein (1982: 146-157) stresses that supply-side economics focuses on capacity creation through capital formation and research. Supply-siders also recognise that saving is a prerequisite for increased capital formation that can raise productivity and the standard of living.

Concerning the role of fiscal and monetary policy, Kemp (1982: 27-39) and Feldstein (1982:146-157) say that monetary policy should be used to stabilise the value of the currency and fiscal incentives to encourage individual and business production, saving and risk taking. Meiselman (1982), however, feels that the lags involved in the effect of changes in the stock of money and the problems caused by uncertainty about future changes in the stock of money, necessitate not only slow and stable money growth, but slow and stable money growth mandated by law.

In modelling a supply-side, Stephen Nickell (1988: 202-221) focuses on factors describing the behaviour of firms and determining wages. A clear distinction is made between supply and demand and also the role of surprises. According to his model, supporting the basic theoretical principles discussed above, a rise in demand will typically lead to a rise in inflation and to an increase in output and employment - causing firms to apply upward pressure on prices relative to wages and workers to apply upward pressure on wages relative to prices. The resultant real wage outcome depends on price setting, which in turn depends on the technology of the firm and competitiveness of the model. If strict normal cost pricing pertains, there is no effect from demand to prices and the rise in inflation will ensure that the price-wage mark-up falls. Real wages, as well as employment, will therefore rise as a consequence of a positive demand shock. If firms, however, are capital constrained, the demand shock will have no effect on output and employment and will typically reduce real wages through the inflationary pressure on prices.

The response of the model to supply shocks will originate from wage changes. A typical supply shock, such as a rise in the real price of imports, will exert upward pressure on wages relative to value-added prices. This pressure will induce a rise in both real wages and inflation and, even for given real demand, will produce a fall in output as each firm individually feels that it is becoming uncompetitive. The result is unemployment and stagflation. If there is no reduction in real demand, inflation will continue to rise for as long as the supply shock causes wage pressure. The specification of the wage equation is crucial in this regard. If real demand falls, inflation will be stabilised. Unemployment will increase still further and the effect on real wages will again be determined by the pricing behaviour of firms.

John F. Helliwell (1995) focuses on the role of measured factor inputs and technical progress contained in the underlying production functions, instead of merely focusing on the equations for prices and wages, supported by explanations of labour supply and demand. He argues that, in spite of the effects of globalisation, there are international differences in the rates of growth of aggregate efficiency and potential output and that these differences are related to national economic structures and policies. Supply-side modelling should recognise this endogeneity and make models appropriately responsive to national policies and institutions. However, these influences are in general slow moving, so that for the purposes of short-term forecasting, more traditional methods of forecasting the growth of potential output as some combination of the growth rates of factor inputs are not likely to be too misleading.

In developing a new version of the London Business School model, Chris Allen, Stephen Hall and James Nixon (1994; Hall 1995: 974-988) based this model around an aggregate restricted cost function. Non-energy production is modelled as a function of four factor inputs: capital, labour, fuels and raw materials. They also modelled technical innovation by the inclusion of a time trend.

In developing a stochastic model of potential or full-employment output, Robert Coen and Bert Hickman (1995) treat full-employment output as an endogenous variable. Their concept incorporates a piecewise exponential trend of technical progress, but it also allows for other factors affecting the path of full-employment productivity and output. In the deterministic context, productivity is affected by capital deepening induced by changes in the wage-rental ratio due to price shocks and changes in taxation, and it additionally reflects shocks to labour demand in the stochastic variant. The labour supply is also affected by real consumption wage shocks, and, in the stochastic variant, by shocks to the average hours and participation rate.

To the extent that the shocks to labour demand stem from the production technology, their stochastic full-employment path resembles that of real business cycle theory, except for the crucial difference that they do not assume perfect competition and continuous market clearing, and hence do allow for departures of actual GDP and factor inputs from full-employment levels.

2.2.6 Key concepts associated with supply-side economics

There are a few interesting, but still contested issues in the supply-side debate. The first is the Laffer effect, regarding the relationship between tax rates and tax revenues. It is based on the assumption that people will work more when their after-tax wages rise and that businesses will invest more than the increase in their after-tax profit or rate of return on investment. This, in turn, will result in greater tax revenue.

The Laffer effect depends on the size of the tax change, the point from which the tax change takes place, as well as the incentives people get to change their work effort, productivity and investment spending due to tax changes. The assumption that people will work more, leading to greater productivity, when their after-tax wages rise and that businesses will invest more than the increase in their after-tax profit or rate of return on investment, is questioned. The debate regarding the elasticity or sensitivity between changes in tax rates and the labour supply or the work-leisure ratio continues. Assuming that this relationship exists, Laffer and other supply-siders utilise the labour and capital wedge models to indicate that tax rates affect the quantity of labour and capital demanded as well. For example, a tax increase will increase the cost of hiring a worker and decrease the real wage received by the worker and therefore decrease both the demand and supply of labour. The tax wedge, which is the difference between the hiring cost and actual wage paid to the worker, consequently increases. The same applies in the case of capital.

Another issue is the effect of tax changes on saving. Although there is a lack of substantial empirical evidence, indications are that tax cuts increase saving and, according to recent studies, decrease interest rates.

Whereas the accepted, conventional doctrine holds that tax cuts have relatively small effects on the supply of savings, as well as on the supply of labour, consensus indicates that tax changes can significantly affect investment. The evidence suggests that tax cuts directed at investment may be the most potent area to stimulate aggregate supply *via* their expansionary effect on the capital stock.

The conventional view holds that tax cuts do, to some extent, increase the supply of labour, saving, investment, and hence, aggregate supply. However, in view of the conventional perception of the elasticities of various factor supplies (with respect to taxes), the conventional view holds that the effect of tax cuts on aggregate supply will not be very large. This view however has been disproved by supply-side models built by *inter alia* Laffer, Evans and Turé.

Supply-siders claim that their suggested policies and measures will increase productivity. They maintain further, as do most Keynesians, that increases in productivity will reduce inflation.

Some like Turé, consider supply-side economics as the application of price theory to government fiscal measures. An income tax reduction, for example, increases the price of leisure, raises the price of current consumption compared to future consumption, increases the value of market work compared to self-work (underground economy) and increases the value of taxable investment compared to tax shelters.

In studying supply-side economics, one has to consider the effect of tax cuts on the supply of labour, on saving, investment, aggregate supply and tax revenues. After analysing the available empirical data, Robert Keleher (1982) concludes that:

(i) a supply-side cut in income and business taxes will probably result in some increase in the supply of labour, saving, investment and aggregate supply;

(ii) due to additional real economic growth, the tax base will increase and revenues will not fall in proportion to tax rates – in short, because of feedback effects, the deficit will not be as large as some predict;

(iii) despite the increase in aggregate supply, tax cuts will produce an increase in budget deficit in the short run, but in the long run, the supply-side effects of tax cuts should be more potent and the deficit less of a concern.

The above theoretical principles form the basis of a supply-side macro-econometric model.

2.3 DEVELOPMENTS IN SUPPLY-SIDE MODELLING

Supply-side economics deal with issues such as the growth in production and supply, productivity, the role of technology, tax incentives for saving and investment, tax effects on employment and wages, relative prices governing these supply-side decisions and the tax revenue (or Laffer) effect. Keynesian economics disregards the incentive effects of tax changes on supply in the economy and ignores the fact that savings are converted into investment. According to the supply-side approach, however, fiscal policy first of all changes relative prices, incentives for leisure or work (income), consumption and investment. These changes have a definite effect on the production and aggregate supply of the economy. But, fiscal policy changes also produce resource reallocations with adverse demand-side implications for employment and the rate of economic growth. All these features need to be addressed when modelling a supply side for purposes of extended policy analysis.

2.3.1 Earlier approaches in supply-side modelling

Early supply-side econometric models are mostly variations or extensions of traditional macro-economic models based on Keynesian or demand-side economics, based on the income-expenditure approach with the level of output and employment principally determined by the level of demand. The following framework or equations represent the demand-side:

$$Y = C + I + G + \Delta IV + X - M \quad (2.1)$$

$$C = c(Y - HP) \quad (2.2)$$

$$I = i(Y, r) \quad (2.3)$$

$$\Delta IV = v(Y) \quad (2.4)$$

$$M = m(Y, ep; p^*) \tag{2.5}$$

$$X = x(Y^*, ep / p^*) \tag{2.6}$$

Equation 2.1 is the standard national income accounting identity, which sums the expenditure components of GDP (private consumption, fixed investment, government spending, changes in inventories, exports and imports). Equation 2.2 is the consumption equation, which explains personal consumption by real income (*Y*) and credit restrictions (*HP*). It is of a Keynesian form with consumers assumed to be constrained by real incomes and credit conditions. Equations 2.3 and 2.4 explain fixed investment and changes in inventories by simple accelerator models (changes in output) with some allowance for interest rate effects on fixed investment. Finally, equations 3.5 and 3.6 explain trade, exports and imports, by domestic and foreign income (y, y^*) and by competitiveness (ep / p^*) where e is the exchange rate measured as the foreign price of domestic currency, p the domestic price level and p^* the foreign price level. A rise in this term is associated with a worsening of competitiveness. Most of the early models did not have an endogenous explanation of exchange rates (e) so that most of the variation in competitiveness in model simulations came from changes in relative prices (p / p^*). Monetary influences were largely absent, their main impacts running through the role of credit conditions in personal consumption and a small interest rate influence on fixed investment.

The determination of aggregate supply was rudimentary. It came not from an explicit output supply relationship or constraint, but from increasing inflation through the mechanism of the Phillips-curve treatment of wages, implying a long-run trade-off between unemployment and inflation (Whitley 1994: 43):

$$\dot{w} = w(u, \dot{P}^e) \tag{2.7}$$

with price expectations $(\dot{P}^e)$ given by past inflation:

$$\dot{P}^e = \dot{P}_{t-1} \tag{2.8}$$

and the price level in turn given by a constant mark-up on costs:

$$P = \beta(w - \pi) + (1 - \beta)P_m \tag{2.9}$$

where $(w - \pi)$ represents unit labour costs (wages less productivity) and P_m is the price of imports.

An important practical problem was that empirical estimates of the wage equation (2.7) proved unstable. It was particularly difficult to find a statistically significant and robust role for excess demand (unemployment) on wages. Unemployment itself was determined by a simple identity between employment and the labour force:

$$U = L - N . \tag{2.10}$$

The labour force (L) was treated as predetermined apart from demographic trend, and employment (N) was based on an inverted production function where employment lagged behind output:

$$N = f(Y) . \tag{2.11}$$

Given the fact that the main source of supply-side influence was through the wage equation, the policy implications which emerge are that demand policies could have powerful effects on output and employment with little role or need for supply-side policies (Whitley 1994: 44).

Supply-side economics, however, stresses the need to take into account the effects of economic policies on incentives to save, invest and work. Therefore, some of the macro models have been modified to take into consideration the effects of fiscal policies on savings, investment, labour supplied, productivity and inflation (Hailstones 1982: 103-104).

Two such models are the Wharton and Evans models. In a version of the Evans model (1980), for example, *the real after-tax interest rate* was added to factors such as disposable income and the price of non-durable consumer goods relative to the price of other consumer goods as a determinant of the consumption of non-durable goods. Thus, a higher after-tax interest rate yield resulting from a tax reduction would encourage saving and lessen consumption. In another equation in the model *the real after-tax wage rate* was added to lagged inflation and lagged unemployment as a determinant of the labour participation rate .

In traditional macro models, a tax cut was always followed by increasing demand and inflation, whereas the supply-side extensions endeavour to show tax cuts raising productivity, increasing supply and reducing inflation as well.

Thus, a cut in taxes would show a higher labour participation rate as the real after-tax wage increased.

Neither the Keynesian nor earlier supply-side models adequately explain stagflation, the simultaneous occurrence of unemployment and inflation. This is because both types of models treat inflation as a full employment phenomenon, which calls for a decrease in effective demand on the Keynesian income-output model (consumption function model) or an increase in the quantity supplied on a supply-side model. Closer inspection of the models, however, would indicate that if inflation occurs at less than full employment, a lowering of the supply price on the Keynesian aggregate demand-aggregate supply model would grant some relief. In a supply-side model an increase in supply (as opposed to an increase in the quantity supplied) will ease inflationary pressure.

Supply-side econometric models need to provide a framework for designing anti-inflationary measures that do not aggravate unemployment during periods of stagflation. In fact, it appears that the answer during such periods is to find ways to reduce the cost of supply rather than increase supply. If the economy is suffering from stagflation, it implies that there is ample supply but insufficient demand to clear the market. Increasing the supply, without a reduction in cost may merely result in inventory accumulation. But, reducing the cost of supply would permit a reduction in price that would generate an increase in the quantity demanded.

2.3.2 Adapted neoclassical approach

Macroeconomic models came under heavy attack in the late 1970s. They had long been criticised for inadequate theoretical foundations, but began to exhibit serious forecasting failures. Their main failure was the inability to predict stagflation, the simultaneous occurrence of unemployment and inflation.

Changes in macroeconomic modelling came not only from the monetarist and rational expectations[1] challenges, but from the frequency of supply shocks during the 1970s, the need to relate to the new economic policies of the 1980s, and the desire for greater theoretical consistency.

The macroeconomic models started to take up the above-mentioned challenges in the 1980s. They utilised a neoclassical framework, albeit with several critical differences. The changes in the models were evolutionary, rather than revolutionary.

The neoclassical approach can be characterised as a combination of market clearing and rational expectations, and it emphasises the role of stocks rather than flows. The neoclassical approach stresses the supply-side of the economy, not through the inclusion of an explicit production function, but rather through a representation of the labour market which is responsive to changes in benefits and taxes, but not to the level of demand. The approach adopted by the mainstream models has not been to follow the competitive paradigm of the classical school; instead, development was centred around a framework of imperfect competition in goods and labour markets, and the adoption of a bargaining approach to wage determination, following the work of Layard and Nickell[2] (1985).

The general acceptance of this framework has meant that wage equations are now specified in terms of the level of real wages. Real wages are in principle affected by any factors that influence the bargaining strengths of employers and employees (such as trade unions), including supply-side variables such as tax rates, unemployment benefits and labour market mismatch. Here the need to model the *incentive* effects of the new macroeconomic policy is evident, although the tax coefficients are typically ill defined in empirical work.

An additional feature of the Layard-Nickell approach is the incorporation of demand pressure

[1] Based on the Lucas critique.

[2] See Nickell (1988) for a detailed exposition of the derivation and structural properties of neoclassical supply-side models.

variables in price-setting, although the specification remains largely cost based. Layard and Nickell emphasise that the long-run solution to the wage and price equations delivers the non-accelerating inflation rate of unemployment (NAIRU). Although both the true neoclassical and the Layard-Nickell approaches support the principle of no long-run trade-off between inflation and unemployment, the concept of the unemployment equilibrium differs. The natural rate of the neoclassical school relates to a competitive solution given the existence of market imperfections, whereas the Layard-Nickell (LN) framework and its NAIRU is based on a bargaining process under imperfect competition (Whitley 1994: 48).

The Layard-Nickell approach is generally accepted as the neoclassical framework for modelling supply-side behaviour and is adopted by many mainstream macroeconomic models, albeit with several structural differences.

The neoclassical approach views inflation as determined wholly by excess money, but the LN supply-side approach holds the view that inflation is generated by excess demand in goods and labour markets and by the inconsistency of wage claims by the unionised sector with the wage that employers are prepared to concede (the *affordable wage*). A necessary feature of the supply-side approach is not only that inflation is generated by additional demand, but that higher inflation itself reduces demand so that in the long-run output is supply determined. Many models have incorporated a measure for capacity utilisation to capture the inflationary effects of excess demand. Although investment expenditures are now more sensitive to inflation than before, often through liquidity effects, the key demand elements which are sensitive to inflation are net trade and consumption.

The developments in macroeconomic models can broadly be summarised by the following set of stylised equations:

Income-expenditure identity:	$Y = C + I + G + \Delta IV + X - M$	(2.12)
Consumption:	$C = c(Y, r, W)$	(2.13)
Investment:	$I = i(Y, w/ck)$	(2.14)
Changes in inventories:	$\Delta IV = v(Y, cv)$	(2.15)
Imports:	$M = m(Y, cu, ep/p^*)$	(2.16)
Exports:	$X = x(Y^*, cu, ep/p^*)$	(2.17)

The consumption equation now includes a role for interest rates (r) and real wealth (W). Investment is influenced by relative factor prices (w/ck) or simply the real cost of capital depending on the precise derivation used, and changes in inventories is influenced by the cost of inventory changes (cv). Exports and imports are additionally determined by capacity utilisation (cu). The implications are that aggregate demand is more interest elastic than before and monetary factors are more important through their direct influence on consumption, investment and inventory changes.

Aggregate supply, based on cost minimising behaviour in the LN-framework, can be described by the following equations:

Wage:	$w - p = w(U, t, z, ep / p^*)$	(2.18)
Price:	$p = p(cu, (w - \pi), ep / p^*)$	(2.19)
Exchange rate:	$e = e(e^e, r - r^*, \gamma)$.	(2.20)

Wages (w) now respond to excess demand (represented by unemployment, U), a vector of tax rates (t), the real exchange rate and wage-push variables (z). The price mark-up (p) is sensitive to demand pressure (cu) and prices charged abroad (ep / p^*). The exchange rate is dependent on future expectations of the exchange rate (e^e), relative interest differentials ($r - r^*$) and a risk premium (γ) is included. Expectations may appear additionally in wage equations (expected prices) or in the demand equations (expected output).

2.4 COMPARISON OF THE STRUCTURAL PROPERTIES OF THE MAINSTREAM SUPPLY-SIDE MODELS

The modelling of the supply-side and particularly the role of taxes have been made possible by the use of the LN framework. Although the LN framework is generally accepted as the leading neoclassical supply-side modelling approach, many macroeconomic models have not yet adopted this framework, but still follow the standard Phillips curve approach. The mainstream models, which have revised their structures to incorporate the neoclassical approach, have however applied the LN principles in several different ways. For purposes of this study it is useful to investigate the main structural properties and differences amongst those supply-side models which have adjusted to the LN framework.

The main differences between the so-called mainstream supply-side models are based on the following conceptual issues:

(i) A cost or a production function approach, i.e. an explicit or implicit incorporation of the production technology;

(ii) The functional form and underlying production technology for the cost/production function;

(iii) Measurement or estimation of technical progress;

(iv) The incorporation and/or measurement of capacity utilisation (expenditure/demand *versus* production/supply as measure for actual output);

(v) The role of potential output;

(vi) The role of the NAIRU/NAWRU;

(vii) Investment (neoclassical/Jorgenson v. Cash flow *v*. Tobin's q);

(viii) A measure for user-cost-of-capital;

(ix) A market-clearing *versus* a non-market clearing approach in labour modelling;

(x) Wage-setting model (framework of market imperfections: union-firm wage-bargaining);

(xi) Price-setting model (framework of market imperfections: mark-up on unit cost of production);

The main differences are made explicit by the modelling research conducted in the UK on the one hand and the models constructed by the OECD on the other hand. The model of the London Business School (LBS) may be regarded as representative of the main properties of the UK models.

A summary of the structural properties of the LBS and OECD models are reported in table 2.1.

2.5 CONCLUSION

Supply-side modelling has become imperative if a macro-econometric model is to be useful for policy analyses that go beyond short-term forecasting requirements. However, the structure and specification of supply-side models should be such that they are consistent with theoretical principles and that they are successful in forecasting stagflation, the simultaneous occurrence of unemployment and inflation.

Against this background, the theoretical principles of supply-side economics were explored, as they need to form the basis in the development of a supply-side macro-econometric model of the South African economy. Supply-side effects and particularly the role of taxes, which are the main

Table 2.1 Structural properties of neoclassical supply-side models based on the Layard-Nickell framework

Structural properties		LBS	OECD
Production	*Cost/production approach*	Cost function	Production function
	Functional form	Translog	Cobb-Douglas and CES
	Technical progress	Labour augmenting (Harrod neutral)	Labour augmenting (Harrod neutral)
Capacity utilisation (cu)	*Actual output*	n.a.	Actual output estimated by production function
	Potential output	n.a.	Normal (trending) output, a structural production function approach
Investment	*Model*	Tobin's q	Neoclassical (Jorgenson)
	User-cost-of-capital (r)	Rental cost	User-cost-of-capital (r) = f(price of capital, depreciation, rates of return)

Labour: demand	*Market- or non-market clearing*	Non-market clearing approach, assuming NAIRU	Non-market clearing approach, assuming NAWRU
Labour: supply	*Exogenous/LFP*	Labour force participation function	Labour force participation function
Wage-setting	*Model*	Wage-bargaining & wage productivity	Wage-bargaining & wage productivity
Price-setting	*Model*	Mark-up on unit costs	Mark-up on unit costs, cu, r
Expectations		Learning in exchange rate function	none

supply-side instruments, are modelled within a neoclassical framework of profit maximising or cost minimising behaviour of firms.

The neoclassical approach can be characterised as a combination of market clearing and rational expectations and it emphasises the role of stocks rather than flows. The neoclassical approach emphasises the supply-side of the economy, not through the inclusion of an explicit production function, but rather through a representation of the labour market which is responsive to changes in benefits and taxes, but not to the level of demand. The approach adopted by the mainstream models has not been to follow the competitive paradigm of the classical school; instead development centred around a framework of imperfect competition in goods and labour markets and the adoption of a bargaining approach to wage determination, following the work of Layard and Nickell (1985).

These neoclassical principles are adopted in several, but different ways by macro-economic modellers. The structural properties of the existing (mainstream) supply-side models were investigated to see how they compare in modelling the neoclassical and associated supply-side principles. It can be concluded that the Layard-Nickell framework for neoclassical supply-side modelling is consistent with both the theoretical and policy principles of supply-side economics and need to form the basis in the development of a consistent supply-side model of the South African economy.

CHAPTER 3

THE SOUTH AFRICAN MACROECONOMIC MODEL AND SUPPLY-SIDE ECONOMICS

3.1 INTRODUCTION

The purpose of the study is to develop a theoretically consistent supply-side model of the South African economy. The ultimate objective is to integrate the supply-side model with a full-sector macroeconomic model of South Africa. The macroeconomic model developed by the econometric research team of the University of Pretoria (SAMEM) is used for this purpose.

The structure of the SAMEM, currently used for forecasting and policy analysis purposes, is demand-driven and therefore vulnerable to valid theoretical and empirical points of critique (see chapter 2). The appropriate solution for maintained theoretical consistency and a consistent framework for policy analysis, is to develop a neoclassical supply-side model based on the principles of the Layard-Nickell framework discussed in chapter 2.

The purpose of this chapter is four-fold:

(i) to present a brief outline of the current structure and shortcomings of SAMEM;
(ii) to restructure SAMEM for the incorporation of a neoclassical supply-side model;
(iii) to identify the properties and objectives of the supply-side model; and
(iv) to present an outline of the proposed methodology for the development of the supply-side model.

3.2 THE STRUCTURE OF THE SOUTH AFRICAN MACROECONOMIC MODEL (SAMEM)

The macroeconomic model of the Department of Economics of the University of Pretoria was originally developed in 1974 with the purpose of short and medium-term forecasts of the South African economy. The original model was developed by De Wet and Dreyer (1976, 1978). Further expansion and developments on the monetary sector were undertaken by De Wet and Herbst (1981) and later by De Wet and Jonkergouw (1995). De Wet and Van der Walt (1994) developed the trade balance as satellite model of the balance of payments sector.

SAMEM consists of three sectors: the real sector, the balance of payments (of which the trade balance is a satellite model) and the monetary sector. The real sector is concerned with the specification of production, expenditure and income and is based on the income-expenditure approach with the level of output and employment principally determined by the level of demand. The current structure of the model is represented by the set of equations in table 3.1 with an explanatory list of variables in table 3.3.

Table 3.1 Structural equations of SAMEM*

Aggregate Demand		
Income-expenditure identities	$yb = bbb - zgnfd + xgnfd + residu$	(3.1)
	$BBB = CDS + CND + IPNL + IV + IPL + CG + IG + RESIDU$	(3.2)
	$bbb = BBB / Pbbb$	(3.3)
	$ybnl = yb - ybl$	(3.4)
	$YB = yb * Pbbp$	(3.5)
Disposable income	$PC = YB - TI - WNLLNL - WLLL$	(3.6)
	$SC = PC - DE - NEBC - TC - OC$	(3.7)
	$YD = YB - SC - FB - DE - TC - TP - TI - YE + OGB - RESIDU$	(3.8)
	$yd = YD / Pv$	(3.9)
Consumption	$cds = f(yd, ESKOM)$	(3.10)
	$cnd = f(M3)$	(3.11)
	$CDS = cds * Pcds$	(3.12)
	$CND = cnd * Pcnd$	(3.13)
Investment	$ipnl = f(bbb, ESKOM)$	(3.14)
	$kvnl = 0.995 * kvnl_{t-1} + ipnl + ig$	(3.15)
	$IPNL = ipnl * Pi$	(3.16)
	$IPL = exogenous$	(3.17)
Government	$CG = exogenous$	(3.18)
	$IG = exogenous$	(3.19)
Change in inventories	$IV = exogenous$	(3.20)
Imports	$zgnfd = ZGNFD / Pz$	(3.21)
Exports	$xgnfd = XGNFD / Px$	(3.22)
Excess demand	$SV = bbb / yb$	(3.23)
Aggregate supply		
Wage	$WNL = exogenous$	(3.24)
Prices	$Pz = f(Pxi, r\$, Pz_{t-1})$	(3.25)
	$Px = f(Pwkm)$	(3.26)
	$Pbbp = f(LPEU, SV, Px)$	(3.27)
	$Pbbb = f(LPEU, SV, Pz)$	(3.28)
	$Pcnd = f(Pbbb)$	(3.29)
	$Pcds = f(Pbbb)$	(3.30)
	$Pv = f(Pcnd, Pcds)$	(3.31)
	$Pi = f(Pbbb)$	(3.32)
Employment	$LNL = f(ybnl)$	(3.33)
	$LPEU = WNLLNL / ybnl$	(3.34)
	$WNLLNL = WNL * LNL$	(3.35)
Unemployment	*None*	(3.36)

* Lower case denotes real values (constant prices) and upper case nominal values.

Equation 3.1 is the standard national income accounting identity in constant prices, divided into two components, namely domestic expenditure (consumer expenditure, fixed investment, government spending and investment and changes in inventories) and net exports (exports and imports). Disposable income in nominal terms (equation 3.8) is computed by subtracting net payments and transfers by households, as well as business and foreign enterprises' shares in income from GDP. Households' expenditure is again divided into two components, i.e. consumption of durable and semi-durable goods (equation 3.10) and consumption of non-durable goods and services (equation 3.11). Personal consumption of durable and semi-durable goods is explained by real disposable income and credit restrictions, i.e. the bond or long-term interest rate (ESKOM). Consumption of non-durable goods and services depends on the cash flow situation of households and is therefore explained by the broad money supply (M3). The change in inventories is an exogenous variable and fixed investment is explained by a simple accelerator model (change in output) with some allowance for interest rate effects. Although a distinction is made between government consumption and investment, both components are exogenous due to the nature of government spending in South Africa. Exports and imports (equations 3.21 and 3.22) enter the real sector after being endogenously determined in the balance of payments sector of the model. They are dependent on domestic and foreign income, relative or competitive prices (domestic prices relative to foreign prices) and the export and import prices of goods and services respectively. Excess demand (equation 3.23) is defined and utilised as the demand pressure variable in the price-setting equations.

The determination and treatment of aggregate supply is very rudimentary and almost non-existent. The underlying production structure, technology and supply constraints of the economy are totally ignored. Wages (equation 3.24) are exogenous (not even explained in terms of the already out-dated Phillips curve mechanism) and influence domestic prices through the wage per unit of output (equation 3.34). Employment (equation 3.33) is explained in terms of the level of output and no recognition is given to an equilibrium level of unemployment, market imperfections and the role of labour unions in the economy. Since wages are exogenous, there is no need to derive the level or rate of unemployment for the economy. Unemployment therefore has no contemporaneous feedback in the model and its role is totally ignored.

The policy implications are that demand policies could have powerful effects on output and employment with no role for supply-side policies.

Based on the above analysis of the structural properties and limitations of SAMEM, it is necessary to improve the theoretical foundations, as well as the forecasting and policy analysis ability of the existing model by incorporating a consistent neoclassical supply-side model of the South African economy. This process is conducted in two steps. First, restructure the existing demand-driven model to create the necessary links between demand (expenditure) and supply. Second, develop (specify, derive and estimate) a supply-side model that is consistent with the neoclasscial theory of profit maximisation or cost minimisation of firms and consistent with a supply-side policy framework.

3.3 RESTRUCTURING THE SOUTH AFRICAN MACROECONOMIC MODEL (SAMEM) TO INCORPORATE A CONSISTENT SUPPLY-SIDE MODEL

Two distinct approaches can be identified for modelling the supply-side of an economy: first, the use of an explicit production function and, second the cost function approach. The advantage of the cost function approach is that it enables the consistent derivation of price, wage and demand functions within a neoclassical supply-side framework, a feature which the production function approach does not include. Where a production function is explicitly estimated, it can be used to derive estimates for capacity utilisation, but the cost function approach typically has to resort to indirect measures or independent equations to determine capacity utilisation.

Before any restructuring of SAMEM can be done, it is necessary to decide on either a production or cost function approach. The production function approach is opted for in this study, since it allows the estimation of capacity utilisation – a key variable in linking production constraints with demand behaviour via costs and prices. However, based on the theoretical consistency of the cost function approach, an attempt will be made to estimate a cost function directly for the South African economy, and derive consistent functions for production (based on Shephard's duality principles), prices and factor demands (see chapter 4 for a detailed discussion).

Restructuring SAMEM to incorporate a supply-side model, therefore necessitates the following adjustments and additions to the existing structural relationships:

(i) Replace the income-expenditure identity (equation 3.1) with a stochastic production function (equation 3.50). Introduce an identity to match gross domestic production at factor cost and market prices (equation 3.51).
(ii) Include an estimate of potential output (equation 3.52).
(iii) Included an estimate for capacity utilisation (equation 3.53).
(iv) Substitute the employment function (equation 3.33) with a labour market model (equations 3.60, 3.62, 3.63 and 3.54), assuming non-market clearing behaviour within a framework of market imperfections.
(v) Substitute exogenous wages (equation 3.24) with a wage-setting equation consistently derived from cost-minimising behaviour within a framework of collective bargaining, thus allowing for the role of labour unions (equation 3.54).
(vi) Substitute the accelerator model for fixed investment (equation 3.14) with a neoclassical model (Jorgenson) for investment, allowing for taxes, depreciation rates, asset value prices and inflation to contribute to the unit-cost-of-capital. Extend the investment model to incorporate the financial constraints on investment, which are very real in the South African scenario (equation 3.45).
(vii) Include an identity for the financing of investment, consistent with the structure of the national accounts (equation 3.41).
(viii) Include a stochastic equation for corporate savings as part of the identity for financial constraints (equation 3.43).

(ix) Replace the domestic price equations (3.25 to 3.28) with equations consistently derived within a framework of cost minimising and market imperfections (equations 3.55, 3.56, 3.65 and 3.66).

(x) Link demand and supply by substituting exogenous inventory changes (equation 3.20) with an identity where inventory changes drop out as the difference between supply-side production and expenditure on gross domestic product (equation 3.49).

(xi) Adjust the identities for gross domestic expenditure to be consistent with the new framework (equations 3.37 and 3.38).

Without specifying the detail of the different supply-side equations, the restructured SAMEM are presented in table 3.2.

Table 3.2 Structural equations of amended SAMEM to incorporate a consistent supply-side model of the South African economy*

Aggregate Demand		
Income-expenditure identities	$bbb = cnd + cds + cg + i + residu$ $BBB = bbb * Pbbb$ $ybnl = yb^{A}_{@m} - ybl$ $YB^{A}_{@m} = yb^{A}_{@m} * vpi$	(3.37) (3.38) (3.39) (3.40)
Disposable income	$FINCON = SP + SC + SG + DE + NETCAPFL + GOLD\_RESERV$ $GOSTC = GOS - TC$ $SC = f(GOSTC)$ $fincon = FINCON / ppi$ $YD = YB - SC - FB - DE - TC - TP - TI - YE + OGB - RESIDU$ $yd = YD / Pv$	(3.41) (3.42) (3.43) (3.44) (3.8) (3.9)
Consumption	$cds = f(yd, ESKOM)$ $cnd = f(M3)$ $CDS = cds * Pcds$ $CND = cnd * Pcnd$	(3.10) (3.11) (3.12) (3.13)
Investment	$i_{fix} = f(yb^{A}_{@f}, ucc, fincon, k)$ $k = 0.95 * k_{t-1} + i_{fix}$ $i = i_{fix} + iv$ $I = i * Pi$	(3.45) (3.46) (3.47) (3.48)
Government	$CG = exogenous$ $IG = exogenous$	(3.18) (3.19)
Change in inventories	$iv = yb^{A}_{@f} - bbb - xgnfd + zgnfd - residu$	(3.49)
Imports	$zgnfd = ZGNFD / Pz$	(3.21)
Exports	$xgnfd = XGNFD / Px$	(3.22)
Excess demand	$SV = bbb / yb^{A}_{@m}$	(3.23)
Aggregate supply		
Production	$yb^{A}_{@f} = f(k, N, technical\ progress)$ $yb^{A}_{@m} = yb^{A}_{@f} + ti$	(3.50) (3.51)

	$yb^{P}_{@f} = f(k, N^{pot}, technical\ progress^{smooth})$	(3.52)
Capacity utilisation	$cu = yb^{A}_{@f} / yb^{P}_{@f}$	(3.53)
Wages	$w = f(product, vpi^{e})$	(3.54)
Prices	$Pz = f(Pxi, r\$, Pz_{t-1})$	(3.25)
	$Px = f(Pwkm)$	(3.26)
	$Pbbp = f(ppi)$	(3.65)
	$Pbbb = f(vpi)$	(3.66)
	$ppi = f(w / product, ucc)$	(3.55)
	$vpi = f(ppi, pz\$, r\$, SV)$	(3.56)
	$Pcnd = f(vpi)$	(3.57)
	$Pcds = f(vpi)$	(3.58)
	$Pv = f(Pcnd, Pcds)$	(3.31)
	$Pi = f(ppi)$	(3.59)
Employment	$N = f(yb^{A}_{@m}, w / ucc)$	(3.60)
	$N^{pot} = f(L^{smooth}, NAWRU)$	(3.61)
	$product = yb^{A}_{@m} / N$	(3.62)
Labour force	$L = f(total\_pop, w)$	(3.63)
Unemployment	$U = L - N$	(3.64)

* Lower case denotes real values (constant prices) and upper case nominal values.

Table 3.3 Explanatory variable list for SAMEM*

bbb (BBB)	Gross domestic expenditure
cds (CDS)	Consumption, durable and semi-durable goods
CG	Public consumption
cnd (CND)	Consumption, non-durable goods and services
cu	Capacity utilisation
DE	Depreciation allowances
ESKOM	Long-term interest rate
FB	Factor payments (net)
fincon (FINCON)	Financing of gross domestic investment (financial constraint)
GOLD_RESERV	Change in gold and other foreign reserves
GOS	Gross operating surplus
GOSTC	Gross operating surplus, adjusted for direct company taxes
i	Gross domestic investment
i_{fix}	Gross domestic fixed investment
ig (IG)	Public investment
IPL	Investment, private agricultural sector
ipnl (IPNL)	Investment, private non-agricultural sector
IV	Change in inventories
k	Capital stock
kvnl	Capital stock, non-agricultural sector
L	Labour force: economic active population
L^{smooth}	Smoothed labour force (time-series technique such as Hodrick-Prescott filter)
LNL	Employment, non-agricultural sector
LPEU	Wage per unit output
M3	M3 money supply
N	Employment
N^{pot}	Potential employment
NAWRU	Non-accelerating wage rate of unemployment
NEBC	Net income from property
NETCAPFL	Net capital flow

OC	Net transfers made to households, general government and rest of the world
OGB	Transfers from government and foreign sector
Pbbb	Deflator: gross domestic expenditure
Pbbp	Deflator: gross domestic product
PC	Profits of companies
Pcds	Deflator: consumption, durable and semi-durable goods
Pcnd	Deflator: consumption, non-durable goods and services
Pi	Deflator: investment
ppi	Production price index
product	Labour productivity
Pv	Deflator: total consumption
Pwkm	World commodity price index
Px	Deflator: total exports
Pxi values	Deflator: industrial countries export unit values
Pz	Deflator: total imports
Pz$	Deflator: total imports in US dollar
r$	Rand/dollar exchange rate
RESIDU (residu)	Residual
SC	Corporate saving
SG	Saving of general government
SP	Personal saving
SV	Excess demand
TC	Taxes on companies
TI (ti)	Net indirect taxes
total_pop	Total population
TP	Personal taxes
U	Unemployment
ucc (UCC)	User-cost-of-capital
vpi	Consumer price index
vpi^e	Expected consumer prices
w	Total wage rate
WLLL	Wage income, agricultural sector
WNL	Wage rate, non-agricultural sector
WNLLNL	Wage income, non-agricultural sector
yb (YB)	Gross domestic product at market prices
$yb^A_{@f}$	Actual gross domestic product at factor cost
$yb^A_{@m}$	Actual gross domestic product at market prices
$yb^P_{@f}$	Potential gross domestic product at factor cost
ybl	Gross domestic product, agricultural sector
ybnl	Gross domestic product, non-agricultural sector at market prices
yd (YD)	Personal disposable income
YE	Private income from property minus interest on public debt
xgnfd (XGNFD)	Exports of goods and non-factor services
zgnfd (ZGNFD)	Imports of goods and non-factor services

* Lower case denotes real values (constant prices) and upper case nominal values.

3.4 THE PROPERTIES AND OBJECTIVES OF THE PROPOSED SUPPLY-SIDE MODEL

Given the deficiencies of demand-side models identified in chapter 2, the analysis and proposed new structure of SAMEM, as well as the proposed Layard-Nickell framework for a consistent neoclassical supply side, the following objectives are identified for the development of a supply-side model of the South African economy:

The *primary objectives* are:

(i) To develop an aggregate neoclassical supply-side model of the South African economy, pertaining to the structural and long-run properties of the economy, as well as the profit maximising and cost minimising decision-making processes of firms;
(ii) To specify, derive and estimate every structural relationship (equation) of the model jointly for the purpose to ensure consistency between costs, demand factors and prices throughout the analytical framework;
(iii) To incorporate an estimate for capacity utilisation which serves as a significant variable in explaining price and wage-setting behaviour and influences every key macroeconomic variable in a well-developed supply-system;
(iv) To endogenise technical progress in the cost/production relationship;
(v) To incorporate price expectations;
(vi) To allow for the specific and rather unique characteristics of the South African economy;
(vii) To incorporate a set of target or policy variables allowing for policy proposals with specific reference to labour problems in South Africa; and
(viii) To maintain a balance between the detail required for policy analysis and the stability of the model to ensure reliable forecasts.

A number of *conceptual issues* have to be decided on and dealt with to achieve the above-mentioned objectives:

(i) A cost or a production function approach in estimating the structural production properties of the South African economy;
(ii) An appropriate functional form and underlying production technology for the cost/production function;
(iii) An appropriate measure or estimate for technical progress;
(iv) Assumptions about the factor intensity of production and the returns to scale property of the South African production structure;
(v) An appropriate measure for capacity utilisation (expenditure/demand *versus* production/supply as measure for actual output);
(vi) An appropriate measure for potential output;
(vii) An appropriate measure for the NAIRU/NAWRU;
(viii) An appropriate model for investment (neoclassical/Jorgenson *versus* cash flow *versus* Tobin's q);
(ix) A measure for user-cost-of-capital;
(x) A market-clearing *versus* a non-market clearing approach in modelling labour;
(xi) A distinction between skilled and unskilled labour;
(xii) An appropriate wage-setting model (framework of market imperfections: union-firm wage-bargaining);
(xiii) An appropriate price-setting model (framework of market imperfections: mark-up on unit cost of production);
(xiv) Exclusion (standard approach) *versus* inclusion of unit cost of capital;

Developing a supply-side model consistent with the above-mentioned objectives entails the estimation of equations for the following structural relationships:

(i) production (following a cost function approach);
(ii) potential production;
(iii) capacity utilisation;
(iv) fixed investment;
(v) corporate saving;
(vi) demand for labour (skilled, unskilled and labour participants in the informal sector);
(vii) labour supply (total and skilled with unskilled as the residual);
(viii) wage-setting (skilled and unskilled);
(ix) unemployment (total, skilled and unskilled); and
(x) price-formation (production and consumption prices).

3.5 ESTIMATION METHODOLOGY

Having stated the objectives and specified the framework for the development of a neoclassical supply side of the South African economy, the next step would be to estimate single equations for each of the above-mentioned relationships within a consistent framework of cost minimising, assuming market imperfections.

The estimation technique used is the Engle and Yoo (1989) three-step cointegration procedure, which is an extension of the Engle-Granger (1987) two-step procedure (see Appendix 1 for an exposition of the technique).

The estimation of every single equation consists of:

(i) an investigation of the theoretical foundations;
(ii) specification of a consistent theoretical/empirical model;
(iii) the data generating process and subsequent identification of the univariate characteristics of the data;
(iv) cointegration (long-run or equilibrium) estimation (Engle-Granger first step);
(v) estimation of the short-run dynamics, i.e. the error correction model (Engle-Granger second step);
(vi) diagnostic testing;
(vii) cointegration correction and adjustment of long-run coefficients (Engle-Yoo third step);
(viii) ex-post dynamic simulation of the model;
(ix) computation and evaluation of the simulation error statistics (Appendix 2); and
(x) investigation and evaluation of the dynamic response properties and robust nature of the model.

The estimated single equations are then combined into a neoclassical supply-side model of the South African economy. The system is closed by introducing a number of identities and definitions, linking every endogenous variable in the model and thereby ensuring a fully dynamic system.

The model is subsequently dynamically simulated and evaluated along the criteria (full ideal principles of model selection) set out in Appendix 3.

First, the theoretical structure of the estimated model (empirical specification) is evaluated to determine the extent to which the model complies with (1) the *a priori* objectives of neoclassical supply-side modelling, (2) economic theory – for the model in general and the individual equations in particular, (3) rival models, i.e. to what extent the model encompasses the characteristics of rival models, and (4) policy analysis, i.e. the relevancy of the specified model for policy analysis.

Second, a simulation (i.e. *ex post* forecast) of the full system of equations is conducted. These dynamic simulation properties of the model are evaluated in terms of (1) the statistical significance (*ex post* forecast ability) and (2) the stability of the model over the simulated sample range. The statistical significance (goodness-of-fit) of the full system is measured in terms of simulation/forecast error statistics and confirmed by the graphical representations of the simulations.

Third, a series of dynamic, ex-post simulations are conducted by shocking every stochastic variable in the system. The simulation results are used to (1) determine the long-run (steady-state) multipliers and elasticities of the system and, once again, (2) to evaluate the statistical significance and sensitivity of the model in terms of the degree, speed and stability of convergence. The robust (stable) nature of the model serves as an indication of the forecasting ability of the model.

Finally, the supply-side model of South Africa will be utilised in a policy analysis of the unemployment problem in South Africa. The purpose is to identify and validate a set of policy proposals that will increase the labour absorption capacity of the economy and subsequently reduce the unemployment problem.

3.6 CONCLUSION

In this chapter the structural properties (demand-driven) and inadequacies of SAMEM are identified given the theoretical and empirical points of critique raised against demand-driven models in Chapter 2. A new structure is proposed, incorporating a consistent neoclassical supply side and allowing for the principles of the Layard-Nickell framework. The subsequent properties and objectives of the neoclassical model are identified. The chapter concludes with an outline of the proposed methodology to be followed in the development and application of the supply-side model.

CHAPTER 4

A NEOCLASSICAL PRODUCTION FUNCTION FOR THE SOUTH AFRICAN ECONOMY: THEORY AND EVIDENCE

4.1 INTRODUCTION

In the past two decades supply-side theory, policy and the modelling thereof, have become more popular in the field of economics. This is due to the inadequacy of demand-oriented theory and policy to explain and deal with unemployment and inflation. It is increasingly recognised that the cost-minimising or profit-maximising decision-making processes of the firms responsible for production activities in the economy, need to be examined and modelled. Supply-side economics stresses the necessity of understanding the structure of the production process and the effect of each of the production factors on the level of output. A further aspect to be taken into account when modelling supply-side behavioural equations, is the incorporation of supply-side policy instruments and their effect on the economy (Nickell 1988: 202).

The purpose of this chapter is to estimate an aggregate neoclassical production function for the South African economy as the key component of a supply-side model. The production function may then be used to analyse the production structure and properties of the South African economy. At the macro-level the production function may be used to explain economic growth, the prices of various factors of production and the extent to which these factors are utilised. At a micro-level, a production function is useful to analyse the degree of substitution between the various factors of production and also the extent to which firms experience decreasing or increasing returns to scale as output expands. On both macro- and micro-level, the production function may be used as a tool to assess the proportion of any increase (decrease) in output over time which may respectively be attributed to, firstly, increases (decreases) in the inputs of factors of production; secondly, to the existence of increasing (decreasing) returns to scale; and thirdly, to the technical progress (or lack of it) taking place in the economy.

Two aspects need consideration when estimating a production function:

(i) the functional form; and
(ii) whether to estimate the production function directly or to estimate a cost function and derive a consistent production function based on duality principles.

Although there are certain advantages to the latter option, duality principles - according to which unique relationships exist between the coefficients of cost and production functions - only apply to restricted functional forms. Examples of these restricted forms are the Cobb-Douglas and the Constant Elasticity of Substitution (CES) functional forms. The Transcendental logarithmic (Translog) form is an example of a more flexible functional form for which the duality principles do not apply. Two different avenues are therefore explored:

(i) A Cobb-Douglas cost function is estimated and used to derive and develop a consistent production function based on duality principles.

(ii) Given the advantages of the more flexible Transcendental Logarithmic (Translog) functional form, the non-homothetic Translog cost function is estimated and tested for the validity of the imposed restrictions, so that it can reduce to the Cobb-Douglas cost function. If the Translog cost function cannot collapse into a Cobb-Douglas cost function, an equivalent Translog production function has to be estimated by imposing restrictions, similar to the ones validly imposed when estimating a cost function.

Once a production function has been estimated based on the above principles, the properties of the South African production structure can be evaluated and interpreted.

4.2 THE THEORETICAL FRAMEWORK: A SURVEY OF THE FUNCTIONAL FORMS FOR PRODUCTION

Several functional forms[1], each representative of the technology of production, evolved from attempts to estimate production behaviour by means of mathematical and statistical modelling. Of the many functional forms, the most commonly used are the Cobb-Douglas, Constant Elasticity of Substitution (CES), Variable Elasticity of Substitution (VES), Transcendental logarithmic (Translog) and the generalised Leontief functions. In order to select the appropriate functional form, the properties of the Cobb-Douglas, CES and the Translog functional forms should be analysed.

The Cobb-Douglas and CES functional forms represent a constant elasticity of substitution production structure. The first has the unique property of a unitary elasticity of substitution, while the latter allows for a less restrictive, not necessarily unitary, but still constant elasticity of substitution. The Transcendental logarithmic (Translog) functional form is representative of a more flexible, variable elasticity of substitution production structure.

4.2.1 The Cobb-Douglas functional form

The best known production function is the Cobb-Douglas function. The Cobb-Douglas production function, first published by C.W. Cobb and P.H. Douglas in 1934, has the following functional form[2]:

$$Q = AV_1^{\alpha}V_2^{\beta} \tag{4.1}$$

with

[1] See Appendix 5 for a review on the theory of production functions.

[2] Cobb and Douglas originally constrained the exponents of V_1 and V_2 so that they sum to unity, i.e. to embody constant returns to scale and therefore reducing the functional form to:

$$Q = AV_1^{\alpha}V_2^{1-\alpha}$$

The production function can also be generalised to incorporate more than two inputs. The form then becomes:

$$Q = AV_1^{\alpha}V_2^{\beta}V_3^{\delta}....V_n^{\Omega}$$

Q = output or production (value added);
A = efficiency parameter[3] (A > 0);
V_i = production factors (inputs) with i = 1, 2 ; and
α and β = input elasticities of production with respect to V_1 and V_2 ($0 < \alpha, \beta < 1$).

The Cobb-Douglas production function has a number of convenient properties.

The marginal products (MP) of the inputs are given by:

$$MP_1 = \frac{\partial Q}{\partial V_1} = \alpha A V_1^{\alpha-1} V_2^{\beta} = \alpha \frac{Q}{V_1}, \qquad MP_2 = \frac{\partial Q}{\partial V_2} = \beta A V_1^{\alpha} V_2^{\beta-1} = \beta \frac{Q}{V_2} \tag{4.2}$$

Both are positive (α, $\beta > 0$) and diminishing (α, $\beta < 1$). Assuming the firm is a price-taker and a profit maximiser, equations 4.2 imply that the marginal productivity conditions for this production function are:

$$\alpha \frac{Q}{V_1} = \frac{p_1}{p}, \qquad \beta \frac{Q}{V_2} = \frac{p_2}{p} \tag{4.3}$$

that can be rewritten as

$$\alpha = \frac{p_1 V_1}{pQ} \quad \text{and} \quad \beta = \frac{p_2 V_2}{pQ} \tag{4.4}$$

Thus, if the marginal productivity conditions hold, the exponents α and β in the Cobb-Douglas function are equal to the respective shares of the inputs in the value of total output.[4]

The cost-minimising condition for the Cobb-Douglas function is given by:

$$MRS = \frac{\partial Q}{\partial V_2} / \frac{\partial Q}{\partial V_1} = \frac{\beta V_1}{\alpha V_2} = \frac{p_2}{p_1} \tag{4.5}$$

The optimising (profit maximising) conditions imply that:

$$\frac{V_1}{V_2} = \left(\frac{\alpha}{\beta}\right)\left(\frac{p_2}{p_1}\right) \tag{4.6}$$

For a given factor price ratio, the greater α/β, the greater the optimal input (V_1/V_2) ratio. Thus, the magnitude of the exponent α, relative to that of β, determines the factor-intensity of a production process represented by the Cobb-Douglas function.

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3 For fixed inputs V_1 and V_2, the larger A, the greater is the maximum output Q obtainable from the inputs.

4 These shares will only be equal to the value of total output in the case of constant returns to scale.

The Cobb-Douglas function is homogeneous of degree $\alpha + \beta$ since

$$Q(\lambda V_1 \lambda V_2) = A(\lambda V_1)^{\alpha}(\lambda V_2)^{\beta} = \lambda^{\alpha+\beta} A V_1^{\alpha} V_2^{\beta} = \lambda^{\alpha+\beta} Q(V_1, V_2) \quad (4.7)$$

For $\alpha + \beta > 1$, the production structure is characterised by increasing returns to scale. For $\alpha + \beta < 1$, the production structure exhibits decreasing returns to scale and if $\alpha + \beta = 1$, constant returns to scale. A significant constraint of the Cobb-Douglas production structure is, however, that the returns-to-scale property remains the same at all levels of output.

The Cobb-Douglas function is also restricted in that the elasticity of substitution is always constant and equal to unity (for all levels of output and for any factor combinations). It therefore represents a technology where a one percent change in the factor price ratio leads to a 1 percent change in the factor input ratio in the opposite direction, that is a one percent increase in p_1 relative to p_2 will lead to a one percent reduction in V_1 relative to V_2.

The Cobb-Douglas functional form has the advantage of being stable and robust and it is relatively easy to estimate. It does, however, have the disadvantage that it is very restrictive and fails to allow for flexibility in the technology of the production sector being analysed. Restricting the Cobb-Douglas production function to a constant and specifically a unitary elasticity of substitution of the inputs, eliminates an investigation of the extent to which factor substitution is possible and how such substitution may vary between firms and industries. The more flexible CES functional form was therefore developed where σ (the elasticity of substitution), although still constant, can take on values other than unity (Fuss and McFadden 1979: 311 - 363).

4.2.2 The Constant Elasticity of Substitution (CES) functional form

Cobb and Douglas pioneered the development of a production function in the 1920s and 1930s. The next meaningful step came forty years later when the economists, Arrow, Chenery, Minhas and Solow published the CES function (Arrow *et. al.*, 1961). This was an attempt to derive a production function with the properties of (i) homogeneity, (ii) constant elasticity of substitution between the inputs, and (iii) the possibility of different elasticities for different industries.

The following form specifies the CES function[5]:

$$Q = \gamma \left(\delta V_1^{-\theta} + (1-\delta) V_2^{-\theta}\right)^{\frac{-1}{\theta}} \quad (4.8)$$

with

Q = output or production (value added);

[5] The CES production function can also be generalised to include more than two inputs:

$$Q = \gamma \left(\delta_1 V_1^{-\theta} + \delta_2 V_2^{-\theta} + \dots\dots\dots + \delta_n V_n^{-\theta}\right)^{\frac{-1}{\theta}}$$

where $\sum\delta = 1$.

γ = efficiency parameter[6] ($\gamma > 0$);
V_i = production factors (inputs) with $i = 1, 2$;
θ = substitution parameter ($-1 < \theta < \infty$); and
δ = distribution parameter ($0 < \delta < 1$)

The marginal products (MP) of the inputs are given by:

$$MP_1 = \frac{\partial Q}{\partial V_1} = \frac{\delta\gamma}{V_1^{1+\theta}}\left[\delta V_1^{-\theta} + (1-\delta)V_1^{-\theta}\right]^{-(1+\theta)/\theta} = \frac{\delta}{\gamma^{\theta}}\left(\frac{Q}{V_1}\right)^{1+\theta},$$

$$MP_2 = \frac{\partial Q}{\partial V_2} = \frac{(1-\delta)\gamma}{V_2^{1+\theta}}\left[\delta V_1^{-\theta} + (1-\delta)V_2^{-\theta}\right]^{-(1+\theta)/\theta} = \frac{(1-\delta)}{\gamma^{\theta}}\left(\frac{Q}{V_2}\right)^{1+\theta} \quad (4.9)$$

Assuming profit maximisation under perfect competition, the marginal productivity conditions corresponding to equation 4.3 are:

$$\frac{\delta}{\gamma^{\theta}}\left(\frac{Q}{V_1}\right)^{1+\theta} = \frac{p_1}{p}, \qquad \frac{(1-\delta)}{\gamma^{\theta}}\left(\frac{Q}{V_2}\right)^{1+\theta} = \frac{p_2}{p} \quad (4.10)$$

The cost-minimising condition for the CES function, subject to a predetermined output, is given by:

$$MRS = \frac{\partial Q}{\partial V_2} / \frac{\partial Q}{\partial V_1} = \left(\frac{1-\delta}{\delta}\right)\left(\frac{V_1}{V_2}\right)^{1+\theta} = \frac{p_2}{p_1} \quad (4.11)$$

The optimising (profit maximising) conditions imply that

$$\frac{V_1}{V_2} = \left(\frac{\delta}{1-\delta}\right)^{1/(1+\theta)}\left(\frac{p_2}{p_1}\right)^{1/(1+\theta)} \quad (4.12)$$

Since the quantity $(\delta/(1-\delta))^{1/(1+\theta)}$ is a constant, it follows that a one percent rise in the factor price ratio p_1/p_2 leads to a $(1/(1+\theta))$ percent rise in the factor input ratio (V_1/V_2).

The elasticity of substitution of the CES function is given by[7]:

$$\sigma = -\frac{d(V_1/V_2)}{V_1/V_2} / \frac{d(MRS)}{MRS} = \frac{1}{\theta+1} \quad (4.13)$$

Possible values for θ range from $\theta = \infty$ (when $\sigma = 0$ and substitution is impossible) to $\theta = -1$ (when $\sigma = \infty$, the isoquants are straight lines and substitution possibilities are greatest). When $\theta = 0$, $\sigma =$

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6 For given values of δ and θ and for fixed inputs V_1 and V_2, the larger γ, the greater the maximum output Q obtainable from the inputs becomes.

7 Because of its relationship with σ, θ is known as the substitution parameter: $\theta = \frac{1}{\sigma} - 1$

1 as the CES function reduces to the Cobb-Douglas function. The Cobb-Douglas is therefore a special case of the CES function. [8]

The cost minimisation condition (equation 4.10) may also be rewritten as:

$$\frac{p_2 V_2}{p_1 V_1} = \left(\frac{1-\delta}{\delta}\right)\left(\frac{V_1}{V_2}\right)^{\theta} \tag{4.14}$$

so that, for a given factor input ratio (V_1/V_2) and a given value of θ, δ increases the ratio of input 2's share in total output relative to the share of input 1.[9] In contrast, the ratio of factor shares in a Cobb-Douglas function is a constant.

The CES function (equation 4.8) implies constant returns to scale and may be generalised to

$$Q = \gamma \ (\delta V_1^{-\theta} + (1-\delta)V_2^{-\theta})^{\frac{-\nu}{\theta}} \tag{4.15}$$

The CES function is homogeneous of degree ν since

$$Q(\lambda V_1 \lambda V_2) = \gamma\left[\delta(\lambda V_1)^{-\theta} + (1-\delta)(\lambda V_2)^{-\theta}\right]^{-\nu/\theta} = \lambda \ \gamma\left[\delta V_1^{-\theta} + (1-\delta)V_2^{-\theta}\right] = \lambda^{\nu} Q \tag{4.16}$$

Thus, for $\nu > 1$, $\nu = 1$ and $\nu < 1$ the function exhibits increasing, constant or decreasing returns to scale respectively.[10]

The CES functional form appears to offer sufficient flexibility in modelling the technical alternatives for a firm producing a single output using two inputs. In the context of several inputs, however, the CES function implies that the partial elasticities of substitution between all pairs of production factors are equal. This rules out the possibility of complementarities between any pairs of factors. The strongly separable CES and Cobb-Douglas functional forms possess the distinctive feature of self-duality. In the context of producer theory, this means that both the production and cost functions are elements of the same set of functional forms.[11] Therefore, preference will dictate

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8 For the CES function to become a Cobb-Douglas function, it is necessary to restrict θ to zero so that σ (elasticity of substitution) is equal to one. Unfortunately, if $\theta = 0$ is substituted into the CES function the equation collapses. A solution is therefore obtained by using L'Hospital's rule. Making use of this rule and differentiating with regard to θ and then substituting $\theta = 0$ into the function yields $Q = \gamma V_1^{\alpha} V_2^{\beta}$, which is a Cobb-Douglas function. $Q = \gamma V_1^{\alpha} V_2^{(1-\alpha)}$ is a Cobb-Douglas function with constant returns to scale. (For the complete mathematical derivation of the Cobb-Douglas function using the CES function, see Heathfield (1987)).

9 For this reason δ is known as the distribution (or capital intensity) parameter.

10 For this reason ν is known as the returns-to-scale parameter.

11 Shephard's duality exists between the production function and the cost function of functional forms exhibiting convex and monotonic production technology properties. The production technology is therefore identically represented by either the production function or the corresponding cost function, which allows for direct transformation between the two. Given the separability and homothetic nature of both the Cobb-Douglas and CES functional forms, it is possible to derive the dual cost function given the production function.

whether one chooses to describe the technology by means of, for example, a CES production function or a CES cost function, since both incorporate the same hypothesis.

Recently, several sets of functional forms, which are more flexible than the functions discussed above, have been proposed. These functional forms allow for an arbitrary set of partial elasticities of substitution between pairs of inputs at a given input price or quantity. They offer substantial gains in terms of flexibility, and enable the investigator to test important hypotheses remaining from earlier work. However, because these functional forms are in general not self-dual, the decision of whether to adopt a production function or a cost function as a point of departure, is of grave importance. The type of analysis envisaged will have to be the deciding factor. One of the most widely used and flexible functional forms to be introduced into econometric analysis is the Translog functional form.

4.2.3 The Transcendental logarithmic functional form

The CES production and cost functions were natural extensions of the Cobb-Douglas functional form in that they permit the elasticity of substitution to deviate from unity, although still constant. Subsequently, a function which allows the elasticity of substitution to vary with output and/or factor proportions was generated and led to the development of variable elasticity of substitution (VES) production functions which also allow for variation in the elasticity of scale[12] (returns to scale).[13] The elasticity of substitution (σ) can vary due to (i) variations in the factor input ratio

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The Cobb-Douglas cost function is specified by:

$$C = \left(\frac{q}{A}\right)^{1/\varepsilon} p_1^{\alpha/\varepsilon} p_2^{\beta/\varepsilon} \left(\frac{\alpha}{\beta}\right)^{\beta/\varepsilon} \left(\frac{\varepsilon}{\alpha}\right)$$ where $\varepsilon = \alpha + \beta$ (elasticity of scale) or

$$C = \left(\frac{q}{A}\right)\left(\frac{p_1}{\alpha}\right)^{\alpha}\left(\frac{p_2}{\beta}\right)^{\beta}$$ if the production function itself is constrained to have constant returns to scale.

The CES cost function is specified by:

$$C = q^{\frac{1}{v}} \gamma^{-1} p_1 p_2 [(1-\delta)^{\sigma} p_1^{-\sigma\theta} + \delta^{\sigma} p_2^{-\sigma\theta}]^{\frac{1}{\sigma\theta}}$$

When the underlying production function is of constant returns to scale ($v = 1$), costs do not vary with output. When $v > 1$, average cost decreases with q (increasing returns to scale) and when $v < 1$, average cost increases with q (decreasing returns to scale).

Both the cost functions are homogeneous of degree one in prices.

12 The elasticity of scale is the ratio of the proportionate increase in output to the proportionate increase in inputs. If it is assumed that both inputs increase by the same percentage so that $dV_1/V_1 = dV_2/V_2 = dV/V$, the elasticity of scale can be defined by the equation:

$$\varepsilon = (dQ/Q)/(dV/V)$$

If $\varepsilon < 1$, then doubling inputs will lead to a less than doubling of output (decreasing returns to scale).
If $\varepsilon = 1$, then doubling inputs will lead to a doubling of output (constant returns to scale).
If $\varepsilon > 1$, then doubling inputs will lead to a more than doubling of output (increasing returns to scale).

13 In the case of both the Cobb-Douglas and CES functional forms, the returns to scale were fixed. If the returns to scale were "n" for one level of output and one factor combination then it will be "n" for all levels of output and all factor combinations. This results in the long-run average cost curve, which is either continuously rising (decreasing returns to scale), a horizontal line (constant returns to scale) or continuously

(V_1/V_2)[14] or (ii) technical progress which affects the ease with which the factors can be substituted for each other, even in the case of a constant V_1/V_2 ratio. One such general function is the Translog production function. The Translog functional form proposed by Christensen, Jorgenson and Lau (1973) approximates the logarithm of output by a quadratic (second order) in the logarithms of the inputs.

For the two-input case the function is:[15]

$$\ln Q = \ln\alpha_0 + \alpha_1 \ln V_1 + \alpha_2 \ln V_2 + \beta_{11}(\ln V_1)^2 + \beta_{22}(\ln V_2)^2 + \beta_{12} \ln V_1 \ln V_2 \quad (4.17)$$

The Translog functional form is a second-order Taylor expansion or approximation of the quantities (in the case of the production function) or prices (in the case of the cost function) of any number of inputs (Allen 1997: 26). The functions (production and cost) are quadratic in the logarithms. Unlike the case with the Cobb-Douglas and CES functions, the Translog function is not restricted by the assumptions of homotheticity and additivity (or separability) and is therefore more flexible. The assumption of homotheticity (in the case of a production function) implies that the factor shares of output are independent of total output, while the additional assumption of separability (additivity) implies that the elasticities of substitution are constant and equal for any pair of inputs. The assumptions of homotheticity[16] and separability can, however, be imposed on the Translog function as testable parameter restrictions. See Appendix 4 for a discussion of the implications of separability and additivity on functional structures.

The Translog form reduces to the Cobb-Douglas form when all second-order terms vanish.[17] It also provides a second order approximation of the CES form with non-linear restrictions on the

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falling (increasing returns to scale). Thus the long-run average cost curve cannot take the "U"-shape often assumed in the theory of the firm.

14 The greater the ratio, i.e. the greater the V_1 intensity of production, the less likely it is to substitute further V_2 for V_1 and the lower σ is likely to be.

15 The Translog production function can be generalised to include more than two inputs:

$$\ln Q = \ln\alpha_0 + \sum_{i=1}^{n} \alpha_i \ln V_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} \ln V_i \ln V_j$$

where $\beta_{ij} = \beta_{ji}$ and $i \neq j$; $i, j = 1, \ldots, n$.

16 The assumption of homotheticity on a Translog production function of the form:

$$\ln Q = \ln\alpha_0 + \sum_{i=1}^{n} \alpha_i \ln V_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} \ln V_i \ln V_j$$

implies the following parameter restrictions:

$$\sum \beta_{ij} = \sum \beta_{ji} = 0, \forall i, j$$

(Chung 1994: 142-143)

17 The Translog production function of the form:

$$\ln Q = \ln\alpha_0 + \sum_{i=1}^{n} \alpha_i \ln V_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} \ln V_i \ln V_j$$

parameters.[18] However, based on the fact that the Translog form is non-homothetic and non-separable, it is not self-dual.[19]

The elasticity of scale (ε) for the Translog function is defined by:

$$\varepsilon = \alpha_1 + \beta_1 + (2\alpha_2 + \gamma_1)\ln V_1 + (2\beta_2 + \gamma_1)\ln V_2 \quad (4.18)$$

[20]

From this it is clear that in general the elasticity of scale changes with factor proportions and with the level of production. In the absence of any *a priori* restrictions imposed on the elasticity of scale, it is therefore necessary to calculate the elasticity of scale for each point (V_1; V_2) on the production function.

The elasticity of substitution (σ) for the Translog function is defined by:

$$\sigma = -\frac{(A+B)}{Q}\left\{A + B - 2\alpha_2\left(\frac{A}{B}\right) - 2\beta_2\left(\frac{B}{A}\right) - 2\gamma_1\right\}^{-1} \quad (4.19)$$

where $A = \beta_1 + 2\beta_2 \ln V_2 + \gamma_1 \ln V_1$ and $B = \alpha_1 + 2\alpha_2 \ln V_1 + \gamma_1 \ln V_2$.

Thus the elasticity of substitution of the Translog function depends on the level of output and on the level of V_1 and V_2.

The Translog cost function is not derived by optimising the Translog production function. The cost function is simply set up in the same way as the production function using costs and prices rather than quantities of inputs (Heathfield 1987: 110-111).

Thus, the non-homothetic and non-separable Translog cost function is defined by:

$$\ln C = \ln\alpha_0 + \alpha_q \ln q + \sum_{i=1}^{n}\alpha_i \ln p_i + \frac{1}{2}\beta_{qq}(\ln q)^2 + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\beta_{ij}\ln p_i \ln p_j + \sum_{i=1}^{n}\beta_{iq}\ln q \ln p_i$$

$$(i \neq j;\ i, j = 1, \dots, n) \quad (4.20)$$

The cost function must, however, satisfy the restriction of being homogenous of degree one in prices, since doubling all prices and leaving all quantities unchanged must double costs.

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reduces to the Cobb-Douglas production function if the following parameter restrictions apply:
$\beta_{ij} = \beta_{ji} = 0, \forall i, j$
(Thomas 1993: 330; Nicholson 1995: 342)

18 See Appendix 11.

19 See Appendix 6.

20 The elasticity of scale is rendered independent of the level of production (but dependent on factor proportions) if $\alpha_1 = -\beta_2$ in which case: $\varepsilon = \alpha_1 + \beta_1 + (2\alpha_2 + \gamma_1)\left[\ln\left(\frac{V_1}{V_2}\right)\right]$.

The elasticity of scale is rendered independent of V_1 by constraining $2\alpha_2 = -\gamma_1$ and independent of V_2 by constraining $2\beta_2 = -\gamma_1$.

The elasticity of scale is rendered independent of V_1 and V_2 altogether by constraining $\gamma_1 = -2\alpha_2 = -2\beta_2$. For this to be further constrained to constant returns to scale then $\alpha_1 + \beta_1 = 1$.

Constraining the cost function to be homogenous of degree 1 in prices requires parameter restrictions of:

$$\sum_{i=1}^{n} \alpha_i = 1 \text{ and } \sum_{i=1}^{n} \beta_{iq} = 0 \text{, } \sum_{i=1}^{n} \beta_{ij} = \sum_{j=1}^{n} \beta_{ij} = 0 \text{, and } \beta_{ij} = \beta_{ji}$$

The underlying production technology associated with the above cost function will be homothetic if $\beta_{iq} = 0$ for all i, linearly homogeneous if $\alpha_q = 1$ and $\beta_{qq} = \beta_{iq} = 0$, and separable (linearly) if $\beta_{ij} = 0$ for all i and j ($i \neq j$) so that all of the cross-product terms of inputs are zero.

An interesting, but important relationship exists between the CES and the Translog functional forms, in that the CES functional form can be expanded into a Translog form, by making use of a Taylor series. The following section proves how this can be done. The necessity of this relationship will become apparent in section 4.5 where the relationship is used to prove that the functional form used to represent the South African economy, is indeed a true representation of the production technology in the South African economy (Fuss and McFadden 1979: 239).

4.3 AN EMPIRICAL PRODUCTION FUNCTION FOR THE SOUTH AFRICAN PRODUCTION SECTOR: A COBB-DOUGLAS APPROACH

In this section an aggregate production function, based on Cobb-Douglas technology, is estimated for the South African economy. The Engle and Yoo (1991) three-step cointegration estimation technique is employed. The resulting production function is subjected to comprehensive evaluation and testing to ensure that the function complies with the "full ideal principles" of model selection (Appendix 3).

4.3.1 The theoretical model

A cost function is estimated and utilised in the derivation of a production function. This derivation is based on the duality theory (Appendix 6). The form initially used to estimate the cost function is a Cobb-Douglas functional form. Therefore, in addition to the assumptions of homotheticity and homogeneity, the stringent assumption of unitary elasticity of substitution applies.

The method used to estimate this Cobb-Douglas cost function is the Engle and Yoo three-step cointegration procedure (Appendix 1). Duality principles are used to derive the production function from the resulting long-run cost function.

The economic theory of cost states that a firm's costs are a function of the input costs and output. It follows that the costs of both production factors (capital and labour) should have a positive impact on the cost of production. These two costs are therefore included in a cost function for the South African economy. In estimating the function, a positive coefficient for the cost of labour and the cost of capital may be expected. Another factor which should have an influence on the cost of production is the technology used to produce a certain output. The expected effect of technology on the cost of production is a negative one; technical advance should cause firms' costs to decline. The expected coefficient for technical progress should be negative in the estimated cost function.

Turning to the level of production, an increase in output should lead to an increase in the costs of firms and, once again, a positive coefficient is expected.

The empirical function for the cost of production (c) in South Africa therefore is:

$$c = f(\underset{+}{gdp@\,factor\ cost}, \underset{+}{user\ cost\ of\ capital}, \underset{+}{labour\ cost}, \underset{-}{technical\ progress})$$

4.3.2 The data

An exposition on the data and related processes utilised in the estimation of the cost/production function is presented in Appendix 7. A variable list and graphical illustration of all the variables encountered in both the long-run cointegration and short-run error correction model are presented in Appendices 8 and 9 respectively.

4.3.3 The estimation results of the cointegration equation

4.3.3.1 *A cointegration equation for the cost of production*

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 long-run coefficients of the Cobb-Douglas cost function were estimated by restricting the sum of the coefficients of input prices to one. The restriction follows from economic theory, defining a cost function as homogeneous of degree 1 in input prices, that is, a doubling in input prices should lead to a doubling in cost. The cointegration results are reported in table 4.1.

Table 4.1 Cointegration equation: Cost of production

Dependent Variable: ln_c90p_lrem5
Method: Least Squares
Sample(adjusted): 1971 1995
Included observations: 25 after adjusting endpoints
ln_c90p_lrem5 = c(1)*ln_bbpfact_90p + c(2)*ln_ucc2_90p + (1-c(2))*ln_wtot_ppi_rat + c(3)*tecno_index

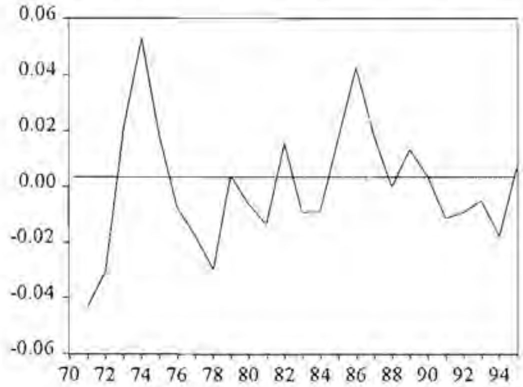
	Coefficient	*Std. Error*	*t-Statistic*	*Prob.*
c(1)	0.300673	0.015849	18.97057	0.0000
c(2)	0.115779	0.011901	9.728241	0.0000

Table 4.1 (*cont.*)

c(3)	-0.079248	0.040007	-1.980867	0.0602
R-squared	0.988108	F-statistic		913.9758
Adjusted R-squared	0.987027	Prob(F-statistic)		0.000000

Comparing the Engle-Granger test statistic of –4.77 with the computed MacKinnon[21] 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 4.1 represents a plot of the stationary residuals.

Figure 4.1 Residuals: Cost of production (ln_c90p_lrem5)



4.3.3.2 *Derivation of the long-run (cointegration) production function*

By applying duality theory, the estimated Engle and Granger cointegration coefficients of the Cobb-Douglas cost function can be used to derive a consistent long-run Cobb-Douglas production function.

Before the production function can be derived, it is necessary to compute whether the economies of scale (r) are increasing, decreasing or constant. From the estimated equation it follows that average cost for the function always increases and therefore, technology in the South African production sector displays decreasing returns to scale. This result is confirmed by using the calculation of economies of scale, given a cost function with technology integrated into the equation, as described by Berndt (1991):

$$r = \frac{1}{1 + c(1)} = \frac{1}{1 + 0.300673} = 0.7688327$$

with $c(1)$ the estimated coefficient of gross domestic product (output) in the cost function.

21 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.

By multiplying each of the input price coefficients and that of technology by the returns to scale (r), the coefficients of the inputs in the production function[22] are obtained (Berndt 1991: 62 - 75).

These calculations are based on the principles of duality and are as follows:

$\alpha = c(2) * r = 0.115779*0.300673 = 0.0890146$

$\beta = (1 - c(2)) * r = (1 - 0.115779)*0.300673 = 0.7003954$

$\delta = c(3) * r = 0.079248 * 0.300673 = 0.0609284$

With c(2) the coefficient of user-cost-of-capital in the estimated long-run cointegrated cost function and $c(3)$ the coefficient of the cost of labour in the estimated long-run cointegrated cost function. From these results it is already apparent that production in South Africa is extremely labour-intensive, which has significant consequences for economic policy.

The Engle and Granger long-run cointegration Cobb-Douglas production function, in non-logarithmic form, can therefore be written as:

$$Q = A_0 e^{(0.0609284 * T)} K^{0.0890146} L^{0.7003954}$$

Although the function gives a good indication of the trend in the dependent variable, there is a difference in the level between the actual and estimated values. It is, therefore, necessary to estimate an associated constant (A_0, i.e. the Hicks-neutral component of technical progress) for the production function. The ordinary least squares estimation results are reported in table 4.2.

Table 4.2 Cointegration equation: Real gross domestic product at factor cost

Dependent Variable: ln_bbpfact_90p
Method: Least Squares
Sample: 1970 1995
Included observations: 26
ln_bbpfact_90p=0.0890146*ln_kap_r+0.7003954*ln_n +
0.0609284*tecno_index + c(1)

	Coefficient	*Std. Error*	*t-Statistic*	*Prob.*
c(1)	9.488127	0.005413	1757.760	0.0000
R-squared	0.969263			
Adjusted R-squared	0.969263			

22 The coefficients of the Cobb-Douglas production function $Q = A_0 e^{\delta T} K^{\alpha} L^{\beta}$, with K = real fixed capital; L = demand for labour; T = the technical index; α, β the coefficients of the elasticities of the inputs, and δ the marginal influence of technical progress on production, are derived by making use of the calculations illustrated by Berndt (1990).

4.3.4 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) (see 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 4.3.

Table 4.3 Error correction model: Real gross domestic product at factor cost

Dependent Variable: Δ(ln_bbpfact_90p)
Method: Least Squares
Sample(adjusted): 1975 1995
Included observations: 21 after adjusting endpoints

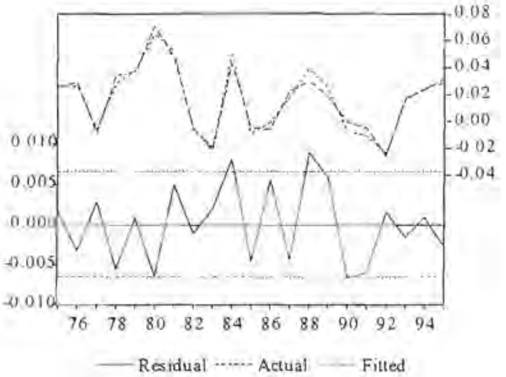
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.445426	0.083627	-5.326362	0.0002
Δ(ln_kap_r)	1.565503	0.342552	4.570115	0.0008
Δ(ln_kap_r(-1))	-1.467576	0.294881	-4.976840	0.0004
Δ(ln_n)	0.606497	0.200341	3.027321	0.0115
Δ(tecno_index)	0.147462	0.050808	2.902366	0.0144
Δ(tecno_index(-4))	0.077070	0.032019	2.407010	0.0348
drought_dum	-0.036744	0.005245	-7.005830	0.0000
sanction_dum	-0.029635	0.005917	-5.008796	0.0004
imf_dum	-0.025683	0.005586	-4.597443	0.0008
c	0.025426	0.009005	2.823603	0.0166

R-squared	0.962824	F-statistic	31.65443
Adjusted R-squared	0.932407	Prob(F-statistic)	0.000001
S.E. of regression	0.006535		

Appendix 7 gives an explanation of the dummy variables included in the error correction model.

A data plot of the actual and fitted values of gross domestic production is provided below (figure 4.2).

Figure 4.2 Actual, fitted and residual values of ln_bbpfact_90p



4.3.5 Diagnostic testing

The production 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 4.4 indicate that the function passes all these tests.

Table 4.4 Diagnostic tests: Real gross domestic product at factor cost (ln_bbpfact_90p)

Purpose of test	*Test*	*d.f.*	*Test statistic*	*Probability*
Normality	Jarque-Bera	JB(2)	1.151718	[0.562222]
Homoscedasticity	ARCH LM	$nR^2(1)$	0.159922	[0.689229]
Homoscedasticity	White	$nR^2(15)$	17.88064	[0.268992]
Serial correlation	Breusch-Godfrey	$nR^2(2)$	3.286585	[0.193342]
Serial correlation	Lung Box Q	Q(12)	8.370700	[0.756000]
Misspecification	Ramsey Reset	LR(2)	2.478033	[0.138886]
Parameter stability	Recursive estimates	Indicative of stability		

4.3.5 Cointegration correction and adjusted coefficients

In this step, the Engle and Yoo technique (Appendix 1) is applied to adjust the coefficients and *t*-statistics so that they are closer to their true values. The variables included in the long-term regression can then be evaluated statistically, and the variables which are not statistically meaningful, can be discarded or adjusted. This approach is similar to the one used in classical regression analysis. Tables 4.5 and 4.6 summarise the third-step estimation results and the adjusted coefficients.

Table 4.5 Engle-Yoo third-step estimation: Real gross domestic product at factor cost (ln_bbpfact_90p)

Dependent Variable: residual_ecm
Method: Least Squares
Sample(adjusted): 1975 1995
Included observations: 21 after adjusting endpoints

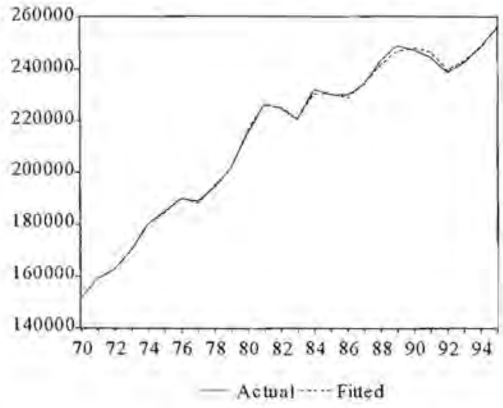
Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.445426)*ln_kap_r	-0.010152	0.012699	-0.799432
(0.445426)*ln_n	0.072389	0.089060	0.812812
(0.445426)*tecno_index	-0.016105	0.019560	-0.823368

Table 4.6 Cointegration correction: Real gross domestic product at factor cost (ln_bbpfact_90p)

Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_kap_r	0.0788626	6.2101425
ln_n	0.7727844	8.6771210
tecno_index	0.0448234	2.2915849

The Engle and Yoo adjusted coefficients are used to dynamically simulate the final version of the model, combining the long and short-run characteristics. The overall fit of the model is depicted in figure 4.3

Figure 4.3 Actual and fitted values of ln_bbpfact_90p



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 4.7 it can be concluded that the estimated equation represents a good fit of the corresponding actual data series.

Table 4.7 Simulation error statistics of real gross domestic product at factor cost

Actual v Fitted : ln_bbpfact_90p	
Root Mean Squared Error	0.005138
Mean Absolute Error	0.004348
Mean Absolute Percentage Error	0.035276
Theil Inequality Coefficient	0.000208
Bias Proportion	0.000000
Variance Proportion	0.004090
Covariance Proportion	0.995910

Economic evaluation of the estimation results renders what was expected *ex ante*. Although the South African production technology is in the process of improving its utilisation of capital and technology, the elasticity of labour is expected to be higher than that of capital since labour is still the most utilised production factor.

A noteworthy feature of the production function emerged from this investigation: that of decreasing returns to scale. The calculated returns to scale are 0.7688327. This implies that a 100 percent increase in both the inputs used in the production sector of our economy will increase production by only 77 percent. This result holds grave consequences for the South African economy and warrants further exploration.

4.4 DYNAMIC SIMULATION: RESPONSE PROPERTIES OF THE MODEL

Next, the dynamic simulation properties of the model are investigated and it is tested for stability and robustness simultaneously. The methodology applied is explained in Appendix 10.

The results of the adjustment process towards either a new long-run equilibrium (in accordance with the elasticities of the respective cointegration relationships) or the baseline equilibrium (in the case of short-run explanatory variables) are shown in the figures below. Vertical axes measure the difference between the outcome of the baseline estimation and the estimation subjected to the exogenous shock, as a percentage of the level of the dependent variable. The speed of adjustment in respective cases is apparent from the graphs. In all instances the adjustment process is completed within the sample range.

Table 4.8 indicates the level of convergence of the dependent variable, gross domestic production. All responses of gross domestic production were consistent with what was expected.

Table 4.8 Difference between the baseline forecast and forecasts with shocked variables, dependent variable: ln_bbpfact_90p

Variable	*Coefficient*	*Expected change (10% of coefficient)*	*Convergence level (% difference)*
ln_kap_r	0.0788626	0.0078863	0.007544
ln_n	0.7727844	0.0772784	0.076434
tecno_index	0.0448234	0.0058920[23]	0.005966

The results of the sensitivity tests documented in table 4.8 are portrayed in figures 4.4, 4.5 and 4.6.

Figure 4.4 Dynamic adjustment (percentage change) in real gross domestic product at factor cost (ln_bbpfact_90p) with a 10 percent increase in real capital stock (ln_kap_r)

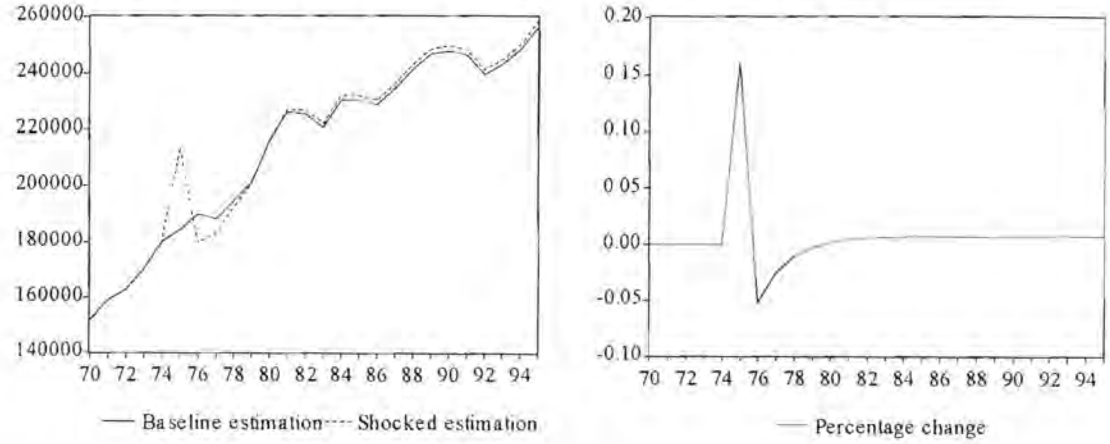


Figure 4.5 Dynamic adjustment (percentage change) in real gross domestic product at factor cost (ln_bbpfact_90p) with a 10 percent increase in the level of employment (ln_n)

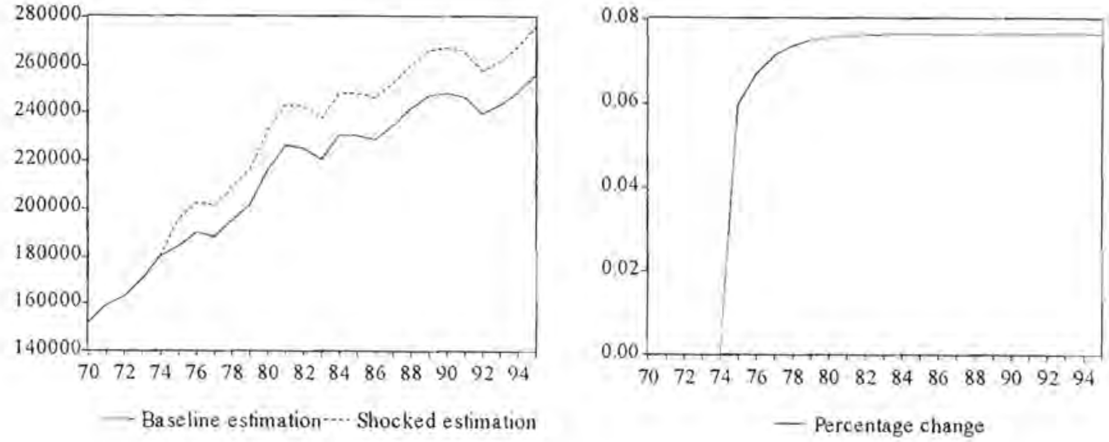
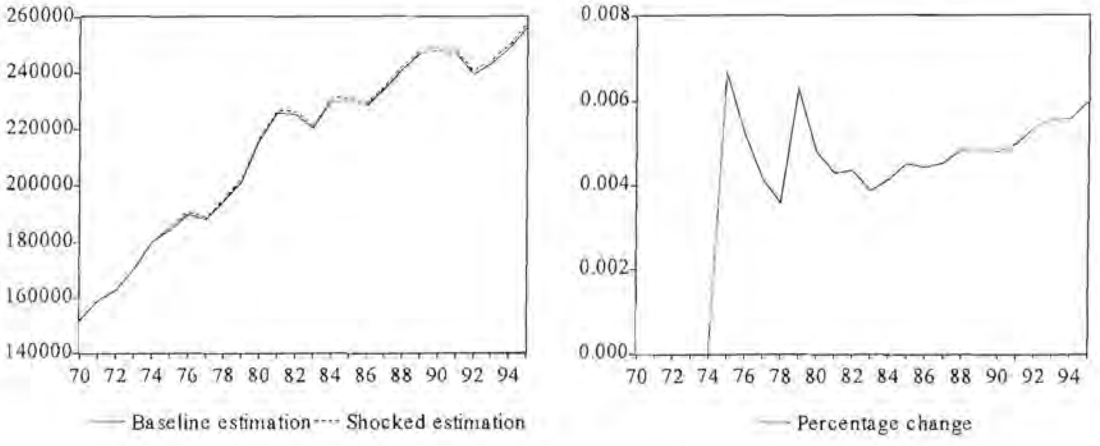


Figure 4.6 Dynamic adjustment (percentage change) in real gross domestic product at factor cost (ln_bbpfact_90p) with a 10 percent increase in technology (tecno_index)



4.5 TESTING THE VALIDITY OF A COBB-DOUGLAS REPRESENTATION

The Cobb-Douglas functional form has the advantage of being a highly stable and robust production function, which can easily be estimated. It also exhibits duality properties which allows for the easy transformation between the Cobb-Douglas cost and production functions. These properties are not evident in the more flexible functional forms. It remains to be proven, however, that the Cobb-Douglas functional form is indeed a valid representation of the technology used in the South African production sector.

Even though the Cobb-Douglas production function estimated above is satisfactory, the rather restrictive assumptions underlying this function are sufficient motivation to estimate a more flexible form. Given the advantages of the more flexible Translog functional form described earlier, the non-homothetic Translog cost function is estimated and tested for the validity of imposed restrictions to see whether it collapses to the Cobb-Douglas cost function. It is essential that this function collapses to a self-dual functional form, i.e. either a Cobb-Douglas or CES form, for the production function to be derived.

4.5.1 From a Translog to a Cobb-Douglas functional form: theoretical derivation

The goal is to estimate a Translog cost function and impose certain restrictions on the parameters of the estimated equation in order to test whether this function collapses to the Cobb-Douglas cost function estimated initially. The theoretical restrictions for the Translog functional form to collapse to the Cobb-Douglas functional form must be examined before empirical testing commences. (Berndt 1991).

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[23] Since the relationship between ln_bbpfact_90p and tecno_index is of semi-log form, the elasticity of ln_bbpfact_90p with respect to tecno_index is not given by the coefficient of tecno_index, but had to be calculated: $\varepsilon = tecno\_index * \hat{a}$ (Studenmund 1997: 228).

The non-homothetic and non-separable Translog cost function is defined by:

$$\ln C = \ln \alpha_0 + \alpha_q \ln q + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2}\beta_{qq}(\ln q)^2 + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\beta_{ij}\ln p_i \ln p_j + \sum_{i=1}^{n}\beta_{iq}\ln q \ln p_i$$

with q real output and p_i and p_j input prices ($i \neq j;\ i, j = 1, \ldots, n$). (4.20)

The cost function is homogenous of degree one in prices if the following restrictions apply:

$$\sum_{i=1}^{n}\alpha_i = 1 \text{ and } \sum_{i=1}^{n}\beta_{iq} = 0\,,\ \sum_{i=1}^{n}\beta_{ij} = \sum_{j=1}^{n}\beta_{ij} = 0\,, \text{ and } \beta_{ij} = \beta_{ji}\,. \quad (4.21)$$

In order for the function to be homothetic, it is necessary and sufficient that $\beta_{iq} = 0$ for all i. Furthermore, a restriction of homogeneity of a constant degree in output occurs if, in addition to these homotheticity restrictions, $\beta_{qq} = 0$. In this case the degree of homogeneity equals $1/\alpha_q$. The function is separable (linearly) if $\beta_{ij} = 0$, for all i and j ($i \neq j$).[24] Constant returns to scale of the dual production function occurs when, in addition to the above homotheticity and homogeneity restrictions, $\alpha_q = 1$. Therefore, the Translog function reduces to the constant-returns-to-scale Cobb-Douglas function when all the above restrictions apply simultaneously.

The Translog production function can be defined by:

$$\ln Q = \ln \alpha_0 + \sum_{i=1}^{n}\alpha_i \ln V_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\beta_{ij}\ln V_i \ln V_j \quad (4.22)$$

where $\beta_{ij} = \beta_{ji}$ and $i \neq j;\ i, j = 1, \ldots, n$.

For the production function to be homothetic, and homogeneous of a constant degree in output it is necessary and sufficient that $\sum \beta_{ij} = \sum \beta_{ji} = 0, \forall i, j$ (Allen 1997: 28; Chung 1994: 142-143; Nicholson 1995: 342). The function is separable (linearly) and reduces to the Cobb-Douglas or CES production function if $\beta_{ij} = \beta_{ji} = 0, \forall i, j$ (Allen 1997: 37; Chung 1994: 243). Constant returns to scale of the dual production function occurs when, in addition to the above homotheticity and homogeneity restrictions, $\alpha_i = 1$ (Allen 1997: 28; Chung 1994: 142-143; Nicholson 1995: 342).

These theoretical principles can now be applied to an estimated Translog cost function and Wald tests can be performed in order to test the restrictions for validity.

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24 If a production function is additive (or separable) and homothetic, the Allen-Uzawa partial elasticities of substitution are equal to the elasticity of substitution (σ) and are therefore equal and constant for all pairs of inputs (Chung 1994: 189, 205). Furthermore, a production function which in addition to being linearly homogeneous and separable, has a Cobb-Douglas or CES structure. (Allen 1997: 19, 35).

4.5.2 Empirical testing of imposed restrictions

The process started with the estimation of an unrestricted, i.e. non-homothetic and non-separable Translog cost function, which is well-behaved in the sense that it is homogeneous of degree one in prices.[25]

The restrictions of homotheticity[26], homogeneity of a constant degree in output[27] and linear separability[28] were imposed step-by-step and tested for validity by means of Wald tests, in order to establish whether the Translog function breaks down to the Cobb-Douglas functional form.

It was found that, given the empirical testing of the imposed restrictions and the theoretical interpretation of the valid restrictions, the restrictions were valid for a Translog cost function in the South African economy. The results of the Wald tests are reported in table 4.9 below.

Table 4.9 Results of the Wald tests performed on the imposed restrictions on the Translog cost function

Test: restriction (Null Hypothesis)	*Probability: F-statistic*	*Probability: Chi-square statistic*	*Valid/Not valid*
c(7) = 0	0.637064	0.631284	Valid restriction
c(4) = 0	0.971763	0.971367	Valid restriction
c(5) and c(6) = 0	0.149564	0.120575	Valid restriction

The non-homothetic Translog cost function collapses to a cost function which is homothetic, homogeneous of a constant degree in output and linearly separable. The function therefore exhibits a constant elasticity of substitution. That is, the imposed restrictions of homotheticity,

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25 $\ln C = \ln \alpha_0 + \alpha_q \ln q + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2}\beta_{qq}(\ln q)^2 + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\beta_{ij} \ln p_i \ln p_j + \sum_{i=1}^{n}\beta_{iq} \ln q \ln p_i$ with

$\sum_{i=1}^{n}\alpha_i = 1$ and $\sum_{i=1}^{n}\beta_{iq} = 0$, $\sum_{i=1}^{n}\beta_{ij} = \sum_{j=1}^{n}\beta_{ij} = 0$, and $\beta_{ij} = \beta_{ji}$, for the function to be homogeneous of degree one in prices. The function is empirically estimated by:

Cost of production = c(2)**cost of capital* + (1-c(2))**cost of labour* + c(3)**gross domestic product* + 0.5*c(4)*(*gross domestic product*)^2 + 0.5*[c(5)*(*cost of capital*)^2 + c(6)*(*cost of labour*)^2 + (0-c(5)-c(6))*[(*cost of labour*)*(*cost of capital*)]] + c(7)*[(*gross domestic product*)*(*cost of capital*)] + (0-c(7))*[(*gross domestic product*)*(*cost of labour*)] + c(8)**technical index*.

26 $\beta_{iq} = 0 \; \forall \; I = 1,\ldots,n$; i.e. c(7) = 0.

27 $\beta_{qq} = 0$; i.e. c(4) = 0. If a function is homogeneous of a constant degree in output it is possible to derive the degree of homogeneity and the economies of scale, which is equal to $\frac{1}{\alpha_q}$, i.e. $\frac{1}{c(3)}$ (Berndt 1991: 69-70) or $\frac{1}{1+\alpha_q}$; i.e. $\frac{1}{1+c(3)}$ with the incorporation of technical progress (Berndt 1991: 71-75).

28 $\beta_{ij} = 0$; i.e. c(5) = c(6) = 0.

homogeneity and separability on the estimated Translog cost function passes the Wald tests. It is therefore possible to derive the degree of homogeneity and the economies of scale. It can be concluded that the Translog cost function breaks down to either a Cobb-Douglas or CES functional form, exhibiting a constant elasticity of substitution. The next step is to test the validity of a CES function and to determine the value of the elasticity of substitution.

Due to the fact that the Translog functional form is not self-dual, it is plausible to assume that the estimation results of a Translog production function will differ from those of the Translog cost function with regard to production technology. It is therefore necessary to estimate an equivalent Translog production function by imposing the justifiable restrictions as tested for the Translog cost function and determine whether this function collapses to the Cobb-Douglas production function.

4.5.3 Testing for elasticity of substitution

Given the fact that the cost function exhibits the properties of homotheticity, homogeneity of a constant degree in output and linear separability, it is justifiable to assume constant elasticity of substitution in the production sector. The elasticity of substitution is, however, not necessarily equal to unity. Therefore, either a CES or Cobb-Douglas production function could be justified as being representative of the production structure in the South African economy as both these functional forms have a constant elasticity of substitution.

However, it should be established whether Kmenta's Taylor approximation of the Translog functional form into a CES-functional form is valid (Appendix 11) and to use Kmenta's Taylor approximation of the CES function to estimate the elasticity of substitution (Thomas 1993: 331).

For this purpose, it is necessary to estimate the homothetic (although still non-separable) Translog production function[29] and to test the validity of the imposed restriction of a constant elasticity of substitution (i.e. the restriction of separability[30]) (Thomas 1993: 331). The Translog production function passed the Wald test for a constant elasticity of substitution and therefore the validity of Kmenta's Taylor approximation of the CES production function. The Wald test results are reported in table 4.10.

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29 The homothetic (although still non-separable) Translog production function is defined by:

$\ln Q = \ln\alpha_0 + \sum_{i=1}^{n}\alpha_i \ln V_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\beta_{ij}\ln V_i \ln V_j$ with $\Sigma\beta_{ij} = 0$; $\beta_{ij} = \beta_{ji}$ and $i \neq j$; i, j = 1, ..., n. This function is empirically estimated by:

Gross domestic product = c(1)**real capital* + c(2)**labour* + c(3)*(*real capital*)^2 + *c(4)*(*labour*)^2 + (0-c(3)-c(4))*[(*real capital*)*(*labour*)] + c(6)**technical index*.

30 In order for the homothetic Translog production function to exhibit the property of separability, i.e. a constant elasticity of substitution, it has to obey the restrictions of: $\beta_{ii} = \beta_{jj} = -\frac{1}{2}\beta_{ij}$, i.e. c(3) = c(4) in the case of a homothetic function (Thomas 1993: 331).

Table 4.10 Results of the Wald test performed on the imposed restrictions on the Translog production function

Test: restriction (Null Hypothesis)	*Probability: F-statistic*	*Probability: Chi-square statistic*	*Valid/Not valid*
c(3) = c(4)	0.811379	0.809035	Valid restriction

Kmenta's CES production function could therefore be estimated to test the elasticity of substitution of the production technology.[31]

This estimation of the CES production function resulted in a θ-coefficient (substitution parameter) close to zero ($\theta = 0.007479$). This represents an elasticity of substitution significantly near unity: $\sigma = \frac{1}{(1+\theta)} = 0.99$.

This is an interesting result. The elasticity of substitution can be defined as the percentage change in the capital-labour ratio, relative to the percentage change in the price ratio: $\sigma = \frac{\partial \ln(K/L)}{\partial \ln(p_L/p_K)}$.

The implication of a unitary elasticity of substitution is that the percentage change in the capital-labour ratio is equal to the percentage change in the price ratio.

This is of particular significance in the South African context, in that the price-ratio dictates the capital-labour ratio. The higher the increase in the price of labour relative to the price of capital, the lower the demand for labour relative to the demand for capital. This confirms the phenomenon in the South African economy of an increasing capital-labour ratio as a result of the rising labour-capital price ratio.

It is shown that the CES production function is in fact a Cobb-Douglas production function when the CES production function features unitary elasticity of substitution. It is therefore concluded that the Cobb-Douglas technology is representative of the production technology of the South African economy.

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31 Kmenta's CES production function was estimated according to the method of Griliches and Ringstad (1971) in order to deal with the possibility of a high degree of multicollinearity between the variables. They rearranged Kmenta's Taylor approximation as:

$$\ln\left(\frac{Q}{V_2}\right) = \ln\gamma + (\nu - 1)\ln V_2 + (\nu\delta)\ln\left(\frac{V_1}{V_2}\right) - \frac{1}{2}\nu\theta\delta(1-\delta)\left[\ln\left(\frac{V_1}{V_2}\right)\right]^2.$$

Estimation of the equation resulted in estimates for γ, ν, δ and θ and therefore information on the properties such as the returns to scale (ν), capital intensity of production (δ) and elasticity of substitution *($\sigma = 1/(1 + \theta)$)*. The closeness of θ to zero serves as a further test whether the Kmenta approximation to the CES function is valid. The estimation procedure used for the estimation of the CES production function is the Engle and Yoo three-step procedure. Because this estimation is only done in order to test the elasticity of substitution of production technology, the economic and statistical results are not reported. The coefficients are however consistent with economic theory and the residuals from the Engle and Yoo cointegration equation are stationary.

4.6 CONCLUSION

The purpose of this chapter is to estimate an aggregate neoclassical production function for the South African economy and to investigate the long-run properties of the production structure.

Recognising the advantages of such an approach, the analysis was based on the estimation of a cost function for the South African production sector and the subsequent derivation of a production function based on duality principles. However, only homothetic and linearly separable functional forms, such as the more restricted Cobb-Douglas and CES functions, are self-dual.

It had to be proven, therefore, that the production structure of the South African economy features homotheticity and linear separability, i.e. a constant elasticity of substitution.

In order to test the validity of either a Cobb-Douglas or CES functional form as a representation of the technology in the South African economy, a Translog cost function was estimated and tested for the validity of imposed restrictions. The Translog cost function could be collapsed to a homothetic and linearly separable cost function. By making use of Kmenta's Taylor approximation of the CES function, it was further proven that the function not only exhibits a constant elasticity of substitution, but that it is very close to unity. It is therefore concluded that a Cobb-Douglas functional form can be used as a representation (approximation) of the production structure of South Africa.

An evaluation of the estimation results obtained from both the Cobb-Douglas and CES functions, led to a couple of interesting long-run properties of the South African economy. Apart from a unitary elasticity of substitution, which implies that the price-ratio dictates the capital-labour ratio, it was concluded that South Africa produces with decreasing returns to scale.

The following important, although not surprising properties, may be attributed to the South African production and growth structure:

(i) Production in South Africa is labour intensive with an output-elasticity of 0.77, stressing the importance of all labour-related issues such as wages, level of skill, the role of labour unions and labour legislation.

(ii) A interesting feature of the production function is the decreasing returns to scale observed. The Engle-Yoo adjusted returns to scale is 0.85. Returns to scale of 0.85 implies that a 100 percent increase in both the inputs used in the production sector of our economy will increase production by only 85 percent. This result holds serious consequences for the South African economy. It must be noted that few empirical studies on the aggregate production structure of the total South African economy have been conducted and information for comparative purposes is not readily available.

(iii) The fact that the Cobb-Douglas production technology is representative of the South African production structure, is confirmation of an unitary elasticity of substitution. The

4.5.2 Empirical testing of imposed restrictions

The process started with the estimation of an unrestricted, i.e. non-homothetic and non-separable Translog cost function, which is well-behaved in the sense that it is homogeneous of degree one in prices.[25]

The restrictions of homotheticity[26], homogeneity of a constant degree in output[27] and linear separability[28] were imposed step-by-step and tested for validity by means of Wald tests, in order to establish whether the Translog function breaks down to the Cobb-Douglas functional form.

It was found that, given the empirical testing of the imposed restrictions and the theoretical interpretation of the valid restrictions, the restrictions were valid for a Translog cost function in the South African economy. The results of the Wald tests are reported in table 4.9 below.

Table 4.9 Results of the Wald tests performed on the imposed restrictions on the Translog cost function

Test: restriction (Null Hypothesis)	*Probability: F-statistic*	*Probability: Chi-square statistic*	*Valid/Not valid*
c(7) = 0	0.637064	0.631284	Valid restriction
c(4) = 0	0.971763	0.971367	Valid restriction
c(5) and c(6) = 0	0.149564	0.120575	Valid restriction

The non-homothetic Translog cost function collapses to a cost function which is homothetic, homogeneous of a constant degree in output and linearly separable. The function therefore exhibits a constant elasticity of substitution. That is, the imposed restrictions of homotheticity,

---

25 $\ln C = \ln \alpha_0 + \alpha_q \ln q + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2}\beta_{qq}(\ln q)^2 + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} \ln p_i \ln p_j + \sum_{i=1}^{n} \beta_{iq} \ln q \ln p_i$ with

$\sum_{i=1}^{n} \alpha_i = 1$ and $\sum_{i=1}^{n} \beta_{iq} = 0$, $\sum_{i=1}^{n} \beta_{ij} = \sum_{j=1}^{n} \beta_{ij} = 0$, and $\beta_{ij} = \beta_{ji}$, for the function to be homogeneous of degree one in prices. The function is empirically estimated by:

Cost of production = c(2)**cost of capital* + (1-c(2))**cost of labour* + c(3)**gross domestic product* + 0.5*c(4)*(*gross domestic product*)^2 + 0.5*[c(5)*(*cost of capital*)^2 + c(6)*(*cost of labour*)^2 + (0-c(5)-c(6))*[(*cost of labour*)*(*cost of capital*)]] + c(7)*[(*gross domestic product*)*(*cost of capital*)] + (0-c(7))*[(*gross domestic product*)*(*cost of labour*)] + c(8)**technical index*.

26 $\beta_{Iq} = 0 \; \forall \; I = 1,\ldots,n$; i.e. c(7) = 0.

27 $\beta_{qq} = 0$; i.e. c(4) = 0. If a function is homogeneous of a constant degree in output it is possible to derive the degree of homogeneity and the economies of scale, which is equal to $\frac{1}{\alpha_q}$; i.e. $\frac{1}{c(3)}$ (Berndt 1991: 69-70) or $\frac{1}{1+\alpha_q}$; i.e. $\frac{1}{1+c(3)}$ with the incorporation of technical progress (Berndt 1991: 71-75).

28 $\beta_{ij} = 0$; i.e. c(5) = c(6) = 0.

homogeneity and separability on the estimated Translog cost function passes the Wald tests. It is therefore possible to derive the degree of homogeneity and the economies of scale. It can be concluded that the Translog cost function breaks down to either a Cobb-Douglas or CES functional form, exhibiting a constant elasticity of substitution. The next step is to test the validity of a CES function and to determine the value of the elasticity of substitution.

Due to the fact that the Translog functional form is not self-dual, it is plausible to assume that the estimation results of a Translog production function will differ from those of the Translog cost function with regard to production technology. It is therefore necessary to estimate an equivalent Translog production function by imposing the justifiable restrictions as tested for the Translog cost function and determine whether this function collapses to the Cobb-Douglas production function.

4.5.3 Testing for elasticity of substitution

Given the fact that the cost function exhibits the properties of homotheticity, homogeneity of a constant degree in output and linear separability, it is justifiable to assume constant elasticity of substitution in the production sector. The elasticity of substitution is, however, not necessarily equal to unity. Therefore, either a CES or Cobb-Douglas production function could be justified as being representative of the production structure in the South African economy as both these functional forms have a constant elasticity of substitution.

However, it should be established whether Kmenta's Taylor approximation of the Translog functional form into a CES-functional form is valid (Appendix 11) and to use Kmenta's Taylor approximation of the CES function to estimate the elasticity of substitution (Thomas 1993: 331).

For this purpose, it is necessary to estimate the homothetic (although still non-separable) Translog production function[29] and to test the validity of the imposed restriction of a constant elasticity of substitution (i.e. the restriction of separability[30]) (Thomas 1993: 331). The Translog production function passed the Wald test for a constant elasticity of substitution and therefore the validity of Kmenta's Taylor approximation of the CES production function. The Wald test results are reported in table 4.10.

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29 The homothetic (although still non-separable) Translog production function is defined by:

$$\ln Q = \ln\alpha_0 + \sum_{i=1}^{n}\alpha_i \ln V_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\beta_{ij}\ln V_i \ln V_j$$ with $\Sigma\beta_{ij} = 0$; $\beta_{ij} = \beta_{ji}$ and $i \neq j$; $i, j = 1, \ldots, n$. This function is empirically estimated by:

Gross domestic product = c(1)**real capital* + c(2)**labour* + c(3)*(*real capital*)^2 + *c(4)*(*labour*)^2 + (0-c(3)-c(4))*[(*real capital*)*(*labour*)] + c(6)**technical index*.

30 In order for the homothetic Translog production function to exhibit the property of separability, i.e. a constant elasticity of substitution, it has to obey the restrictions of: $\beta_{ii} = \beta_{jj} = -\frac{1}{2}\beta_{ij}$, i.e. c(3) = c(4) in the case of a homothetic function (Thomas 1993: 331).

Table 4.10 Results of the Wald test performed on the imposed restrictions on the Translog production function

Test: restriction (Null Hypothesis)	*Probability: F-statistic*	*Probability: Chi-square statistic*	*Valid/Not valid*
c(3) = c(4)	0.811379	0.809035	Valid restriction

Kmenta's CES production function could therefore be estimated to test the elasticity of substitution of the production technology.[31]

This estimation of the CES production function resulted in a θ-coefficient (substitution parameter) close to zero ($\theta = 0.007479$). This represents an elasticity of substitution significantly near unity: $\sigma = \frac{1}{(1+\theta)} = 0.99$.

This is an interesting result. The elasticity of substitution can be defined as the percentage change in the capital-labour ratio, relative to the percentage change in the price ratio: $\sigma = \frac{\partial \ln(K/L)}{\partial \ln(p_L/p_K)}$.

The implication of a unitary elasticity of substitution is that the percentage change in the capital-labour ratio is equal to the percentage change in the price ratio.

This is of particular significance in the South African context, in that the price-ratio dictates the capital-labour ratio. The higher the increase in the price of labour relative to the price of capital, the lower the demand for labour relative to the demand for capital. This confirms the phenomenon in the South African economy of an increasing capital-labour ratio as a result of the rising labour-capital price ratio.

It is shown that the CES production function is in fact a Cobb-Douglas production function when the CES production function features unitary elasticity of substitution. It is therefore concluded that the Cobb-Douglas technology is representative of the production technology of the South African economy.

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31 Kmenta's CES production function was estimated according to the method of Griliches and Ringstad (1971) in order to deal with the possibility of a high degree of multicollinearity between the variables. They rearranged Kmenta's Taylor approximation as:

$$\ln\left(\frac{Q}{V_2}\right) = \ln\gamma + (\nu - 1)\ln V_2 + (\nu\delta)\ln\left(\frac{V_1}{V_2}\right) - \frac{1}{2}\nu\theta\delta(1-\delta)\left[\ln\left(\frac{V_1}{V_2}\right)\right]^2.$$

Estimation of the equation resulted in estimates for γ, ν, δ and θ and therefore information on the properties such as the returns to scale (ν), capital intensity of production (δ) and elasticity of substitution ($\sigma = 1/(1 + \theta)$). The closeness of θ to zero serves as a further test whether the Kmenta approximation to the CES function is valid. The estimation procedure used for the estimation of the CES production function is the Engle and Yoo three-step procedure. Because this estimation is only done in order to test the elasticity of substitution of production technology, the economic and statistical results are not reported. The coefficients are however consistent with economic theory and the residuals from the Engle and Yoo cointegration equation are stationary.

4.6 CONCLUSION

The purpose of this chapter is to estimate an aggregate neoclassical production function for the South African economy and to investigate the long-run properties of the production structure.

Recognising the advantages of such an approach, the analysis was based on the estimation of a cost function for the South African production sector and the subsequent derivation of a production function based on duality principles. However, only homothetic and linearly separable functional forms, such as the more restricted Cobb-Douglas and CES functions, are self-dual.

It had to be proven, therefore, that the production structure of the South African economy features homotheticity and linear separability, i.e. a constant elasticity of substitution.

In order to test the validity of either a Cobb-Douglas or CES functional form as a representation of the technology in the South African economy, a Translog cost function was estimated and tested for the validity of imposed restrictions. The Translog cost function could be collapsed to a homothetic and linearly separable cost function. By making use of Kmenta's Taylor approximation of the CES function, it was further proven that the function not only exhibits a constant elasticity of substitution, but that it is very close to unity. It is therefore concluded that a Cobb-Douglas functional form can be used as a representation (approximation) of the production structure of South Africa.

An evaluation of the estimation results obtained from both the Cobb-Douglas and CES functions, led to a couple of interesting long-run properties of the South African economy. Apart from a unitary elasticity of substitution, which implies that the price-ratio dictates the capital-labour ratio, it was concluded that South Africa produces with decreasing returns to scale.

The following important, although not surprising properties, may be attributed to the South African production and growth structure:

(i) Production in South Africa is labour intensive with an output-elasticity of 0.77, stressing the importance of all labour-related issues such as wages, level of skill, the role of labour unions and labour legislation.

(ii) A interesting feature of the production function is the decreasing returns to scale observed. The Engle-Yoo adjusted returns to scale is 0.85. Returns to scale of 0.85 implies that a 100 percent increase in both the inputs used in the production sector of our economy will increase production by only 85 percent. This result holds serious consequences for the South African economy. It must be noted that few empirical studies on the aggregate production structure of the total South African economy have been conducted and information for comparative purposes is not readily available.

(iii) The fact that the Cobb-Douglas production technology is representative of the South African production structure, is confirmation of an unitary elasticity of substitution. The implication of a unitary elasticity of substitution is that the percentage change in the capital-labour ratio is equal to the percentage change in the price ratio.

This is of particular significance in the South African context, since the price-ratio dictates the capital-labour ratio. The higher the increase in the price of labour relative to the price of capital, the lower the demand for labour relative to the demand for capital. This confirms the phenomenon in the South African economy of an increasing capital-labour ratio as a result of the rising labour-capital price ratio.

From the above analyses it is clear that South Africa, which has an abundance of relatively expensive unskilled labour, can benefit materially by addressing structural unemployment through education and training. Improved training and education will enhance productivity and ultimately production through both rising employment and technical progress. Increased output growth will, in turn, stimulate the demand for capital (investment), the demand for skilled labour as well as technical progress. The process becomes self-sustaining, as output growth leads to further increases in employment, productivity and ultimately again economic growth.

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.

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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

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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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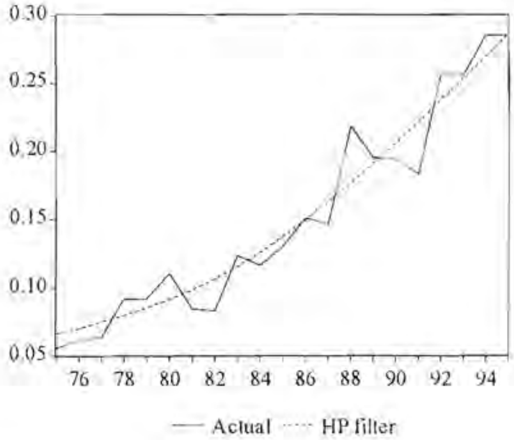
12 Surveys of the empirical literature on the NAWRU by Rose (1988) and Setterfield *et al.* (1992) suggest that robust structural estimates of the NAWRU have proven elusive. Both studies find that estimates vary considerably depending on the methodology used, the variables in the estimation, and the 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

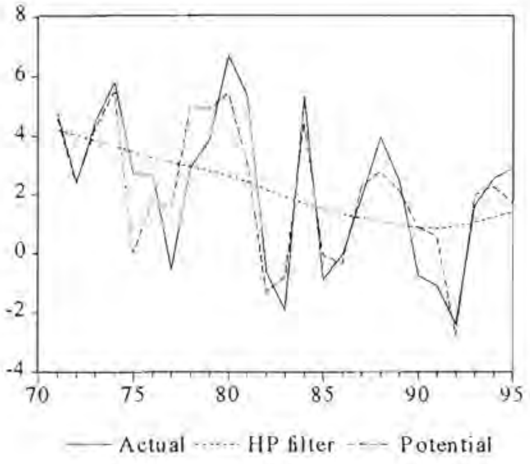
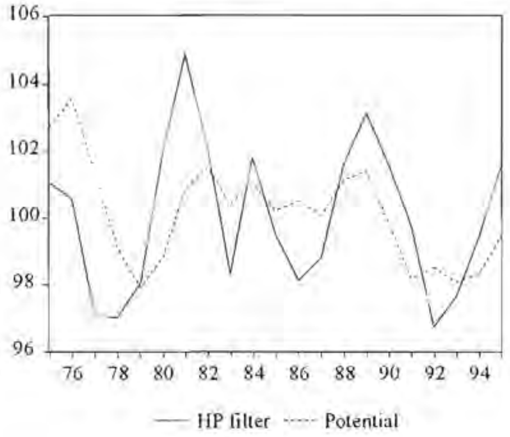


Figure 5.3 Output gap (capacity utilisation)



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

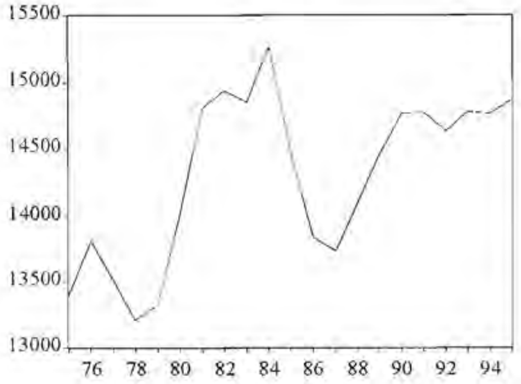


Figure 5.5 Unemployment rate

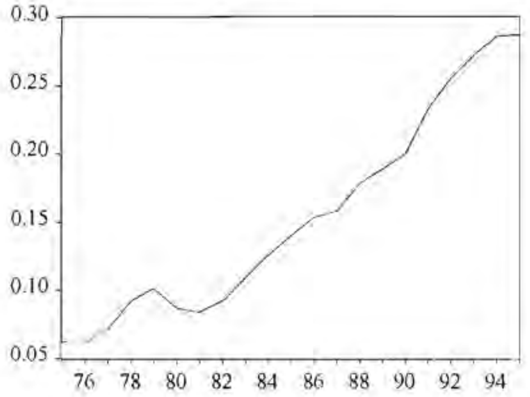


Figure 5.6 Total, skilled and unskilled labour supply

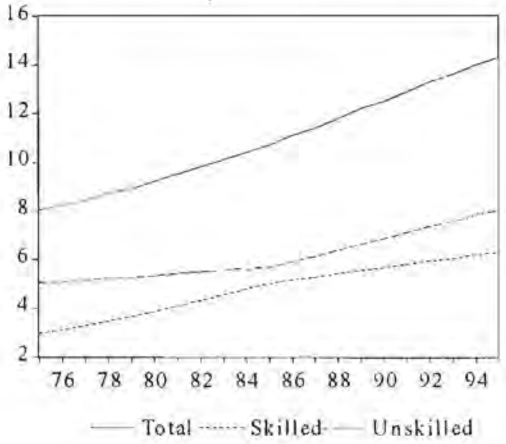


Figure 5.7 Skilled/Unskilled wage rate

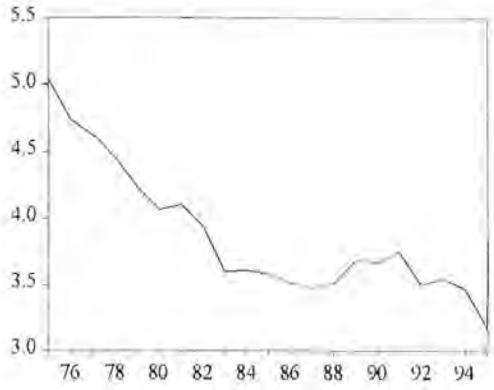
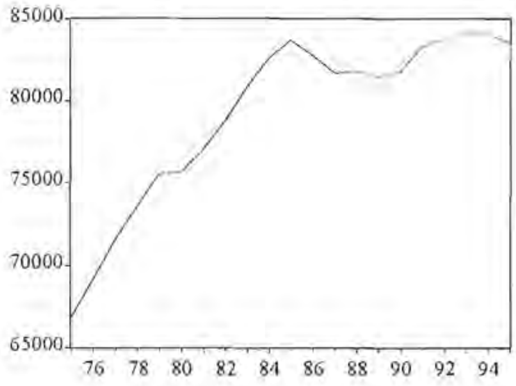


Figure 5.8 Capital-labour ratio



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:

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

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):

$$K_t^* = \mu \cdot Y_t \tag{6.3}$$

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:

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

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:

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

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

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

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).

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[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.

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,

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

[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)

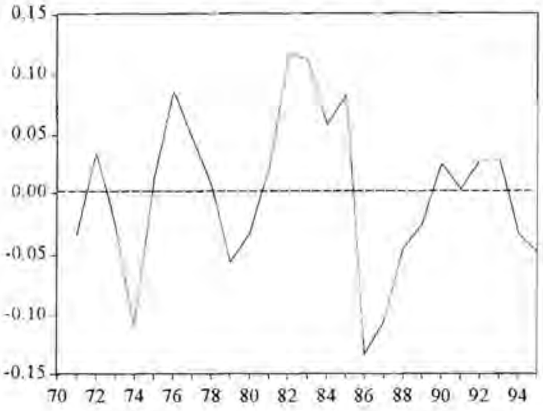


Table 6.2 Error correction model: Real fixed investment

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

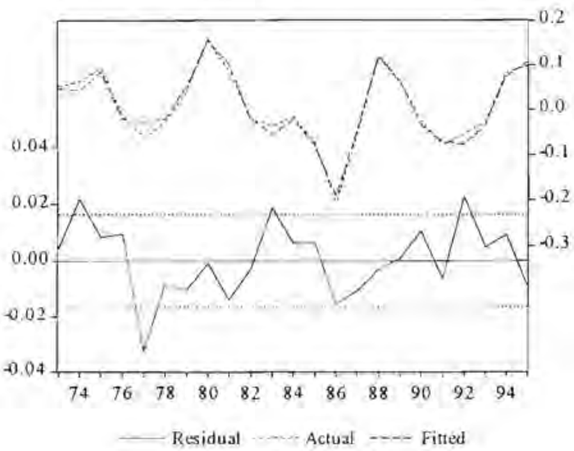
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.941250	0.105223	-8.945332	0.0000
Δ(kap_r(-1))	3.97E-06	5.12E-07	7.748606	0.0000
Δ(ln_vpi)	-0.941551	0.171373	-5.494178	0.0001
Δ(ln_vpi(-2))	0.976882	0.185696	5.260663	0.0001
Δ(ln_p_manuf(-1))	-1.037919	0.185598	-5.592299	0.0001
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

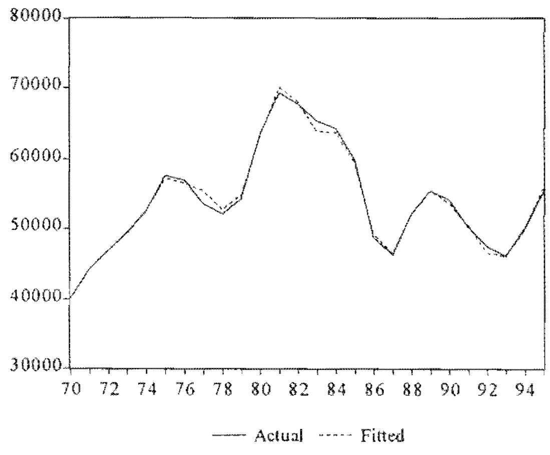
Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.94125)*ln_bbpfact_90p	0.005695	0.024834	0.229322
(0.94125)*ln_ucc2_90p	0.012817	0.013217	0.969749
(0.94125)*ln_fincond_ppi	0.003303	0.027384	0.120614
(0.94125)*kap_r	-1.02E-07	1.09E-07	-0.935943

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)

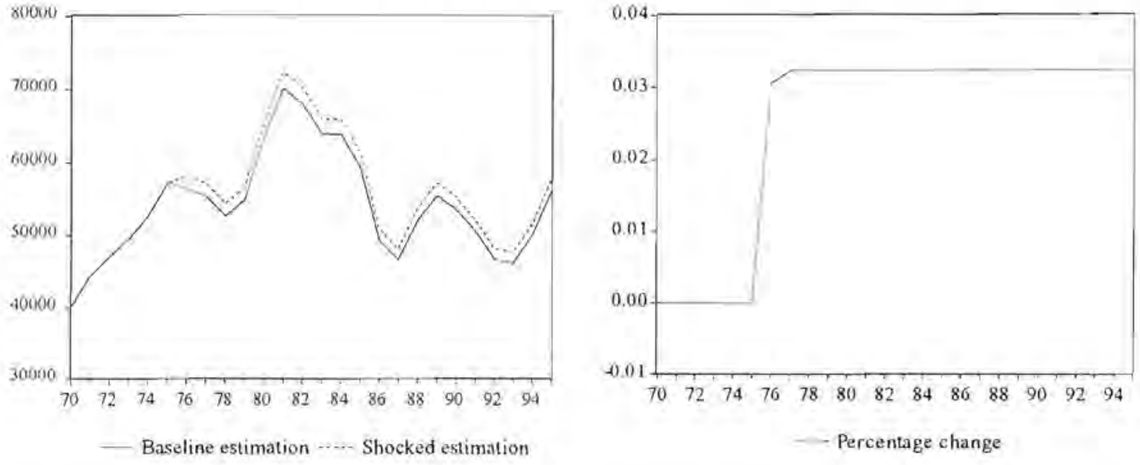


Figure 6.5 Dynamic adjustment (percentage change) in real fixed investment (ln_if) with a 10 percent increase in real user cost of capital (ln_ucc2_90p)

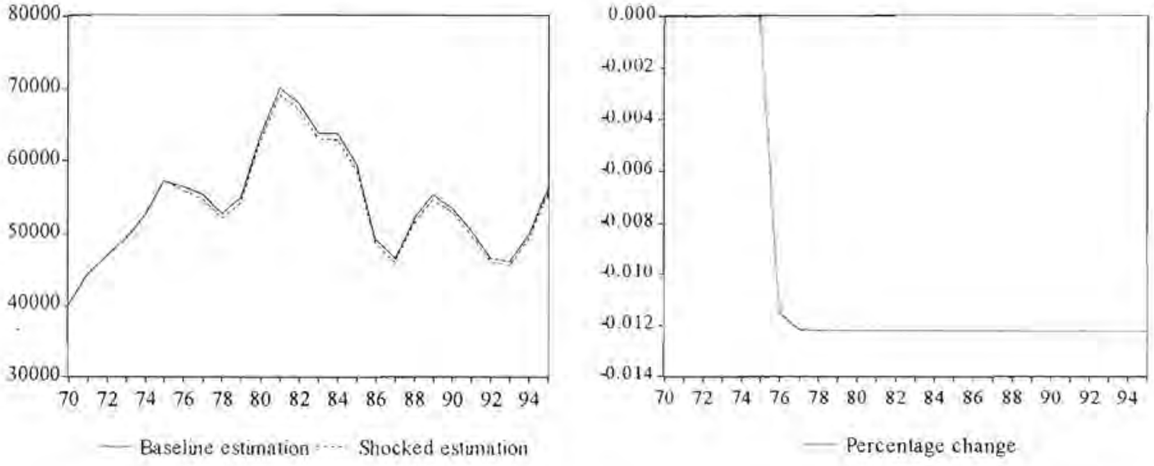


Figure 6.6 Dynamic adjustment (percentage change) in real fixed investment (ln_if) with a 10 percent increase in real financing of gross domestic investment (ln_fincond_ppi)

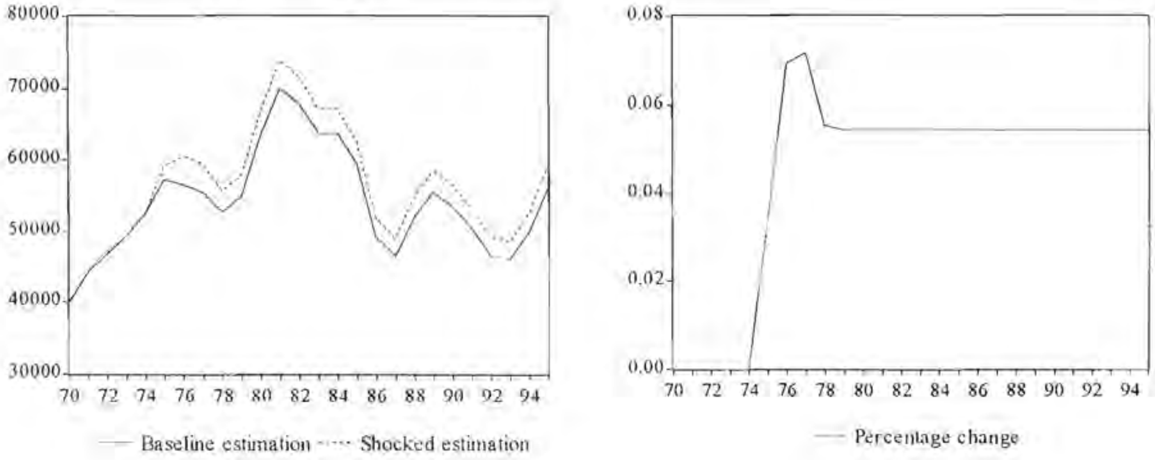
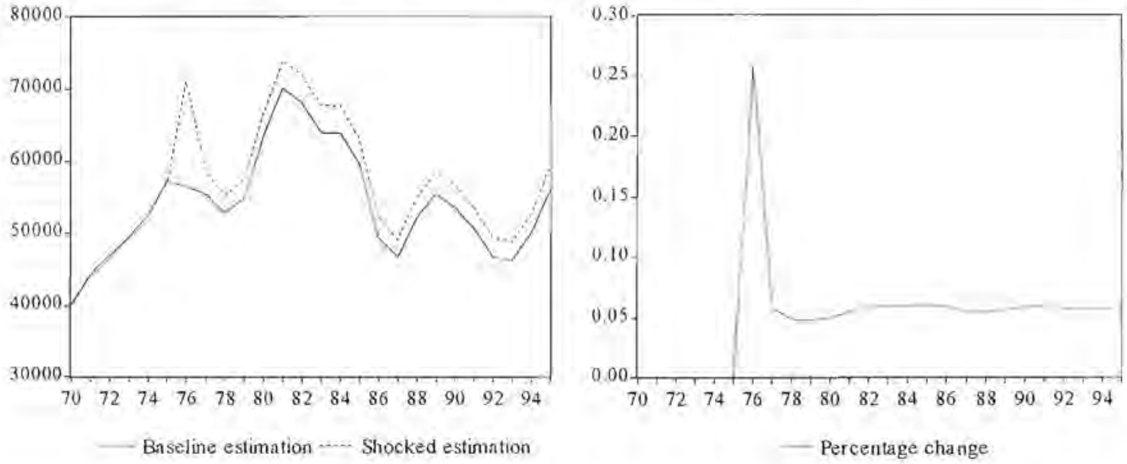


Figure 6.7 Dynamic adjustment (percentage change) in real fixed investment (ln_if) with a 10 percent increase in real capital stock (kap_r)



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.

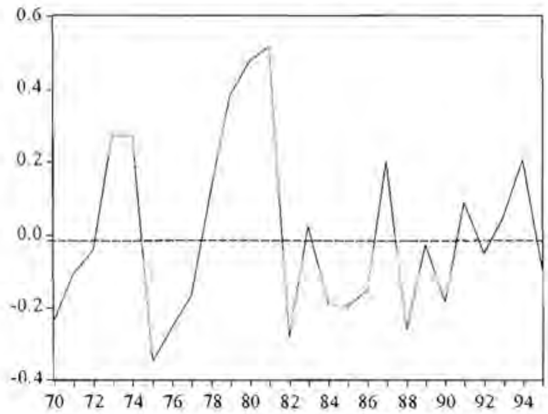
Table 6.8 Cointegration equation: Nominal corporate savings

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, $1 \leq n \leq 6$, 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.

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

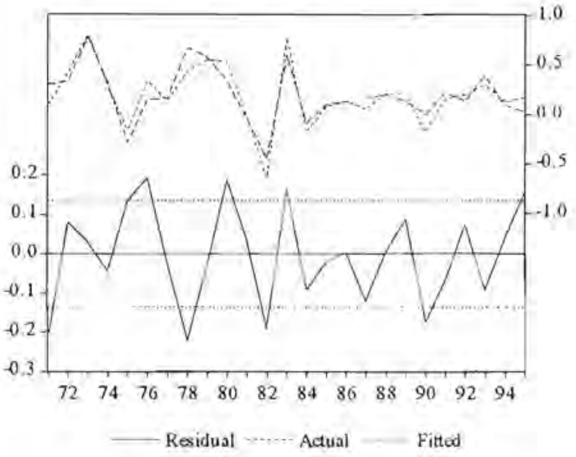
Dependent Variable: Δ(ln_sc_cp)
Method: Least Squares
Sample(adjusted): 1971 1995
Included observations: 25 after adjusting endpoints

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

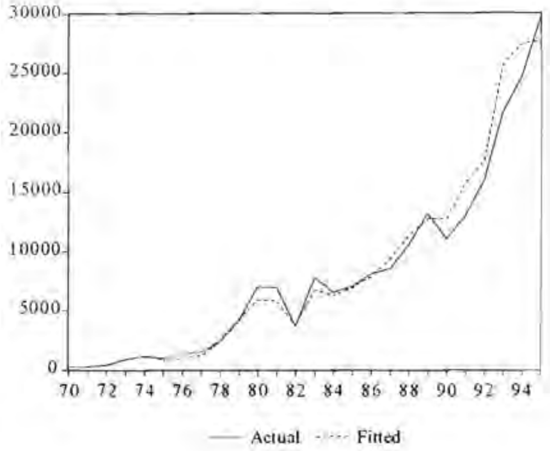
Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.122745)*ln_gostc_cp	-0.003376	0.019377	-0.174200

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

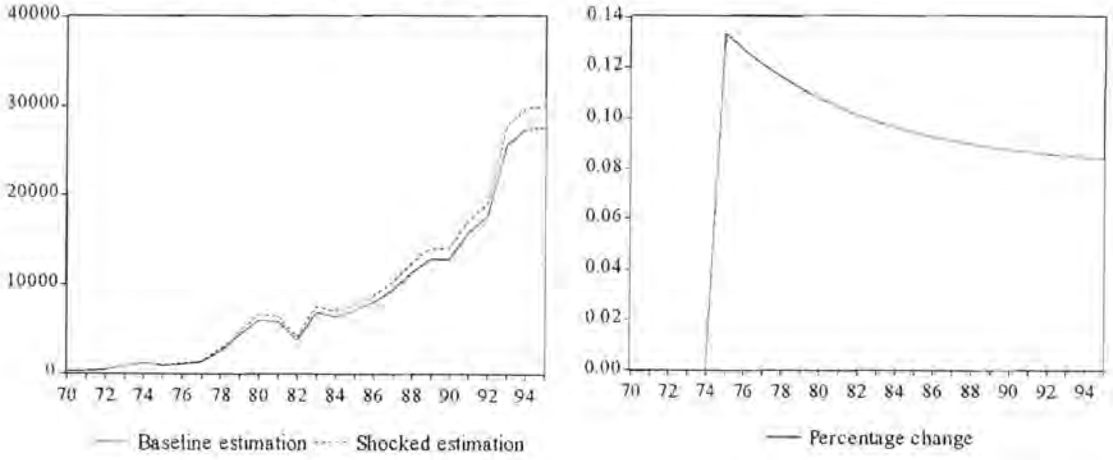
Table 6.14 reports the level of convergence of corporate savings and verifies the model's stability and robustness.

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:

$$N_t^s = EAP * LFP \qquad (7.15)$$

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:

$$LFP_t = f(w_t^c, Z_t^s) \qquad (7.16)$$

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^*:

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

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.

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

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:

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

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

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

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

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

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

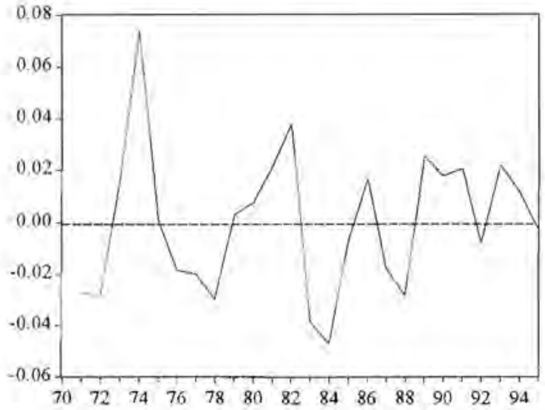
R-squared	0.991987	F-statistic	1361.835
Adjusted R-squared	0.991259	Prob(F-statistic)	0.000000

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.

---

[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

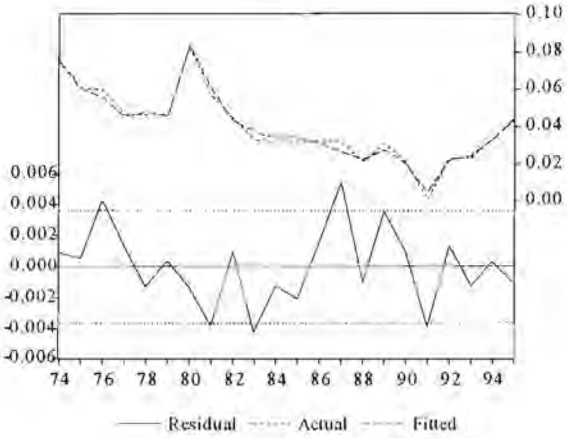
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.294219	0.076298	-3.856204	0.0032
Δ(ln_bbp_90p)	0.329872	0.039923	8.262628	0.0000
Δ(ln_bbp_90p(-1))	0.496150	0.050496	9.825513	0.0000
Δ(ln_bbp_90p(-2))	0.415129	0.068378	6.071130	0.0001
Δ(ln_rel_wsu_rat)	-0.162451	0.040032	-4.058061	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

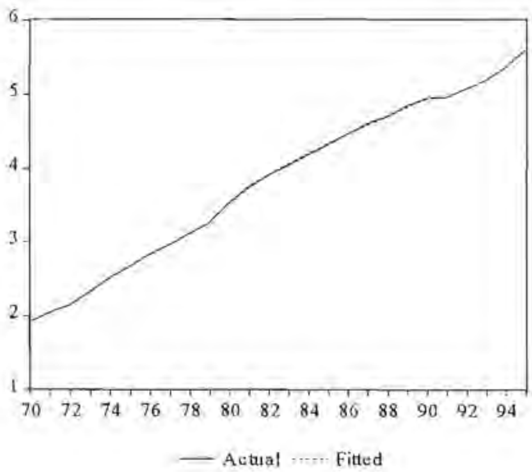
Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.294219)*ln_bbp_90p	-0.000534	0.001891	-0.282242
(0.294219)*ln_rel_wsu_rat	0.015958	0.031994	0.498787
(0.294219)*ln_rel_wscost_u	-0.001277	0.004775	-0.267475

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

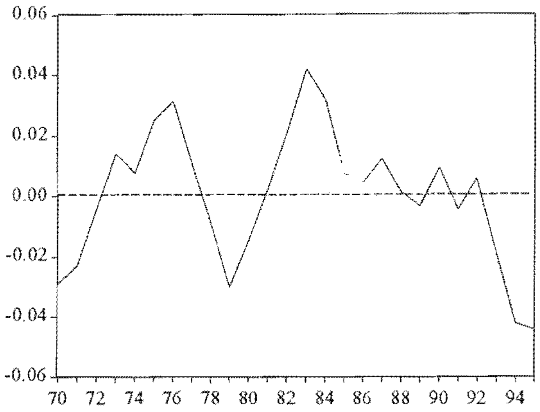
Dependent Variable: ln_nu
Method: Least Squares
Sample(adjusted): 1970 1995
Included observations: 26 after adjusting endpoints

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

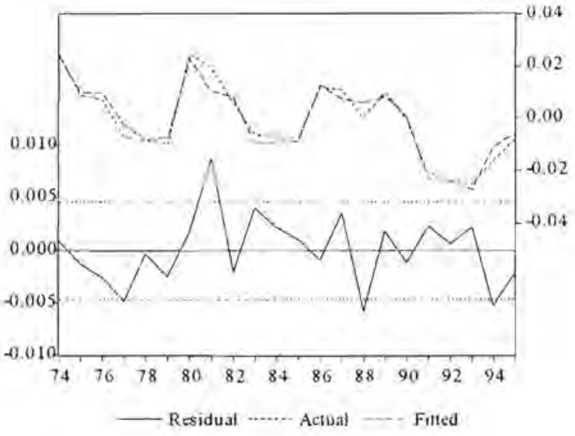
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.130607	0.064762	-2.016733	0.0688
Δ(ln_socind)	-0.083803	0.019051	-4.398812	0.0011
Δ(ln_socind(-1))	0.059588	0.018826	3.165141	0.0090
Δ(ln_interposind)	-0.074636	0.009589	-7.783107	0.0000
Δ(ln_interposind(-3))	-0.019511	0.008591	-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

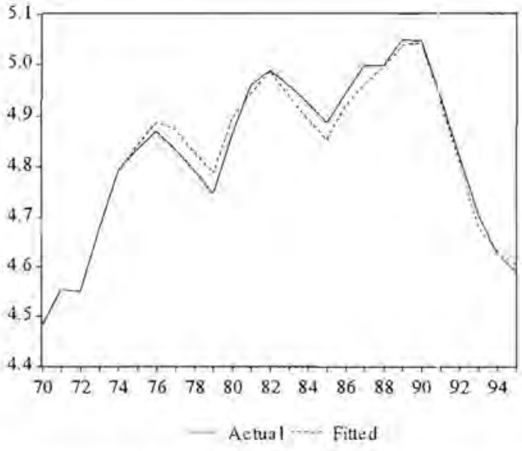
Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.130607)*ln_bbp_90p	0.022273	0.074260	0.299932
(0.130607)*ln_wuppi_rat	-0.031699	0.105696	-0.299909

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

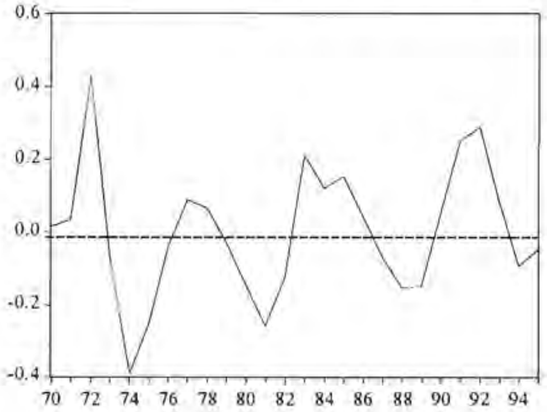
Dependent Variable: ln_n_informal
Method: Least Squares
Sample(adjusted): 1970 1995
Included observations: 26 after adjusting endpoints

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

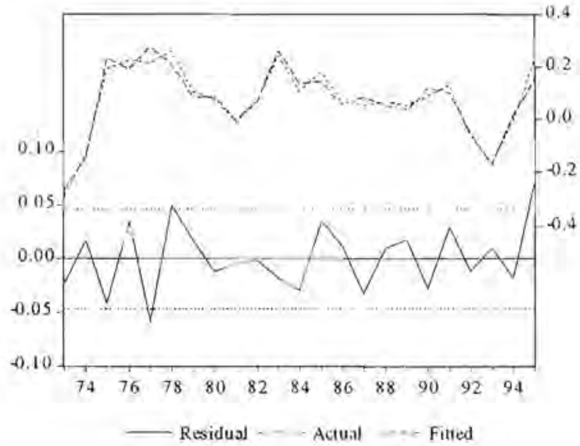
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.516895	0.095506	-5.412184	0.0003
Δ(ln_n_informal(-1))	0.291756	0.088837	3.284163	0.0082
Δ(ln_n_informal(-2))	-0.439398	0.152038	-2.890060	0.0161
Δ(ln_socind(-2))	-0.689871	0.220594	-3.127335	0.0107
Δ(ln_bbp_min_90p(-1))	1.128687	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

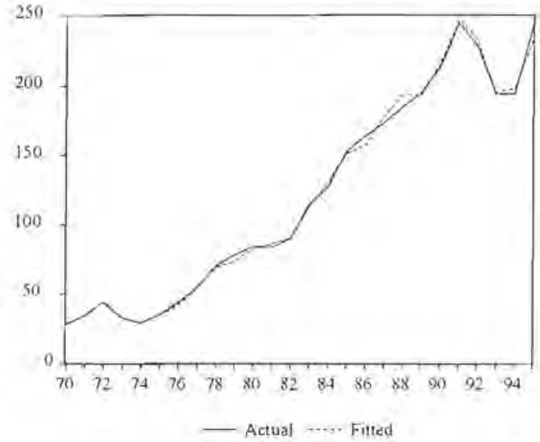


Table 7.18 Simulation error statistics of labour participants in informal sector

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

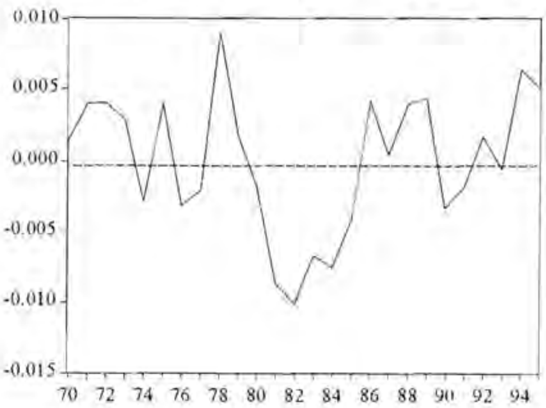
Dependent Variable: ln_s
Method: Least Squares
Sample(adjusted): 1970 1995
Included observations: 26 after adjusting endpoints

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

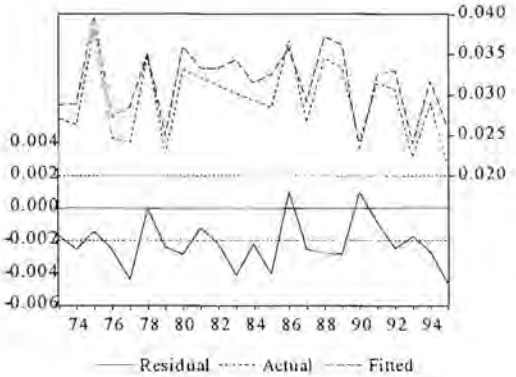
Table 7.20 (*cont.*)

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)

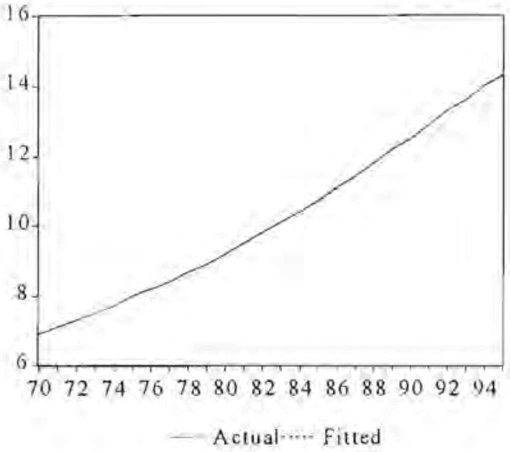
Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_total_pop	0.4812201	1159.5665
ln_wtot_rate	0.1355454	276.62327

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

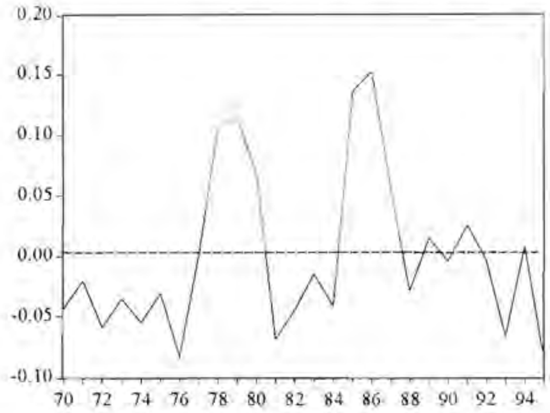
Dependent Variable: ln_ss
Method: Least Squares
Sample(adjusted): 1970 1995
Included observations: 26 after adjusting endpoints

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

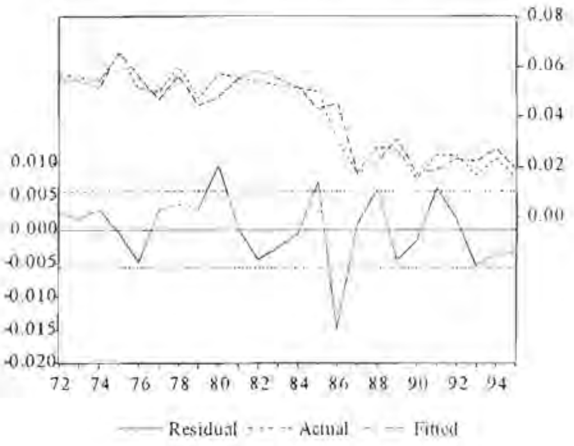
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.040049	0.019057	-2.101557	0.0492
Δ(ln_s)	1.268536	0.269037	4.715099	0.0002
Δ(ln_ss(-1))	0.739383	0.088745	8.331577	0.0000
braindrain_dum	-0.008025	0.003288	-2.440369	0.0246
c	-0.024742	0.008157	-3.033187	0.0068

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

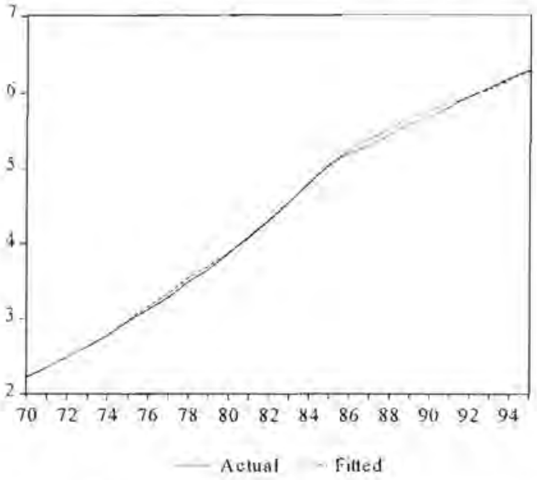
Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.040049)*ln_educind	-0.091983	0.068304	-1.346667
(0.040049)*ln_wtot_vpi_rat	0.000679	0.002769	0.245113

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.

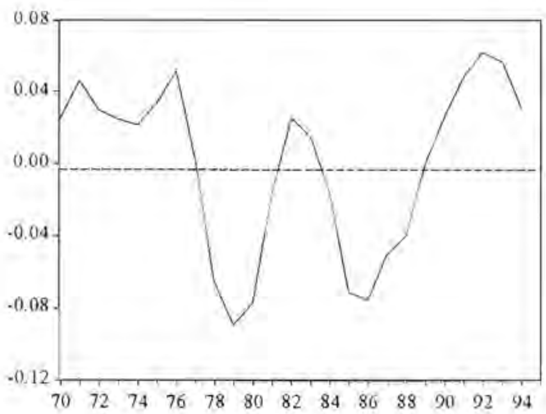
Table 7.31 Cointegration equation: Nominal skilled wage rate

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

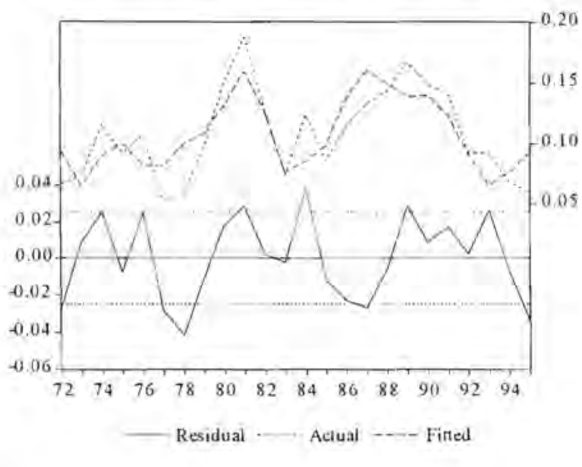
Dependent Variable: Δ(ln_ws_rate)
Method: Least Squares
Sample(adjusted): 1972 1995
Included observations: 24 after adjusting endpoints

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)

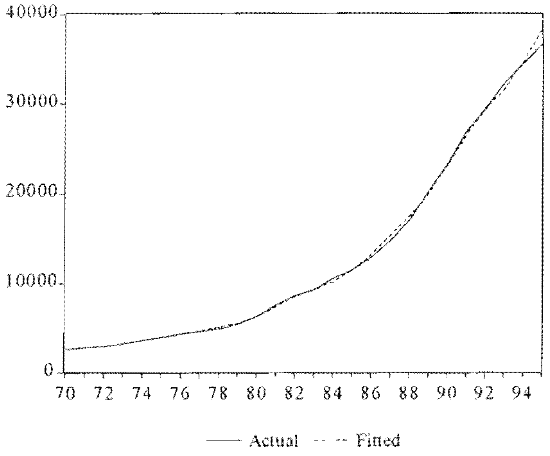
Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_vpi(1)	0.876221	88.614583
ln_product	0.675239	264.69581

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

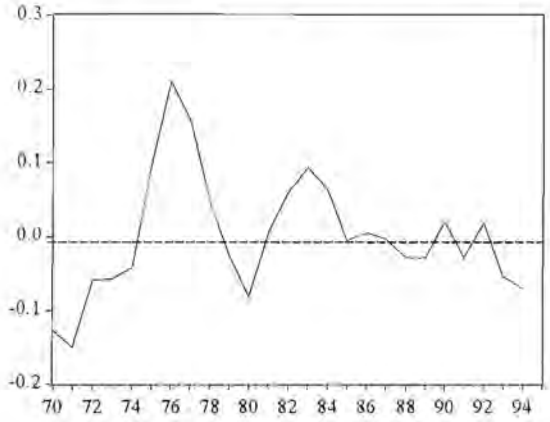
Dependent Variable: ln_wuvpi_rat
Method: Least Squares
Sample(adjusted): 1970 1994
Included observations: 25 after adjusting endpoints

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

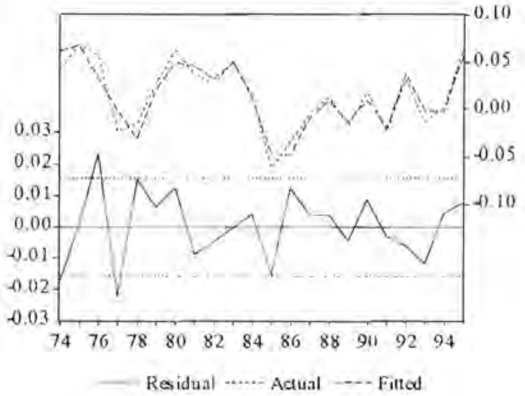
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.186843	0.070747	-2.641006	0.0230
Δ(ln_socind)	0.186627	0.058317	3.200236	0.0085
Δ(ln_socind(-2))	-0.130427	0.069680	-1.871793	0.0880
Δ(ln_socind(-3))	0.178179	0.066587	2.675901	0.0216
Δ(ln_xgoud_px(-1))	0.170801	0.047591	3.588941	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

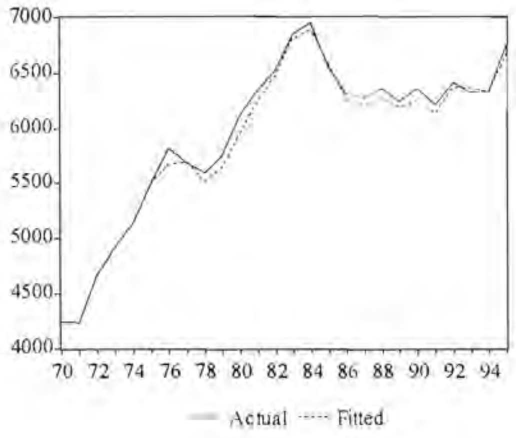


Table 7.42 Simulation error statistics of real unskilled wage rate

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)**

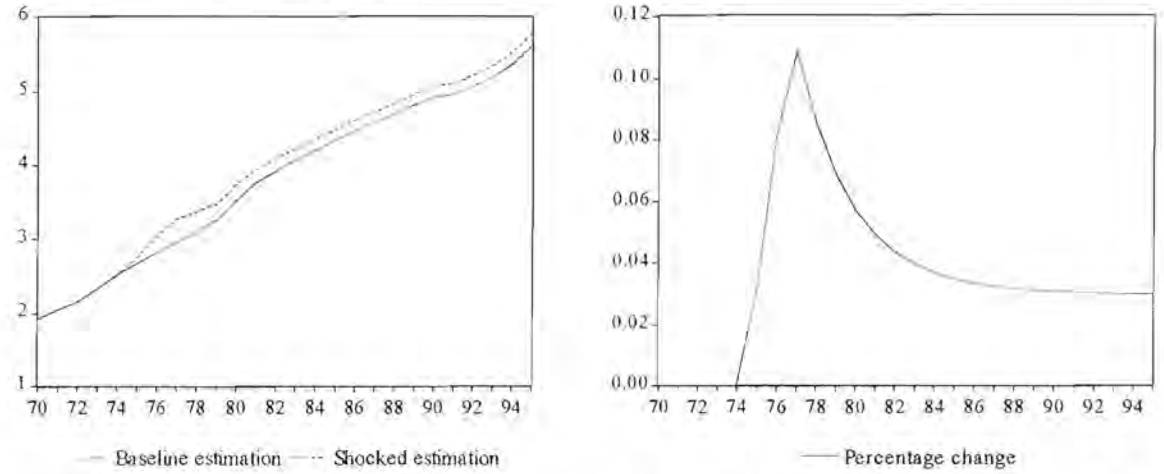


Figure 7.23 **Dynamic adjustment (percentage change) in demand for skilled labour (ln_ns) with a 10 percent increase in skilled wage rate relative to unskilled wage rate (ln_rel_wsu_rat)**

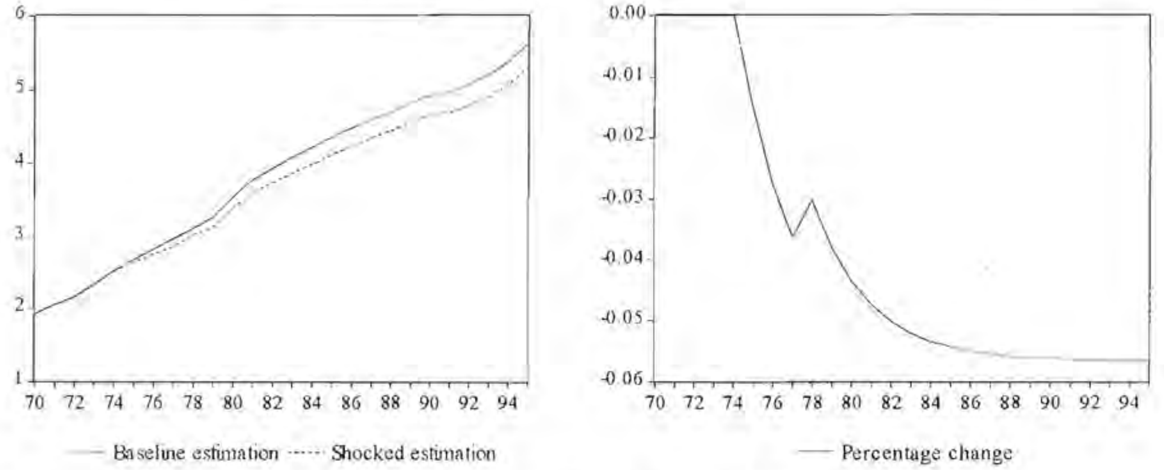
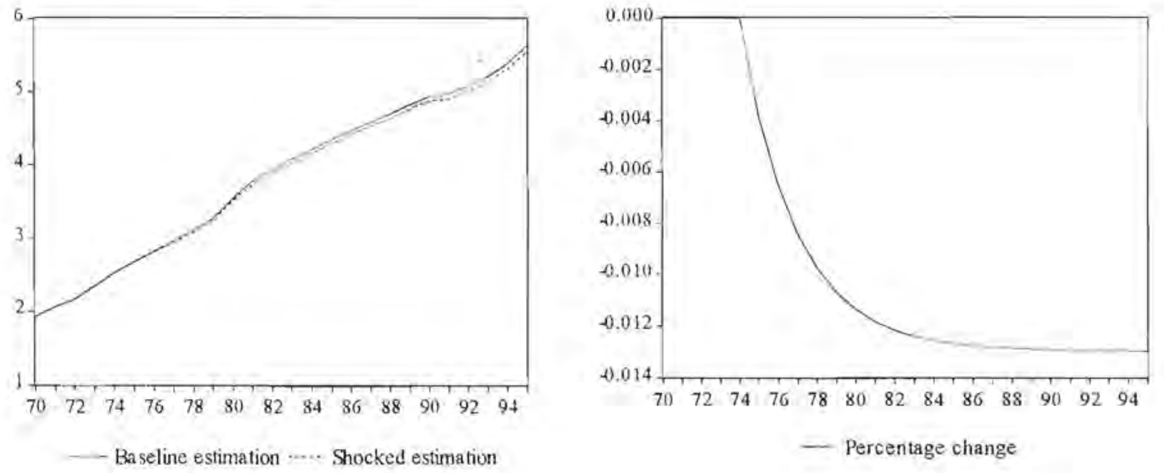


Figure 7.24 **Dynamic adjustment (percentage change) in demand for skilled labour (ln_ns) with a 10 percent increase in skilled labour cost relative to user cost of capital (ln_rel_wscost_u)**



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)

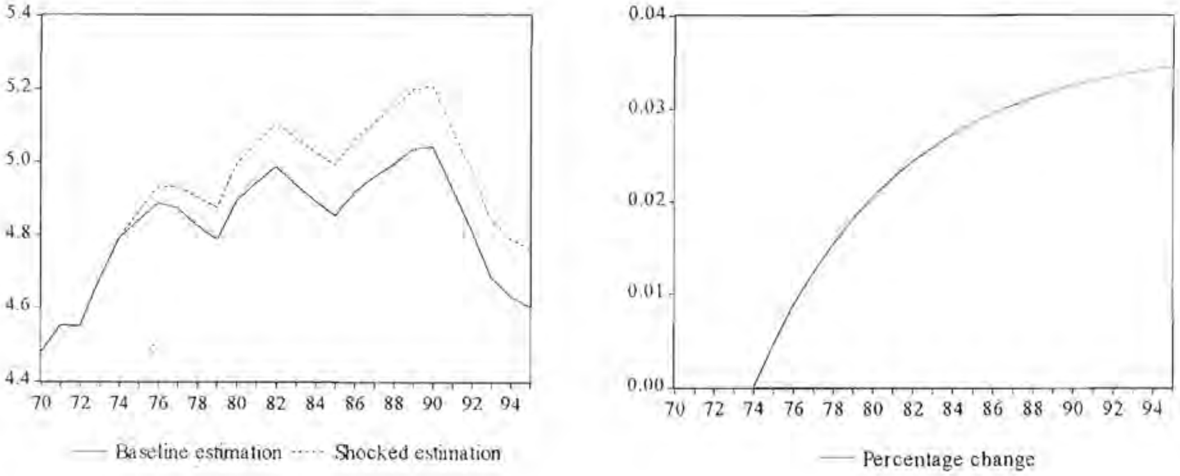
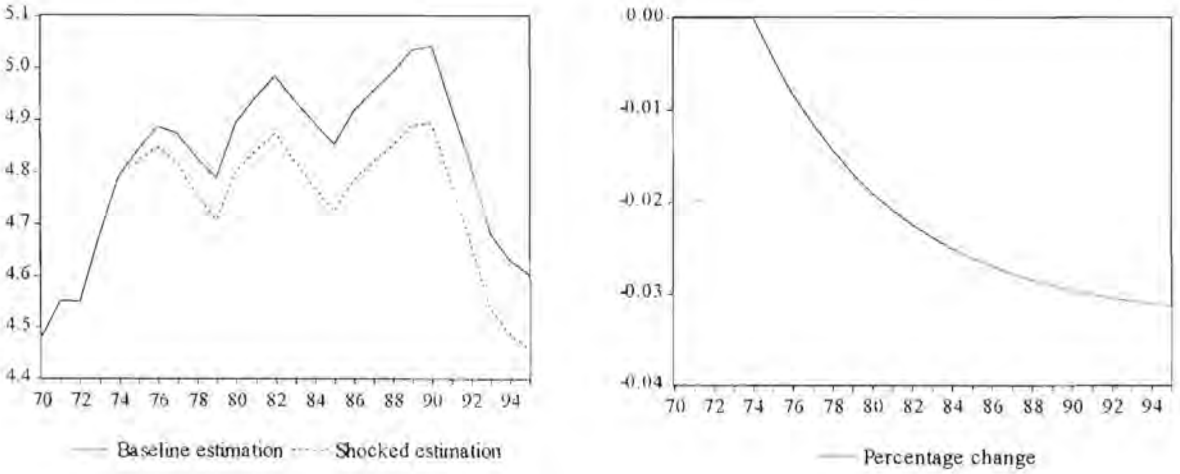


Figure 7.26 Dynamic adjustment (percentage change) in demand for unskilled labour (ln_nu) with a 10 percent increase in real unskilled wage rate (ln_wuppi_rat)



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)

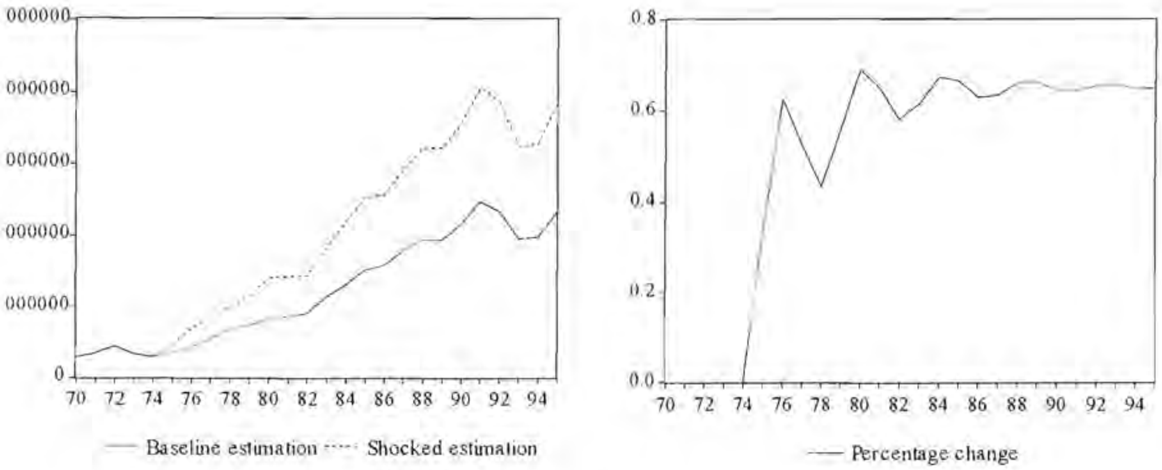
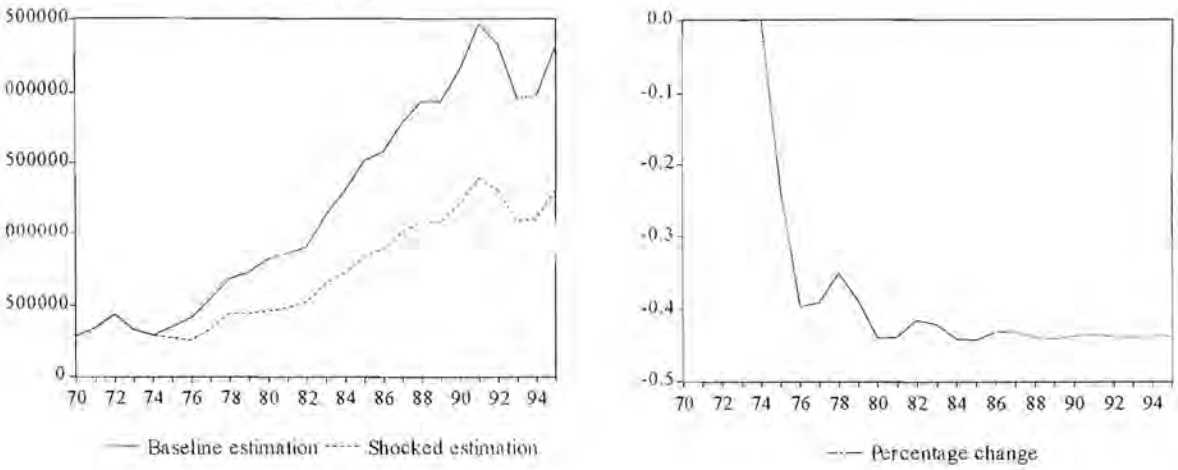


Figure 7.28 Dynamic adjustment (percentage change) in labour participants in informal sector (ln_n_informal) with a 10 percent increase in real total wage rate (ln_wtot_vpi_rat)



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)

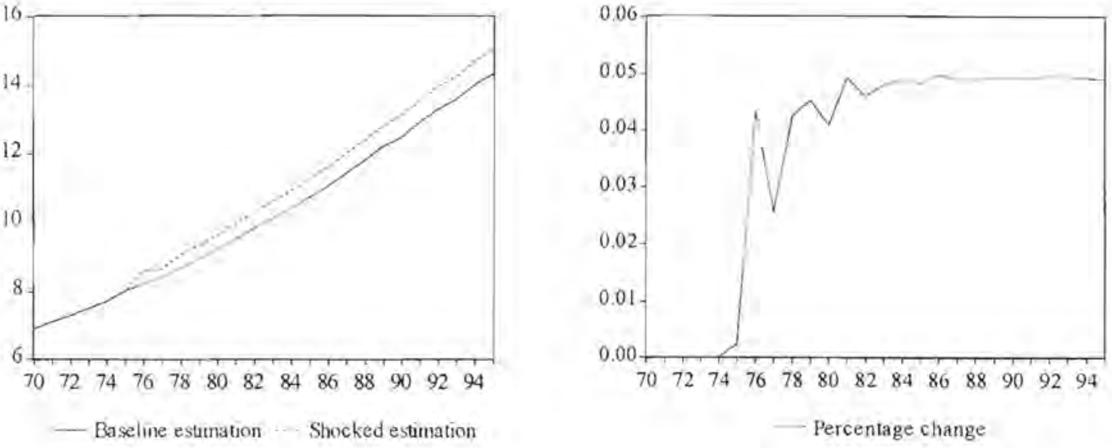
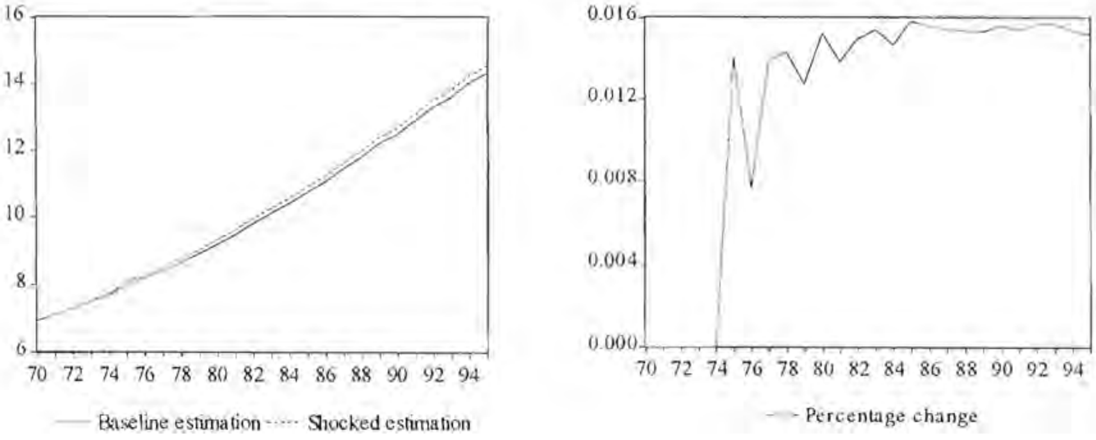


Figure 7.30 Dynamic adjustment (percentage change) in total labour supply (ln_s) with a 10 percent increase in nominal total wage rate (ln_wtot_rate)



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)

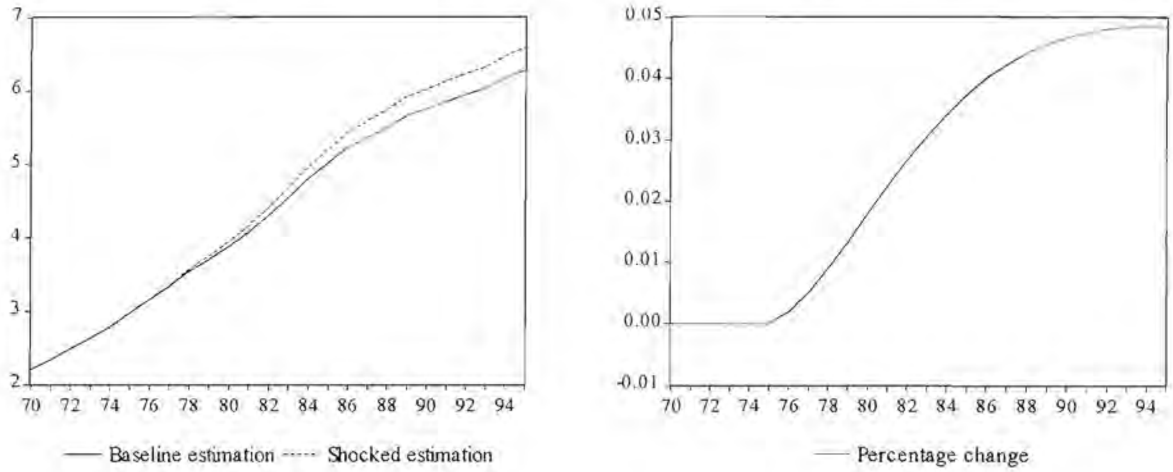
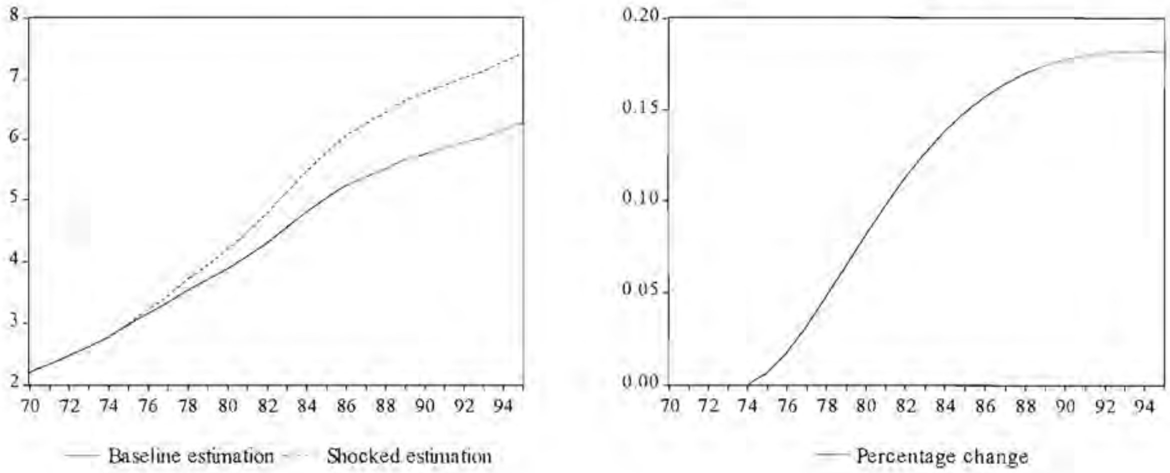


Figure 7.32 Dynamic adjustment (percentage change) in skilled labour supply (ln_ss) with a 10 percent increase in real total wage rate (ln_wtot_vpi_rat)



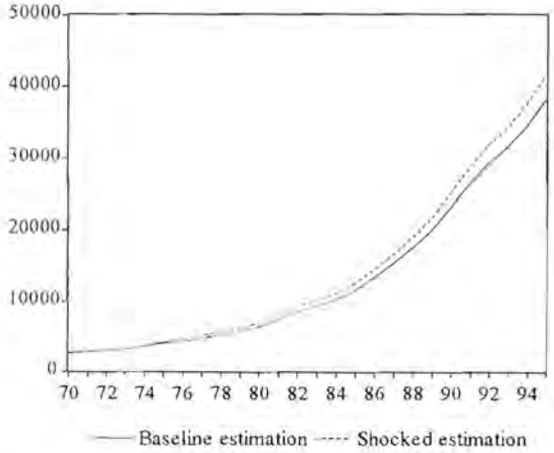
7.4.5 Wage determination

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)



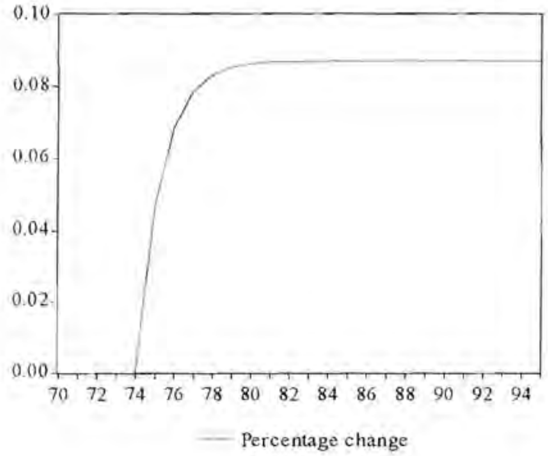
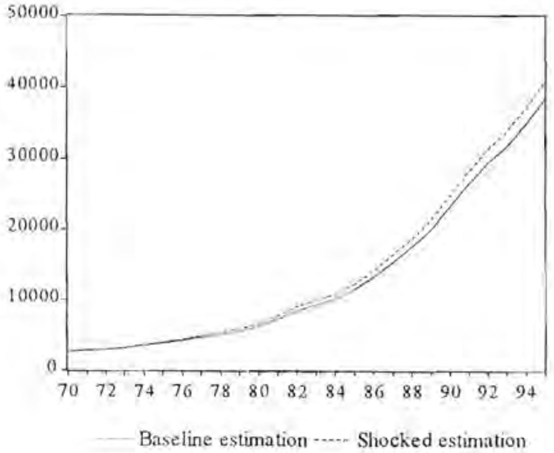
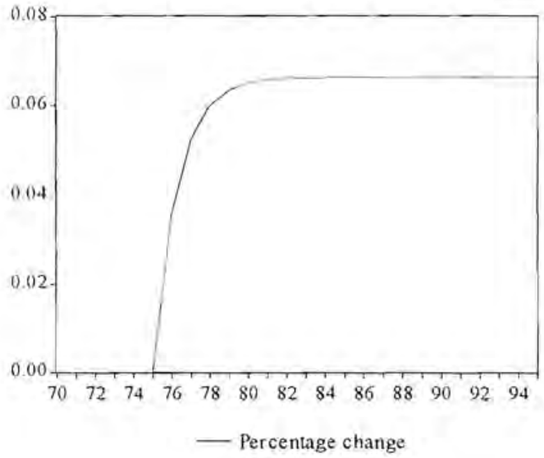


Figure 7.34 Dynamic adjustment (percentage change) in nominal skilled wage rate (ln_ws_rate) with a 10 percent increase in productivity (ln_product)





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)

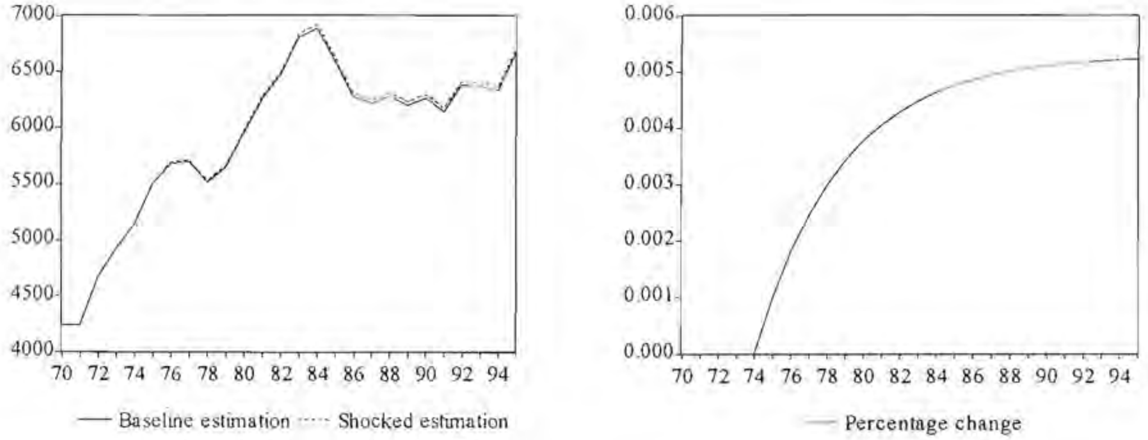


Figure 7.36 Dynamic adjustment (percentage change) in real unskilled wage rate (ln_wuvpi_rat) with a 10 percent increase in real net gold exports (ln_xgoud_px)

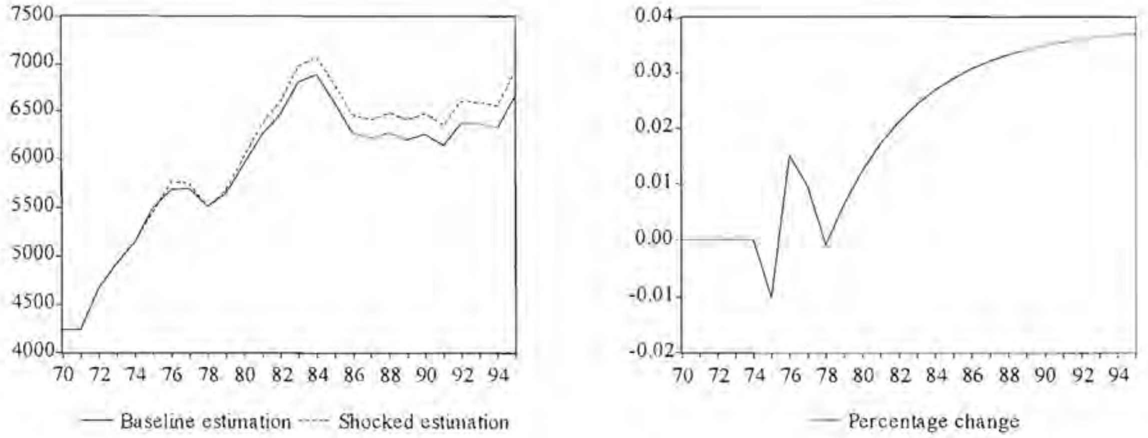
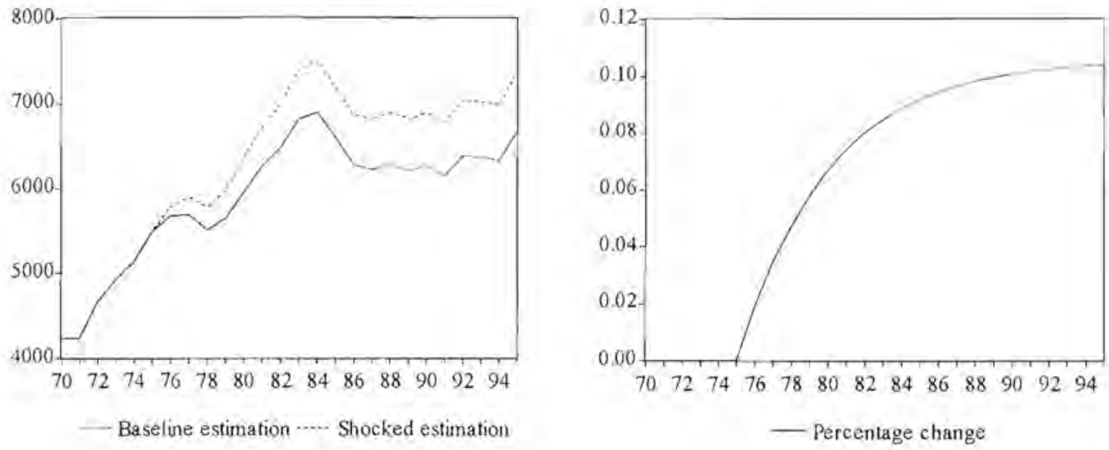


Figure 7.37 Dynamic adjustment (percentage change) in real unskilled wage rate (ln_wuvpi_rat) with a 10 percent increase in productivity (ln_product)



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.

CHAPTER 8

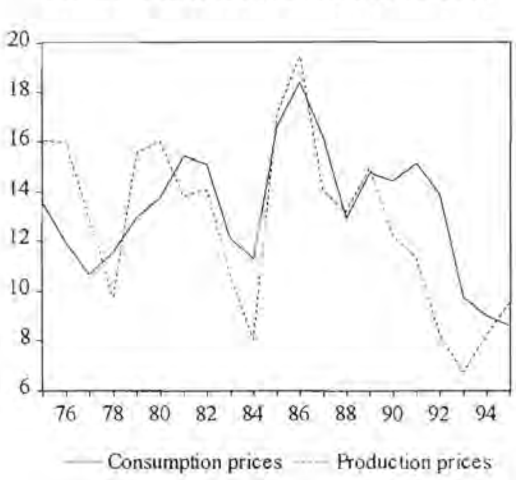
PRICE SETTING IN A NEOCLASSICAL FRAMEWORK

8.1 INTRODUCTION

The key decision for firms operating in a neoclassical, i.e. profit-maximising or cost-minimising framework is where to set their prices.

The purpose of this chapter is to develop a pricing structure for the neoclassical supply-side model. This offers the additional advantage of being able to explain the high inflation levels the South African economy has been plagued with since 1970 (see figure 8.1). For purposes of consistency, the Layard-Nickell approach, utilised in chapter 7 to model wages and employment, is again employed. It is based on the estimation of an aggregate cost function and, as explained before, it is utilised in a slightly different way in this study (see chapter 7). However, the approach still entails the joint derivation and estimation of factor demand and price equations, ensuring consistency in the neoclassical framework.

Figure 8.1 Inflation in South Africa: 1970-1995



8.2 THEORETICAL FRAMEWORK

In a neoclassical profit-maximising framework with imperfect market competition, such as the one suggested by Layard and Nickell (1985, 1986; Nickell 1988), firms set prices as a mark-up on the marginal cost of production, proxied by average or unit costs (Burda and Wyplosz 1993: 256).

$$P^p = m * AC \qquad \text{where} \qquad m = \frac{1}{1 - 1/\eta} > 1; \qquad m' \geq 0 \tag{8.1}$$

with P^p production prices, m the price mark-up, AC average or unit cost of production and η price elasticity of demand.

The mark-up (m) depends on the sensitivity of the market to price changes, measured by the price elasticity of demand. As it is natural to think of m as being influenced by the short-run demand position, it may be specified in terms of a demand pressure variable, such as expected demand relative to normal output (Nickell 1988).

$$m = m(Y^{ed} / Y^{*}) \qquad (8.2)$$

Although the cost of production includes both labour and capital costs, it is standard practice to base a model of price-setting on normal unit (average) costs, where "normal" in this context refers to labour costs only, excluding the cost of capital.[1]

Assuming normal unit costs (similar to Layard and Nickell), average cost of production may be specified in terms of (1) changes in nominal wage rates relative to labour productivity, (2) cyclical demand pressures such as deviations in actual unemployment rates from the equilibrium rate of unemployment, rates of capacity utilisation, etc., and (3) exogenous supply shocks (Burda and Wyplosz 1993: 243-248).

Layard and Nickell go a step further by expanding the price equation to incorporate expected competitors' prices, yielding a price-setting equation of the form:

$$P^{p} / W = h(P^{p} / P^{e}) m(Y^{ed} / Y^{*}) g(Y^{*} / \alpha L) \qquad (8.3)$$

where W is nominal wages inclusive of employers' labour taxes, P^{p} / P^{e} is production (value-added) relative to expected prices and $Y^{*} / \alpha L$ is the normal labour productivity (Nickell 1988: 203-204).

Consumer prices (P^{c}), which are directly related to production prices, may now be specified as:

$$P^{c} = f(P^{p}, t^{i}, P^{m}) \qquad (8.4)$$

where t^{i} is indirect taxes and P^{m} import prices on consumption goods.

8.3 ESTIMATION RESULTS

In this section, models of production and consumption prices are proposed, estimated and validated by utilising the Engle and Yoo cointegration technique and a battery of diagnostic tests and evaluation procedures. The specifications are based on a strategy of mark-up pricing in a profit-maximising framework.

---

[1] This approach is followed by Layard and Nickell and differs from that followed by (for example) the OECD, where the cost of capital is also included in the specification of price equations (Helliwell 1985; Turner *et al.* 1996).

8.3.1 The theoretical model

The Layard-Nickell framework of mark-up pricing is used as the basis to model price-setting behaviour in South Africa. Whereas Layard and Nickell assume normal unit costs, this study has opted for an approach where unit capital costs are also included in the price equation. Long-run production or value-added prices P^p are therefore specified and estimated as:

$$P^p = f((W / product), r)$$
$$\qquad\quad + \qquad\quad +$$

where W is the nominal wage rate, $product$ is labour productivity and r is nominal user-cost-of-capital (Appendix 7). A measure for capacity utilisation (cu) is included in the short-run specification of the model to capture potential demand pressures.

Based on the theoretical exposition in the previous section, consumption prices (P^c) are specified as:

$$P^c = f(P^p, P^m, GDE / GDP)$$

where GDE / GDP (gross domestic expenditure relative to gross domestic production in nominal terms, i.e. excess demand) creates a link with the demand side and captures any demand pressure effect.

In order to distinguish between the contribution of the rand exchange rate relative to the contribution of true prices of import goods, import prices in rand (P_R^m) are included as:

$$P^m = P_R^m = P_\$^m * R / \$$$

where $P_\$^m$ is import prices in dollar and $R / \$$ the rand/dollar exchange rate, South Africa's leading exchange rate.

Consumption prices (P^c) are therefore estimated in the form:[2]

$$P^c = f(P^p, P_\$^m, R / \$, GDE / GDP)$$
$$\qquad + \quad + \quad + \qquad +$$

2 Restrictions had to be placed on the coefficients of P^p and $P_\$^m$ due to obvious problems in the data series.

8.3.2 The data

The data-generating processes, as well as an explanation of the methodology, are provided in Appendix 7. Appendices 8 and 9 present an explanatory list and graphical representation of variables utilised in both the long-run cointegration and short-run error correction model.

8.3.3 Production prices

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

In estimating the long-run relationship empirically specified in the previous section for production or value-added prices, the cointegration results of table 8.1 were obtained, with an Engle-Granger test statistic of –3.11.

Table 8.1 Cointegration equation: Production price index

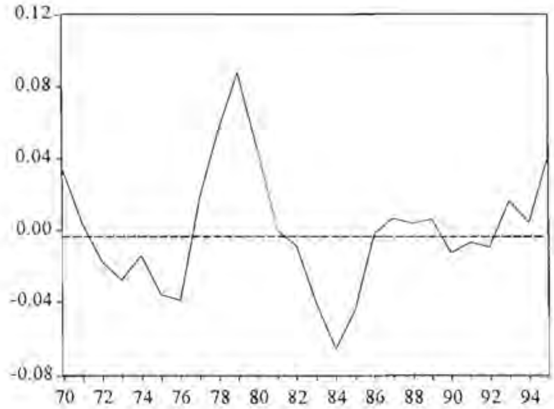
Dependent Variable: ln_ppi
Method: Least Squares
Sample(adjusted): 1970 1995
Included observations: 26 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
ln_ucc2_nom	0.267628	0.113043	2.367486	0.0267
ln_w_prod	0.605172	0.105318	5.746112	0.0000
c	-4.146606	0.880478	-4.709497	0.0001

R-squared	0.998734	F-statistic	9071.626
Adjusted R-squared	0.998624	Prob(F-statistic)	0.000000

An illustration of the stationary residuals is provided in figure 8.2.

Figure 8.2 Residuals: production price index (ln_ppi)



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

The short-run dynamics of the model are reported in table 8.2.

Table 8.2 Error correction model: Production price index

Dependent Variable: Δ(ln_ppi)
Method: Least Squares
Date: 09/20/99 Time: 02:45
Sample(adjusted): 1972 1995
Included observations: 24 after adjusting endpoints

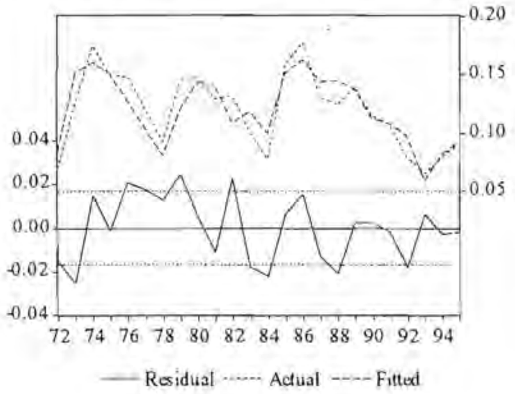
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.283469	0.114908	-2.466917	0.0233
ln_cu(-2)	0.012082	0.002748	4.396891	0.0003
Δ(ln_interposind)	-0.127054	0.028129	-4.516836	0.0002
Δ(sanction_dum)	0.032431	0.012571	2.579837	0.0184
Δ(ln_w_prod)	0.351462	0.086008	4.086365	0.0006

R-squared	0.782778	F-statistic	17.11707
Adjusted R-squared	0.737048	Prob(F-statistic)	0.000004
S.E. of regression	0.016722		

The dynamic adjustment to the long-run equilibrium is explained, in addition to the long-run explanatory variables, by a measure for capacity utilisation (*ln_cu*) capturing the effects of demand pressure, a set of international factors (*ln_interposind*) emphasising the role of the degree of openness of the South African economy on domestic prices and a dummy variable for economic sanctions (Appendix 7).

The estimation results are plotted in figure 8.3.

Figure 8.3 Actual, fitted and residual values of ln_ppi



(iii) *Diagnostic testing*

The estimated function is statistically well-behaved and passes the full set of diagnostic tests. The results are reported in table 8.3.

Table 8.3 Diagnostic tests: Production price index (ln_ppi)

Purpose of test	*Test*	*d.f.*	*Test statistic*	*Probability*
Normality	Jarque-Bera	JB(2)	1.338548	[0.521080]
Homoscedasticity	ARCH LM	$nR^2(1)$	0.086306	[0.768927]
Homoscedasticity	White	$nR^2(10)$	9.181205	[0.514997]
Serial correlation	Breusch-Godfrey	$nR^2(2)$	0.616509	[0.734728]
Serial correlation	Lung Box Q	Q(12)	9.132500	[0.692000]
Misspecification	Ramsey Reset	LR(2)	0.272135	[0.872784]
Parameter stability	Recursive estimates	Indicative of stability		

(iv) *Cointegration correction and adjusted coefficients*

After the estimation of the error correction model, the third-step cointegration correction was carried out (table 8.4) to determine the adjusted coefficients and *t*-values (table 8.5).

Table 8.4 Engle-Yoo third-step estimation: Production price index (ln_ppi)

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

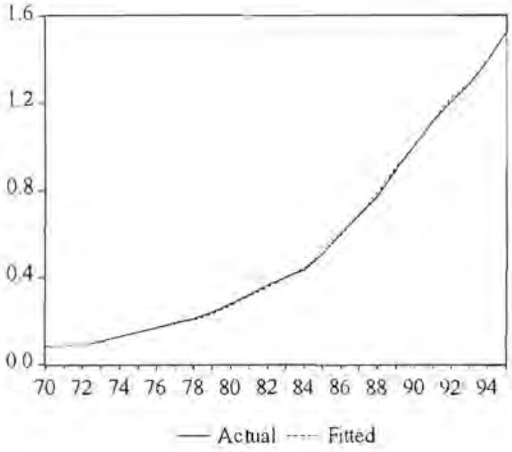
Variable	*Coefficient*	*Std. Error*	*t-Statistic*
(0.283469)*ln_ucc2_nom	-0.006231	0.008910	-0.699308
(0.283469)*ln_w_prod	-0.001954	0.003043	-0.642090

Table 8.5 Cointegration correction: Production price index (ln_ppi)

Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_ucc2_nom	0.261397	29.337486
ln_w_prod	0.603218	198.23135

A dynamic simulation of the estimated model resulted in figure 8.4.

Figure 8.4 Actual and fitted values of ln_ppi



The associated simulation error statistics,[3] all indicative of a good fit, are reported in table 8.6.

Table 8.6 Simulation error statistics of production price index

Actual v Fitted : ln_ppi	
Root Mean Squared Error	0.014879
Mean Absolute Error	0.012546
Mean Absolute Percentage Error	1.993426
Theil Inequality Coefficient	0.006033
Bias Proportion	0.000000
Variance Proportion	0.020916
Covariance Proportion	0.979084

8.3.4 Consumption prices

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

The equilibrium estimation results are reported in table 8.7, with the associated Engle-Granger test statistic of −2.84, indicative of a cointegrated long-run relationship.

[3] See Appendix 2.

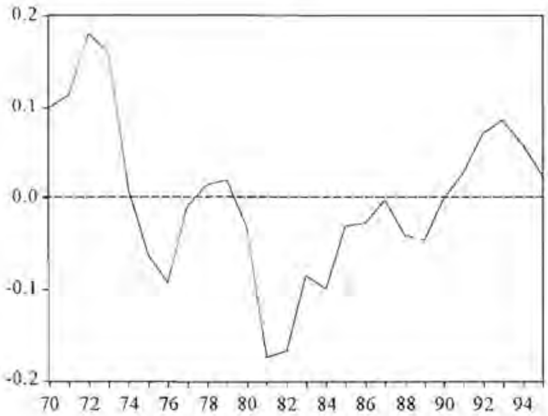
Table 8.7 Cointegration equation: Consumer price index

Dependent Variable: ln_vpi
Method: Least Squares
Sample(adjusted): 1970 1995
Included observations: 26 after adjusting endpoints
ln_vpi = 0.7*ln_ppi + 0.3*ln_pz$ + c(1)*ln_exces_dem_cp + c(2)*ln_r$ + c(3)

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
c(1)	1.505656	0.463474	3.248629	0.0035
c(2)	0.334323	0.031960	10.46080	0.0000
c(3)	-1.478081	0.153974	-9.599528	0.0000
R-squared	0.991513	F-statistic		1343.568
Adjusted R-squared	0.990775	Prob(F-statistic)		0.000000

A plot of the stationary residuals is illustrated in figure 8.5.

Figure 8.5 Residuals: Consumer price index (ln_vpi)



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

The estimation results of the error correction model are reported in table 8.8.

In addition to the long-run explanatory variables, a monetary inflationary variable, the prime overdraft rate (ln_prime_rate) contributes to the explanation of the short-run variation in consumer prices.

Table 8.8 Error correction model: Consumer price index

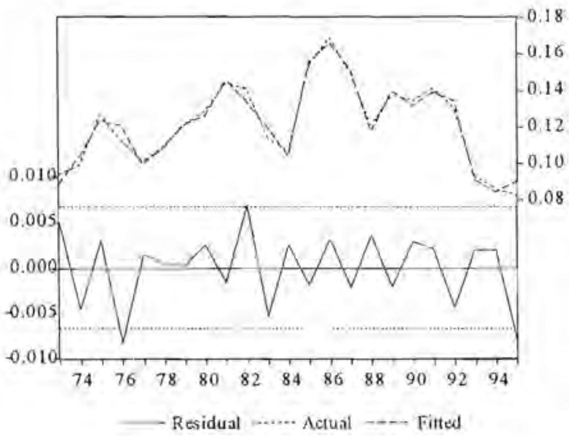
Dependent Variable: Δ(ln_vpi)
Method: Least Squares
Sample(adjusted): 1973 1995
Included observations: 23 after adjusting endpoints

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
residual(-1)	-0.298653	0.067905	-4.398079	0.0023
Δ(ln_ppi)	0.454890	0.106073	4.288464	0.0027
Δ(ln_ppi(-1))	0.847749	0.209674	4.043178	0.0037
Δ(ln_ppi(-2))	-0.258956	0.124184	-2.085253	0.0705
Δ(ln_exces_dem_cp)	0.592261	0.120751	4.904811	0.0012
Δ(ln_exces_dem_cp(-2))	-0.392387	0.075653	-5.186646	0.0008
Δ(ln_prime_rate)	-0.166641	0.031384	-5.309776	0.0007
Δ(ln_prime_rate(-1))	0.070108	0.014600	4.801921	0.0014
Δ(ln_vpi(-1))	-0.498413	0.211873	-2.352410	0.0465
Δ(ln_pz$)	-0.150988	0.065846	-2.293063	0.0510
Δ(ln_pz$(-1))	-0.472941	0.115748	-4.085948	0.0035
Δ(ln_pz$(-2))	0.089553	0.027964	3.202507	0.0126
Δ(ln_r$)	-0.104279	0.054366	-1.918108	0.0914
Δ(ln_r$(-1))	-0.440339	0.116080	-3.793407	0.0053
c	0.122906	0.021777	5.643762	0.0005

R-squared	0.969542	F-statistic	18.18992
Adjusted R-squared	0.916241	Prob(F-statistic)	0.000156
S.E. of regression	0.006670		

Figure 8.6 illustrates the overall fit of the estimated function.

Figure 8.6 Actual, fitted and residual values of ln_vpi



(iii) *Diagnostic testing*

The estimated function was subjected to rigorous diagnostic testing. The results, indicative of a statistically well-behaved function, are reported in table 8.9.

Table 8.9 Diagnostic tests: Consumer price index (ln_vpi)

Purpose of test	*Test*	*d.f.*	*Test statistic*	*Probability*
Normality	Jarque-Bera	JB(2)	1.439940	[0.486767]
Homoscedasticity	ARCH LM	$nR^2(1)$	0.103165	[0.748064]
Homoscedasticity	White	Insufficient number of observations		
Serial correlation	Breusch-Godfrey	$nR^2(2)$	7.836501	[0.021218]
Serial correlation	Lung Box Q	Q(12)	19.59300	[0.075000]
Misspecification	Ramsey Reset	LR(2)	2.183798	[0.335579]
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 8.10 and 8.11 respectively.

Table 8.10 Engle-Yoo third-step estimation: Consumer price index (ln_vpi)

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

Variable	Coefficient	Std. Error	t-Statistic
(0.298653)*ln_exces_dem_cp	-0.074497	0.075732	-0.983690
(0.298653)*ln_r$	-0.000642	0.000839	-0.765107

Table 8.11 Cointegration correction: Consumer price index (ln_vpi)

Variable	*Adjusted Coefficient*	*Adjusted t-Statistic*
ln_exces_dem_cp	1.431159	18.897679
ln_r$	0.333681	397.71275

The dynamic simulation results as well as the statistical confirmation of the goodness-of-fit of the model are presented by figure 8.7 and table 8.12 respectively.

Figure 8.7 Actual and fitted values on ln_vpi

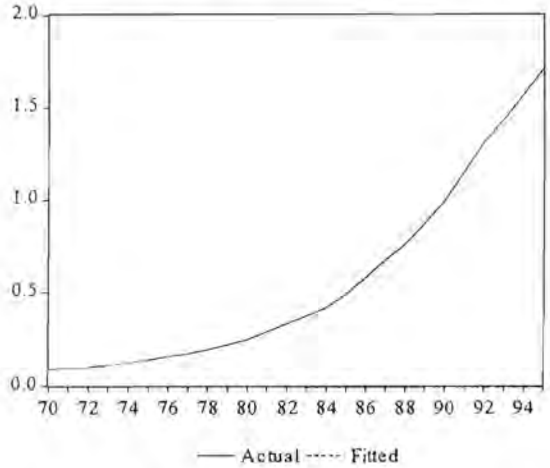


Table 8.12 Simulation error statistics of consumer price index

Actual v Fitted : ln_cpi	
Root Mean Squared Error	0.003934
Mean Absolute Error	0.003303
Mean Absolute Percentage Error	0.551477
Theil Inequality Coefficient	0.001666
Bias Proportion	0.000000
Variance Proportion	0.006762
Covariance Proportion	0.993238

8.4 DYNAMIC SIMULATION: RESPONSE PROPERTIES OF THE MODEL

The methodology explained in Appendix 10 is now applied to investigate the dynamic properties of the price models and, simultaneously, to test them for stability and robustness.

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.

8.4.1 Production prices

Table 8.13 Difference between the baseline forecast and forecasts with shocked variables, dependent variable: ln_ppi

Variable	*Coefficient*	*Expected change (10% of coefficient)*	*Convergence level (% difference)*
ln_ucc2_nom	0.261397	0.026140	0.025194
ln_w_prod	0.603218	0.060322	0.059145

Figure 8.8 Dynamic adjustment (percentage change) in production price index (ln_ppi) with a 10 percent increase in nominal user-cost-of-capital (ln_ucc2_nom)

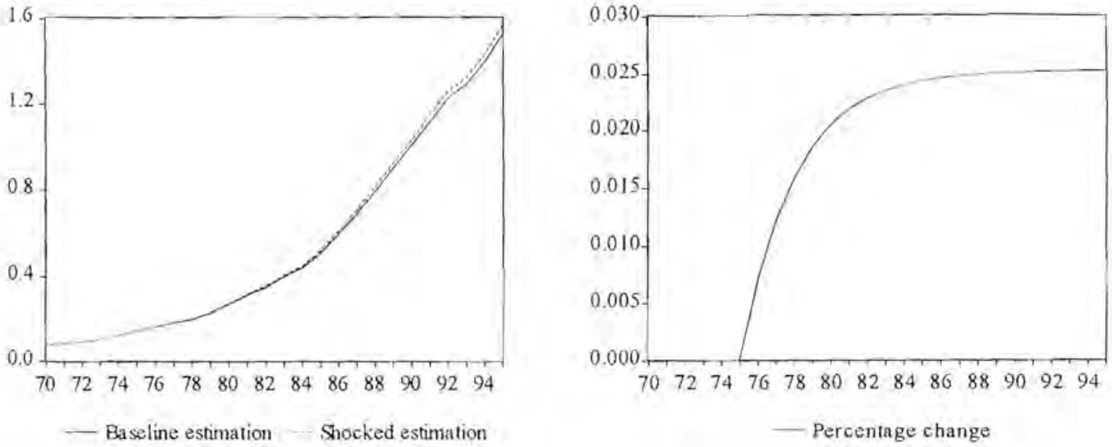
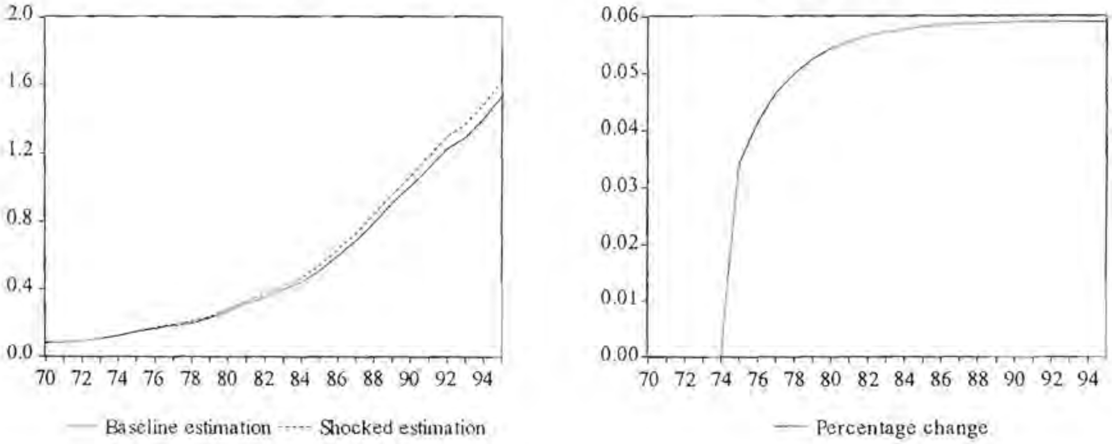


Figure 8.9 Dynamic adjustment (percentage change) in production price index (ln_ppi) with a 10 percent increase in wage productivity (ln_w_prod)



8.4.2 Consumption prices

Table 8.14 Difference between the baseline forecast and forecasts with shocked variables, dependent variable: ln_vpi

Variable	*Coefficient*	*Expected change (10% of coefficient)*	*Convergence level (% difference)*
ln_ppi	0.700000	0.070000	0.068967
ln_pz$	0.300000	0.030000	0.028004
ln_exces_dem_cp	1.431159	0.143116	0.143758
ln_r$	0.333681	0.033368	0.031213

Figure 8.10 **Dynamic adjustment (percentage change) in consumer price index (ln_vpi) with a 10 percent increase in production price index (ln_ppi)**

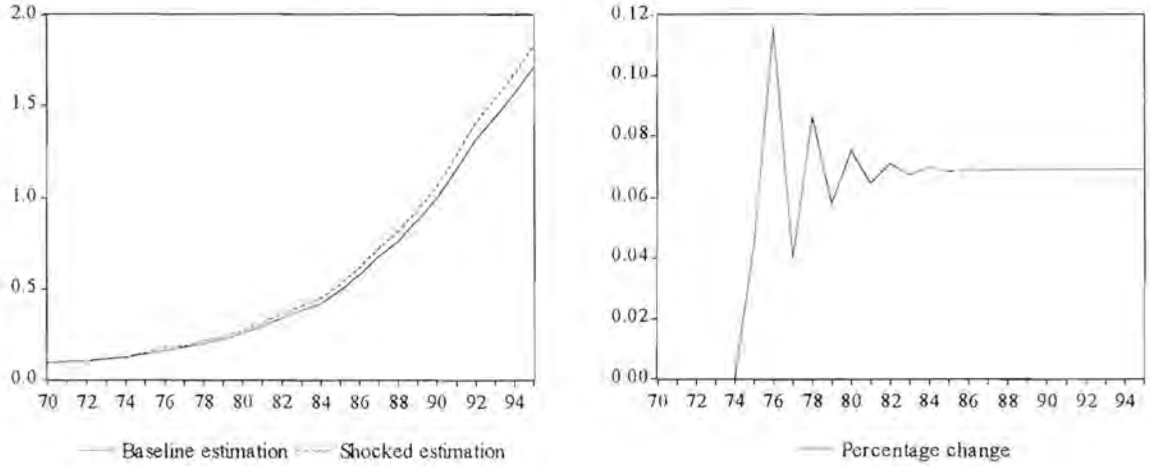


Figure 8.11 **Dynamic adjustment (percentage change) in consumer price index (ln_vpi) with a 10 percent increase in import prices in US dollar (ln_pz$)**

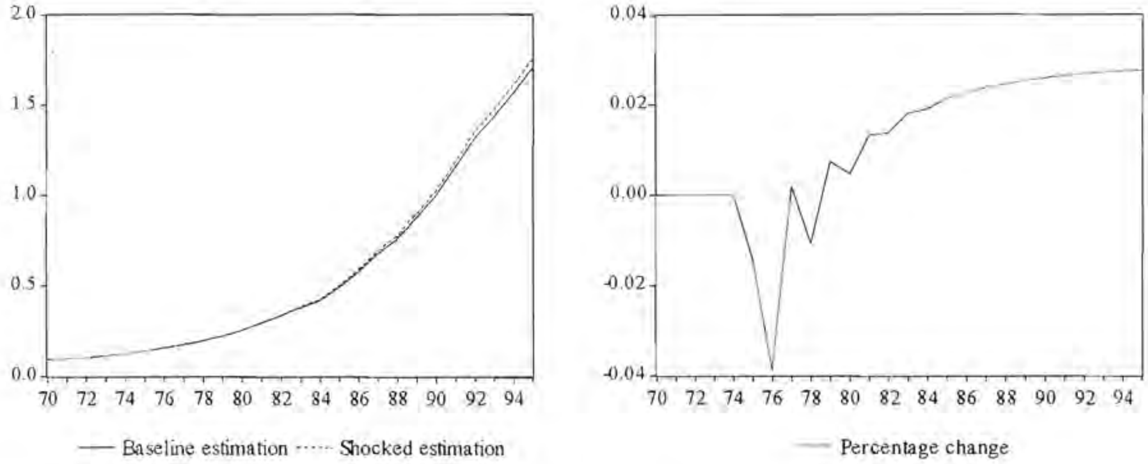


Figure 8.12 **Dynamic adjustment (percentage change) in consumer price index (ln_vpi) with a 10 percent increase in nominal excess demand (ln_excess_dem_cp)**

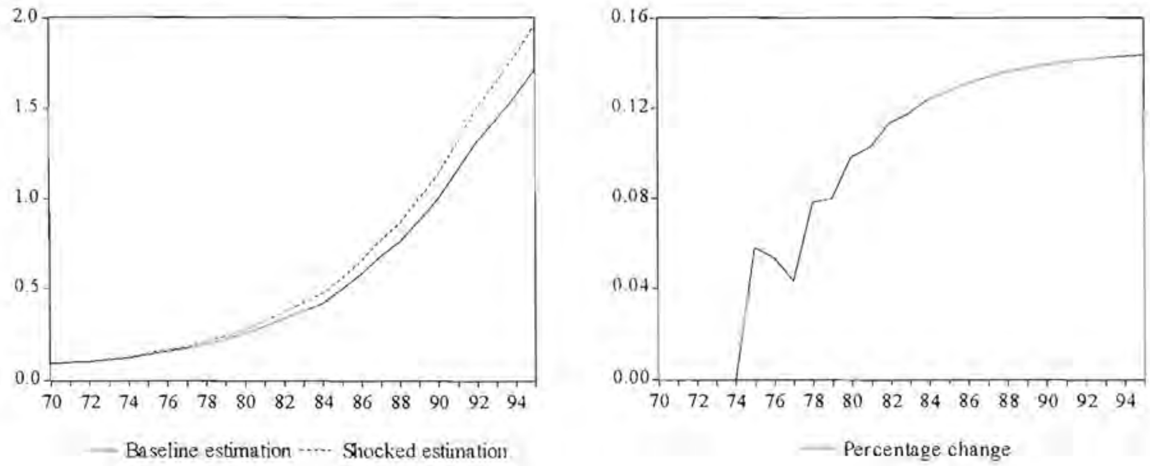
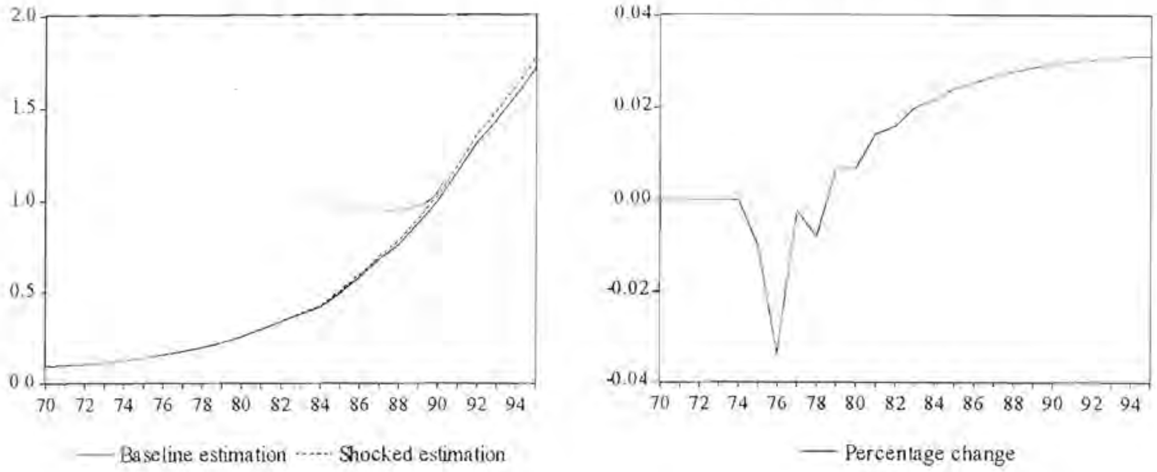


Figure 8.13 Dynamic adjustment (percentage change) in consumer price index (ln_vpi) with a 10 percent increase in rand/dollar exchange rate (ln_r$)



8.5 CONCLUSION

In this chapter, models for both production (value-added) and consumption prices were proposed, estimated and validated. Consistency is maintained by deriving prices in similar fashion as wages (chapter 7) from an estimated cost function for the South African economy.

Assuming imperfect competition in a neoclassical, profit maximising framework, firms set their prices as a mark-up on the unit cost of production. Extending on the Layard-Nickell framework, the pricing models estimated in this study do not assume "normal" unit costs, but incorporate the unit costs of capital in addition to labour costs. The estimation results were consistent with the theoretical specification and *a priori* information on the price-setting behaviour of firms.

Regarding to inflation in South Africa, the estimated models suggest that (1) wage increases, relative to productivity growth exert the most pressure on production prices (60 percent), and (2) the consequences of the high degree of openness of the South African economy, represented by a set of international factors, are large contributors to domestic inflation.

CHAPTER 9

A SOUTH AFRICAN SUPPLY-SIDE MODEL: CLOSING THE SYSTEM AND MODEL EVALUATION

9.1 INTRODUCTION

In this chapter the estimations for production, fixed investment, corporate savings, the labour model and the pricing system are combined into a neoclassical supply-side model of the South African economy. The system is closed by introducing a number of identities and definitions, linking every endogenous variable in the model to ensure a fully dynamic system.

The model is subsequently evaluated along the criteria (full ideal principles of model selection) set out in Appendix 3.

First, the theoretical structure of the estimated model (empirical specification) is evaluated to determine the compliancy of the model with (1) the *a priori* objectives of neoclassical supply-side modelling, (2) economic theory – for the model in general and the individual equations in particular, (3) rival models, i.e. the extent to which the model encompasses the characteristics of rival models, and (4) policy analysis, i.e. the relevancy of the specified model for policy analysis.

Second, a simulation (i.e. *ex post* forecast) of the full system of equations is conducted. The dynamic simulation properties of the model are evaluated in terms of (1) the statistical significance (*ex-post* forecast ability) and (2) the stability of the model over the simulated sample range. The statistical significance (goodness-of-fit) of the full system is measured in terms of simulation/forecast error statistics and confirmed by the graphical representations of the simulations.

Third, a series of dynamic, ex-post simulations are conducted by shocking every stochastic variable in the system. The simulation results are used to (1) determine the long-run (steady-state) multipliers and elasticities of the system and, once again, (2) to evaluate the statistical significance and sensitivity of the model in terms of the degree, speed and stability of convergence. The robust (stable) nature of the model serves as an indication of the forecasting ability of the model.

9.2 CLOSING THE SYSTEM: A NEOCLASSICAL SUPPLY-SIDE MODEL OF THE SOUTH AFRICAN ECONOMY

Having specified and estimated individual functions in a consistent cost-minimising framework for:

(i) real gross domestic production;
(ii) real fixed domestic investment;
(iii) nominal corporate savings;
(iv) demand for skilled labour;
(v) demand for unskilled labour;
(vi) labour participants in the informal sector;
(vii) total labour supply;

(viii) skilled labour supply;
(ix) nominal skilled wage rate;
(x) real unskilled wage rate;
(xi) production (value-added) prices; and
(xii) consumption prices,

the production, investment, labour and price systems are combined and linked by a number of identities and definitions into a neoclassical supply-side model of the South African economy.

The empirical specification (equations and estimated parameters) of the estimated supply-side system follows:[1]

SUPPLY-SIDE MODEL

IDENTITIES & DEFINITIONS

Capacity utilisation

cu = ((bbpfact_90p/bbppot_90p)*100)
ln_cu = log(cu)

Production

bbpfact_90p = EXP(ln_bbpfact_90p)
bbpfact_cp = bbpfact_90p*ppi

bbp_90p = bbpfact_90p + (txind - subs)/pnettx
ln_bbp_90p = log(bbp_90p)
bbp_cp = bbp_90p*vpi

bbppot_90p = EXP(ln_bbppot_90p)

Capital stock

kap_r = ((1 - 0.05)*kap_r(-1)) + if
ln_kap_r = log(kap_r)

kap_lab_rat = (kap_r/n)
ln_kap_lab_rat = log(kap_lab_rat)

Investment : domestic

if = EXP(ln_if)
if_cp = if*ppi

totdomi_cp = if_cp + inv_cp

Financing of investment

fincond_cp = sp_cp + sg_cp + sc_cp + de_cp + netcapfl + gold_reserv_cp

[1] A list of variables is presented in Appendix 8.

fincond_ppi = fincond_cp/ppi
ln_fincond_ppi = log(fincond_ppi)

Corporate savings

sc_cp = EXP(ln_sc_cp)
sc_cp_rat = sc_cp/bbp_cp

lab_rem_cp = w_tot*n
gos_cp = bbpfact_cp - lab_rem_cp
gostc_cp = gos_cp - tc_cp
ln_gostc_cp = log(gostc_cp)

Labour productivity

product = (bbp_90p/n_sarb)/49004.99*100
ln_product = log(product)

Wages : unskilled labour

wu_vpi_rate = EXP(ln_wuvpi_rat)
wu_vpi = wu_vpi_rate*n_u

w_u = wu_vpi*vpi
wu_rate = wu_vpi_rate*vpi

wu_ppi = w_u/ppi
wu_ppi_rate = wu_ppi/n_u
ln_wuppi_rat = log(wu_ppi_rate)

Wages : skilled labour

ws_rate = EXP(ln_ws_rate)

ws_vpi_rate = ws_rate/vpi
ws_vpi = ws_vpi_rate*n_s
ln_wsvpi_rat = log(ws_vpi_rate)

w_s = ws_vpi*vpi

Wages : total labour force

w_tot = w_s + w_u
wtot_rate = w_tot/n
ln_wtot_rate = log(wtot_rate)

wtot_vpi = (w_s + w_u)/vpi
ln_wtot_vpi = log((w_s + w_u)/vpi)
wtot_vpi_rat = ((w_s + w_u)/vpi)/n
ln_wtot_vpi_rat = log(wtot_vpi_rat)

wu_share = w_u/w_tot
ws_share = w_s/w_tot

Wage productivity

w_prod = w_tot/product
ln_w_prod = log(w_prod)

Relative wages

rel_wsu = w_s/w_u
rel_wsu_rat = (w_s/n_s)/(w_u/n_u)
ln_rel_wsu_rat = log(rel_wsu_rat)

Cost of labour

Pension contribution = 0.06 (6%)
Medical contribution = 0.1 (10%)
Non-wage contributions = medical + pension = 0.16 (16%)
Corporate income tax rate = 0.3 (30%)

w_cost_cp = ((wtot_rate)*(1 + 0.16))/(1 - (tc_rate_cp)*(1 + 0.3))

ws_cost_cp = ws_share*w_cost_cp
ws_cost_ppi = ws_cost_cp/ppi
ln_wscost_ppi = log(ws_cost_ppi)

wu_cost_cp = wu_share*w_cost_cp
wu_cost_ppi = wu_cost_cp/ppi
ln_wucost_ppi = log(wu_cost_ppi)

rel_wscost_ucc = ws_cost_ppi/ucc2_90p
ln_rel_wscost_u = log(rel_wscost_ucc)

rel_wucost_ucc = wu_cost_ppi/ucc2_90p
ln_rel_wucost_u = log(rel_wucost_ucc)

Demand for labour (employment)

n_informal = EXP(ln_n_informal)

n_s = EXP(ln_ns)

n_u = EXP(ln_nu)

n = n_s + n_u
ln_n = log(n)
n_sarb = n-n_diff

n_pot = (s_smooth*(1 - nawru_hpf))
ln_n_pot = log(n_pot)

Supply of labour

s = EXP(ln_s)

s_rat = s/total_pop*1000
s_smooth = ((total_pop)*(s_rat_hpf))/1000

s_s = EXP(ln_ss)
ss_rat = s_s/s

s_u = s - s_s

Employment rates

empl_rat = (n/s)
ln_empl_rat = log(empl_rat)

empl_rat_s = (n_s/s_s)
ln_emplrat_s = log(empl_rat_s)

empl_rat_u = (n_u/s_u)
ln_emplrat_u = log(empl_rat_u)

Unemployment rates

unempl_rat = (s-n)/s
ln_unempl_rat = log(unempl_rat)

unempl_rat_s = (s_s-n_s)/s_s
ln_unemplrat_s = log(unempl_rat_s)

unempl_rat_u = (s_u-n_u)/s_u
ln_unemplrat_u = log(unempl_rat_u)

unempl = s - n
unempl_s = s_s - n_s
unempl_u = s_u - n_u

Index: technology

tecno_index = (educ_index/1.51)*0.15 + (product/100)*0.15 + (rel_i_r/1.805383)*0.05 + (time + tecno_innov)*0.65

Index: education

ln_educind = log(educ_index)

Index: socio-economic conditions

soc_index = (educ_index/0.51)*0.20 + (energy_ind/100)*0.15 + (health_index/0.62)*0.15 + (1/(crime_index/1.65))*0.1 + (income_index/4353)*0.2 + (h_transf_receiv/727)*0.1 + (unpl_ben/556693)*0.1

ln_socind = log(soc_index)

Index: union pressure

depend_rat = (total_pop - s)/s

union_power = union_members/n
ln_unionpower = log(union_power)

union_mil = union_work_lost/n

union_pres_ind = ((union_power/243623.8)*0.60 + (union_mil/272984.5)*0.10 + (depend_rat/1.965280)*0.30)

ln_uniopresind = log(union_pres_ind)

Index: international position

indinves_r = indinvest/ppi
rel_indi_r = (indinvest/totdomi_cp)/ppi

dirinves_r = dirinvest/ppi
rel_diri_r = (dirinvest/totdomi_cp)/ppi

rel_i_r = ((indinvest + dirinvest)/totdomi_cp)/ppi

exchange_rate = 100/r_$

netcapfl_r = netcapfl/ppi

intern_posind = ((exchange_rate/0.386444)*0.2 + (intern_comp)*0.05 + (rel_diri_r/0.44804)*0.5 + (rel_indi_r/1.357343)*0.2 + (worldshare/0.706)*0.05)

ln_interposind = log(intern_posind)

Government

pnettx = (txind - subs)/(bbp_90p - bbpfact_90p)

Exports

xgoud_ppi = xgoud_cp/ppi
ln_xgoud_ppi = log(xgoud_ppi)

xgoud_px = xgoud_cp/px
ln_xgoud_px = log(xgoud_px)

gprys_r = (gprys_$*r_$)/100
ln_gprys_r = log(gprys_r)

User-cost-of-capital

dipi = if_cp/if

pk_ppi = pk - ppigrowth

tc_rate_cp = tc_cp/bbpfact_cp
tc_rate_ppi = tc_rate_cp/ppi

ucc2_90p = dipi*((pk_ppi/100) + 0.2)/(1 - tc_rate_ppi)
ln_ucc2_90p = log(ucc2_90p)

ucc2_nom = dipi*((pk/100) + 0.2)/(1 - tc_rate_cp)
ln_ucc2_nom = log(ucc2_nom)

Prices

vpi = EXP(ln_vpi) + error_vpi
vpigrowth = (vpi - vpi(-1))/vpi(-1)*100

ppi = EXP(ln_ppi) + error_ppi
ppigrowth = (ppi - ppi(-1))/ppi(-1)*100

Import prices

pz_$ = pz*exchange_rate
ln_pz$ = log(pz_$)

Excess demand

excess_dem_cp = bbb_cp/bbp_cp
ln_exces_dem_cp = log(excess_dem_cp)

STOCHASTIC FUNCTIONS

Production function derived from cost function

Actual production

etmin1_bbp = ln_bbpfact_90p(-1) - 0.0788626*ln_kap_r(-1) - 0.7727844*ln_n(-1) - 0.0448234*tecno_index(-1) - 9.488127

ln_bbpfact_90p = -0.445426*etmin1_bbp + 1.565503*(ln_kap_r - ln_kap_r(-1)) - 1.467576*(ln_kap_r(-1) - ln_kap_r(-2)) + 0.606197*(ln_n - ln_n(-1)) + 0.147462*(tecno_index- tecno_index(-1)) + 0.077070*(tecno_index(-4) - tecno_index(-5)) - 0.036744*(drought_dum) - 0.029635*(sanction_dum) - 0.025683*(imf_dum) + 0.025426 + ln_bbpfact_90p(-1)

Potential production

etmin1_bbpp = ln_bbppot_90p(-1) - 0.0788626*ln_kap_r(-1) - 0.7727844*ln_n_pot(-1) - 0.0448234*tecno_hpf(-1) - 9.488127

ln_bbppot_90p = -0.445426*etmin1_bbpp + 1.565503*(ln_kap_r - ln_kap_r(-1)) - 1.467576*(ln_kap_r(-1) - ln_kap_r(-2)) + 0.606197*(ln_n_pot- ln_n_pot(-1)) + 0.147462*(tecno_hpf- tecno_hpf(-1)) + 0.077070*(tecno_hpf(-4) – tecno_hpf(-5)) - 0.036744*(drought_dum) - 0.029635*(sanction_dum) - 0.025683*(imf_dum) + 0.025426 + ln_bbppot_90p(-1)

Investment function

etmin1_if = ln_if(-1) - 0.335012*ln_bbpfact_90p(-1) + 0.128864*(ln_ucc2_90p(-1)) - 0.555366*ln_fincond_ppi(-1) - 6.31E-07*kap_r(-1)

ln_if = 3.97E-06*(kap_r(-1) - kap_r(-2)) - 0.941551*(ln_vpi - ln_vpi(-1)) + 0.976882*(ln_vpi(-2) - ln_vpi(-3)) - 1.037919*(ln_p_manuf(-1) - ln_p_manuf(-2)) +0.412439*(ln_p_manuf(-3) - ln_p_manuf(-4)) + 0.355705*(ln_fincond_ppi - ln_fincond_ppi(-1)) + 0.158596*(ln_fincond_ppi(-1) - ln_fincond_ppi(-2)) + 0.162331*(ln_fincond_ppi(-2) - ln_fincond_ppi(-3)) - 0.941250*etmin1_if + ln_if(-1)

Savings function

etmin1_sc = ln_sc_cp(-1) - (0.810837)*ln_gostc_cp(-1)

ln_sc_cp = - 0.122745*etmin1_sc + 1.312995*(ln_gostc_cp - ln_gostc_cp(-1)) - 0.400409*(imf_dum - imf_dum(-1)) + 0.323139*(opec_dum2) - 0.243745*(sanction_dum - sanction_dum(-1)) + ln_sc_cp(-1)

Labour demand - informal

etmin1_n_inf = ln_n_informal(-1) + 25.03542 - 6.530056*ln_bbp_90p(-1) + 4.399687*ln_wtot_vpi_rat(-1)

ln_n_informal = 0.291756*(ln_n_informal(-1) - ln_n_informal(-2)) - 0.439398*(ln_n_informal(-2) - ln_n_informal(-3)) + 0.318244*(ln_interposind - ln_interposind(-1)) + 0.496072*(ln_r$(-1) - ln_r$(-2)) + 0.771041*(ln_r$(-2) - ln_r$(-3)) +0.181036*(ln_xgoud_ppi - ln_xgoud_ppi(-1)) - 0.521724*(ln_xgoud_ppi(-2) - ln_xgoud_ppi(-3)) + 0.293102*(ln_gprys_$(-1) - ln_gprys_$(-2)) + 0.360206*(ln_gprys_$(-2) - ln_gprys_$(-3)) - 0.689871*(ln_socind(-2) - ln_socind(-3)) + 1.128687*(ln_bbp_min_90p(-1) - ln_bbp_min_90p(-2)) + 0.410871*(ln_unempl_rat - ln_unempl_rat(-1)) - 0.516895*etmin1_n_inf + ln_n_informal(-1)

Labour demand - skilled

etmin1_ns = ln_ns(-1) -0.309833*ln_bbp_90p(-1) + 0.61238*ln_rel_wsu_rat(-1) + 0.137105*ln_rel_wscost_u(-1)

ln_ns = 0.018879- 0.294219*etmin1_ns + 0.329872*(ln_bbp_90p - ln_bbp_90p(-1)) + 0.496150*(ln_bbp_90p(-1) - ln_bbp_90p(-2)) + 0.415129*(ln_bbp_90p(-2) - ln_bbp_90p(-3)) - 0.162451*(ln_rel_wsu_rat - ln_rel_wsu_rat(-1)) + 0.132016*(ln_rel_wsu_rat(-3) - ln_rel_wsu_rat(-4)) + 0.078446*(ln_interposind(-2) - ln_interposind(-3)) - 0.023055*(sanction_dum - sanction_dum(-1)) + 0.250117*(ln_kap_lab_rat(-1) - ln_kap_lab_rat(-2)) - 0.037895*(ln_rel_wscost_u - ln_rel_wscost_u(-1)) - 0.022202*(ln_uniopresind(-2) - ln_uniopresind(-3)) + ln_ns(-1)

Labour demand - unskilled

etmin1_nu = ln_nu(-1) - 0.375655*ln_bbp_90p(-1) + 0.353469*ln_wuppi_rat(-1)

ln_nu = -0.130607*etmin1_nu - 0.083803*(ln_socind - ln_socind(-1)) + 0.059588*(ln_socind(-1) - ln_socind(-2)) - 0.074636*(ln_interposind - ln_interposind(-1)) - 0.019511*(ln_interposind(-3) - ln_interposind(-4)) + 0.068958*(ln_gprys_r(-2) - ln_gprys_r(-3)) + 0.022791*(sanction_dum – sanction_dum(-1)) - 0.030357*(ln_uniopresind(-1) - ln_uniopresind(-2)) + 0.046513*(ln_uniopresind(-3) - ln_uniopresind(-4)) - 0.101683*(ln_bbp_90p(-1) - ln_bbp_90p(-2)) - 0.022128 + ln_nu(-1)

Supply of labour : total

etmin1_s = ln_s(-1) - 0.4812201*ln_total_pop(-1) - 0.1355454*ln_wtot_rate(-1) + 3.834824

ln_s = - 0.897759*etmin1_s - 0.552752*(ln_s(-1) - ln_s(-2)) - 0.347900*(ln_s(-2) - ln_s(-3)) - 0.201420*(ln_empl_rat(-1) - ln_empl_rat(-2)) + 0.101256*(ln_empl_rat(-2) - ln_empl_rat(-3)) + 0.010675*(ln_cu(-1)) - 0.021152*(ln_interposind - ln_interposind(-1)) - 0.020555*(ln_interposind(-1) - ln_interposind(-2)) - 0.010088*(ln_interposind(-2) - ln_interposind(-3)) + ln_s(-1)

Supply of labour : skilled

etmin1_ss = ln_ss(-1) - 0.47599*ln_educind(-1) - 1.677626*ln_wtot_vpi_rat(-1) + 14.59531

ln_ss = - 0.040049*etmin1_ss + 1.268536*(ln_s - ln_s(-1)) + 0.739383*(ln_ss(-1) - ln_ss(-2)) - 0.008025*braindrain_dum -0.024742 + ln_ss(-1)

Wage rate : unskilled

etmin1_wu = ln_wuvpi_rat(-1) - 0.055575*ln_vpi(1-1) - 0.393319*ln_xgoud_px(-1) - 1.055957*ln_product2(-1)

ln_wuvpi_rat = - 0.186843*etmin1_wu + 0.186627*(ln_socind - ln_socind(-1)) - 0.130427*(ln_socind(-2) - ln_socind(-3)) + 0.178179*(ln_socind(-3) – ln_socind(-4)) - 0.107496*(ln_xgoud_px - ln_xgoud_px(-1)) + 0.170801*(ln_xgoud_px(-1) - ln_xgoud_px(-2)) - 0.101029*(ln_xgoud_px(-2) - ln_xgoud_px(-3)) - 0.163723*(ln_xgoud_px(-3) - ln_xgoud_px(-4)) + 0.216062*(ln_uniopresind(-1) - ln_uniopresind(-2)) + 0.140599*(ln_gprys_$(-3) - ln_gprys_$(-4)) - 0.033496*sanction_dum + ln_wuvpi_rat(-1)

Wage rate : skilled

etmin1_ws = ln_ws_rate(-1) - 0.876221*ln_vpi - 0.675239*ln_product(-1) - 6.807242

ln_ws_rate =- 0.546388*etmin1_ws + 0.857995*(ln_emplrat_s(-1) - ln_emplrat_s(-2)) + 0.075203*(ln_interposind - ln_interposind(-1)) + 0.029546*braindrain_dum + 0.107963 + ln_ws_rate(-1)

Production price index

etmin1_ppi = ln_ppi(-1) - 0.261397*ln_ucc2_nom(-1) - 0.603218*ln_w_prod(-1) + 4.146606

ln_ppi = -0.283469*etmin1_ppi + 0.012082*(ln_cu(-2)) - 0.127054*(ln_interposind - ln_interposind(-1)) + 0.032431*(sanction_dum - sanction_dum(-1)) + 0.351462*(ln_w_prod - ln_w_prod(-1)) + ln_ppi(-1)

Consumer price index

etmin1_vpi = ln_vpi(-1) - 0.7*ln_ppi(-1) - 0.3*ln_pz$(-1) - 1.431159*ln_exces_dem_cp(-1) - 0.333681*ln_r$(-1) + 1.478081

ln_vpi = - 0.298653*etmin1_vpi + 0.454890*(ln_ppi - ln_ppi(-1)) + 0.847749*(ln_ppi(-1) - ln_ppi(-2)) - 0.258956*(ln_ppi(-2) - ln_ppi(-3)) + 0.592261*(ln_exces_dem_cp - ln_exces_dem_cp(-1)) - 0.392387*(ln_exces_dem_cp(-2) - ln_exces_dem_cp(-3)) - 0.166641*(ln_prime_rate - ln_prime_rate(-1)) + 0.070108*(ln_prime_rate(-1) - ln_prime_rate(-2)) - 0.498413*(ln_vpi(-1) - ln_vpi(-2)) - 0.150988*(ln_pz$ - ln_pz$(-1)) - 0.472941*(ln_pz$(-1) - ln_pz$(-2)) + 0.089553*(ln_pz$(-2) - ln_pz$(-3)) - 0.104279*(ln_r$ - ln_r$(-1)) - 0.440339*(ln_r$(-1) - ln_r$(-2)) + 0.122906 + ln_vpi(-1)

9.3 MODEL EVALUATION

The estimated model is evaluated according to a number of criteria. The full system, as well as the individual equations, have to (1) be consistent with economic theory, (2) be economically and statistically significant, (3) provide an adequate representation of the data, (4) encompass the characteristics of rival models and (5) not be overly sensitive to sample range, variable menu or other equations of the system.

Macroeconomic models must in addition to the above-mentioned points of criteria be evaluated in terms of the objective(s) of their construction, albeit structural analysis, relevance to policy analysis and/or forecasting.

9.3.1 Structural (theoretical) properties

The first aim is to identify the structural and theoretical properties of the final supply-side system and to determine extent to which they comply with (1) the primary objectives; (2) economic theory; (3) rival models and (4) a framework for policy analysis and forecasting.

The discussion is structured by identifying (1) the primary objectives, (2) the associated conceptual issues, (3) the subsequent structural properties of the model and (4) comparative aspects in rival models.

The *primary objectives* stated in the beginning of the research were:

(i) To develop an aggregate neoclassical supply-side model of the South African economy, pertaining to the structural and long-run properties of the economy, as well as the profit-maximising and cost-minimising decision-making processes of firms;

(ii) To specify, derive and estimate every structural relationship (equation) of the model jointly to ensure consistency between costs, demand factors and prices throughout the analytical framework;

(iii) To incorporate an estimate for capacity utilisation which serves as a significant variable in explaining price- and wage-setting behaviour and which also influences every key macroeconomic variable in a well-developed supply-system;

(iv) To endogenise technical progress in the cost/production relationship;

(v) To incorporate price expectations;

(vi) To allow for the specific and rather unique characteristics of the South African economy;

(vii) To incorporate a set of target or policy variables allowing for policy proposals with specific reference to the unemployment problem in South Africa; and

(viii) To maintain a balance between the detail required for policy analysis and the stability of the model to ensure reliable forecasts.

A number of *conceptual issues* had to be decided on and dealt with in striving to achieve the above-mentioned objectives:

(i) A cost or a production function approach in estimating the structural production properties of the South African economy;

(ii) An appropriate functional form and underlying production technology for the cost/production function;

(iii) An appropriate measure or estimate for technical progress;

(iv) Assumptions about the factor intensity of production and the returns to scale property of the South African production structure;

(v) An appropriate measure for capacity utilisation (expenditure/demand *versus* production/supply as measure for actual output);

(vi) An appropriate measure for potential output;

(vii) An appropriate measure for the NAIRU/NAWRU;

(viii) An appropriate model for investment (neoclassical/Jorgenson *versus* cash-flow *versus* Tobin's q);

(ix) A measure for user-cost-of-capital;

(x) A market-clearing *versus* a non-market clearing approach in modelling labour;

(xi) A distinction between skilled and unskilled labour;

(xii) An appropriate wage-setting model (framework of market imperfections: union-firm wage-bargaining);

(xiii) An appropriate price-setting model (framework of market imperfections: mark-up on unit cost of production); and

(xiv) Exclusion (standard approach) *versus* inclusion of unit cost of capital.

Bearing the primary objectives in mind and dealing with the previously mentioned conceptual issues, resulted in an estimated supply-side model with the following *structural properties*:

(i) Neoclassical supply-side system;

(ii) Based on cost-minimising behaviour of firms, a cost function was estimated and used to derive a production function on the principles of Shephard's duality;

(iii) The Cobb-Douglas functional form, restricting the elasticity of substitution to unity, was validated as an appropriate representation of the production structure in South Africa;

(iv) South Africa has been proven to produce labour intensively and with decreasing returns to scale;

(v) Technical progress has been endogenised by incorporating imported technical innovation, human capital augmentation and labour augmentation (Harrod neutral);

(vi) Capacity utilisation is measured in terms of actual value-added output (estimated by the production function) relative to potential output, where potential output is structurally determined by means of the production function;

(vii) Potential labour is not smoothed as in the case of "normal" output, but estimated by incorporating the NAWRU;

(viii) The NAWRU (non-accelerating wage rate of unemployment) is measured in terms of the gap between unemployment and wages;

(ix) Real fixed investment has been proven to be significantly dependent on financial constraints – the cash flow model has been combined with the Jorgenson neoclassical model in explaining investment in South Africa;

(x) The Jorgenson measure for user-cost-of-capital has been derived and utilised for the South African context. This measure combines four effects, i.e. the price of capital, rates of return, depreciation and taxes;

(xi) Every factor demand and price equation was derived and estimated consistent with the estimated cost function;

(xii) A distinction is made between skilled and unskilled labour markets, emphasising the role of education and explaining the structural nature of the unemployment problem in South Africa;

(xiii) The reasons for a growing number of labour participants in the informal sector are modelled (e.g. lack of labour absorption capacity in the formal sector);

(xiv) Wage-setting is explained in terms of a union-firm bargaining model, i.e. under imperfect competition, incorporating the effects of labour productivity, expected inflation and a set of wage pressure variables;

(xv) Prices are also explained in a framework of market imperfections, where firms set their prices as a mark-up on unit cost of production;

(xvi) The standard assumption of "normal" unit costs is extended by incorporating the unit cost of capital;

(xvii) Value added or production prices are primarily dependent on the unit cost of capital, the unit cost of labour adjusted for labour productivity and capacity utilisation;

(xviii) Consumption prices are dependent on production prices, import prices, the exchange rate, and demand pressures (excess demand) on the long-run;

(xix) Unique characteristics of the South African economy were modelled: (1) the international vulnerability of the South African economy due to the large degree of openness and the relatively small size of the economy; (2) the period of economic sanctions and disinvestment resulted from the country's political dispensation - causing a structural break in each of the relevant data series; (3) South Africa's dependence on foreign investment and financing; (4) the powerful and militant role of labour unions; and (5) socio-economic problems – the heritage of "apartheid"; and

(xx) Some target variables are included in the model to allow for policy proposals: taxes, subsidies, prime overdraft rate of banks, tax depreciation rates, education, health index, crime index, government transfers to households, unemployment benefits and electricity provision.

Every structural (stochastic) equation included in the neoclassical system has been theoretically validated (see chapters 4 to 8).

Table 9.1 presents the encompassing results of the South African supply-side model. The structural properties are compared with those of rival models. The LBS and OECD models, which may be considered as leaders in the field of macroeconometric modelling, are utilised for this purpose. The work of Layard and Nickell (1985, 1986; Nickell, 1988) has most recently set the tone for supply-side modelling and has been incorporated by both the LBS and OECD models in varying degrees.

9.3.2 Dynamic simulation properties

A dynamic simulation (*ex-post* forecast) of the complete supply-side model is conducted to evaluate the statistical significance and stability of the model. The graphical illustrations (figure 9.1) of the simulation results (actual *versus* fitted values) serve as an indication of the ability of the model to adequately represent the historical data (statistical significance) and the stability of the model. The statistical significance (goodness-of-fit) of the full system is also measured in terms of a set of simulation/forecast error statistics[2] (table 9.2).

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[2] See Appendix 2 for an exposition of the simulation error statistics.

Table 9.1 **Encompassing results**

Structural properties		**LBS**	**OECD**	**SA**
Production sector	*Cost/production approach*	Cost function	Production function	Cost to production function
	Functional form	Translog	Cobb-Douglas and CES	Cobb-Douglas
	Technical progress	Labour augmenting (Harrod neutral)	Labour augmenting (Harrod neutral)	Labour augmenting (Harrod neutral), human capital augmenting, imported technical innovation and exogenous innovation
Capacity utilisation (cu)	*Actual output*	n.a.	Actual output estimated by production function	Actual output estimated by production function
	Potential output	n.a.	Normal (trending) output, a structural production function approach	Potential output, a structural production function approach
Investment	*Model*	Tobin`s q	Neoclassical (Jorgenson)	Neoclassical (Jorgenson) combined with cash flow model (financial constraints)
	User-cost-of-capital (r)	Rental cost	User-cost-of-capital (r) = f(price of capital, depreciation, rates of return)	User-cost-of-capital (r) = f(price of capital, depreciation, rates of return, taxes)
Labour: demand	*Market- or non-market clearing*	Non-market clearing approach, assuming NAIRU	Non-market clearing approach, assuming NAWRU	Non-market clearing approach, assuming NAWRU
Labour: supply	*Exogenous/LFP*	Labour force participation function	Labour force participation function	Labour force participation function
Wage-setting	*Model*	Wage-bargaining & wage productivity	Wage-bargaining & wage productivity	Wage-bargaining & wage productivity
Price-setting	*Model*	Mark-up on unit costs	Mark-up on unit costs, cu, r	Mark-up on unit costs, cu, r
Expectations		Learning in exchange rate function	none	Expected inflation in wage equation

Table 9.2 Dynamic simulation accuracy (goodness-of-fit) of the individual stochastic variables in the supply-side model

Stochastic variables		Simulation error statistics[3]				
		Root mean square simulation error (RMSE)	*Mean absolute simulation error (MAE)*	*Root mean square percentage error (RMSPE)*	*Mean absolute percentage error (MAPE)*	*Theil inequality coefficient (U)*
Real GDP at factor cost	*ln_bbpfact_90p*	0.005277	-0.001180	0.000429	-0.000096	0.000071
Real fixed investment	*ln_if*	0.051037	-0.011412	0.004608	-0.001030	0.000403
Nominal corporate savings	*ln_sc_cp*	0.012768	0.002855	0.002754	-0.000616	0.000132
Skilled labour demand	*ln_ns*	0.092575	0.020700	0.072106	0.016123	0.006126
Unskilled labour demand	*ln_nu*	0.030334	0.006783	0.019231	0.004300	0.001656
Labour participants in the informal sector	*ln_n_informal*	0.061234	-0.013692	0.004723	-0.001056	0.000383
Labour supply	*ln_s*	0.000988	-0.000221	0.000558	-0.000125	0.000037
Skilled labour supply	*ln_ss*	0.090179	-0.020165	0.065682	-0.014687	0.005501
Nominal skilled wage rate	*ln_ws_rate*	0.061612	-0.013777	0.007000	-0.001565	0.000581
Real unskilled wage rate	*ln_wuvpi_rat*	0.037693	-0.008428	0.004327	-0.000968	0.000374
Production price index	*ln_ppi*	0.061172	0.013678	0.011815	-0.002642	0.004760
Consumer price index	*ln_vpi*	0.085137	0.019037	0.092775	-0.020745	0.006483

[3] See Appendix 2 for an exposition of the relevant formulae.

Figure 9.1 Dynamic simulation properties of the supply-side model

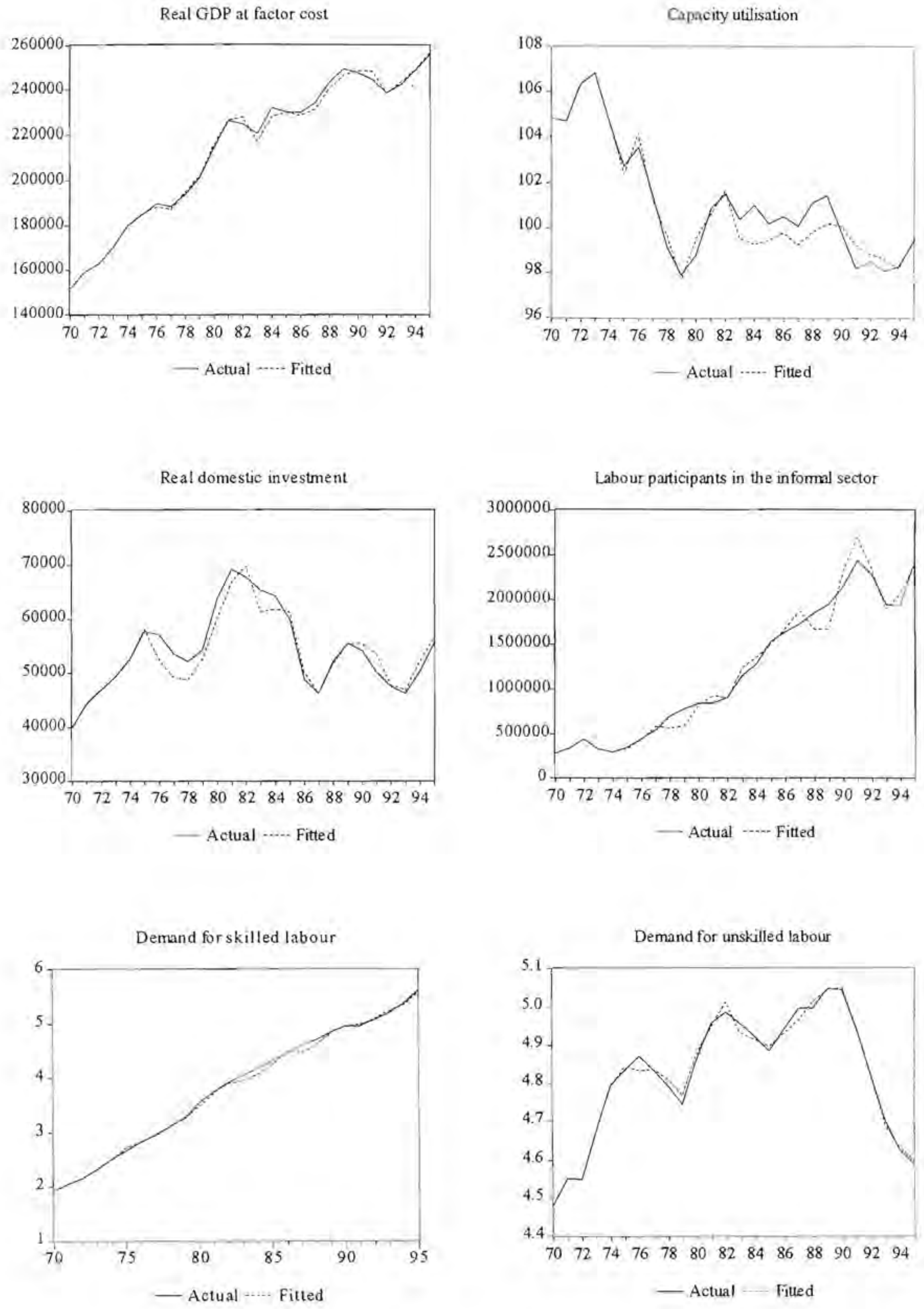


Figure 9.1 *(cont.)*

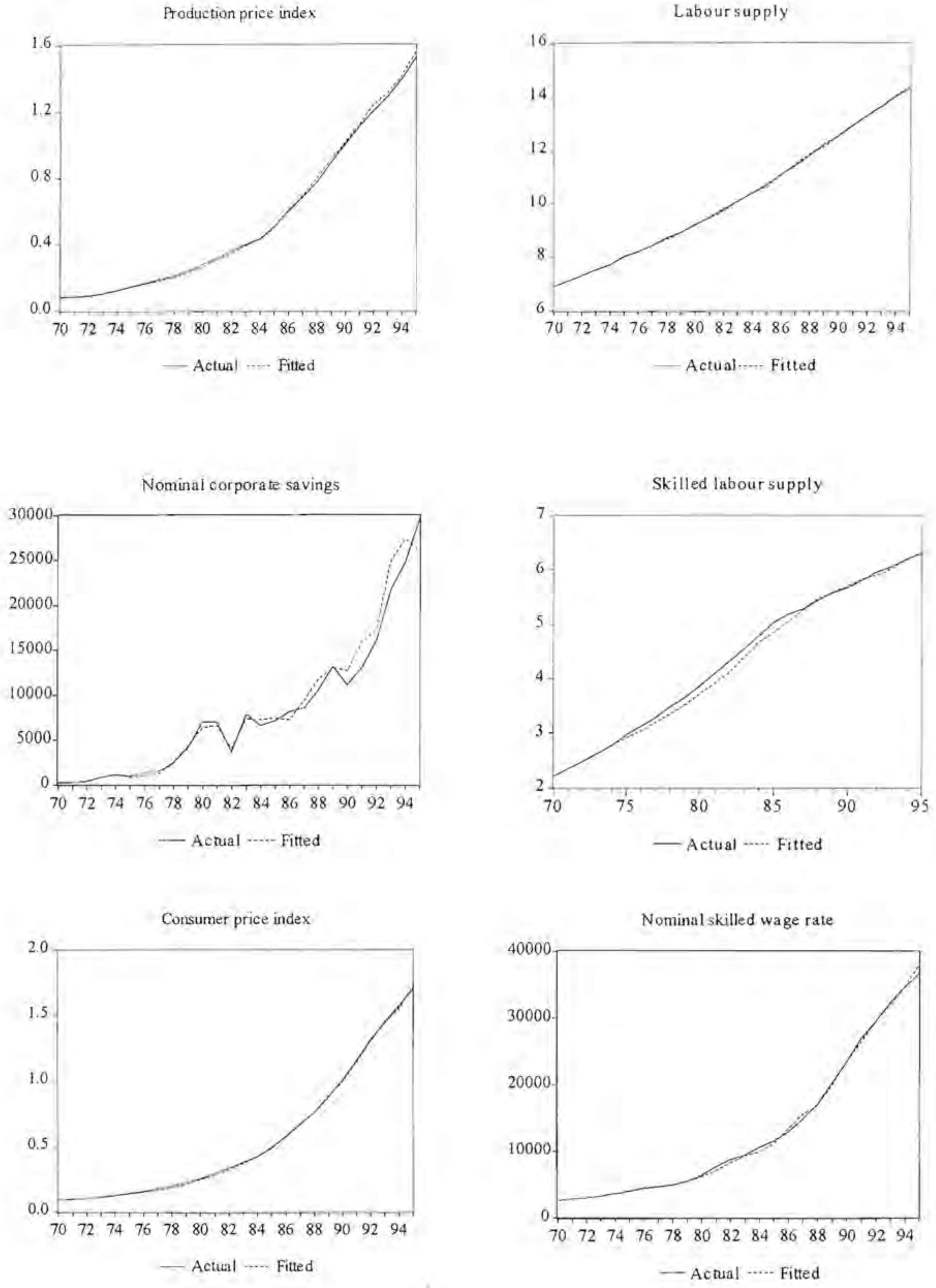
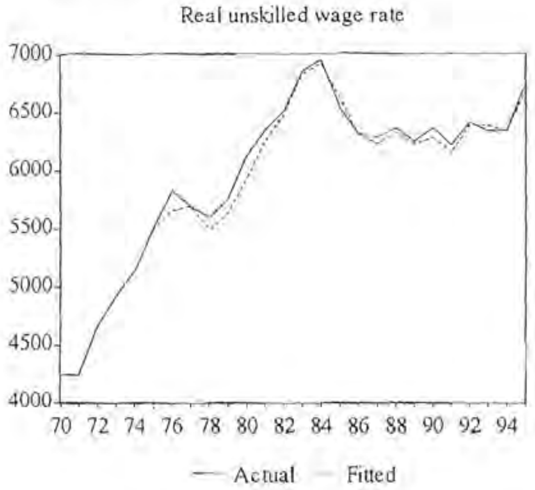


Figure 9.1 (*cont.*)



9.3.3 Long-run response properties

The purpose of this section is to determine the long-run multipliers and elasticities of the neoclassical supply-side model. Since the system of equations is non-linear, it is not possible to derive or compute these properties directly from the reduced form. For this reason a series of dynamic, *ex post* simulations are conducted by shocking a stochastic (hereafter "shocked" or "source") variable in the system to determine the multiplier (relative change) and elasticity (relative percentage change) for every response variable in reaction to the shocked (source) variable.

The multipliers/elasticities are obtained by comparing every response variable's baseline simulation path with its shocked simulation path. A multiplier is defined as the change in the response variable relative to the absolute value of the shock applied, while an elasticity is defined as the percentage change in the response variable relative to the percentage shock applied. The multiplier (elasticity) at convergence is the long-run, steady-state or comparative static multiplier (elasticity)[4], while the multipliers (elasticities) determined along the simulation path are referred to as the dynamic multipliers (elasticities).

The multipliers of a particular source variable are determined by applying a constant exogenous shock to the source variable from 1975 onwards, i.e. by increasing the source data series with a constant value equal to 10 percent of its 1975-observed value.[5] The model is dynamically simulated and every response variable's simulation or convergence path compared with its baseline path to determine the respective multipliers.

The elasticities of a particular source variable are determined by applying a constant percentage shock to the source variable, i.e. by increasing the source data series with 10 percent from 1975

4 Klein (1983: 135).

5 The shocks applied to unskilled labour demand and the unskilled wage rate are only 1 percent where a 10 percent shock was applied for every other stochastic variable in the system.

onwards[6]. Again the model is dynamically simulated and the response variable's convergence and baseline paths are compared to determine the respective elasticities.

These processes are repeated for every stochastic variable in the system – a series of simulations are conducted to determine the matrix of multipliers and elasticities.

From evaluating the results for the dynamic multipliers and elasticities, it is clear that the sample range is too small to always ensure convergence within the sample. A couple of the response variables' multipliers and elasticities did not ambiguously converge within the sample range. For the purpose to facilitate the detection of convergence Hodrick-Prescott filters were applied and the smoothed and actual dynamic multipliers/elasticities graphed and evaluated.

The convergence or long-run (proxied by the last value), as well as the average values for the dynamic multipliers and elasticities are presented in tables 9.3 and 9.4 respectively. The dynamic multipliers and elasticities of every response variable for one particular shock are graphically illustrated. Figures A15.1 to A15.11 in Appendix 15 provide the series of graphical illustrations for every shock applied.

The economic interpretation of some of the significant responses are evaluated in the next chapter where an attempt is made to propose a set of policy rules that will alleviate the unemployment problem in South Africa, i.e. improve the labour absorption capacity of the economy. It is, however, worthy to note at this stage that the obtained long-run properties of the neoclassical supply-side model are consistent with *a priori* expectations.

9.4 CONCLUSION

The purpose of this chapter was to combine each of the individually estimated components into a neoclassical supply-side model and to close the system by introducing a number of identities and definitions that will link the endogenous variables in the system.

Both the single equations and the model as a whole were evaluated in terms of the full ideal principles of model selection (Appendix 3), which in brief are: (1) economic consistency, (2) statistical significance, (3) data adequacy, (4) its being encompassing and (5) its sensitivity.

In particular, the estimated model had to comply with the *a priori* objectives of the study and had to be relevant for both policy analysis and forecasting purposes. The model was dynamically simulated for various scenarios (baseline and numerous shocks) to identify and determine the structural and long-run properties of the neoclassical system.

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[6] The shocks applied to unskilled labour demand and the unskilled wage rate are again only 1 percent as opposed to the 10 percent for every other stochastic variable in the system.

It is concluded that the model and its properties comply with both the full ideal principles and *a priori* objectives of the research, and is suitable to be utilised for both policy analysis and forecasting purposes.

Table 9.3 Response properties of the supply-side model (complete system): long-run multiplier[7] and elasticity[8] effects (convergence values)

Response variables		Shocked (source) variables										
		Real GDP at factor cost	Real fixed investment	Nominal corporate savings	Skilled labour demand	Unskilled labour demand	Labour supply	Skilled labour supply	Nominal skilled wage rate	Real unskilled wage rate	Production price index	Consumer price index
Real GDP at factor cost	*multiplier*	*na*	0.48	-1.97	4.72	0.44	-0.31	0.01	-18.29	2.68	2.17	-1.67
	elasticity	*na*	0.10	0.02	0.50	0.09	-0.10	0.001	-0.29	0.59	0.12	-0.09
Real fixed investment	*multiplier*	0.16	*na*	-11.40	-1.28	-0.09	-0.02	0.03	-0.02	-2.98	0.41	-1.39
	elasticity	0.61	*na*	0.09	-1.40	-0.07	-0.03	0.02	-0.21	-3.47	-1.02	-1.46
Nominal corporate savings	*multiplier*	-0.03	0.02	*na*	-0.84	0.16	0.03	0.04	0.95	-1.93	0.48	-0.13
	elasticity	-0.20	0.12	*na*	-2.17	0.41	0.12	0.05	0.006	-4.78	-0.57	-1.73
Skilled labour demand	*multiplier*	0.03	0.03	-0.93	*na*	0.05	-0.14	-0.08	0.33	1.63	-0.09	0.14
	elasticity	0.14	0.02	0.003	*na*	0.04	-0.22	-0.03	-0.42	1.78	0.19	0.11
Unskilled labour demand	*multiplier*	0.05	0.05	-0.77	0.57	*na*	-0.02	0.02	-1.68	0.09	0.33	-0.12
	elasticity	0.21	0.05	0.004	0.57	*na*	-0.03	0.02	-0.25	0.09	0.33	-0.16
Labour supply	*multiplier*	-0.02	-0.02	-0.03	-0.16	-0.02	*na*	0.01	0.79	0.15	-0.29	0.25
	elasticity	-0.03	-0.01	-0.002	-0.04	-0.008	*na*	-0.001	0.11	0.07	-0.38	0.14
Skilled labour supply	*multiplier*	0.09	-0.07	-0.05	-0.78	-0.61	-0.74	*na*	5.13	0.71	-0.90	-0.45
	elasticity	0.32	-0.06	-0.02	-0.48	-0.50	-1.04	*na*	1.21	0.68	-0.02	-0.05
Nominal skilled wage rate	*multiplier*	-0.03	-0.05	-0.24	-0.31	-0.14	0.13	0.04	*na*	-0.22	-0.35	0.27
	elasticity	-0.21	-0.09	-0.02	-0.41	-0.20	0.30	0.005	*na*	-0.37	-0.13	0.87
Real unskilled wage rate	*multiplier*	0.06	-0.03	0.72	-0.98	-0.37	0.13	0.03	2.51	*na*	-0.47	0.08
	elasticity	0.21	-0.02	-0.002	-0.74	-0.29	0.16	-0.006	0.46	*na*	-0.31	0.07
Production price index	*multiplier*	-0.15	-0.11	-4.78	2.70	0.19	-0.01	-0.03	-1.71	5.60	*na*	1.89
	elasticity	-0.20	-0.07	-0.02	1.05	0.04	-0.007	0.004	-0.03	2.26	*na*	0.82
Consumer price index	*multiplier*	-0.28	-0.22	-1.44	0.03	-0.24	0.06	-0.007	1.60	1.04	-0.76	*na*
	elasticity	-0.38	-0.09	-0.02	0.05	-0.09	0.03	-0.008	0.15	0.47	0.12	*na*
Labour participants in the informal sector	*multiplier*	0.07	0.02	-0.003	0.07	0.006	0.04	-0.004	-0.03	0.004	0.02	-0.01
	elasticity	0.34	0.09	0.005	0.56	0.03	-0.17	-0.001	-0.38	0.02	0.22	-0.07

7 An exogenous shock applied to each stochastic variables by increasing the series from 1975 onwards with a constant value. The shocks are equal to 1% of the 1975-observed value for unskilled labour demand and real unskilled wage rate and 10% of the 1975-observed value for every other stochastic variable.

8 An exogenous shock applied to each stochastic function by increasing unskilled labour demand and real unskilled wage rate from 1975 onwards with 1%, and increasing each of the stochastic variables from 1975 onwards with 10%.

Table 9.4 Response properties of the supply-side model (complete system): long-run multiplier and elasticity effects (average values)

Response variables		Shocked (source) variables										
		Real GDP at factor cost	Real fixed investment	Nominal corporate savings	Skilled labour demand	Unskilled labour demand	Labour supply	Skilled labour supply	Nominal skilled wage rate	Real unskilled wage rate	Production price index	Consumer price index
Real GDP at factor cost	*multiplier*	*na*	0.45	0.70	2.89	0.76	-0.04	0.20	-14.14	1.39	1.18	-1.55
	elasticity	*na*	0.11	0.02	0.33	0.17	-0.007	0.03	-0.24	0.32	0.07	-0.10
Real fixed investment	*multiplier*	0.13	*na*	0.99	-0.97	-0.19	0.01	0.03	-1.54	-2.03	-1.54	-2.25
	elasticity	0.45	*na*	0.20	-0.84	-0.17	0.03	0.03	-0.23	-2.16	-0.97	-1.05
Nominal corporate savings	*multiplier*	-0.01	-0.008	*na*	-0.30	-0.02	-0.005	-0.002	0.24	-0.67	0.03	-0.22
	elasticity	-0.33	-0.11	*na*	-1.55	-0.24	-0.003	0.006	-0.13	-3.31	-0.65	-1.52
Skilled labour demand	*multiplier*	0.05	0.06	0.003	*na*	0.06	-0.04	0.03	-2.86	1.07	0.11	0.06
	elasticity	0.25	0.08	0.02	*na*	0.08	-0.01	0.06	-0.57	1.42	0.10	0.04
Unskilled labour demand	*multiplier*	0.04	0.08	0.11	0.33	*na*	0.007	0.02	-0.88	-0.12	0.37	-0.29
	elasticity	0.14	0.09	0.02	0.28	*na*	0.02	0.02	-0.10	-0.14	0.22	-0.14
Labour supply	*multiplier*	-0.008	-0.01	-0.13	-0.02	-0.06	*na*	-0.02	1.29	0.22	-0.02	0.54
	elasticity	-0.01	-0.005	-0.001	-0.00003	-0.03	*na*	-0.10	0.10	0.12	0.02	0.14
Skilled labour supply	*multiplier*	0.06	-0.05	-0.37	-0.17	-0.31	0.30	*na*	6.21	0.77	-0.48	0.01
	elasticity	0.25	-0.06	-0.01	-0.07	-0.30	1.20	*na*	0.90	0.92	-0.19	0.08
Nominal skilled wage rate	*multiplier*	-0.01	-0.02	-0.10	-0.10	-0.05	0.05	0.008	*na*	-0.04	-0.03	0.35
	elasticity	-0.14	-0.05	-0.01	-0.15	-0.14	0.01	-0.11	*na*	-0.03	0.15	1.05
Real unskilled wage rate	*multiplier*	0.05	-0.06	-0.21	-0.61	-0.28	-0.008	-0.04	2.57	*na*	-0.36	0.19
	elasticity	0.18	-0.05	-0.01	-0.41	-0.22	-0.04	-0.03	0.28	*na*	-0.16	0.07
Production price index	*multiplier*	-0.05	0.02	-1.27	1.15	0.21	0.01	0.01	-0.36	2.13	*na*	1.43
	elasticity	-0.11	0.08	0.01	0.78	0.19	-0.02	-0.008	0.08	1.64	*na*	0.77
Consumer price index	*multiplier*	-0.12	-0.07	-0.57	0.06	-0.06	0.02	-0.005	0.93	0.43	-0.13	*na*
	elasticity	-0.33	-0.03	-0.007	0.10	-0.02	-0.006	-0.02	0.14	0.40	0.29	*na*
Labour participants in the informal sector	*multiplier*	0.04	0.01	0.00008	0.03	0.003	-0.01	0.002	-0.03	-0.00005	0.009	-0.008
	elasticity	0.27	0.08	0.01	0.24	0.02	0.03	0.04	-0.30	-0.008	0.11	-0.02

CHAPTER 10

THE SOUTH AFRICAN SUPPLY-SIDE MODEL: CRITICAL POLICY IMPLICATIONS

10.1 INTRODUCTION

The development of a supply-side model of the South African economy will be worthless if it can not be used in an attempt to solve the economy's gravest problem: growing unemployment and ever-increasing poverty.

The unemployment problem will only be alleviated by means of sustainable long-term economic growth and stability, and although aggregate demand and aggregate supply jointly determine the economic growth rate, aggregate supply is the greater force behind the growth process. Expressed in general terms, the economy's output of final goods and services (real income) results from both quantitative and qualitative causes, namely the physical inputs of labour and capital as well as their productivity. From the perspective of the labour force, long-term economic growth holds the promise of more jobs and rising per capita output, real wages and living standards.

The level of unemployment associated with a consistent level of output, can be explained in terms of the structural long-run, or supply-side, properties. The essence of a neoclassical supply-side model is to capture and explain the underlying production structure of the economy, associated with consistent factor demand and price relationships of an economy. The resultant levels of production and employment are forthcoming from firms' decision-making processes, which, in turn, are driven by profit-maximising or cost-minimising goals.

The purpose of this chapter is three-fold:

(i) to give a brief description of the labour conditions and unemployment problem in South Africa;
(ii) to identify a set of policy rules (proposals) which may increase the labour absorption capacity of the economy and subsequently reduce the unemployment problem; and
(iii) to empirically validate the suggested policy rules through a series of dynamic simulations of the estimated supply-side model.

10.2 RISING UNEMPLOYMENT IN SOUTH AFRICA

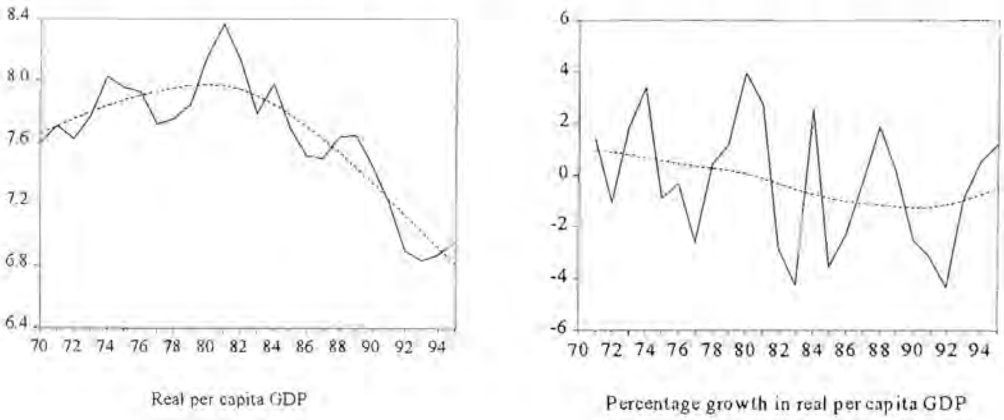
10.2.1 South Africa's economic growth path: 1970-1995

The growth performance of South Africa stands in sharp contrast to that of other emerging countries such as the Far Eastern "Newly Industrialised Countries" (NICs). The lack of necessary political reform, as well as the adoption of an inward-oriented and protectionist institutional framework during the apartheid era, led to a serious deterioration of the South African economy. Direct control measures, weak export incentives, low real interest rates and an overvalued exchange rate prevailed at the beginning of the 1980s. Given the openness of the South African economy, the sudden collapse of world commodity prices during the 1980s, along with a serious drought, a prolonged economic recession ensued. The sanctions and disinvestment campaign, which culminated in the debt standstill agreement (1985) and subsequent repayment agreements, halted economic growth and development of an already weak economy.

The result was that the South African economy moved into a low growth equilibrium trap. This trap was caused by huge capital outflows, compelling policy authorities to maintain a surplus on the current account of the balance of payments in order to meet the country's debt repayments. This again caused the adjustment process to turn inward and anti-cyclical. Mostly high, positive real interest rates, exchange controls and low real government investment, characterised the adjustment process of the economy between 1985 and 1993.

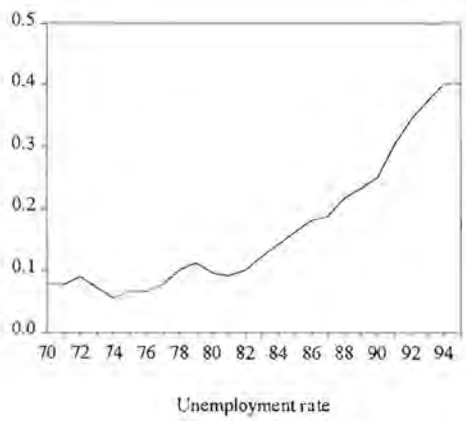
This dismal growth performance had several harmful effects, such as negative per capita real growth rates and an increasingly unequal distribution of income. Economic welfare in South Africa, measured in terms of real per capital income, has declined progressively since 1970 (figure 10.1).

Figure 10.1 South Africa's real per capita GDP: 1970-1995 (actual and smoothed values)



Arguably the most serious of these effects, was the resulting increase in unemployment (figure 10.2).

Figure 10.2 South Africa's unemployment rate: 1970-1995



The link between the poor growth performance and the rising unemployment problem is obvious. Less production implies less employment. The severely sub-optimal South African growth performance was however not the only cause of rising unemployment. Structural changes in the production process, such as capital-deepening, and changes in the labour market, such as increased labour militancy, contributed to the magnitude of the problem. This conclusion is supported by the fact that South Africa experienced periods where income growth was small but positive, while employment continued to decline (BEPA 1998).

10.2.2 Labour conditions in South Africa

The fact that high unemployment and insufficient labour absorption remain at the core of South Africa's labour problems, despite periods of positive economic growth, have plagued policy makers, regardless of the type of political dispensation, since the 1970s.

In many countries, labour markets seem to have effectively lost their capacity to perform their allocative, informational and distributional function, and thus become relatively inflexible in adjusting to internal and external shocks to the economy. The main factors seriously influencing the capacity of the economy to adjust to changing circumstances, are interventionist actions by governments, aggressive trade union behaviour, minimum wage arrangements, excessive social security provision, inefficient production and poor management practices, inadequate labour skills and the training of workers, inappropriate production technologies, as well as poor productivity growth.

These characteristics are also present in the South African labour market. The capacity of the formal economy to provide sufficient employment opportunities for its growing labour force has steadily been eroded to the present position where it is virtually extinct. This situation is inflicting an immense cost on society and it also impacts on the socio-economic conditions and political developments in the country.

The labour market displays various inter-related properties that have a direct impact on labour market performance. The labour market conditions are furthermore influenced by several economic and non-economic factors:

(i) Lack of sustainable (long-term) growth and productivity.

(ii) Institutional labour conditions have created a rigid labour environment which is detrimental for intensified competition in a global economy and labour-saving technical progress. Examples of these institutional labour market disincentives resulting in inefficient labour markets are: welfare, social security and unemployment payments; high levels of minimum wages; powerful trade unions; extensive regulations governing hours of work, business zones and leave conditions; payroll taxes; job protection laws; difficult and costly dismissal procedures, etc. The affirmative action policy is a particularly detrimental to job creation in South Africa.

(iii) A deep-seated labour problem relates to the quantity and quality of the potentially available labour force, which are mainly determined by the size and growth of the population, labour force participation rates, hours worked, the level of investment in human capital (education and training), labour mobility (especially migration) and socio-economic conditions.

An analysis performed by the Bureau of Economic Policy and Analysis (BEPA 1998)[1] shows several distinctive trends that impact negatively on the labour absorption capacity of the economy. These trends include the relatively high population growth rate and the major and growing share of young persons in the population, which trends have to be evaluated against the background of a continuously lower real GDP growth rate. The labour force, represented by the economically active population,[2] has increased from 30 percent of the total population in 1960 to 35 percent in 1994. Net migration has added to the strain on the economy's capacity to fulfil the need for jobs. Until the early 1990s, South Africa experienced a substantial net gain in migration, which mainly consisted of high-level or skilled labour. The sanctions and disinvestment campaign against South Africa has, however, contributed to an increasing net loss of high-level labour (the "brain-drain") since the mid-1990s, while the poor economic conditions in South Africa's neighbouring countries have resulted in the influx of poor, unskilled and often illegal immigrants.

This shift in the composition of the labour force has only intensified the problem which has been omnipresent in South Africa's economic history: an abundance of unskilled and a relative shortage of skilled workers.

(iv) Employment growth has also been constrained by a long-term process of capital deepening. Concomitantly, the capital-output ratio in the South African economy rose substantially (figure 10.3). This has been associated with sharp increases in wages and other labour costs, like those caused by strikes, stayaways and the so-called institutional disincentives mentioned earlier. Labour problems have caused firms to adopt excessively capital-intensive production methods that are obviously detrimental to employment.

(v) Since 1960, real and nominal earnings per worker have increased by about 2,5 and 12,3 percent per annum respectively, against the background of increasing unemployment. Wage inequalities and wage increases exceeding the inflation rate have contributed to the labour market's inefficiency and the ever-increasing rate of structural unemployment (BEPA 1998).

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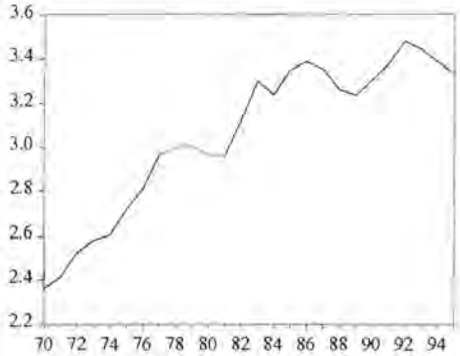
1 The author of this study participate in research published by the Bureau of Economic Policy and Analysis (BEPA) on "Improving the labour absorption capacity of the South African economy" in 1998. The labour absorption problem was diagnosed, described and key policy proposals were formulated to alleviate the problem. Recognition is herebe given to the findings of the report, which form the basis for the extended and applied research in this chapter.

2 The *economically active population* is defined as persons between the ages of 15 and 65 years who are potentially willing and able to take up a job opportunity.

(vi) Some of the characteristics of the South African socio-economic environment contribute to the weak performance of the economy. These are: a high dependency ratio (1:5) amongst those formally employed; skewed distributions of skills and income; scarcity and an uneven distribution of basic housing, telecommunication, sources of energy and infrastructure across racial and provincial boundaries and an unequal access to and availability of medical services (BEPA 1998).

Figure 10.3 Capital-output ratio for South Africa: 1970-1995



The South African labour market can be divided into two broad segments, namely markets for skilled and markets for unskilled/semi-skilled labour. The skilled labour segment operates according to the general guidelines of the competitive market model. This market showed flexibility to handle and discount demand, supply and external changes and shocks (BEPA 1998).

On the other hand, the unskilled and semi-skilled labour markets, which accommodate the majority of labour-market participants in the economy, are not operating efficiently in terms of their allocative, distributional and informational functions. This market segment appears highly rigid in discounting demand, supply and external changes and shocks. Trade unions and consequently labour legislation contributed to the observed market rigidity.

To summarise, unemployment in South Africa has two major causes: unskilled labour and inflexible markets. To effectively address the massive unemployment problem in the country, these are the issues to attend to.

10.3 THE SOLUTION: PROPOSED SET OF POLICY MEASURES

Unemployment in South Africa displays a non-cyclical pattern, i.e. unemployment rates tend to increase steadily despite periods of relatively high economic growth. Demand-management policies are inadequate to solve the problem. The nature of unemployment increasingly displays structural characteristics and the labour market shows larger imbalances and rigidities.

The labour market has lost its capacity to perform its allocative, informational and distributional functions efficiently. In addition, it has become relatively inflexible in adapting to internal and external shocks to the economy. The main factors influencing the labour market are government interventionist actions, aggressive trade union activities, minimum wage arrangements, exorbitant social benefit packages of workers, inadequate skills and training of workers, inappropriate production technologies and low productivity. These structural deficiencies have a direct impact on the socio-economic conditions and political developments in the country.

10.3.1 Lessons for South Africa

Based on the experience of successful economies, the labour market plays an important role in determining the success of adjustment and reform, as well as the level of living standards. The labour market and labour policy form part of a dynamic economic system and policy framework, which should meet the conditions for economic growth, development and job creation. These conditions were referred to in the study conducted by the Bureau of Economic Policy and Analysis (BEPA 1998). The conditions briefly are:

(i) Efficiency in production, which can only be achieved by means of higher rates of growth in manufacturing and exports; faster growth in physical capital, supported by higher rates of domestic saving; and generally higher levels of production.

(ii) Economic stability by means of disciplined fiscal policy, a stable exchange rate and balance of payments, liberalisation and stabilisation of policy measures and flexible labour markets. Macroeconomic stability will initiate a cycle of high investment rates and strong productivity growth.

(iii) Correct policy application, i.e. consistency, co-ordination, choice and sequencing of policies, is necessary to facilitate the outward-orientation of economic activity.

(iv) An economic environment conducive to the attainability of the above three conditions. Such an environment:

- constitutes a domain within which economic growth, development and job creation flourish;
- builds the correct infrastructure, develops human resources and the technical and entrepreneurial capabilities to manufacture and export;
- establishes the institutional basis for growth, namely land reform programmes, housing programmes, assistance to workers and firms and the creation of small- and medium- size business enterprises;
- is business- and investment-friendly;
- provides adequate infrastructure;
- improves education to obtain higher levels of human capital;
- secures financial institutions;
- promotes declining fertility; and
- creates the right climate to sustain flexible labour markets and increased productivity.

A set of conditions with regard to labour markets in particular follows from the successes of the Far Eastern economies:

(i) Dynamic labour markets that allow free movement of demand and supply to ensure a continuous increase in wage employment.

(ii) Limited government intervention in labour markets, allowing wages and employment to be determined largely by market forces.

(iii) Efficient, flexible and responsive labour markets allowing for the rapid adjustment of skills to those in demand, which improves resource allocation across firms and thereby contributes to growth.

(iv) Limited and small government share in employment.

(v) Incentive based wage-setting processes (wage-plus-bonus method).

(vi) Company- or firm-based labour unions.

10.3.2 Policy proposals to increase labour absorption

The labour market in South Africa has not performed its allocative, distributive and informational functions efficiently, as can be seen against the backdrop of the massive structural unemployment in the economy, and the virtual disappearance of the economy's capacity to create jobs for a growing labour force. These shortcomings contribute directly to severe poverty, a very skew distribution of income and other socio-economic inequities. These factors have to be taken into account in any package of policy proposals.

10.3.2.1 Policy proposals based on international experience

From an analysis of the world's successful economies follows that higher economic growth as the driving force behind job creation, is imperative. High and consistent economic growth within a stable macroeconomic environment is of decisive importance and the prerequisite for future employment growth.

Based on the analysis of BEPA (1998), it is clear that an optimal set of policy proposals for sustained growth, development and labour absorption should (1) be based on international experience; (2) focus on the identified labour market inefficiencies; and (3) be aimed at redressing the defects in the socio-economic environment.

Policy proposals based on the lessons from and experiences of other emerging market economies, as well as analysing the growth path of the South African economy, contain of four key elements:

(i) trade liberalisation, i.e. increased efficiency in production which includes outward-oriented growth (increased exports and world market share) and labour market flexibility;

(ii) promotion of labour-intensive small and medium-sized enterprises by encouraging entrepreneurial training and opportunities, mechanisms involving SMEs in public projects, deregulation, infrastructure building, etc.;

(iii) economic (fiscal, monetary and political) stability;

(iv) environmental development, which requires investment in both physical infrastructure and human capital; and

(v) labour policy promoting flexible and responsive labour markets.

10.3.2.2 Labour market proposals

For purposes of policy analysis, a framework distinguishing between three categories of policy proposals is specified: (1) labour supply; (2) labour demand; and (3) improvement of the efficiency of the labour market. It should be noted that the separation of these approaches is a theoretical exercise. In practice labour supply, demand and market efficiency are highly interrelated and it is not possible to derive a unique set of policy proposals for any of them independently.

(i) *Policies focusing on labour supply*

Apart from the relatively high population growth rate that should be halted, the following areas need to be the focus of policy-makers:

- Market-based land reform and rural development (including agriculture) since a large portion of the total population still lives in rural areas and are to a great extent dependent on agriculture as their source of living.
- Removal of discriminatory practices.
- A revised immigration policy addressing the influx of illegal immigrants across South Africa's borders, the loss of high-level manpower due to the political and economic instability and domestic employment of overseas skilled labour.
- Promotion of investment in human capital to develop skills and upgrade the quality of the labour force.

(ii) *Policies focusing on labour demand*

The demand for labour and subsequent rate of employment is directly related to the rate of economic growth due to the profit-maximising behaviour of firms. Policy measures to raise the economic growth rate to substantially higher levels are, therefore, of prime importance over the longer term, if job-creation objectives are to be met. A more rapid rate of job-creation will simultaneously alleviate poverty and reduce differences in income distribution and thus materially assist in socio-economic reform.

A higher economic growth level (export-led) would imply changes in the demand for labour and needs to be considered in a set of policy proposals. Export-led production will imply (1) an increasing demand for skilled labour relative to unskilled labour; (2) cost-effectiveness of production in an internationally competitive environment; (3) technically advanced production; (4) improved management techniques; (5) an efficient and cost-effective firm-union negotiation framework; (6) flexibility and stability in the labour market; and (7) involvement of small and medium-sized business firms.

The above-mentioned priorities necessitate the training and retraining of both workers and management, the co-ordination of technology requirements, higher productivity, improved efficiency in wage-setting and bargaining, etc. Generally put, policies must be geared towards the establishment and promotion of more labour-intensive production methods.

(iii) *Policy approaches to improve the efficiency of the labour market*

The labour market like all other markets in the economy should have the capacity to adjust to any external (and internal) demand and/or supply shock. To fully exploit the opportunities of world markets, the labour market should be able to rapidly discount changing conditions. The economy, workers and employers will all benefit from efficient labour markets.

The efficiency and flexibility of labour markets can be improved if attention is given to:

(1) the avoidance of excessive wage demands (wage demands in excess of productivity performance);
(2) the establishment of wage and salary discipline over the longer term to help combat inflation;
(3) the promotion of competition in all markets and the improvement of labour mobility, removal of *de facto* discriminatory labour practices, continuous upgrading of skills through training and retraining (both employers and workers) and the further liberalisation of foreign trade policies;
(4) the expansion of investment in human capital to meet the requirement of higher economic growth;
(5) establishment of voluntary participatory principles in the collective bargaining process;
(6) the limiting of the demonstration effect of excessive public service remuneration packages on the general economy;
(7) encouragement of the establishment and functioning of workplace forums;
(8) the provision of more and timely labour market information;
(9) to strike an equitable balance between worker and employer rights and responsibilities (e.g. limiting increasing labour costs, i.e. remuneration, stayaway and strike costs, dismissal costs, wage regulation costs, job security provisions, etc.);
(10) reappraisal of the right to strike and minimising intimidation and victimisation;

(11) provision of certain minimum standards in the workplace; workers' rights that must be weighed against the needs of employers and the economy;

(12) a re-examination of the effects of centralised minimum wage determination in relation to cyclical and structural economic development.

It follows that there are many facets related to the functioning of the labour market that need the attention of policy-makers. Macroeconomic stability, i.e. a situation where all the real and financial markets in the economy are simultaneously moving towards equilibrium, will create a climate conducive to job-creating economic growth. Presently, the major problem in South Africa is that the labour market is in disequilibrium, whilst the other major markets are showing a greater degree of stability. This situation calls for an appropriate combination and co-ordination of economic policy.

10.3.2.3 Policy proposals to address the socio-economic environment

The following proposals have emerged as some of the most critical issues to be addressed following the analysis of the socio-economic environment:

(i) Mass education and training (investment in human capital), creating a labour force with transferable and advanced skills which can reduce firms' cost of innovation.

(ii) Increased investment in housing with associated infrastructure, including electricity and telephones, facilitates the growth of home-based economic activity, which fosters not only informal job opportunities, but also formal small entrepreneurial skills. It could also support adult training programmes through facilitating the learning-by-doing acquisition of transferable skills and improve the employment generating capacity of the construction sector in general and the housing sector in particular.

(iii) The promotion of entrepreneurial skills for purposes of human capital building.

(iv) Prevention or control of crime and corruption, restoring stability and creating an investment-friendly environment conducive to job-creation.

10.4 EMPIRICAL VALIDATION OF PROPOSED POLICIES

Policy analysis in this study is conducted within a neoclassical framework and by utilising the structure of the estimated supply-side model of South Africa. For the purpose of testing and evaluating the above-mentioned policy proposals, the proposals are collectively integrated into policy scenarios. Target variables are specified, each representative of a particular policy scenario. A series of dynamic simulations is run by applying exogenous shocks to the target variables to determine their short and long-term effects on particularly labour absorption. Table 10.1 presents the policy proposals tested within particular policy scenarios and the associated target variables employed to simulate and validate the specific set of policy rules (policy scenario).

Table 10.1 Exposition of policy scenarios

Individual policy scenarios				
Scenario		*Target variable(s)*	*Policy proposal(s)*	*Policy aim*
0	*Control*	demand for skilled labour (*n_s*); demand for unskilled labour (*n_u*)	*n.a.*	*n.a.*
1	*Substitute unskilled for skilled labour demand*	demand for skilled labour (*n_s*); demand for unskilled labour (*n_u*)	- education and training programmes (environmental development); - greater mobility of labour; - export-led growth; - development of rural areas; - removal of discriminatory practices (e.g. policy of affirmative action); - promotion of a competitive environment; - improved management techniques; - involvement of small and medium-sized firms; - optimise the role of labour unions	- efficiency in production - improved quality of labour supply - improved demand for labour - improved labour market efficiency - improved socio-economic environment - improved economic and political stability
2	*Increased education and training*	education index (*educ_index*)	- education and training programmes; - improvement of management skills; - promotion of entrepreneurial skills	- efficiency in production - improved quality of labour supply - improved demand for labour - improved labour market efficiency - improved socio-economic environment - improved economic and political stability
3	*Increased financing of investment*	corporate saving (*sc_cp*); personal saving (*sp_cp*); saving of the general government (*sg_cp*); net capital flow (*netcapfl_cp*); change in gold and other foreign reserves (*gold_reserv_cp*)	- investment and savings-friendly environment (domestic and international); - political stability; - less crime and corruption; - fiscal discipline (lower tax rates); - cost-effective production opportunities	- efficiency in production - improved quality of labour supply - improved demand for labour - improved labour market efficiency - improved socio-economic environment - improved economic and political stability
4	*Increased foreign investment (direct and indirect)*	total foreign direct investment (*dirinvest*); total foreign non-direct investment (*indinvest*)	- investment and savings-friendly environment (domestic and international); - political stability; - less crime and corruption; - cost-effective production opportunities; - relaxation of foreign exchange control policy	- efficiency in production - improved quality of labour supply - improved demand for labour - improved labour market efficiency - improved socio-economic environment - improved economic and political stability
5	*Decrease in real unskilled wage rate*	real unskilled wage rate (*wu_vpi_rat*)	- cost-effectiveness of production (e.g. removal of minimum wage policy, lower payroll taxes, less costly dismissal procedures, wage discipline, etc.); - labour market flexibility (e.g. removal of policy of affirmative action); - less union power and militancy; - optimal collective wage bargaining framework; - education and training programmes; - immigration policy favouring skilled labour	- efficiency in production - improved quality of labour supply - improved demand for labour - improved labour market efficiency - improved socio-economic environment - improved economic and political stability

Table 10.1 (*cont.*)

Individual policy scenarios				
Scenario		*Target variable(s)*	*Policy proposal(s)*	*Policy aim*
6	*Technical innovation*	dummy: technology innovation (*tecno_innov*)	- eduction and training programmes; - promotion of investment in human capital (research programmes, etc.); - immigration policy favouring skilled labour; - promotion of international competitiveness	- efficiency in production - improved quality of labour supply - improved demand for labour - improved labour market efficiency - improved socio-economic environment - improved economic and political stability
7	*Decreased union power and militancy*	union members (*union_members*); strikes and stoppages: man-days lost (*union_work_lost*)	- less union power and militancy	- efficiency in production - improved quality of labour supply - improved demand for labour - improved labour market efficiency - improved socio-economic environment - improved economic and political stability
8	*Transition from informal to formal employment*	labour participants in informal sector (*n_informal*); demand for skilled labour (*n_s*); demand for unskilled labour (*n_u*)	- education and training programmes (environmental development); - greater mobility of labour; - export-led growth; - development of rural areas; - removal of discriminatory practices (e.g. policy of affirmative action); - promotion of a competitive environment; - improved management techniques; - promotion of small and medium-sized firms; - less union power and militancy	- efficiency in production - improved quality of labour supply - improved demand for labour - improved labour market efficiency - improved socio-economic environment - improved economic and political stability
9	*Improved socio-economic conditions*	crime index (*crime_index*); education index (*educ_index*); electricity index (*energy_ind*); health index (*health_index*); net transfers received by households (*h_transf_receiv*); per capita disposable income (*income_index*); unemployment benefit (*unpl_ben*)	- less crime and corruption; - education and training programmes; - housing and electricity provision; - improved health services (availability, accessibility, cost and quality); - optimal unemployment benefits; - optimal tax structure	- efficiency in production - improved quality of labour supply - improved demand for labour - improved labour market efficiency - improved socio-economic environment - improved economic and political stability

The dynamic simulation results of the policy scenarios are summarised in table 10.2. A dynamic simulation is run for every policy scenario with a 10 percent shock[3] applied to the particular set of target variables. The response properties of the supply-side model are evaluated by comparing the long-run elasticities (converged percentage difference between the baseline and shocked simulation path) of every response variable with the *a priori* desired policy responses. The averages of the dynamic elasticities (average of the series of elasticities along the simulation path) are also documented as an indication of the short-run dynamic effects of the policy shock. All stochastic variables of the supply-side model were monitored for their responses. Both the comparison between the baseline and shocked simulation paths and the percentage differences (elasticities) along the simulation path between the baseline and shocked variable, are graphically

[3] A 4 percent shock is applied to scenario 1, i.e. the substitution of unskilled for skilled labour demand.

illustrated for every response variable in a particular scenario. The graphical illustrations for every scenario are provided in figures A16.1 to A16.10 in Appendix 16.

A summary of an evaluation of the results is presented in table 10.3.

The simulation results of the policy proposals were consistent with the desired policy objectives to increase the labour absorption capacity of the economy. However, none of the simulations in isolation led to substantial economic growth. The reason: an increase in employment *ceteris paribus*, will not generate economic growth given the current decreasing returns to scale production structure and without substantial increases in labour productivity. Simulation of the individual policy scenarios suggest that the South African economy is in need of a complete structural reform and individual and isolated policy attempts will not guarantee success. A well-structured and co-ordinated mix of policy rules is needed to obtain the most optimal results, i.e. sustained (long-run) economic growth, development and employment within a stable (political and economic) environment.

For this reason, it is necessary to simulate and evaluate different combinations of the individual policy scenarios to obtain the optimal policy mix that will increase the labour absorption capacity of the economy. The simulation results are presented in table 10.4, the graphical illustrations, similar to those of the individual scenarios, are provided in figures A16.11 to A16.16 in Appendix 16 and a summarised evaluation of the simulation results is documented in table 10.5.

Although every combined policy mix improved both the labour absorption capacity and economic growth rate, the optimal policy mix for increasing the labour absorption capacity is a combination of technical innovation, increased financing for investment, less union power and militancy, the formalisation of the informal sector and improved socio-economic conditions (combined scenario 6). Depending on the secondary priorities, the next choice of policy mix is to include an improvement in socio-economic conditions. Improving the socio-economic conditions raises productivity and wages, but a lower rate of employment in the longer term will have to be tolerated. International experience has proven that exorbitant social benefit packages serve as disincentives and are detrimental to the cause of improved labour market efficiency and employment.

The fact remains that South Africa's unemployment problem will not be efficiently dealt with by ignoring the necessity of structural changes conducive to long-term economic growth development and employment.

10.5 CONCLUSION

The purpose of this chapter was (1) to give a brief description of labour conditions and the unemployment problem in South Africa; (2) to identify a set of policy measures (proposals) that will possibly increase the labour absorption capacity of the economy and subsequently reduce the unemployment problem; and (3) to empirically validate the suggested policy measures through a series of dynamic simulations of the estimated supply-side model.

From analysing the labour market in South Africa, it is clear that it has not performed its allocative, distributive and informational functions efficiently, as may be seen against the backdrop of the massive structural unemployment in the economy, and the virtual disappearance of the economy's capacity to create jobs for a growing labour force.

The main factors that seriously influence the labour market are government interventionist actions, aggressive trade union activities, minimum wage arrangements, exorbitant social benefit packages of workers, inadequate skills and training of workers, inappropriate production technologies and low productivity.

These shortcomings are structural in nature and have a direct bearing on severe poverty, socio-economic inequities, and the very skew distribution of income. These factors have to be taken into account in any package of policy proposals.

A number of policy proposals were suggested, targeting (1) labour supply, (2) demand for labour and (3) the efficiency of the labour market. The proposals were based on international experience and South Africa's growth and employment performance.

The policy proposals were validated by dynamic simulation of the neoclassical supply-side model of South Africa proposed in this study. The proposals were collectively integrated into policy scenarios, target variables were specified, each representative of a particular policy scenario and a series of dynamic simulations were run by applying exogenous shocks to the target variables. The responses of the individual policy scenarios suggest that the South African economy is in need of a complete structural reform and individual and isolated policy attempts will not guarantee success.

A well-structured and co-ordinated mix of policy rules is needed to obtain the optimal results, i.e. sustained (long-run) economic growth, development and employment within a stable (political and economic) environment. For this reason, it was necessary to simulate and evaluate different combinations of the individual policy scenarios.

Depending on priorities, a few combinations of policy proposals were identified that could be employed for South Africa. The optimal policy mix for increasing the labour absorption capacity, was a combination of (1) technical innovation, (2) increased financing for investment, (3) less union power and militancy, (4) the formalisation of the informal sector and (5) an improvement of socio-economic conditions. However, regardless of the policy mix chosen, the message remains clear: in order for South Africa to achieve sustained growth, development and employment, the structural problems of low productivity and inflexible, unresponsive labour markets have to be addressed aggressively.

Table 10.2 Response properties of the supply-side model controlling for different scenarios (policy shocks)

Response variables		Individual scenarios and percentages of shocks applied									
		0	1	2	3	4	5	6	7	8	9
		Control: Minimum level of unemployment	Substitute unskilled for skilled labour (employment)	Increased education and training	Increased financing of investment	Increased foreign investment (direct and indirect)	Decrease in real unskilled wage rate	Technical innovation	Decreased union power and militancy	Transition from informal to formal employment	Improved socio-economic conditions
		na	4%	10%	10%	10%	10%	10%	10%	10%	10%
Real GDP growth	*average % difference*	0.2	0.03	0.01	0.02	-0.01	-0.1	0.2	0.0	0.1	0.01
	last % difference	≈ 0.4	≈ 0.1	≡ 0.01	≡ 0.02	≈ 0.01	≡ -0.1	↑ 0.4	≈ 0.0	≡ 0.1	≈ 0.0
Real domestic investment	*average % difference*	-4.0	-3.4	0.04	5.7	0.6	9.5	0.7	0.4	-3.3	-0.4
	last % difference	↓ -9.1	↓ -4.2	≡ 0.04	↑ 6.8	↓ -0.04	↑ 16.6	↑ 1.2	≈ 0.5	↓ -7.3	↓↑ -0.3
Capital-labour ratio	*average % difference*	-5.0	-2.3	-0.1	2.6	0.7	6.7	-0.3	0.3	-3.6	-0.5
	last % difference	↓ -11.1	↓ -4.1	↓ -0.2	↑ 4.4	↑↓ 0.5	↑ 13.6	↓ -0.7	↑ 0.5	↓ -7.8	↓ -0.6
Productivity	*average % difference*	-3.9	-0.8	-0.1	-0.3	0.4	3.1	0.8	0.1	-2.8	-0.2
	last % difference	↓ -9.3	↓ -1.7	≈ -0.2	≡ -0.3	↓ 0.1	↑ 6.4	↑ 1.3	↑ 0.2	↓ -6.1	≈ -0.3
Nominal corporate savings	*average % difference*	-8.3	-4.8	-0.2	-0.8	0.2	13.0	-1.7	0.5	-6.8	-0.7
	last % difference	↓ -17.9	≈ -4.2	≡ -0.2	≡ -0.8	↑↓ -0.3	↑ 19.4	↓ -4.5	↑↓ 0.4	↓ -14.0	↑ -0.2
Labour demand	*average % difference*	*control*	0.6	0.2	0.4	-0.3	-2.4	0.6	-0.1	2.5	0.2
	last % difference	*control*	↑ 1.2	↑ 0.3	≈ 0.5	↑ -0.1	↓ -4.1	↑ 1.3	↓ -0.2	↑ 4.9	↑↓ 0.3
Skilled labour demand	*average % difference*	*control*	3.9	0.3	0.4	-0.01	-5.8	0.9	-0.2	2.3	0.7
	last % difference	*control*	↓ 2.8	↑↓ 0.2	≈ 0.4	≈ -0.02	↓ -7.2	↑ 1.7	↓↑ -0.2	↑ 4.4	↑↓ 0.3
Unskilled labour demand	*average % difference*	*control*	-2.1	0.03	0.4	-0.5	0.7	0.4	-0.01	2.6	-0.1
	last % difference	*control*	↑ -0.7	↑ 0.2	≈ 0.4	↑ -0.2	↑↓ -0.3	↑ 0.8	↓ -0.1	↑ 5.6	↑ 0.2
Labour supply	*average % difference*	-0.2	0.3	-0.03	-0.02	0.04	-0.6	0.0	-0.02	-0.1	0.01
	last % difference	↓ -0.9	↓ -0.01	≡ -0.03	↓ -0.06	↑ 0.07	↓↑ -0.4	↓ -0.02	↑ 0.0	↓ -0.3	↓ -0.04
Skilled labour supply	*average % difference*	-2.2	2.3	2.9	-0.3	0.8	-4.0	0.7	-0.2	-1.1	3.4
	last % difference	↓ -6.8	↑↓ 1.2	↑ 4.4	≈ -0.4	≈ 0.7	↓↑ -3.1	↑ 1.4	↓↑ -0.02	↓ -3.6	≈ 4.5
Unskilled labour supply	*average % difference*	1.3	-1.3	-2.4	0.2	-0.6	2.2	-0.6	0.1	0.7	-2.7
	last % difference	↑ 3.8	↓↑ -1.0	↓ -3.7	↑↓ 0.2	↓↑ -0.4	↑↓ 1.7	↓ -1.1	↑↓ 0.02	↑ 2.3	≈ -3.6
Unemployment	*average % difference*	*control*	-0.3	-1.1	-2.8	2.4	7.9	-3.0	0.4	-12.5	-1.1
	last % difference	*control*	≈ -2.9	≈ -1.0	↑ -1.2	↓ 0.5	≈ 8.6	≈ -3.0	≈ 0.4	≈ -13.0	↓↑ -0.8
Unemployment : skilled labour force	*average % difference*	*control*	-12.4	23.6	-6.1	8.3	11.1	-1.1	0.4	-27.1	26.0
	last % difference	*control*	≈ -11.0	↑ 36.5	≈ -6.0	≈ 6.4	↑ 28.8	↑↓ -1.6	↓↑ 1.4	↓ -64.8	↑ 36.0
Unemployment : unskilled labour force	*average % difference*	*control*	5.0	-11.7	-1.6	0.1	7.2	-3.8	0.4	-7.2	-12.8
	last % difference	*control*	≈ -1.2	↓↑ -8.9	≈ -0.1	≈ -0.8	↑↓ 4.4	↓↑ -3.6	≈ 0.2	↑ -2.2	↓↑ -8.5
Real skilled wage rate (cpi deflated)	*average % difference*	-1.6	-0.5	-0.4	-0.1	0.2	1.8	0.7	0.08	-1.1	-0.4
	last % difference	↓ -4.4	≈ -1.0	≡ -0.4	≈ -0.07	↓ -0.02	↑ 3.3	↑ 1.2	↑ 0.1	↓ -2.8	↓↑ -0.3
Real unskilled wage rate (cpi deflated)	*average % difference*	-2.6	-0.6	0.02	-0.3	0.4	*control*	0.5	-0.3	-1.9	0.4
	last % difference	↓ -6.7	↓ -1.2	↓ -0.2	↓↑ -0.3	↓ 0.3	*control*	↑ 0.9	↑ 0.06	↓ -4.5	↓ -0.3
Skilled/Unskilled wage rate ratio	*average % difference*	1.0	0.08	-0.4	0.1	-0.2	9.6	0.2	0.4	0.8	-0.8
	last % difference	↑ 2.4	≈ 0.0	≈ -0.3	≈ 0.2	≈ -0.3	↓ 8.6	↓↑ 0.4	↓ 0.1	↑ 1.7	↓↑ 0.0
Wage/User-cost-of-capital ratio	*average % difference*	-2.3	0.1	-0.1	-0.3	0.5	0.4	0.6	0.03	-1.5	-0.1
	last % difference	↓ -6.8	↓ -1.4	≡ -0.1	≈ -0.1	↓ 0.0	↑ 3.5	↑ 1.0	↑ 0.2	↓ -4.1	↓ -0.3
CPI growth (CPI inflation)	*average % difference*	0.0	0.04	-0.1	-0.01	0.06	-0.07	-0.1	0.0	0.02	-0.01
	last % difference	≡ 0.0	≈ -0.2	≡ -0.1	≈ 0.0	≈ 0.0	≈ -0.01	≈ -0.2	≡ 0.0	≡ 0.0	≈ -0.01
PPI growth (PPI inflation)	*average % difference*	0.4	0.2	0.0	-0.01	0.1	-0.5	0.0	-0.02	0.3	0.02
	last % difference	≡ 0.4	≈ -0.1	≡ 0.0	≈ -0.1	≈ 0.1	≈ -0.3	≈ 0.0	≈ 0.0	≡ 0.3	≈ -0.1

Key to notation	
≈ (a)	Series is converging on a
≡ (a)	Series is oscillating around a
↑ (a)	Series is increasing at an increasing rate to a
↑ -(a)	Series is decreasing at a decreasing rate to a
↓ (a)	Series is increasing at a decreasing rate to a
↓ -(a)	Series is decreasing at an increasing rate to a
↑↓(a)	Series is increasing at an increasing, then decreasing rate to a
↓↑(a)	Series is increasing at a decreasing, then increasing rate to a
↑↓-(a)	Series is decreasing at a decreasing, then increasing rate to a
↓↑-(a)	Series is decreasing at an increasing, then decreasing rate to a
control	Variable controlled for in the scenario

Table 10.3 Evaluation of individual policy scenarios

Individual scenario 0: Minimum level of unemployment (Control)		
Control variable(s)		↑ *n_s* = min (*unempl_u*) and ↑ *n_u* = min (*unempl_u*)
Responses	*Growth*	Increased (↑ *n*)
	Corporate savings	Decreased due to higher labour cost (↑ *n* >↓ *w_tot*)
	Investment	Decreased due to decreasing corporate savings (↓ *fincond_cp*)
	Capital/labour ratio	Decreased (↓ *kap_r* / ↑ *n*)
	Productivity	Decreased (↑ *bbp_90p* < ↑ *n*)
	Demand for labour	Controlled for an increase
	Supply of labour	Decreased (↓ *w_u* and ↓ *w_s*)
	Unemployment level	Controlled for a decrease
	Wages	Decreased (↑ *n* but ↓ *product*)
	Prices	Decrease
Comments		No substantial increase in economic growth unless higher employment is associated with a higher level of productivity

Individual scenario 1: Substitute unskilled for skilled labour demand		
Control variable(s)		↓ *n_u* = ↑ *n_s*
Responses	*Growth*	Increased (↑*n*)
	Corporate savings	Increased on short-run (↓ *n* < ↑ *w_tot*), then decreased (↑ *n* > ↓ *w_tot*)
	Investment	Decreased (↓ *sc_cp* → ↓ *fincond_cp*)
	Capital/labour ratio	Decreased at an increasing rate (↓ *kap_r* / ↑ *n*)
	Productivity	Increased on short-run (↓ *bbp_90p* >↓*n*), then decreased (↑ *bbp_90p* < ↑ *n*)
	Demand for labour	Decreased on the short-run (4% ↓ *n_u* > 4% ↑ *n_s*), then increased (↓ *w_s*, ↓ *w_u* and ↑ *bbpfact_90p*)
	Supply of labour	Increased at a decreasing due to higher employment opportunities for skilled labour (the supply of unskilled labour is wage inelastic)
	Unemployment level	Decreased at an increasing rate (↑ *n* >↑ *s*)
	Wages	After an initial increase in skilled wages, wages decreased due to decreasing productivity. Skilled wages, however, decreased less than unskilled wages resulting in an increase in the skilled/unskilled wage rate ratio
	Prices	Increased
Comments		No substantial increase in economic growth unless higher employment is associated with a higher level of productivity

Individual scenario 2: Increased education and training		
Control variable(s)		↑ *educ_index*
Responses	*Growth*	Increased (↑ *n_s* and ↑ *tecno_index*)
	Corporate savings	Decreased (↑ *n* > ↓ *w_tot*)
	Investment	Increased (↑ *bbpfact_90p*)
	Capital/labour ratio	Decreased (↓ *kap_r* / ↑ *n*)
	Productivity	Decreased (↑ *bbpfact_90p* < ↑ *n*)
	Demand for labour	Increased (↓ *w_s*, ↓ *w_u* and ↑ *bbpfact_90p*)
	Supply of labour	Substantial increase in supply of skilled labour relative to unskilled labour, but decrease in total labour supply due to decrease in wages.
	Unemployment level	Decreased (↑ *n* > ↑ *s*)
	Wages	Decreased (↓ *product*)
	Prices	Decreased
Comments		Increased levels of education do not generate substantial economic growth but induce wage decreases

Individual scenario 3: Increase financing of investment		
Control variable(s)		↑ *sc_cp*, ↑ *sg_cp*, ↑ *sp_cp*, ↑ *netcapfl* and ↑ *gold_reserv_cp*
Responses	*Growth*	Increased (↑ *n* and ↑ *kap_r*)
	Corporate savings	Controlled for an increased
	Investment	Increased (↑ *sc_cp* → ↑ *fincond_cp*)
	Capital/labour ratio	Increased at an increasing rate (↑ *kap_r* > ↑ *n*)
	Productivity	Decreased (↑ *bbp_90p* < ↑ *n*)
	Demand for labour	Increased (↓ *w_u*, ↓ *w_s* and ↑ *bbpfact_90p*)
	Supply of labour	Almost no effect
	Unemployment level	Decreased (↑ *n*)
	Wages	Decreased (↓ *product*)
	Prices	Decreased
Comments		Disappointingly low increase in economic growth. The reasons: (1) South Africa's production structure is labour intensive (any capital increases will have a smaller effect on growth than increases in employment) ; and South Africa produces under conditions of decreasing returns to scale.

Individual scenario 4: Increased foreign investment (direct and indirect)		
Control variable(s)		↑ *dirinvest*, ↑ *indinvest*
Responses	*Growth*	The short-run increase is followed by a decrease due to the capital-intensive nature of foreign investment relative to the labour-intensive production structure of the South African economy (↓ *n* and ↑ *kap_r*)
	Corporate savings	Increased due to lower labour cost (↓ *n* > ↑ *w_tot*)
	Investment	Increased (↑ *sc_cp* → ↑ *fincond_cp*)
	Capital/labour ratio	Increased at an increasing rate (↑ *kap_r* > ↑ *n*)
	Productivity	Increased (↓ *n*)
	Demand for labour	Decreased due to the capital-intensive nature of foreign investment, as well an increase in wages and lack of economic growth
	Supply of labour	Almost no effect on total labour supply
	Unemployment level	Increased (↓ *n*)
	Wages	Increased (↑ *product*)
	Prices	Decreased
Comments		An increase in unemployment but again a disappointingly low increase in economic growth. The unemployment problem in South Africa will only be solved if both the supply (increase in skilled relative to unskilled) and demand (economic growth) for labour are addressed.

Individual scenario 5: Decreased real unskilled wage rate		
Control variable(s)		↓*wu_vpi_rate*
Responses	*Growth*	Decreased due to the labour-intensive production structure of the South African economy (↓*n* and ↑ *kap_r*)
	Corporate savings	Increased due to lower labour cost (↓ *n* > ↑ *w_tot*)
	Investment	Increased (↑ *sc_cp* → ↑ *fincond_cp*)
	Capital/labour ratio	Increased at an increasing rate (↑ *kap_r* > ↑ *n*)
	Productivity	Increased (↓ *n*)
	Demand for labour	Decrease in demand for skilled labour (*n_s*) and increase in the demand for unskilled labour (*n_u*), but *n_u* is relative price-inelastic, while *n_s* is relative price-elastic. Therefore: ↑*n_u* < ↓*n_s*, resulting in ↓*n*. Other contributing factors are ↑ *w_s*, ↑ *w_u* and ↓ *bbpfact_90p*
	Supply of labour	Almost no effect on total labour supply
	Unemployment level	Increased (↓ *n*)
	Wages	Skilled wages increased (↑*product*) while unskilled wages decreased (controlled)
	Prices	Decreased
Comments		A decrease in unskilled wages relative to skilled wages, result in an increase in the demand for unskilled (unproductive) relative to skilled labour. This again causes a decrease in economic growth. A minimum wage policy (affecting the demand and supply of unskilled labour), may therefore indeed result in an ↑employment, since the demand and supply of unskilled labour are price/wage inelastic relative to the demand and supply of skilled labour. This will only happen in isolation of other policy measures such as the new labour act focusing on affirmative action employment, i.e. the substitution of skilled labour for unskilled labour.

Individual scenario 6: Technical innovation

Control variable(s)		↑ *tecno_innov*
Responses	*Growth*	Increased substantially (↑ *n*, ↑ *kap_r* and ↑ *product*)
	Corporate savings	Decreased due to higher labour cost (↑ *n* and ↑ *w_tot*)
	Investment	Increased (↑ *bbpfact_90p*)
	Capital/labour ratio	Decreased (↑ *kap_r* < ↑ *n*)
	Productivity	Increased (↑ *bbpfact_90p* > ↑ *n*)
	Demand for labour	Increased at an increasing rate (↑ *bbpfact_90p*)
	Supply of labour	Increased on the short-term (↑ *w_s* and ↑ *w_u*)
	Unemployment level	Decreased (↑ *n* > ↑ *s*)
	Wages	Increased (↑ *product*)
	Prices	Decreased
Comments		An increase in the efficiency of production in South Africa will generate economic growth, demand for labour (skilled and unskilled), decrease unemployment, raise the disposable income of workers and reduce inflation.

Individual scenario 7: Decreased union power and militancy

Control variable(s)		↓ *union_members*, ↓ *union_work_lost*
Responses	*Growth*	No change
	Corporate savings	Increased due to lower labour cost (↓ *n* > ↑ *w_tot*)
	Investment	Increased (↑ *sc_cp* → ↑ *fincond_cp*)
	Capital/labour ratio	Increased (↑ *kap_r* and ↓ *n*)
	Productivity	Increased (↓ *n*)
	Demand for labour	Increased on the short-run ((↑ *n_u* due to ↓ *w_u*) + (↓ *n_s* due to ↑ (*w_s/w_u*))), then demand for labour decreased ((↑ *product* → ↑ *w_u* → ↓ *n_u*) and (↑ *product* → ↑ *w_s* → ↓ *n_s*)). On average: ↓ *n*
	Supply of labour	Decreased (↓ *w_tot*)
	Unemployment level	Decreased on the short-run (↑ *n* and ↓ *s*)
	Wages	Decreased on the short-run (↓ *union_pressure*), then increased (↑ *product*)
	Prices	Decreased
Comments		A decrease in labour union power and militancy result in initial higher employment due to lower labour cost.

Individual scenario 8: Transition from informal to formal employment

Control variable(s)		↓ *n_informal* = ↑ *n_u* + ↑ *n_s* (according to market share)
Responses	*Growth*	Increased (↑ *n*)
	Corporate savings	Decreased due to higher labour cost (↑ *n* > ↓ *w_tot*)
	Investment	Decreased (↓ *sc_cp* → ↓ *fincond_cp*)
	Capital/labour ratio	Decreased at an increasing rate (↓ *kap_r* and ↑ *n*)
	Productivity	Decreased (↑ *bbp_90p* < ↑ *n*)
	Demand for labour	Increased at an increasing rate (↑ *bbpfact_90p* and ↓ *w_tot*)
	Supply of labour	Decreased (↓ *w_tot*)
	Unemployment level	Decreased substantially (↑ *n* and ↓ *s*)
	Wages	Decreased (↓ *product*)
	Prices	Increased slightly
Comments		Again lower than expected growth due to decreasing productivity.

Individual scenario 9: Increased socio-economic conditions

Control variable(s)		↑ *educ_index*, ↑ *energy_ind*, ↑ *health_index*, ↑ *income_index*, ↑ *h_transf_r* and ↓ *crime_index*
Responses	*Growth*	Increased (↑ *n*)
	Corporate savings	Decreased due to higher labour cost (↑ *n* > ↓ *w_tot*)
	Investment	Decreased (↓ *sc_cp* → ↓ *fincond_cp*)
	Capital/labour ratio	Decreased (↓ *kap_r* and ↑ *n*)
	Productivity	Decreased (↑ *bbp_90p* < ↑ *n*)
	Demand for labour	Increased (↑ *bbpfact_90p* and ↓ *w_tot*)
	Supply of labour	Almost no change
	Unemployment level	Decreased (↑ *n*)
	Wages	Decreased (↓ *product*)
	Prices	Increased
Comments		Growth is negatively influenced by decreasing productivity; this again the result of production under decreasing returns to scale.

Table 10.4 Response properties of the supply-side model controlling for different scenarios (policy shocks)

Response variables		Combined scenarios					
		1	*2*	*3*	*4*	*5*	*6*
		Technology index, education, foreign investment & innovation	*Technology index & financing of investment*	*Technology index, financing of investment, union power & -militancy*	*Technology index, financing of investment, union power & -militancy, formalisation of informal employment*	*Technology index, financing of investment, union power & -militancy, socio-economic conditions*	*Technology index, financing of investment, union power & -militancy, formalisation of informal employment, socio-economic conditions*
Real GDP growth	*average % difference*	0.2	0.2	0.2	0.4	0.2	0.4
	last % difference	↑0.4	↑0.4	↑0.3	≈ 0.7	≈ 0.3	≈ 0.5
Real domestic investment	*average % difference*	1.1	7.0	7.3	3.0	7.0	2.7
	last % difference	≈ 1.1	↑8.2	↑8.7	↓-1.2	↑8.4	↓-1.4
Capital-labour ratio	*average % difference*	0.1	2.8	3.1	-1.1	2.8	-1.3
	last % difference	↑↓-0.5	↑3.9	↑4.4	↓-5.3	↑4.0	↓-5.6
Productivity	*average % difference*	1.0	0.7	0.8	-2.2	0.8	-2.3
	last % difference	↓↑1.2	↓↑1.1	↓↑1.3	↓-5.7	↓↑1.2	↓-5.7
Nominal corporate savings	*average % difference*	-1.8	-2.6	-2.1	-10.0	-2.5	-10.3
	last % difference	↑↓-4.9	↑↓-5.5	↑↓-5.2	↓-23.3	↑↓-5.3	↓-23.4
Labour demand	*average % difference*	0.6	1.0	0.9	3.6	1.0	3.6
	last % difference	↑1.5	↑1.9	↑1.7	↑7.7	↑1.8	↑7.7
Skilled labour demand	*average % difference*	1.3	1.7	1.5	4.1	1.7	4.3
	last % difference	↓↑2.0	↑2.4	↑2.2	↑7.6	↑2.2	↑7.7
Unskilled labour demand	*average % difference*	-0.02	0.4	0.4	3.3	0.3	3.1
	last % difference	↑0.8	↑1.2	↑1.1	↑7.8	↑1.2	↑7.8
Labour supply	*average % difference*	0.01	-0.01	-0.03	-0.1	0.00	-0.09
	last % difference	≈ -0.01	↓-0.1	↓-0.08	↓-0.4	↓-0.08	↓-0.4
Skilled labour supply	*average % difference*	4.5	4.3	4.1	2.7	4.2	3.0
	last % difference	↑6.4	↑6.0	↑6.0	↑↓1.9	↑5.9	↑↓1.9
Unskilled labour supply	*average % difference*	-3.6	-3.4	-3.3	-2.3	-3.3	-2.5
	last % difference	≈ -5.0	↓-4.9	↓-4.8	↓↑-2.2	↓-4.8	↓↑-2.2
Unemployment	*average % difference*	-2.3	-5.2	-4.8	-18.2	-4.3	-17.7
	last % difference	↓-3.5	≈ -4.8	≈ -4.4	≈ -20.0	≈ -4.5	≈ -20.0
Unemployment : skilled labour force	*average % difference*	31.0	24.7	25.1	-7.2	23.9	-6.0
	last % difference	≈ 40.0	↑33.6	↑34.9	↑↓-42.2	↑34.3	↑↓-42.3
Unemployment : unskilled labour force	*average % difference*	-16.4	-17.9	-17.5	-24.0	-16.0	-23.6
	last % difference	↓↑-12.8	↓↑-12.9	↓↑-12.7	↓↑-15.5	↓↑-12.7	↓↑-15.6
Real skilled wage rate (cpi deflated)	*average % difference*	0.5	0.3	0.4	-0.7	0.4	-0.8
	last % difference	↓↑1.2	↓↑1.1	↓↑1.3	↓-1.9	↓↑1.3	↓-2.0
Real unskilled wage rate (cpi deflated)	*average % difference*	0.9	0.6	0.3	-1.7	0.7	-1.3
	last % difference	↑↓0.8	↑↓0.6	↑0.6	↓-4.4	↓↑0.6	↓-4.4
Skilled/Unskilled wage rate ratio	*average % difference*	-0.4	-0.3	0.1	1.0	-0.3	0.6
	last % difference	↓↑0.3	↓↑0.6	↓↑0.7	↓↑2.6	↓↑0.6	↑2.6
Wage/User-cost-of-capital ratio	*average % difference*	0.9	0.6	0.6	-1.0	0.7	-0.9
	last % difference	≈ 0.9	↓↑0.8	↓↑1.0	↓-3.5	↓↑0.9	↓-3.5
CPI growth (CPI inflation)	*average % difference*	-0.11	-0.13	-0.13	-0.1	-0.13	-0.1
	last % difference	≈ -0.2	≈ -0.3	≈ -0.2	≈ -0.2	≈ -0.2	≈ -0.3
PPI growth (PPI inflation)	*average % difference*	-0.01	-0.01	-0.02	0.4	-0.02	0.4
	last % difference	≈ 0.03	≈ -0.1	≈ -0.1	≡ 0.4	≈ -0.1	≡ 0.4

Table 10.5 Evaluation of combined policy scenarios

Combined scenario 1: *individual scenarios 2 + 4 + 6*		
olicy proposals (shocks)		mproved technology: technical innovation, education and training, and foreign investment (direct and indirect).
ontrol variables		*educ_index* ;↑ *dirinvest*; ↑ *indinvest* and ↑ *tecno_innov*
esponses	*rowth*	ncreased (↑ *kap_r*, ↑ *n* and ↑ *product*)
	orporate savings	ecreased (↑ *gosic_cp* < ↑ (*w_tot* × *n*))
	nvestment	ncreased (↑ rel_wscost_ucc; ↑ rel_wucost_ucc and ↑ *bbpfact_90p*)
	apital/labour ratio	ncreased (↑ *kap_r* > ↑ *n*)
	roductivity	ncreased (↑ *bbp_90p* > ↑ *n*)
	emand for labour	ncreased (↑ *bbpfact_90p*)
	upply of labour	ncreased supply of skilled labour relative to unskilled labour (↑ *w_s* and ↑ *educ_index*)
	nemployment level	ecreased (↑ *n* > ↑ *s*)
	ages	ncreased (↑ *product*)
	rices	ecreased (↑ product > ↑ w_tot and ↑ ucc2_cp)
omments		omparing these combined results with those of individual scenarios contributing to an increase in the labour bsorption, it is confirmed that increased productivity is a necessary condition for higher employment to ontribute to higher growth in a production structure operating under decreasing returns to scale. The raise in roductivity was brought about by increased education and training.

Combined scenario 2: *combined scenario 1 + individual scenario 3*		
Policy proposals (shocks)		Improved technology: technical innovation, education and training and foreign investment (direct and indirect); and increased investment finance.
Control variables		↑ *educ_index* ;↑ *dirinvest*; ↑ *indinvest*, ↑ *tecno_innov*; ↑ *sc_cp*; ↑ *sg_cp*; ↑ *sp_cp*; ↑ *netcapfl* and ↑ *gold_reserv_cp*
Responses	*Growth*	Increased (↑ *kap_r*, ↑ *n* and ↑ *product*)
	Corporate savings	Decreased (↑ *gostc_cp* < ↑ (*w_tot* × *n*))
	Investment	Increased (↑ *fincond_cp*; ↑ rel_wscost_ucc; ↑ rel_wucost_ucc and ↑ *bbpfact_90p*)
	Capital/labour ratio	Increased (↑ *kap_r* > ↑ *n*)
	Productivity	Increased (↑ *bbp_90p* > ↑ *n*)
	Demand for labour	Increased (↑ *bbpfact_90p*)
	Supply of labour	Increased supply of skilled labour relative to unskilled labour (↑ *w_s* and ↑ *educ_index*)
	Unemployment level	Decreased (↑ *n* > ↑ *s*)
	Wages	Increased (↑ *product*)
	Prices	Decreased (↑ product > ↑ w_tot and ↑ ucc2_cp)
Comments		Investment increased substantially more than in combined scenario1 as a result of the availability of funds for investment. However, it did not have a significant impact on the growth rate due to the labour-internsive nature of the South African production structure.

Combined scenario 3: *combined scenario 2 + individual scenario 7*		
Policy proposals (shocks)		Improved technology: technical innovation, education and training and foreign investment (direct and indirect); increased investment finance; and limited labour union power & militancy.
Control variables		↑ *educ_index* ;↑ *dirinvest*; ↑ *indinvest*, ↑ *tecno_innov*; ↑ *sc_cp*; ↑ *sg_cp*; ↑ *sp_cp*; ↑ *netcapfl*; ↑ *gold_reserv_cp*; ↓ *union_members* and ↓ *union_work_lost*
Responses	*Growth*	Increased (↑ *kap_r*; ↑ *n* and ↑ *product*)
	Corporate savings	Decreased (↑ *gostc_cp* < ↑ (*w_tot* × *n*))
	Investment	Increased (↑ *fincond_cp*; ↑ rel_wscost_ucc; ↑ rel_wucost_ucc and ↑ *bbpfact_90p*)
	Capital/labour ratio	Increased (↑ *kap_r* > ↑ *n*)
	Productivity	Increased (↑ *bbp_90p* > ↑ *n*)
	Demand for labour	Increased (↑ *bbpfact_90p*)
	Supply of labour	Increased supply of skilled labour relative to unskilled labour (↑ *w_s* and ↑ *educ_index*)
	Unemployment level	Decreased in total (↑ *n* > ↑ *s*)
	Wages	Increased (↑ *product*)
	Prices	Decreased (↑ product > ↑ w_tot and ↑ ucc2_cp)
Comments		The greatest contribution of less union power and militancy is lower wage productivity (i.e. lower wages relative to higher productivity), resulting in a lower cost/price structure for the total economy.

Table 10.5 (*cont.*)

Combined scenario 4: *combined scenario 3 + individual scenario 8*		
Policy proposals (shocks)		Improved technology: technical innovation, education and training and foreign investment (direct and indirect); increased investment finance; limited labour union power & militancy; and formalisation of informal employment
Control variables		↑ educ_index ;↑ dirinvest; ↑ indinvest; ↑ tecno_innov; ↑ sc_cp; ↑ sg_cp; ↑ sp_cp; ↑ netcapfl; ↑ gold_reserv_cp; ↓ union_members; ↓ union_work_lost and ↓ n_informal = ↑ n_u + ↑ n_s (according to market share)
Responses	*Growth*	Increased (↑ kap_r and ↑ n)
	Corporate savings	Decreased (↑ gostc_cp ÷ (↓w_tot × ↑n))
	Investment	Increased (↑ fincond_cp and ↑ bbpfact_90p)
	Capital/labour ratio	Decreased (↑ kap_r ÷ ↑ n)
	Productivity	Decreased (↑ bbp_90p ÷ ↑ n)
	Demand for labour	Increased (↑ bbpfact_90p; ↓ w_u and ↓ w_s)due to ↑growth
	Supply of labour	Increased supply of skilled labour relative to unskilled labour (↑ w_s and ↑ educ_index)
	Unemployment level	Decreased substantially (↑ n ÷ ↑ s)
	Wages	Decreased (↓ product)
	Prices	Consumer prices decreased and production prices increased (↓ product ÷ ↓ w_tot and ↑ ucc2_cp)
Comments		Creating formal job opportunities for informal labour participants and thereby reversing the capital-deepening process, will obviously generate economic growth in a labour-intensive production structure. However, the significance of the contribution of more workers to economic growth will depend on their productivity.

Combined scenario 5: *combined scenario 3 + individual scenario 9*		
Policy proposals (shocks)		Improved technology : technical innovation, education and training and foreign investment (direct and indirect); increased investment finance; limited labour union power & militancy; and improved socio-economic conditions
Control variables		↑ educ_index ;↑ dirinvest; ↑ indinvest; ↑ tecno_innov; ↑ sc_cp; ↑ sg_cp; ↑ sp_cp; ↑ netcapfl; ↑ gold_reserv_cp; ↓ union_members; ↓ union_work_lost ; ↑ energy_ind; ↑ health_index; ↑ income_index; ↑ h_transf_r and ↓ crime_index
Responses	*Growth*	Increased (↑ kap_r, ↑ n and ↑ product)
	Corporate savings	Decreased (↑ gostc_cp ÷ ↑ (w_tot × n))
	Investment	Increased (↑ fincond_cp; ↑ rel_wscost_ucc; ↑ rel_wucost_ucc and ↑ bbpfact_90p)
	Capital/labour ratio	Increased (↑ kap_r ÷ ↑ n)
	Productivity	Increased (↑ bbp_90p ÷ ↑ n)
	Demand for labour	Increased (↑ bbpfact_90p)
	Supply of labour	Increased supply of skilled labour relative to unskilled labour (↑ w_s and ↑ educ_index)
	Unemployment level	Decreased (↑ n ÷ ↑ s)
	Wages	Increased (↑ product)
	Prices	Decreased (↑ product ÷ ↑ w_tot and ↑ ucc2_cp)
Comments		Improving socio-economic conditions is a necessary but not sufficient condition for economic growth, development and employment. However, improving the social conditions of especially the formally disadvantaged in South Africa, will ultimately increase the quality of the labour force with the subsequent advantages. It also holds several indirect advantages for the South African economy – one being the political correctness of such a policy, conducive to an investment-friendly environment.

Combined scenario 6: *combined scenario 3 + (individual scenarios 8 + 9)*		
Policy proposals (shocks)		Improved technology: technical innovation, education and training and foreign investment (direct and indirect); increased investment finance; limited labour union power & militancy; formalisation of informal employment; and improved socio-economic conditions
Control variables		↑ educ_index ;↑ dirinvest; ↑ indinvest; ↑ tecno_innov; ↑ sc_cp; ↑ sg_cp; ↑ sp_cp; ↑ netcapfl; ↑ gold_reserv_cp; ↓ union_members; ↓ union_work_lost; ↓ n_informal = ↑ n_u + ↑ n_s (according to market share); ↑ energy_ind; ↑ health_index; ↑ income_index; ↑ h_transf_r and ↓ crime_index
Responses	*Growth*	Increased (↑ kap_r and ↑ n)
	Corporate savings	Decreased (↑ gostc_cp ÷ (↓w_tot ×↑ n))
	Investment	Increased (↑ fincond_cp and ↑ bbpfact_90p)
	Capital/labour ratio	Decreased (↑ kap_r ÷ ↑ n)
	Productivity	Decreased (↑ bbp_90p ÷ ↑ n)
	Demand for labour	Increased (↑ bbpfact_90p, ↓ w_s and ↓ w_u)
	Supply of labour	Increased supply of skilled labour relative to unskilled labour (↑ w_s and ↑ educ_index)
	Unemployment level	Decreased substantially (↑ n ÷ ↑ s)
	Wages	Decreased (↓ product)
	Prices	Consumer prices decreased and production prices increased (↓ product ÷ ↓ w_tot and ↑ ucc2_cp)
Comments		The above package of policy rules has proven to be optimal in improving the labour absorption capacity of the economy, raising the quality and therefore productivity of the labour force, and subsequently generating long-run (sustained) economic growth (which in turn is conducive to further employment) in a stable economic environment.

CHAPTER 11

SUMMARY AND CONCLUSION

11.1 INTRODUCTION

Recognition of supply-side fundamentals in economic theory, policy and modelling has become imperative. The deficiencies of demand-oriented theory, policy and models to solve unemployment and inflation discredited the seemingly irrefutable Keynesian principles underlying economic policy for many decades. Their inadequacy to account for and deal with the problems of stagnation, lagging productivity, double-digit inflation, high interest rates and depreciating currencies, led to the emergence of supply-side economics.

Macroeconomic models were criticised for theoretical inconsistency, forecasting failures and inadequate policy analysis and had to adapt to supply-side modelling in the 1970s. Specific consideration was given to the long-run equilibrium properties and stability of models with respect to output, employment and inflation, which in turn crucially depend on the consistency and structure of supply-side specifications. Supply-side properties are modelled in a neoclassical framework, acknowledging the cost-minimising behaviour of firms. The approach adopted by macroeconomic modellers was not one of market clearing in a perfectly competitive environment, but centred around a framework of imperfect competition in goods and labour markets and a bargaining approach to wage determination.

The purpose of the study was to develop a theoretically consistent supply-side model of the South African economy, with the final objective to integrate the supply-side model with a full-sector macroeconomic model of South Africa. The demand-driven macroeconomic model developed by the econometric research team of the University of Pretoria (SAMEM) was used for this purpose.

The study was conducted in three stages:

(i) A description of the theory and background of supply-side modelling, which entailed a thorough investigation of the theoretical principles of supply-side economics and the developments in macroeconomic modelling to coincide with the requirements for theoretical consistency, forecasting and policy analysis in particular. These results are used to evaluate and restructure the demand-driven SAMEM.

(ii) The specification, estimation and validation of a neoclassical supply-side model of the South African economy, encompassing the recent, leading developments in the field such as cost-minimising behaviour, market imperfections and collective bargaining. This involves the derivation and estimation of single equations for production (actual and potential), capacity utilisation, fixed investment, corporate savings, demand for labour (skilled and unskilled), labour supply (total and skilled), wage rates (skilled and unskilled), unemployment (NAWRU) and prices (production and consumption prices).

(iii) Critical policy implications which resulted from a series of policy scenario simulations of the system of supply-side equations are derived, in order to propose an optimal set of policy measures that will resolve or at least alleviate the severe labour market inefficiencies and related unemployment problem of the South African economy.

11.2 SUPPLY-SIDE ECONOMICS

Although some economists believe supply-side economics to be a modern concept, its origin can be traced back to the classical doctrines of the 1800s and 1900s. Widespread unemployment and the worldwide depression of the 1930s led to the demand-management policies of the Keynesian Revolution, with its rejection of the classical assumptions. Keynesian analysis became the widely accepted foundations of economic policy, but its failure to address and explain the simultaneous occurrence of unemployment and inflation, led to the emergence of supply-side economics and the development of supply-side propositions.

Against this background, the theoretical principles of supply-side economics were explored, as they need to form the basis in the development of a supply-side macro-econometric model of the South African economy. Supply-side effects and particularly the role of taxation, which is the main supply-side instrument, are modelled within a neoclassical framework of profit-maximising or cost-minimising behaviour of firms. These neoclassical principles are adopted in several, different ways by macro-economic modellers. The structural properties of the existing (mainstream) supply-side models are investigated to see how they compare in modelling the neoclassical and associated supply-side principles.

Supply-side modelling has become essential if a macro-econometric model is to be useful for policy analyses beyond short-term forecasting requirements. However, the structure and specification of supply-side models should be such that they are consistent with theoretical principles and that they are successful in forecasting stagflation.

The neoclassical approach can be characterised as a combination of market-clearing and rational expectations and it emphasises the role of stocks rather than flows. The neoclassical approach stresses the supply side of the economy, not through the inclusion of an explicit production function, but rather through a representation of the labour market which is responsive to changes in benefits and taxes, but not to the level of demand. The approach adopted by the mainstream models has not been the competitive paradigm of the classical school; instead, development has centred around a framework of imperfect competition in goods and labour markets and a bargaining approach to wage determination, following the work of Layard and Nickell (1985).

These neoclassical principles are adopted in several, different ways by macro-economic modellers. The structural properties of the existing (mainstream) supply-side models were investigated to see how they compare in modelling the neoclassical and associated supply-side principles. It can be concluded that the Layard-Nickell framework for neoclassical supply-side modelling is consistent with both the theoretical and policy principles of supply-side economics and should form the basis for the development of a consistent supply-side model of the South African economy.

Apart from analysing the theoretical propositions and empirical implications of supply-side economics, the structural properties (demand-driven) and inadequacies of SAMEM had to be identified. A new structure for the South African macroeconomic model was proposed, incorporating a consistent neoclassical supply side and allowing for the principles of the Layard-Nickell framework. A set of neoclassical properties and objectives, as well as a research methodology was identified, which set the boundaries of investigation.

11.3 RESULTS AND IMPLICATIONS

In chapter 4, an aggregate neoclassical production function for the South African economy was estimated and investigated for the long-run properties of the production structure.

The analysis was based on the estimation of a cost function for the South African production sector and the subsequent derivation of a production function based on duality principles. The cost-function approach guarantees theoretical consistency between costs, prices and factor demands in a neoclassical framework. However, only homothetic and linearly separable functional forms, such as the more restricted Cobb-Douglas and CES functions, are self-dual.

It had to be proven, therefore, that the production structure of the South African economy features homotheticity and linear separability, i.e. a constant elasticity of substitution.

In order to test the validity of either a Cobb-Douglas or CES functional form as a representation of the technology in the South African economy, a Translog cost function was estimated and tested for the validity of imposed restrictions. It was proven that the Translog cost function can be converted to a homothetic and linearly separable cost function. By making use of Kmenta's Taylor approximation of the CES function, it was further proven that the function not only exhibits a constant elasticity of substitution, but that it is very close to unity. It is therefore concluded that a Cobb-Douglas functional form may be used as approximation of the production structure of South Africa.

An evaluation of the estimation results obtained from both the Cobb-Douglas and CES functions, revealed a couple of interesting long-run properties of the South African economy. Apart from a unitary elasticity of substitution, which implies that the price ratio dictates the capital-labour ratio, it was concluded that South Africa produces with decreasing returns to scale.

The following important if not surprising properties, may be attributed to the South African production and growth structure:

(i) Production in South Africa is labour intensive with an output-elasticity of 0.77, stressing the importance of all labour-related issues such as wages, level of skill, the role of labour unions and labour legislation.

(ii) An interesting feature of the production function is the decreasing returns to scale observed. The Engle-Yoo adjusted returns to scale is 0.85. Returns to scale of 0.85 implies that a 100 percent increase in both the inputs used in the production sector of our economy will increase production by only 85 percent. This result holds serious consequences for the South African economy. It must be noted that few empirical studies on the aggregate production structure of the total South African economy have been conducted and information for comparative purposes is not readily available.

(iii) The fact that the Cobb-Douglas production technology is representative of the South African production structure, is confirmation of a unitary elasticity of substitution. The implication of a unitary elasticity of substitution is that the percentage change in the capital-labour ratio is equal to the percentage change in the price ratio.

This is of particular significance in the South African context, since the price ratio dictates the capital-labour ratio. The higher the increase in the price of labour relative to the price of capital, the lower the demand for labour relative to the demand for capital. This confirms the phenomenon in the South African economy of an increasing capital-labour ratio as a result of the rising labour-capital price ratio.

From the above it is clear that South Africa, which has an abundance of relatively expensive unskilled labour, can benefit materially by addressing structural unemployment through education and training. Improved training and education will enhance productivity and ultimately production through both rising employment and technical progress. Increased output growth will, in turn, stimulate the demand for capital (investment), the demand for skilled labour as well as technical progress. The process becomes self-sustaining, as output growth leads to further increases in employment, productivity and, ultimately, again economic growth.

In chapter 5 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. Based on the structural nature of the analysis, the preferred measure identified is one based on a production function approach that explicitly takes account of structural information, in particular with respect to the NAWRU.

As a result, potential output was estimated by using an estimated production function for the South African economy. This was done by substituting trend technology, actual capital stock and potential employment into the Cobb-Douglas estimated production function (hapter 4).

Trend technology was obtained by smoothing the endogenously determined technical progress variable (technology index) by applying the Hodrick-Presscott filter. Potential employment was 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 level and trend of the estimated potential output were validated by comparing the results with a Hodrick-Prescott smoothed series for GDP.

The results obtained 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 requiring 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 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 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-tax 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 for the user-cost-of-capital (cost/price factors) and additional factors such as taxes, subsidies and depreciation rates. These factors constitute the pre-tax gross operating surplus of the firm, i.e. the pre-tax 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 established itself as a robust mechanism for explaining investment behaviour as an integral part of the South African economy.

In chapter 7 a labour model of the South African economy was developed as part of a neoclassical supply-side of the macroeconometric model. The distinction between skilled and unskilled labour turned out to be very significant in explaining the deficiencies of the South African labour market in general and the structural unemployment problem in particular. At the same time, an attempt was 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 were 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, was utilised. The approach also incorporates the role of labour unions and labour taxes on employers. Although the Layard-Nickell framework is based on 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 compliant with both economic and statistical *a priori* conditions. The labour model is therefore established as a robust mechanism in explaining wages and unemployment in the South African economy.

In chapter 8, models for both production (value-added) and consumption prices were proposed, estimated and validated. Consistency is maintained by deriving prices in similar fashion as wages (chapter 7) from an estimated cost function for the South African economy.

Assuming imperfect competition in a neoclassical, profit-maximising framework, firms set their prices as a mark-up on the unit cost of production. Extending on the Layard-Nickell framework, the pricing models estimated in this study do not assume "normal" unit costs, but incorporate the unit costs of capital in addition to labour costs. The estimation results were consistent with the theoretical specification and *a priori* information on the price-setting behaviour of firms.

Regarding inflation in South Africa, the estimated models suggest that (1) wage increases, relative to productivity growth, exert the most pressure on production prices (60 percent) and (2) the consequences of the high degree of openness of the South African economy, represented by a set of international factors, are large contributors to domestic inflation.

The individually estimated components were combined in chapter 9 in a neoclassical supply-side model and the system was closed by introducing a number of identities and definitions that link the endogenous variables in the system.

Both the single equations and the model as a whole were evaluated in terms of the full ideal principles of model selection which briefly are: (1) economic consistency, (2) statistical significance, (3) data adequacy, (4) whether it is encompassing and (5) sensitivity.

In particular, the estimated model had to comply with the *a priori* objectives of the study and had to be relevant for both policy analysis and forecasting purposes. The model was dynamically simulated for various scenarios (baseline and numerous shocks) to determine the structural and long-run properties of the neoclassical system.

It is concluded that the model and its properties comply with both the full ideal principles and *a priori* objectives of the research and is suitable to be utilised for both policy analysis and forecasting purposes.

11.4 CRITICAL POLICY IMPLICATIONS

In the final section of the study, (1) a brief description of the labour conditions and unemployment problem in South Africa was provided; (2) a set of policy measures (proposals) that will possibly increase the labour absorption capacity of the economy and subsequently reduce the unemployment problem was identified; and (3) the suggested policy measures were empirically validated through a series of dynamic simulations of the estimated supply-side model.

The analysis of the labour market in South Africa confirmed that it does not perform its allocative, distributive and informational functions efficiently, as may be seen against the backdrop of the massive structural unemployment in the economy and the virtual disappearance of the economy's capacity to create jobs for a growing labour force.

The factors mainly influencing the labour market, are government interventionist actions, aggressive trade union activities, minimum wage arrangements, exorbitant social benefit packages of workers, inadequate skills and training of workers, inappropriate production technologies and low productivity.

These shortcomings are structural in nature and have a direct bearing on poverty, socio-economic inequities and the distribution of income. These factors have to be taken into account in any package of policy proposals.

A number of policy proposals were suggested, targeting (1) labour supply, (2) demand for labour and (3) the efficiency of the labour market. The proposals were based on international experience and South Africa's growth and employment performance.

The policy proposals were validated by dynamic simulation of the neoclassical supply-side model of South Africa proposed in this study. The proposals were collectively integrated into policy scenarios, target variables were specified, each representative of a particular policy scenario and a series of dynamic simulations were run by applying exogenous shocks to the target variables. The responses of the individual policy scenarios suggest that the South African economy is in need of comprehensive structural reform; uncoordinated policy attempts will not guarantee success.

A well-structured and coordinated policy mix is needed to obtain optimal results, i.e. sustained (long-run) economic growth and development and employment within a stable (political and economical) environment. For this reason, it was necessary to simulate and evaluate different combinations of the individual policy scenarios.

Depending on priorities, a few combinations of policy proposals were proposed. The most optimal policy mix for increasing the labour absorption capacity, was a combination of (1) technical innovation, (2) increased financing for investment, (3) less union power and militancy, (4) the formalisation of the informal sector and (5) an improvement of socio-economic conditions. However, regardless of the chosen policy mix, the message remains clear: in order for South Africa to achieve sustained growth, development and employment, the structural problems of low productivity and inflexible, unresponsive labour markets have to be addressed aggressively.

11.5 CONCLUSION AND SUGGESTED FURTHER RESEARCH

The serious nature and extent of structural unemployment, a symptom of the labour market inefficiency in South Africa, are of grave concern to economists and policy makers alike. The labour absorption capacity of the economy is far too low to create new job opportunities for the growing economically active population, resulting in increasing hardship and poverty. The South African economy is in dire need of a comprehensive structural make-over and this study has aimed at providing an empirical tool, consistent with neoclassical supply theory and empirical developments, for analysing the structural nature of the problem and providing an optimal set of policy measures.

Most of the unemployed are, however, directly or indirectly involved in the informal sector, in urban as well as rural areas (BEPA 1999). Many of these have very low levels of income and skills, low level of literacy, low self-esteem, squatter housing and very few basic amenities (water, electricity, sanitation, etc.). These people are caught in a poverty trap and their participation in the informal economy is restricted to subsistence activities.

Besides informal subsistence activities which at the basic stages have few job-creation possibilities, there are also economically viable and growth-related activities present in the informal sector. Given the right opportunities, institutional conditions and policies, the latter activities could significantly contribute to the upliftment of the standard of living, promote the human empowerment process and, in particular, create more jobs. Thus, the informal sector provides a temporary haven to the unemployed and destitute (Schoeman and Blignaut 1998).

Against this background, one suggestion for further research is to allow for a contemporaneous feedback from the informal sector, which will improve the policy analysis power of the proposed supply-side model of South Africa.

Another suggestion relates to the estimation technique applied. Further research may be conducted by evaluating the estimation results obtained from the Johansen multivariate cointegration estimation technique relative to the results obtained from the univariate Engle-Granger and Engle-Yoo estimation techniques, particularly in macroeconomic modelling constrained by a small sample range.

In this study an explicit production function was employed, but consistently derived from an estimated cost function with the purpose of deriving a measure for capacity utilisation. Although consistency is ensured within the neoclassical framework, the estimated production structure is restrictive in being of a Cobb-Douglas nature. A more flexible approach, still consistent with cost-minimising, would imply the direct estimation of a transcendental logarithmic (Translog) cost function and consistent derivation and estimation of price and factor demand equations based on Shephard's lemma. This approach is utilised by the London Business School of economics in modelling the supply side of the UK economy. This approach, however, does not allow the derivation of a production function based on duality principles and excludes the derivation of a consistent measure for capacity utilisation, which has important implications for the structure of a macroeconomic model incorporating both demand and supply sides.

A final contribution would be to integrate the proposed supply-side model with the restructured demand-driven macroeconomic model (SAMEM) in a dynamic simulation exercise to evaluate the full spectrum of demand and supply responses.

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APPENDIX 1: ESTIMATION TECHNIQUE

The estimation technique used was the Engle and Yoo (1991) three-step procedure, which is an extension of the Engle-Granger (1987) two-step procedure. This approach consists first, of a simple test for the presence of cointegration between variables, indicating whether a particular set of variables represents a combination that is consistent with a long-run equilibrium relationship.

At the second stage, an ECM is constructed in order to estimate the short-run or dynamic adjustment process to long-run equilibrium. The ECM indicates the dynamic relationship between variables, i.e. fluctuations in the dependent variable around its long-run trend are explained by fluctuations in the explanatory variables around their long-term trends. "The idea is simply that a proportion of the disequilibrium from one period is corrected in the next" (Engle and Granger 1986: 254). Long-term effects are accounted for by the inclusion of the error term (*e*) of the long-term cointegration relationship in the ECM (Harris 1995: 24).

All the variables in an ECM were transformed (differenced) into stationary variables. A regression of the stationary form of the dependent variable on the other stationary variables and the first lag of the error term of the cointegrating regression was then performed. Other variables besides those included in the cointegrating regression may be considered for inclusion in the ECM. Examples of such variables are those which were discarded from the cointegrating regression, stationary variables (in levels) and variables, which theoretically will only influence the short-run trend of the dependent variable and were therefore also not considered for inclusion in the cointegrating regression. Since all the variables in the ECM are stationary, the assumptions of classical regression analysis are fulfilled. Therefore, standard diagnostic tests can be used to determine which variables should be included in the final specification of the ECM (Harris 1995: 24).

The third step is applied to adjust the coefficients and *t*-statistics so that they are closer to their true values. This ensures that the variables included in the long-run regression could be evaluated statistically. Engle and Yoo (1989) have proposed a "third step" in addition to the Engle and Granger two-step estimation technique, which step is computationally tractable and overcomes two of the disadvantages of the two-step procedure.

This step provides a correction to the parameter estimates of the first stage, static regression that makes them asymptotically equivalent to FIML and provides a set of standard errors, which allows the valid calculation of standard *t*-tests.

The third step consists simply of a further regression of the conditioning variable from the static regression multiplied by minus the error correction parameter, regressed on the errors from the second-stage error correction model. The coefficients from this model are the corrections to the parameter estimates while their standard errors are the relevant standard errors for inference.

The three steps are then:

i) First estimate a standard cointegrating regression of the form:
$Y_t = \alpha^1 X_t + Z_t$

where Z_t is the OLS (ordinary least square) residual to give first-stage estimates of α^1.

ii) Then estimate a second-stage dynamic model (ECM) using the residuals from the cointegrating regression to impose the long-run constraint:
$\Delta Y_t = \Phi(L)\Delta Y_{t-1} + \Omega(L)\Delta X_t + \delta Z_{t-1} + \mu_t$.

iii) The third stage then consists of the regression:
$\mu_t = \varepsilon(-\hat{\delta} X_t) + \upsilon_t$.

The correction for the first-stage estimates is then simply: $\alpha^3 = \alpha^1 + \varepsilon$ and the correct standard errors for α^3 are given by the standard errors for ε (SE_ε) in the third-stage regression.

The *t*-values for α^3 are given by:

$$t = \frac{\alpha^3}{SE_\varepsilon}$$

APPENDIX 2: SIMULATION ERROR STATISTICS

Root mean square simulation error:

$$\text{RMSE} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{y}_t)^2}$$

Mean absolute simulation error:

$$\text{MAE} = \frac{1}{T}\left|y_t - \hat{y}_t\right|$$

Root mean square percentage error:

$$\text{RMSPE} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\frac{y_t - \hat{y}_t}{y_t}\right)^2}$$

Mean absolute percentage error:

$$\text{MAPE} = \frac{1}{T}\sum_{t=1}^{T}\left|\frac{y_t - \hat{y}_t}{y_t}\right|^2$$

Theil inequality coefficient:

$$\text{U} = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{y}_t)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(\hat{y}_t)^2}\sqrt{\frac{1}{T}\sum_{t=1}^{T}(y_t)^2}},$$

that lies between zero and one, where zero indicates a perfect fit.

The Theil inequality coefficient can be decomposed into three proportions:

Bias, $\text{U}^{\text{M}} = \dfrac{(\bar{\hat{y}} - \bar{y})^2}{\frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{y}_t)^2}$,

measuring the extent to which the average values of the simulated and actual series deviate from each other,

Variance, $\text{U}^{\text{S}} = \dfrac{(\sigma_{\hat{y}} - \sigma_y)^2}{\frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{y}_t)^2}$,

indicating the degree of variability in the series, and

Covariance, $U^C = \dfrac{2(1-\rho)\sigma_{\hat{y}}\sigma}{\frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{y}_t)^2}$,

representing the remaining unsystematic error.

This is based on the fact that the mean squared error can be decomposed as:

$$\frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{y}_t)^2 = (\bar{\hat{y}} - \bar{y})^2 + (\sigma_{\hat{y}} - \sigma_y)^2 + 2(1-\rho)\sigma_{\hat{y}}\sigma_y$$

where $\bar{\hat{y}}$, $\bar{y}$, $\sigma_{\hat{y}}$ and σ_y are the means and standard deviations of the series $\hat{y}_t$ and y_t, respectively, and

$$\rho = (1/\sigma_y\sigma_y T)\sum_{t=1}^{T}(\hat{y}_t - \bar{\hat{y}})(y_t - \bar{y})$$

is the correlation coefficient
(Pindyck and Rubinfeld: 338-342).

APPENDIX 3: FULL IDEAL PRINCIPLES

The process of model selection involves the following five criteria:

(i) *Consistency*

The model should have logically possible signs and magnitudes of parameters and predictions. It should be consistent with existing long-run equilibria between the variables.

(ii) *Significance*

The estimated model should exhibit economic and statistical significance of its parameters, as examined through a vast array of statistical indicators (significance tests) as well as economic theory (economic significance). The model must be economically as well as statistically meaningful.

(iii) *Data adequacy*

Various indications of adequacy should suggest that the model provides an adequate representation of the data. This is where numerous statistical tests are applied, focusing on explanatory power as well as testing the adequacy of the underlying econometric assumptions. Tests of the latter can be classified into three groups (Likelihood ratio, Wald and Lagrange multipliers). These are asymptotically equivalent, but have different small-sample properties. The choice of tests is problem dependent. However, any given equation must be tested as thoroughly as possible.

(iv) *Encompassing*

The model should encompass the characteristics of rival models, so that the latter contain no information that would be useful to improve the preferred model. Several econometric procedures have been suggested to examine whether, in some sense, any alternative model could be expected to deliver superior properties.

(v) *Sensitivity*

Finally, the model should not display too much sensitivity to the sample size, the variable menu, or to other equations of the system. Sensitivity tests can be applied to individual equations and full systems.

The following table summarises the methods to test model selection criteria.

Table A3.1: Model selection criteria

Model selection criteria		
Category	*Property*	*Examples/Methods*
Consistency	a) Inadmissibility b) Poor operating characteristics	Signs, magnitude of parameters and predictions No flow equilibria Inconsistent with long-run equilibrium
Significance	a) Economic b) Statistical i) Nominal significance levels ii) Optimized significance levels	Quantitative impact of unacceptable magnitude F-tests, t-tests, Wald tests, etc Various information criteria
Indices of inadequacy	a) For the conditional mean b) For the conditional variance c) For normality	RESET, LM-test for serial correlation Various heteroscedasticity tests Jarque-Bera test
Encompassing	a) The mean b) The variance	F-test t-test
Sensitivity	a) To sample size b) To variable menu c) To equations of model	Chow-test Extreme bound analysis Simulation

Source: Adrian Pagan's course Economics 517 Model Selection and Evaluation, taught at the University of Rochester in the Fall 1987.

APPENDIX 4: IMPLICATIONS OF ADDITIVITY AND SEPARABILITY ON PRODUCTION FUNCTIONAL STRUCTURES

The notion of strong separability or strong additivity has major implications for the functional structure. In particular, a production function that is strongly separable must have a Cobb-Douglas or CES structure. Tests for strong separability are therefore equivalent to tests of flexible functional forms against restricted Cobb-Douglas or CES functions.

Given a function $y = f(x_1, x_2, \ldots\ldots, x_n)$, it is strongly additive if $\frac{\partial^2 y}{\partial x_i \partial x_j} = 0, (i \neq j)$ and strongly separable (from x_k) if $\frac{\partial[(\partial y / \partial x_i)/(\partial y / \partial x_j)]}{\partial x_k} = 0, (i \neq j \neq k)$.

If a monotonic transformation (e.g. taking the logarithmic form) of the function satisfies the additivity condition, it is referred to as being quasi-additive (Chung 1994: 112). Christensen *et al.* (1973) and Berndt and Christensen (1973) showed that a production function is homogeneous and strongly separable if and only if it can be represented as either a Cobb-Douglas or CES production function (Allen 1997: 20). If a function is additive and homothetic, the Allen-Uzuwa partial elasticities of substitution between any pair of inputs are equal and constant (Chung 1994: 189).

The notion of weak separability, on the other hand, is important because it is a necessary condition to enable aggregation, whether inputs (in the case of a cost function) or outputs (in the case of a production function). A production function, y = f(x), is said to be weakly separable if the marginal rate of substitution between any two inputs, x_i and x_j, belonging to the same group, N^s, is independent of the quantities of inputs outside of N^s:

$$\frac{\partial[(\partial y / \partial x_i)/(\partial y / \partial x_j)]}{\partial x_k} = 0, (i \neq j \neq k; \forall i, j \in N^s, k \in N^t, s \neq t).$$

Berndt and Christensen (1973) showed that weak separability, combined with homotheticity, are necessary and sufficient for the equality of all Allen elasticities of substitution with respect to different subsets of partition, i.e. $\sigma_{ik}^A = \sigma_{jk}^A, (\forall i, j \in N^s, k \in N^t, s \neq t)$.

Berndt and Christensen (1973) derived conditions for weak separability in the Translog function:

$$lnQ = ln\alpha_0 + \sum_{k=1} \alpha_k \ln V_k + \frac{1}{2} \sum_{k=1} \sum_{l=1} \beta_{kl} \ln V_k \ln V_l \quad .$$

The necessary conditions for separability are:

$$(\beta_{ik}\alpha_j - \beta_{jk}\alpha_i) + \sum_{m=1} (\beta_{ik}\beta_{jm} - \beta_{jk}\beta_{im}) \ln V_m = 0, \forall i, j \in N^s, k \in N^t, s \neq t; m = 1, \ldots, n.$$

They showed that there are two possible sets of conditions under which these equations would be satisfied:

First, a set of linear restrictions:
$\beta_{ik} = \beta_{jk} = 0, \forall i, j \in N^s, k \in N^t, s \neq t$.

Alternatively, a set of non-linear restrictions:
$$\frac{\alpha_i}{\alpha_j} = \frac{\beta_{ik}}{\beta_{jk}} = \frac{\beta_{im}}{\beta_{jm}} = 0, \forall i, j \in N^s, k \in N^t, s \neq t; m = 1, \ldots, n$$
(Allen 1997: 36-37)

In the case of the two-input Translog production function:

$$lnQ = ln\alpha_0 + \alpha_1 lnV_1 + \alpha_2 lnV_2 + \beta_{11}(lnV_1)^2 + \beta_{22}(lnV_2)^2 + \beta_{12} lnV_1 lnV_2 ,$$

the assumption of a constant elasticity of substitution (i.e. assumptions of homotheticity and separability) implies the parameter restrictions of:
$$\beta_{11} = \beta_{22} = -\frac{1}{2}\beta_{12}$$
(Thomas 1993: 331).

APPENDIX 5: A REVIEW ON PRODUCTION FUNCTIONS

The production function, in traditional theory of the firm, expresses output (Q) as a function of inputs, that is:

$$Q = Q\,(V_1; V_2; \ldots.. V_n), \qquad \text{(A5.1)}$$

with

Q = Output / Level of production; and
V_I = i'th production factor (i = 1,2,.....n).

The variables Q, and V_i are flow variables so that the production function above expresses a flow of output as a function of the flow of services provided by the factor inputs. All the variables are assumed to be continuously variable, infinitely divisible and the inputs are assumed to be continuously substitutable at all levels of production. For given levels of inputs (V_i), equation A5.1 defines a maximum possible level of output, Q. This means that the technical problem of how to achieve the greatest output from given levels of inputs is assumed to be solved. However, because of factor substitutability, a given output can be produced by many alternative combinations of inputs. The problem of deciding which combinations of inputs provide the given level of output at minimum cost is therefore an economic problem. The production function is thus not confined to the least cost combinations of all the inputs utilised (Heathfield 1987: 45).

A production function exhibits the following economic properties:

(i) The marginal product of each input is always positive, that is:

$$\frac{\partial Q}{\partial V_n} > 0\,. \qquad \text{(A5.2)}$$

(ii) However, although the production function must be such that the marginal products of the inputs are always positive, they have to be diminishing, illustrating the law of diminishing marginal productivity, that is:

$$\frac{\partial^2 Q}{\partial V_n^2} < 0\,. \qquad \text{(A5.3)}$$

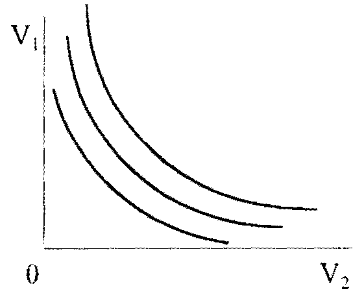
(iii) It exhibits increasing, decreasing or constant returns to scale. The returns to scale implied by a production function depend on the response of output to an equi-proportionate change in all the inputs. If equation A5.1 is homogenous of degree n, then depending on whether n is less than, equal to, or greater than unity, equi-proportionate increases in the inputs will lead to less than proportionate, equi-proportionate, or more than proportionate increases in output. In terms of equation A5.1,

$$Q(\lambda V_n) = \lambda^n Q(V_n) \qquad \text{(A5.4)}$$

where λ is the equi-proportionate change in factor inputs. It must be remembered, however, that all production functions are not homogeneous and that some, while exhibiting increasing returns to scale at, for example, low levels of inputs, may show decreasing returns to scale at higher input and output levels.

(iv) The fact that inputs are assumed to be continuously substitutable means that there are an infinite number of possible combinations of factor inputs (implying a wide variety of alternative techniques) which may be used to produce a given output. The slope of an isoquant yields the rate at which one factor can be substituted for another without altering the level of output. (Isoquants for the two-input case are illustrated in Figure 1). The absolute value of this slope is known as the marginal (also known as technical) rate of substitution (MRS), with

Figure 1: An isoquant map



Source: Nicholson 1994: 317

$$MRS = -\frac{dV_1}{dV_2}. \qquad \text{(A5.5)}$$

Taking the total derivative of equation A5.5 and assuming output is constant along the isoquant, result in

$$dQ = \frac{\partial Q}{\partial V_1} dV_1 + \frac{\partial Q}{\partial V_2} dV_2 = 0. \qquad \text{(A5.6)}$$

Thus

$$MRS = -\frac{dV_1}{dV_2} = \frac{\partial Q}{\partial V_2} / \frac{\partial Q}{\partial V_1} \qquad \text{(A5.7)}$$

The MRS is therefore equal to the ratio of the two marginal products. The greater the ratio of V_2 inputs to V_1 inputs the greater the quantity of V_2 needed to replace one unit of V_1 without reducing output. This means that isoquants are convex to the origin. The more convex the isoquants, the more limited, generally, the substitution possibilities.

(v) The MRS and therefore also the degree of convexity or shape of the isoquants, influence the elasticity of substitution (σ), which serves as an independent measure of the substitution possibilities of the production function. The elasticity of substitution (σ), defined as

$$\sigma = -\frac{d(V_1/V_2)}{V_1/V_2} / \frac{d(MRS)}{MRS} \qquad \text{(A5.8)}$$

therefore measures the proportionate change in the marginal rate of technical substitution along an isoquant. Thus, if the isoquants are relatively flat (i.e. substitution is relatively easy), then movements along an isoquant (i.e. changes in the input ratio) are accompanied by little change in the MRS and hence the elasticity of substitution is high. However, if the isoquants have a pronounced curvature, implying that substitution possibilities are more limited, then σ will be low.

Given, however, the marginal productivity conditions

$$\frac{\partial Q}{\partial V_1} = \frac{p_1}{p} \, and \, \frac{\partial Q}{\partial V_2} = \frac{p_2}{p} \qquad \text{(A5.9)}$$

with p_1, p_2 and p the prices of input$_1$, input$_2$ and output respectively, the cost-minimising condition yields

$$MRS = \frac{\partial Q}{\partial V_2} / \frac{\partial Q}{\partial V_1} = \frac{p_2}{p_1} \qquad \text{(A5.10)}$$

Redefining the elasticity of substitution (σ) as

$$\sigma = - \frac{d(V_1/V_2)}{V_1/V_2} / \frac{d(p_2/p_1)}{p_2/p_1} \qquad \text{(A5.11)}$$

Thus σ is given by the proportionate change in the input ratio divided by the proportionate change in the factor price ratio. When the price of input$_2$ rises relative to that of input$_1$, firms will attempt to substitute input$_1$ for input$_2$ and increase the input$_1$/input$_2$ ratio. When such substitution is possible only to a limited extent, a given proportionate change in p_2/p_1 will lead to only small changes in the input$_1$/ and the elasticity of substitution will be small. However, when considerable substitution is possible, σ will be large.

At this point it is important to take note of the concept of homotheticity. A homothetic production function is a function where the technical (marginal) rate of substitution depends only on the ratio between the inputs utilised, and not on the level of total production. The slope of the curves depends only on the ratio of the inputs used, and does not depend on the distance from the origin. Isoquants representing higher levels of production are simply copies of those for lower production. Cobb-Douglas and CES production functions are homothetic functional forms. More specifically, the Cobb-Douglas technology may be defined as a homothetic, unitary elasticity of substitution production technology (Nicholson 1994: 98).

Several functional forms of production functions, which represent the technology of production, have evolved during the history of estimating production behaviour by means of mathematical and statistical modelling. Although there are many functional forms, the most commonly used are the Cobb-Douglas, constant elasticity of substitution (CES), variable elasticity of substitution (VES), Transcendental logarithmic (Translog) and the generalised Leontief functions. In order to

Solving equations A6.2 and A6.3 with respect to x_1 and x_2 gives:

$$x_1 = x_1(p_1, p_2, C) \quad \text{(A6.4)}$$
$$x_2 = x_2(p_1, p_2, C). \quad \text{(A6.5)}$$

Equations A6.4 and A6.5 can be substituted into equation A6.1 to give:

$$C = C(p_1, p_2, y). \quad \text{(A6.6)}$$

Compare equations A6.1 and A6.6. Normalising output ($y = 1$), there exits a duality between the production function and the corresponding cost function. The duality observed is called Shephard's duality (Chung 1994:201-202).

Given the relationship between a production and cost function, estimation of a production function can, therefore, be carried out directly or indirectly. The indirect approach is based upon the duality theory whereby a production function is derived from an estimated cost function. An alternative approach can be followed, by means of which the production function is estimated directly. The indirect approach is used in this study to overcome the obstacles posed by data constraints associated with the direct approach.

By evaluating different functional forms to estimate a production function and by using duality theory, the production function can be empirically estimated. This estimation will consist of an estimation of the Cobb-Douglas cost function. The cost function will then be used to derive the Cobb-Douglas production function. The validity of the Cobb-Douglas functional form, as representation of the production technology of the South African economy, is tested. The restrictive assumptions of a constant and unitary elasticity of substitution are tested by estimating a Translog production function, imposing the restrictions step-by-step and testing their validity to determine whether the Translog collapses to the Cobb-Douglas functional form.

APPENDIX 7: AN EXPOSITION OF THE DATA UTILISED IN THE SUPPLY-SIDE MODEL

The necessary data was obtained from the South African Reserve Bank's Quarterly Bulletin, South African Statistics (SA Statistics) and the Development Bank of Southern Africa (DBSA). Annual, constant price data from 1970 to 1995 was used to estimate the parameters of the model. Where appropriate data was transformed, 1990 served as base year. Series affected by inflation were deflated by the appropriate price index.

All data, except the real capital stock[1] in the real fixed investment function and the technology index included in the cost/production function, was transformed into logarithmic form. Apart from the fact that the structure of the transcendental functional form requires that logarithmic variables be used, there are certain advantages to the estimation of logarithmic models. Logarithmic models transform non-linear models (relationships) into linear form, which allows the use of linear estimation procedures. The estimated regressors are coefficients of elasticity (partial multipliers), rather than coefficients of marginal effects. Logarithmic transformations also help to overcome problems due to non-stationarity.

The following time series had to be derived for the variables defined in the various theoretical models:

(i) *Real gross domestic cost of production at factor cost*

An investigation of the South African input-output table concluded that only 5 percent of the gross operating surplus, published by the South African Reserve Bank, relates to production (capital and entrepreneurial) costs. The definition for the real gross domestic cost of production at factor cost (c) can therefore be expressed as:

$$c = \frac{labour\ \ remuneration\ +\ 0.05 * gross\ \ operating\ \ surplus}{production\ \ price\ \ index}$$

with the series for nominal labour remuneration, nominal gross operating surplus and the production price index obtained from the SARB Quarterly Bulletin.

(ii) *Cost of labour*

The cost of labour represents the nominal wage bill of the country and is calculated by adding the wages of skilled workers and unskilled workers in South Africa. Unskilled workers are classified as those workers without matriculation or an equivalent

[1] Investment decisions are made with the purpose of profit maximisation, i.e. investment decisions (the extent to which capital stock needs to be increased) are made to obtain an optimal level of capital, i.e. the point where the marginal product of capital ($\Delta Y/\Delta K$) equals real user-cost-of-capital. Therefore, in the empirical estimation of an investment function, although the natural logarithms of all relevant variables are used, capital stock must be used in its level-form. It implies that the relative change in investment is not dependent on the relative change in capital stock, but on its absolute level. Remember that the logarithmic form of any variable represents the relative change of that variable over time.

qualification. Skilled workers are classified as those workers with matriculation or a higher qualification. The cost of labour (ℓ) can be represented by the following expression:

$$\ell = \frac{(wage\ \ rate\ \ of\ \ unskilled\ \ labour\ +\ wage\ \ rate\ \ of\ \ skilled\ \ labour)}{production\ \ price\ \ index}$$

Data for skilled and unskilled wage rates was obtained from the Development Bank of South Africa.

(iii) *User-cost-of-capital*

While the cost of labour can be calculated by adding directly observable series, the cost of capital has to be inferred. The neo-classical approach by Hall and Jorgenson's (1967) is used to derive a measure for the user-cost-of-capital (r). See Appendix 14 for a discussion of the theory. The measure for user-cost-of-capital (r) can be expressed as:

$$r = price\ of\ capital\left(\frac{(interest\ rate) - (inflation\ \ rate) + (rate\ of\ depreciation)}{1 - tax\ ratio}\right)$$

with the price of capital approximated by the deflator for gross domestic fixed investment; the production price index is utilised as the appropriate inflation rate; the rate of depreciation is set at 20 percent per annum[2], and the tax ratio is defined as the direct tax rate of incorporated business enterprises relative to the gross domestic product at factor cost.

(iv) *Technical progress*

Instead of resorting to either the Hicks-neutral ($A = A_0$) or the more commonly used, although still restrictive, Harrod-neutral (labour-augmenting) technical progress specifications, an attempt was made to at least partially endogenise technical progress in the cost/production relation. See Appendix 12 for a discussion on the various kinds of technical progress. A technological index is included in the function to represent technical progress. With the construction of the index, recognition is given to work done by Budd and Hobbis (1989) by capturing the role of imported technical innovation, proxied by foreign investment relative to domestic investment. The index is extended to allow for human capital augmentation (through the inclusion of an education index), labour augmentation (through the inclusion of a productivity index) and exogenous factors such as once-off innovations. A time trend is also included to allow for a degree of neutrality.

The technological index (t) can therefore be represented by the following expression:

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2 This rate is assumed to be 20 percent, based on the fact that firms write their capital stock off over a period of usually 5 years in an attempt to optimise the tax deductions based on the depreciation of capital goods.

$$t=\left(\frac{education\ \ index}{1.51}\right)*0.15+\left(\frac{productivity}{100}\right)*0.15+\left(\frac{relative\ \ foreign\ \ investment}{1.805383}\right)*0.05+$$
$$\left(\frac{time\ +\ technical\ \ innovation}{1}\right)*0.65$$

(v) *Financing of gross domestic investment*

The financial constraint variable (*fc*), i.e. the "financing of gross domestic investment" according to the system of national accounts, enters the system of equations as an identity, adding together private savings (sp), government savings (sg), corporate savings (sc), replacement investment or depreciation in real capital stock (*depr*), net foreign capital flow (*capflow*) and the change in gold and other foreign reserves (*reserv*):

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

However, since the financing of gross domestic investment equals total gross domestic investment in a general equilibrium framework such as the system of national accounts, data series for both these entities may be utilised. These series are only published in nominal terms and had to be deflated with the production price index to obtain the constant price values.

An explanatory list of all the variables encountered in the long-run cointegration relationship and the error correction model (ECM) is presented in Appendix 8.

Tests for non-stationarity (the presence of a unit root) were subsequently performed. Inferences concerning the stationarity properties of data were based on a range of evidence, of which the formal ADF test is merely one component. Economic theory, structural properties of the data, *a priori* information concerning political and other exogenous shocks to the economy over the sample period (more often than not resulting in structural breaks), data plots (Appendix 9), residual plots, plots of the autocorrelation function and spectral analysis all form part of the evidence used to draw conclusions on the stationarity of the data. This comprehensive set of inference guidelines prompted the conclusion that all relevant variables are integrated of order 1, i.e. stationary in first differences.

The results of the Augmented Dickey-Fuller tests as well as an exposition of the testing procedure are reported in Appendix 17.

Apart from the long-run explanatory variables also included in the ECM, a few dummy variables were included in several individual models to avoid a bias in the estimation which may arise if significant events in the South African economy are ignored. These variables smooth out the significant and substantial effects of the following incidents:

(i) *Economic sanctions (sanction_dum)*

During the latter half of the eighties and the early nineties, South Africa was heavily affected by sanctions as a result of growing international discontent with the country's political dispensation. Sanctions had an adverse effect on the domestic cost of production. A higher demand for local inputs increased the prices of these production factors, while imported inputs became increasingly scarce and expensive. It also affected production directly in that local producers no longer had access to several, more productive imported inputs.

(ii) *Drought (drought_dum)*

South Africa experienced a severe drought in 1983 and a prolonged one from 1992 to 1995. These droughts had a direct, negative effect on agricultural production and increased the production cost of the secondary industries dependent on agricultural inputs.

(iii) *IMF support (imf_dum)*

South Africa benefited from IMF assistance from 1975 to 1977. These contributions stimulated the demand side of the economy and, at least in theory, also production. These funds were also used to assist production in South Africa directly

(iv) *Opec oil shocks (opec_dum)*

The oil price shocks of the 1970s resulted in dramatic increases in domestic fuel prices and as a consequence activated a chain of price and cost surges in the economy. The economy in general and firms in particular could not escape the negative effects of increasing costs, decreasing profits and savings, and slumping economic growth.

(v) *Emigration of skilled labour (braindrain_dum)*

International sanctions and disinvestment during the mid-1980s and early 1990s, coupled with a new political dispensation endorsing labour acts of affirmative action, created an unstable and unprofitable environment for especially skilled labour in South Africa. This led to a substantial outflow of highly qualified and professional labour which the domestic economy is in serious need of.

APPENDIX 8: VARIABLE LIST

series	natural logarithms	Variable names	Data source
bbb_cp		Gross domestic expenditure at current prices	KB6012jj
bbp_90p	ln_bbp_90p	Gross domestic product at market prices at constant 1990 prices	KB6006yj
bbp_cp		Gross domestic product at market prices at current prices	KB6006jj
bbp_min_90p	ln_bbp_min_90p	Gross domestic product : mining and quarrying at constant 1990 prices	KB6032yj
bbpfact_90p	ln_bbpfact_90p	Gross domestic product at factor cost at constant 1990 prices	KB6003yj
bbpfact_cp		Gross domestic product at factor cost at current prices	KB6003jj
bpppot_90p	ln_bbppot_90p	Potential gross domestic product at factor cost at constant 1990 prices	Solved by production function
braindrain_dum		Dummy: emigration of skilled labour	*na*
c90p_lrem_gos5	ln_c90p_lrem5	Gross domestic cost of production at constant 1990 prices	cost_lrem_gos95/ppi
cost_lrem_gos5		Gross domestic cost of production at current prices	(lab_rem - 0.05*gos_cp)
crime_index	ln_crimeind	Crime index	crime incidents/total_pop/1990-number/1000 (South African survey)
cu	ln_cu	Percentage utilisation of production capacity : manufacturing sector	KB7078jj
de_cp	.	Provision for depreciation at current prices	KB6002jj
depend_rat		Dependency ratio	(total_pop - s*1000)/(s*1000)
dipi		Deflator : gross domestic fixed investment	(if_cp/if_r_sarb)
dirinves_r	ln_dirinves_r	Total foreign direct investment at constant 1990 prices	dirinvest/ppi
dirinvest		Total foreign direct investment at current prices	KB5162jj
drought_dum		Dummy: periods of severe drought	*na*
educ_index	ln_educind	Education index	((matrics passed/total_pop/1990-number)*100)
empl_rat	ln_empl_rat	Employment ratio	n/s
empl_rat_s	ln_empl_rat_s	Employment ratio : skilled labour sector	n_s/s_s
empl_rat_u	ln_empl_rat_u	Employment ratio : unskilled labour sector	n_u/s_u
energy_ind	ln_energy_ind	Energy index = electricity index	KB7068jj
excess_dem_cp	ln_exces_dem_cp	Excess demand at current prices	bbb_cp/bbp_cp
exchange_rate		Dollar/rand exchange rate	100/r_$

series	natural logarithms	Variable names	Data source
fincond_cp	ln_fincond_cp	Financing of gross domestic investment at current prices	(sp_cp + sc_cp + sg_cp + de_cp + netcapfl + gold_reserv_cp) = totdomi_cp
fincond_ppi	ln_fincond_ppi	Financing of gross domestic investment at constant 1990 prices : PPI deflated	(sp_cp + sc_cp + sg_cp + de_cp - netcapfl - gold_reserv_cp)/ppi = totdomi_cp/ppi
gold_reserv_cp		Change in gold and other foreign reserves at current prices	KB6205jj
gos_cp		Gross operating surplus at current prices	KB6212jj
gostc_cp	ln_gostc_cp	After-taxed gross operating surplus at current prices	gos_cp – tc_cp
gprys_$	ln_gprys_$	London gold price in US dollar	KB5357jj*100
gprys_r	ln_gprys_r	London gold price in SA rand	KB5356jj *100 (gprys_$*r_$)
h_transf_receiv	ln_h_transf	Net current transfers received by households from government, incorporated business enterprises and the rest of the world	h_tran_rec_c (KB6231jj)+ h_tran_rec_g (KB6257jj) + h_tran_rec_w (KB6243jj) - h_tran_pay_g (KB6252jj) - h_tran_pay_w (KB6248jj)
health_index	ln_healthind	Health index	(number of medical practisions / total_pop)/1990-number/1000 (SA Statistics, www.statssa.gov.za/ publications/ statistics_in_brief/ health)
if	ln_if	Gross domestic fixed investment at constant 1990 prices	if_cp/ppi
if_cp		Gross domestic fixed investment at current prices	KB6009jj
if_r_sarb		Gross domestic fixed investment at constant 1990 prices	KB6009yj
imf_dum		Dummy: IMF contributions and loans	*na*
income_index	ln_incomeind	Income index : per capita personal disposable income at constant 1990 prices	KB6272yj
indinves_r	ln_indinves_r	Total foreign non-direct investment at constant 1990 prices	indinvest/ppi
indinvest		Total foreign non-direct investment at current prices	KB5180jj
intern_comp	ln_intern_comp	International competitiveness of South African economy	domestic export prices relative to world export prices (IFS)
intern_posind	ln_interposind	International position index	((exchange_rate/1990-number)*0.2 + (intern_comp/1990-number)*0.05 + (rel_diri_r/1990-number)*0.5 + (rel_indi_r/1990-number)*0.2 + (worldshare/1990-number)*0.05)
inv_cp		Total change in inventories at current prices	KB6010jj
kap_lab_rat	ln_kap_lab_rat	Capital-labour ratio	kap_r/(lab_rem_cp/ppi)*1000

series	natural logarithms	Variable names	Data source
kap_r	ln_kap_r	Capital stock at constant 1990 prices	KB6149yj
lab_rem_cp		Remuneration of employees at current prices	KB6000jj
n	ln_n	Demand for labour (Employment)	SA Statistics, www.statssa.gov.za/ publications/ statistics_in_brief/ labour *or* DBSA: Development Information Business Unit – standardised employment series
n_diff		Difference between employment figures from SA Statistics and employment figures from sarb	n - n_sarb
n_ind_sarb		Demand for labour in noon-agricultural sectors : 1990 = 100	KB7009jj
n_informal	ln_n_informal	Labour participants in the informal sector	DBSA (n_informal (DBSA) + n (SA Statistics) + unempl (SA Statistics)= s (SA Statistics))
n_pot	ln_n_pot	Potential demand for labour (employment)	(s_smooth*(1 - nawru_hpf))
n_s	ln_ns	Demand for skilled labour (skilled employment)	(percentages of DBSA applied to n of SA Statistics)/100
n_sarb		Demand for labour (excluding agricultural sector)	(n_ind_sarb)*1990-number/100 000 000
n_u	ln_nu	Demand for unskilled labour (unskilled employment)	(percentages of DBSA applied to n of SA Statistics)/100
nawru		Non-accelerating wage rate of unemployment	unempl_rat - (d(unempl_rat)/d^3(ln_wtot_vpi))*d^2(ln_wtot_vpi)
nawru_hpf		Hodrick-Prescott filter used to smooth nawru	*na*
netcapfl		Net capital flow at current prices	KB5024jj
netcapfl_r		Net capital flow at constant 1990 prices	netcapfl/ppi
opec_dum		Dummy: OPEC oil price shocks	*na*
p_manuf	ln_p_manuf	Production prices : manufacturing (1990 = 100)	KB7046jj/63.6
pk		Price of capital	KB2004jj (escom stock)
pk_ppi		Price of capital at constant 1990 prices : PPI deflated	pk - ppigrowth
pnettx		Deflator : net indirect taxes	(txind - subs)/(bbp_90p - bbpfact_90p) (vpigrowth in future)
ppi	ln_ppi	Production prices : total (1990 = 100)	KB7048jj/65.4

series	natural logarithms	Variable names	Data source
ppigrowth	ln_ppigrowth	Production inflation	((ppi - ppi(-1)/ppi(-1))*100
prime_rate	ln_prime_rate	Predominant prime overdraft rate of clearing banks at current prices	KB1403g
product_sarb	ln_product_sarb	Labour productivity according to SARB statistics, excluding agricultural sector	(bbp_90p/n_sarb)/1990-number
product	ln_product	Labour productivity	(bbp_90p/n/1990-number
px	ln_px	Deflator : exports of goods and non-factor services	xgnfd_cp/xgnfd_90p
px_sa_$		Deflator : South African exports in US dollar prices	IFS: 19974…DZF; WT028
px_world_$		Deflator : World exports in US dollar prices	IFS: 00174…DZF; WT028
pz	ln_pz	Deflator : imports of goods and non-factor services	zgnfd_cp/zgnfd_90p
pz_$	ln_pz$	Import prices in US dollar	pz*exchange_rate
r_$	ln_r$	Rand-dollar exchange rate	KB5339jj
rel_diri_r	ln_rel_diri_r	Direct foreign investment relative to gross domestic investment at constant prices	(dirinvest/if_cp)/ppi
rel_i_r	ln_rel_i_r	Total foreign investment relative to gross domestic investment at constant 1990 prices	((dirinvest + indinvest)/if_cp)/ppi
rel_indi_r	ln_rel_indi_r	Indirect foreign investment relative to gross domestic investment at constant 1990 prices	(indinvest/if_cp)/ppi
rel_wscost_ucc	ln_rel_wscost_u	Skilled labour cost relative to user-cost-of-capital	ws_cost_ppi/ucc2_90p
rel_wsu	ln_rel_wsu	Skilled wages relative to unskilled wages	w_s/w_u
rel_wsu_rat	ln_rel_wsu_rat	Skilled wage rate relative to the unskilled wage rate	(w_s/n_s)/(w_u/n_u)
rel_wucost_ucc	ln_rel_wucost_u	Unskilled labour cost relative to user-cost-of-capital	wu_cost_ppi/ucc2_90p
s	ln_s	Total labour supply	SA Statistics, www.statssa.gov.za/ publications/ statistics_in_brief/ labour
s_rat	ln_srat	Total labour supply ratio	s/total_pop
s_rat_hpf		Hodrick-Prescott filter used to smooth total supply of labour	*na*
s_s	ln_ss	Skilled labour supply	SA Statistics (www.statssa.gov.za/ publications/ statistics_in_brief/ labour) data for s, but ratio according to DBSA
s_smooth		Smoothed labour supply	*na*

series	natural logarithms	Variable names	Data source
s_u	ln_su	Unskilled labour supply	SA Statistics (www.statssa.gov.za/ publications/ statistics_in_brief/ labour) data for s, but ratio according to DBSA
sanction_dum		Dummy : sanctions	*na*
sc_cp	ln_sc_cp	Corporate saving at current prices	KB6201jj
sc_cp_rat		Corporate savings rate at current prices	sc_cp/bbp_cp
sg_cp		Saving of the general government at current prices	KB6202jj
share_ns		Demand for labour share of skilled workers	OHS: Workers by level of education (grade 10/NTC I + grade 11/NTC II + grade 12/NTC III + diplomas + degrees), SA Statistics (www.statssa.gov.za/ publications/ statistics_in_brief/ labour)
share_nu		Demand for labour share of unskilled workers	(1 – share_ns)
share_ss		Labour supply share of skilled workers	OHS: Level of education (grade 10/NTC I + grade 11/NTC II + grade 12/NTC III + diplomas + degrees), SA Statistics (www.statssa.gov.za/ publications/ statistics_in_brief/ labour)
share_su		Labour supply share of unskilled workers	(1 – share_ss)
share_ws		Wage share of skilled labour	DBSA: high level + mid level
share_wu		Wage share of unskilled labour	DBSA: semi-level + unskilled
soc_index	ln_socind	Socio-economic index	(educ_index/1990-number)*0.20 + (energy_ind/1990-number)*0.15 + (health_index/1990-number)*0.15 + (1/(crime_index/1990-number))*0.1 + (income_index/1990-number)*0.2 + (h_transf_receiv/1990-number)*0.1 + (unpl_ben/1990-number)*0.1
sp_cp		Personal saving at current prices	KB6200jj
ss_rat	ln_ssrat	Skilled labour supply ratio	s_s/s
subs		Subsidies at current prices	KB6005jj
tc_cp		Direct taxes of incorporated business enterprises at current prices	KB6230jj
tc_ppi		Direct taxes of incorporated business enterprises at constant 1990 prices: PPI deflated	tc_cp/ppi

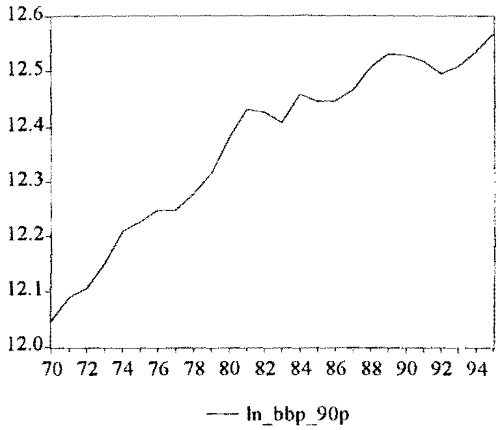
series	natural logarithms	Variable names	Data source
tc_rate_cp		Direct tax rate of incorporated business enterprises at current prices	tc_cp/bbpfact_cp
tc_rate_ppi	ln_tcrate_ppi	Direct tax rate of incorporated business enterprises at constant 1990 prices : PPI deflated	tc_ppi/bbpfact_90p
tecno_hpf		Hodrick-Prescott filter used to smooth technology index	*na*
tecno_index		Technology index	(educ_index/1990-number)*0.15 + (product/1990-number)*0.15 + (rel_i_r/1990-number)*0.05 + (time/10 + tecno_innov)*0.65
tecno_innov		Dummy: technology innovation	*na*
total_pop	ln_total_pop	Total population	SA Statistics, www.statssa.gov.za/ publications/ statistics_in_brief/ demography
totdomi_cp		Gross domestic investment at current prices	KB6180jj
txind	ln_txind	Indirect taxes at current prices	KB6004jj
ucc2_90p	ln_ucc2_90p	User-cost-of-capital at constant 1990 prices	dipi*((pk_ppi/100) + 0.2)/(1 - tc_rate_ppi)
ucc2_nom	ln_ucc2_nom	User-cost-of-capital at current prices	dipi*((pk/100) + 0.2)/(1 - tc_rate_cp)
unempl		Total unemployment	unempl_rat*s
unempl_rat	ln_unempl_rat	Unemployment rate	SA Statistics, www.statssa.gov.za/ publications/ statistics_in_brief/ labour
unempl_rat_s	ln_unemplrat_s	Unemployment rate : skilled labour	unempl_s/n_s
unempl_rat_u	ln_unemplrat_u	Unemployment rate : unskilled labour	unempl_u/n_u
unempl_s		Skilled labour force unemployment	s_s – n_s
unempl_u		Unskilled labour force unemployment	s_u – n_u
union_members		Union members	ILO Review *or* NMC, Department of labour *or* South African Institute of Race Relations Survey
union_mil	ln_unionmil	Union militancy	union_work_lost/n
union_power	ln_unionpower	Union power	union_members/n
union_pres_ind	ln_uniopresind	Union pressure index	((union_power/1990-number)*0.60 + (union_mil/1990-number)*0.10 + (depend_rat/1990-number)*0.30)
union_work_lost		Strikes and stoppages : man-days lost	KB7018jj

series	natural logarithms	Variable names	Data source
unpl_ben		Unemployment benefit	SA Statistics : SA labour statistics, table 4.2.1.1 (SA Statistics, www.statssa.gov.za/ publications/ statistics_in_brief/ labour)
vpi	ln_vpi	Consumer price index	KB7032jj
vpigrowth	ln_vpigrowth	Consumption inflation	(vpi - vpi(-1))/vpi(-1)*100
w_cost_cp		Cost of labour at current prices	((wtot_rate)*(1 + 0.16))/(1 - (tc_rate_cp)*(1 + 0.3)) *with* *pension contribution = 0.06 (6%)* *medical contribution = 0.1 (10%)* *non-wage contributions = medical + pension = 0.16 (16%)* *corporate income tax rate = 0.3 (30%)*
w_prod	ln_w_prod	Wage productivity	(w_tot/product)/100
w_s		Skilled wages at current prices	w_tot*share_ws
w_tot		Total wages at current prices	(w_s + w_u) *or* KB6000jj
w_u		Unskilled wages at current prices	w_tot*share_wu
worldshare	ln_worldshare	World market share	(x_sa_$/x_world_$)/10 (IFS)
ws_cost_cp		Cost of skilled labour at current prices	w_cost_cp*share_ws
ws_cost_ppi	ln_wscost_ppi	Cost of skilled labour at constant 1990 prices : PPI deflated	ws_cost_cp/ppi
ws_rate	ln_ws_rate	Skilled wage rate at current prices	w_s/n_s
ws_vpi		Skilled wages at constant 1990 prices : CPI deflated	w_s/vpi
ws_vpi_rate	ln_wsvpi_rat	Skilled wage rate at constant 1990 prices : CPI deflated	ws_vpi/n_s
wtot_ppi_rat	ln_wtot_ppi_rat	Total wage rate at constant 1990 prices : PPI deflated	(wtot_rate/ppi)/n
wtot_rate	ln_wtot_rate	Total wage rate at current prices	w_tot/n
wtot_vpi	ln_wtot_vpi	Total wages at constant 1990 prices : CPI deflated	(w_tot)/vpi
wtot_vpi_rat	ln_wtot_vpi_rat	Total wage rate at constant 1990 prices : CPI deflated	(wtot_rate/vpi)/n
wu_cost_cp		Cost of unskilled labour at current prices	w_cost_cp*share_wu
wu_cost_ppi	ln_wucost_ppi	Cost of unskilled labour at constant 1990 prices : PPI deflated	wu_cost_cp/ppi
wu_ppi		Unskilled wages at constant 1990 prices : PPI deflated	w_u/ppi

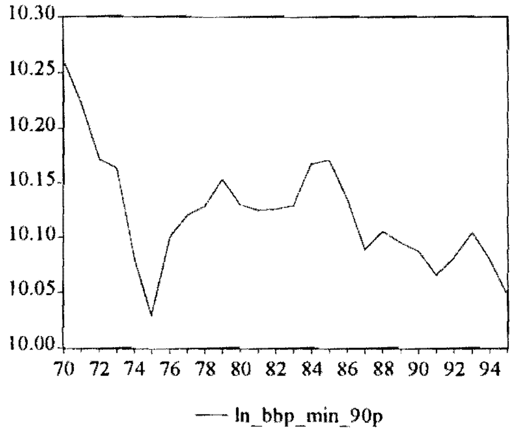
series	natural logarithms	Variable names	Data source
wu_ppi_rate	ln_wuppi_rat	Unskilled wage rate at constant 1990 prices : PPI deflated	wu_ppi/n_u
wu_rate		Unskilled wage rate at current prices	w_u/n_u
wu_vpi		Unskilled wages at constant 1990 prices : CPI deflated	w_u/vpi
wu_vpi_rate	ln_wuvpi_rat	Unskilled wage rate at constant 1990 prices : CPI deflated	wu_vpi/n_u
x_sa_$		South African exports at US dollar prices	IFS: 19970…DZF; WT025
x_world_$		World exports at US dollar prices	IFS: 00170…DZF; WT025
xgnfd_90p		Exports of goods and non-factor services at constant 1990 prices	KB6013yj
xgnfd_cp		Exports of goods and non-factor services at current prices	KB6013jj
xgoud_cp		Net gold exports at current prices	KB5001jj
xgoud_ppi	ln_xgoud_ppi	Net gold exports at constant 1990 prices : PPI deflated	xgoud_cp/ppi
xgoud_px	ln_xgoud_px	Net gold exports at constant 1990 prices : deflated by export prices	xgoud_cp/px
zgnfd_90p		Imports of goods and non-factor services at constant 1990 prices	KB6014yj
zgnfd_cp		Imports of goods and non-factor services at current prices	KB6014jj

APPENDIX 9: GRAPHICAL REPRESENTATION OF THE DATA

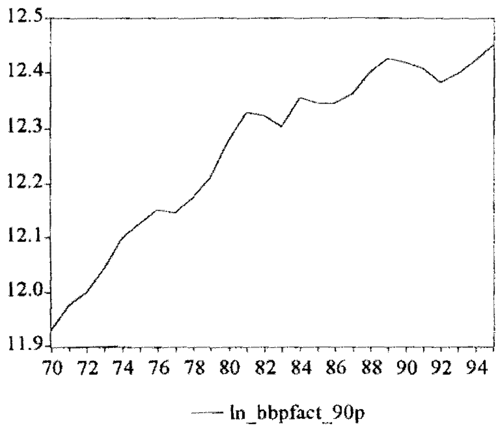
Real GDP at market prices



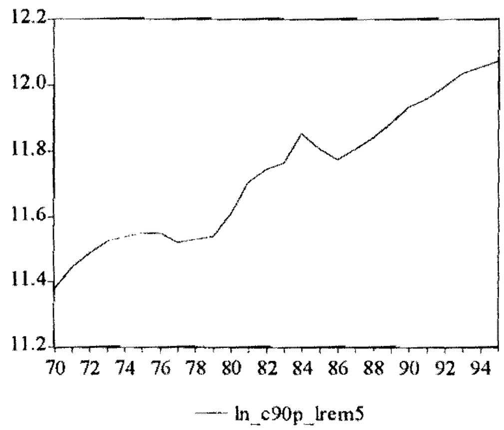
Real GDP: mining and quarrying



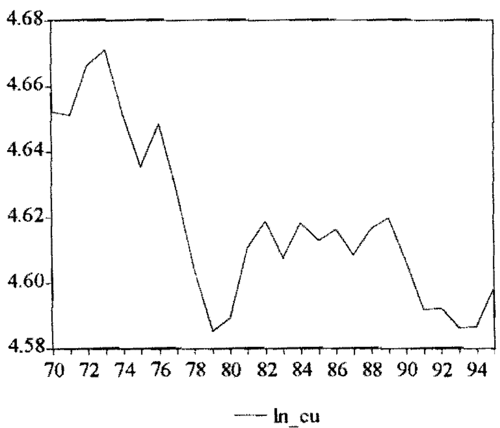
Real GDP at factor cost



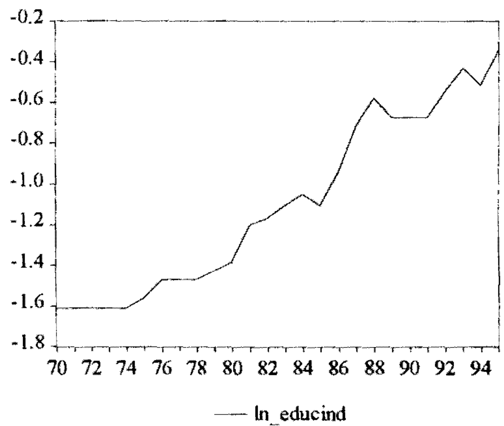
Real gross domestic cost of production



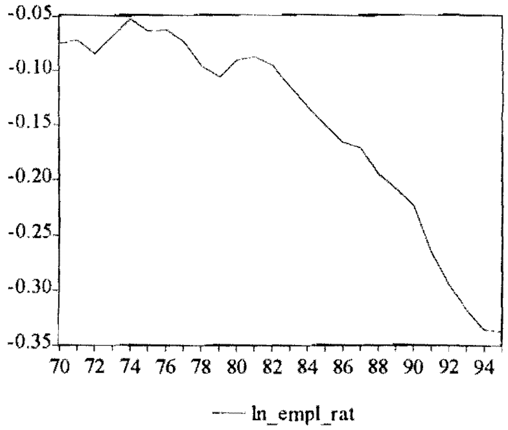
Capacity utilisation



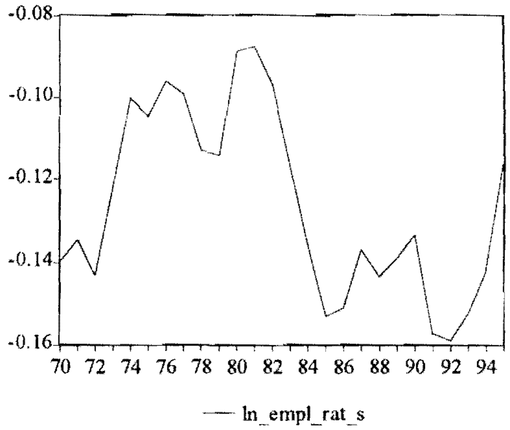
Education index



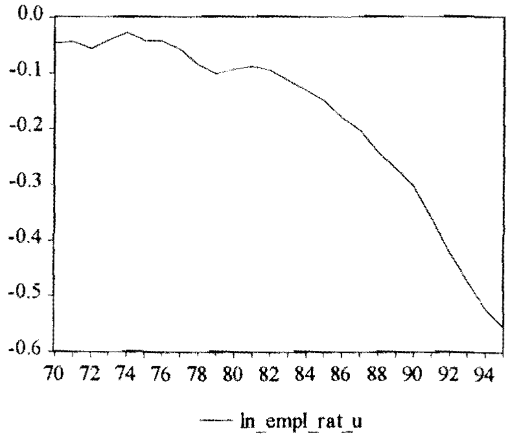
Employment ratio



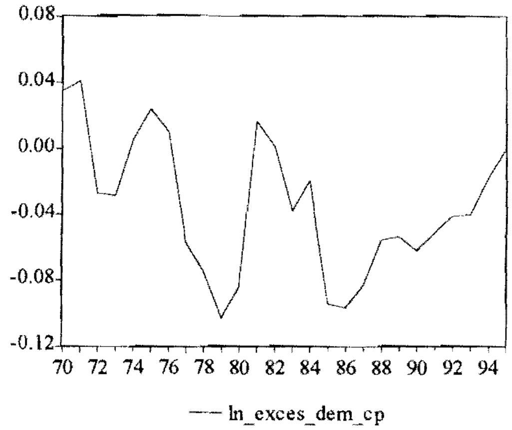
Skilled employment ratio



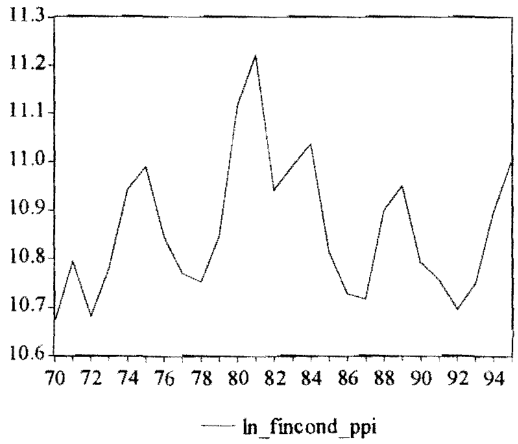
Unskilled employment ratio



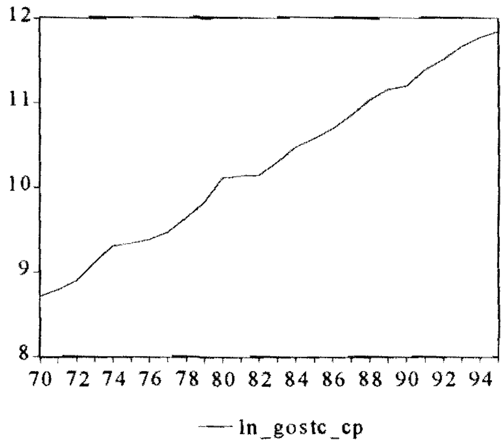
Nominal excess demand



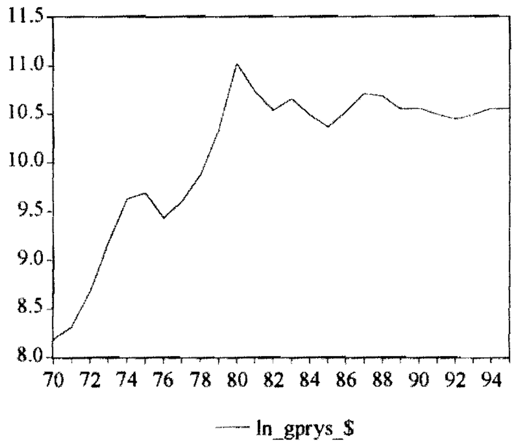
Real financing of gross domestic investment



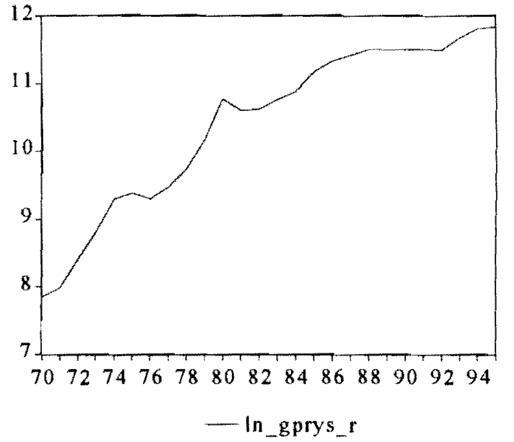
Nominal after-taxed operating surplus



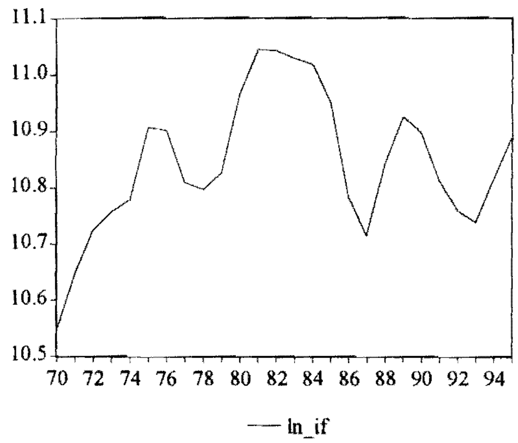
Gold price in US dollar



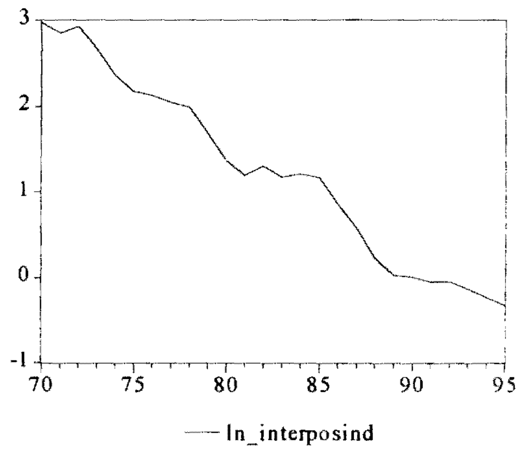
Gold price in SA rand



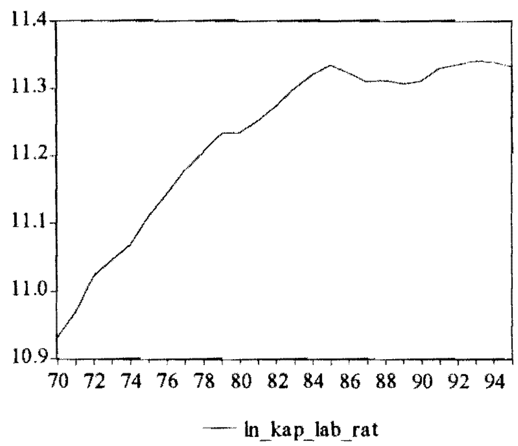
Real domestic fixed investment



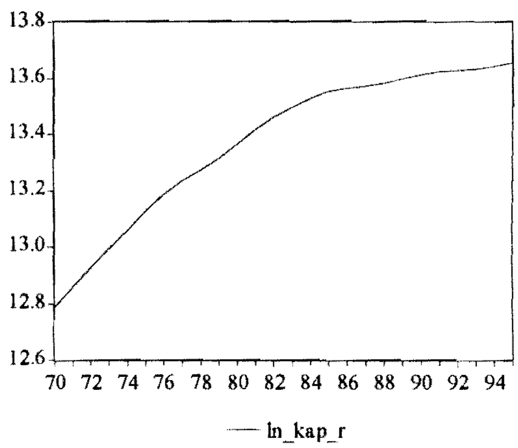
International position index

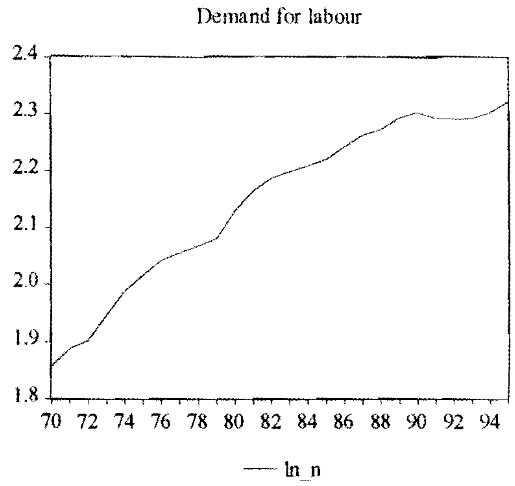


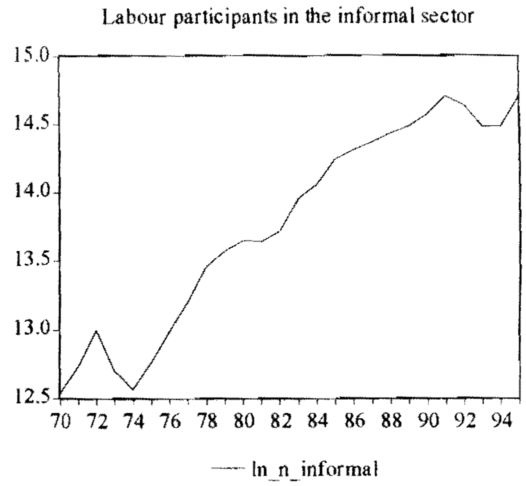
Capital-labour ratio

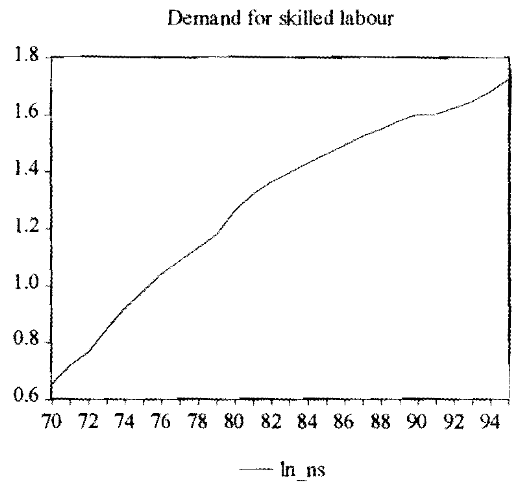


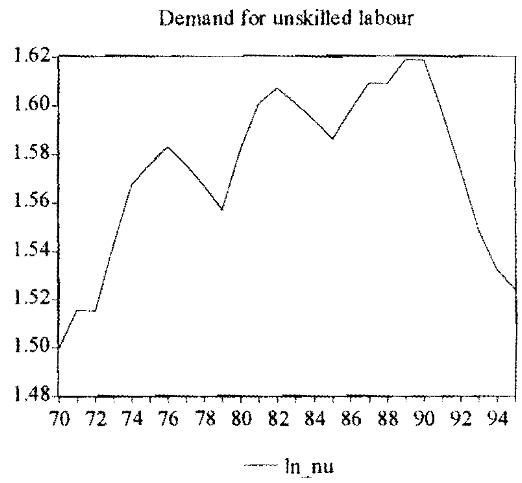
Real capital stock

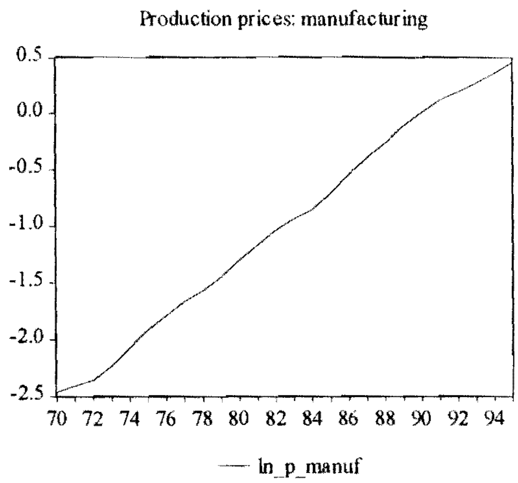


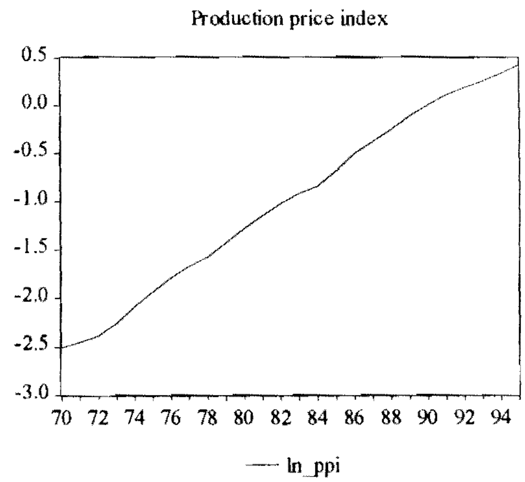

Demand for labour
2.4
2.3
2.2
2.1
2.0
1.9
1.8
70 72 74 76 78 80 82 84 86 88 90 92 94
ln_n


Labour participants in the informal sector
15.0
14.5
14.0
13.5
13.0
12.5
70 72 74 76 78 80 82 84 86 88 90 92 94
ln_n_informal

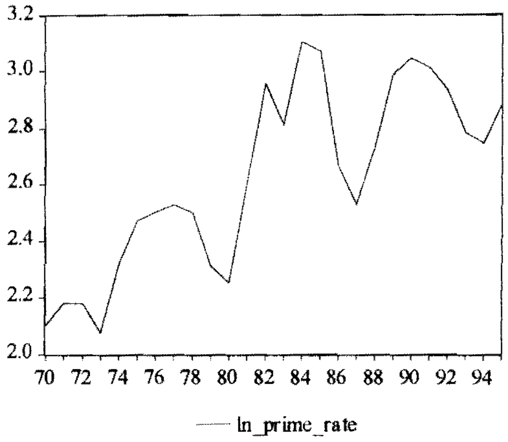

Demand for skilled labour
1.8
1.6
1.4
1.2
1.0
0.8
0.6
70 72 74 76 78 80 82 84 86 88 90 92 94
ln_ns


Demand for unskilled labour
1.62
1.60
1.58
1.56
1.54
1.52
1.50
1.48
70 72 74 76 78 80 82 84 86 88 90 92 94
ln_nu

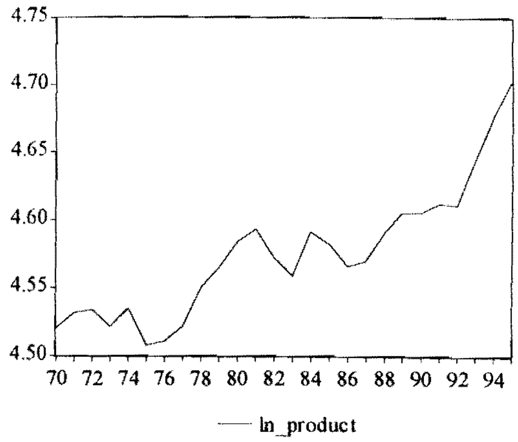

Production prices: manufacturing
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
70 72 74 76 78 80 82 84 86 88 90 92 94
ln_p_manuf


Production price index
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
70 72 74 76 78 80 82 84 86 88 90 92 94
ln_ppi

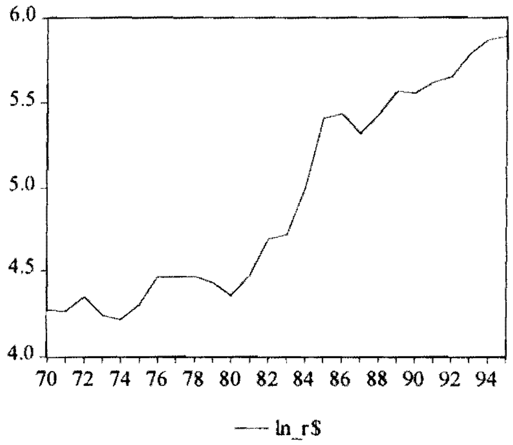
Predominant prime overdraft rate of clearing banks



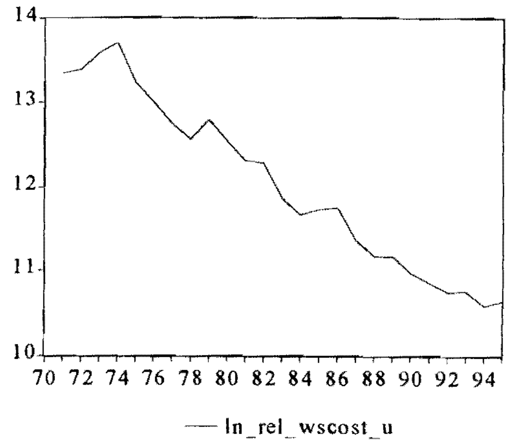
Productivity



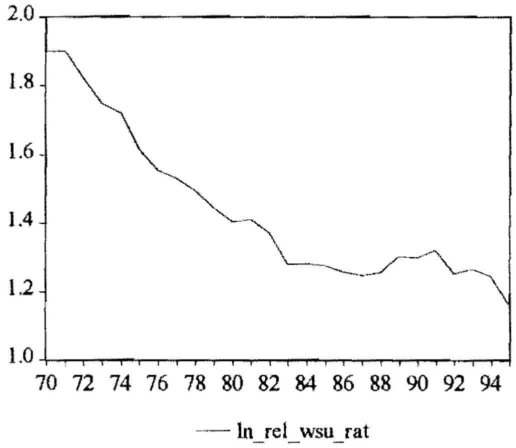
Rand-dollar exchange rate



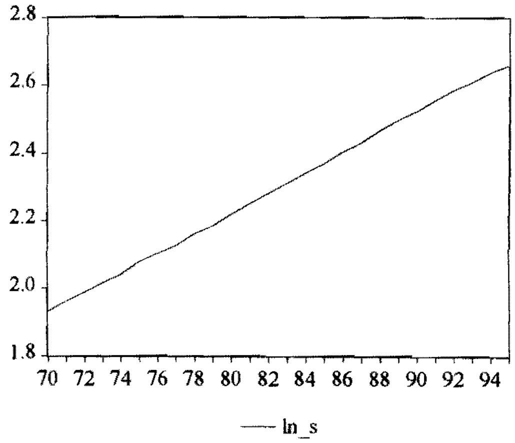
Skilled labour cost relative to user-cost-of-capital

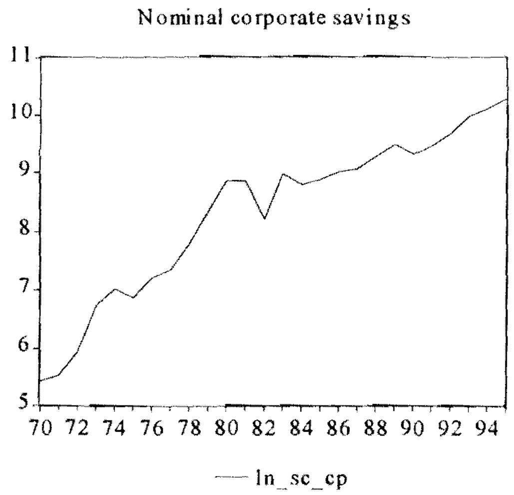


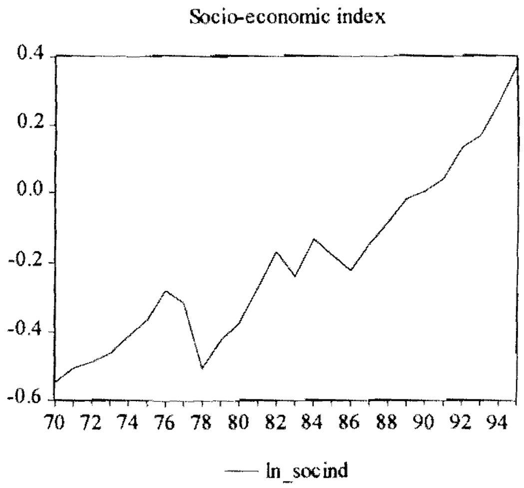
Skilled/Unskilled wate rate

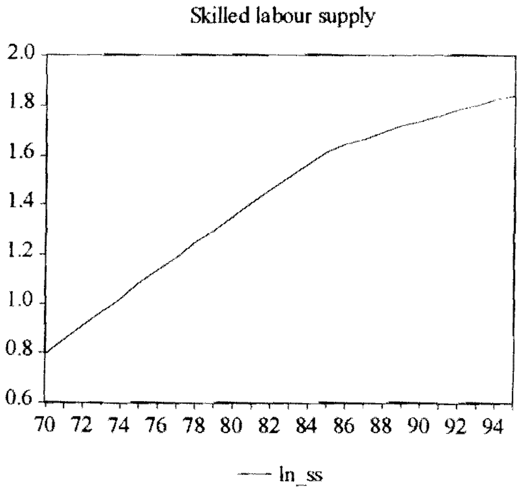


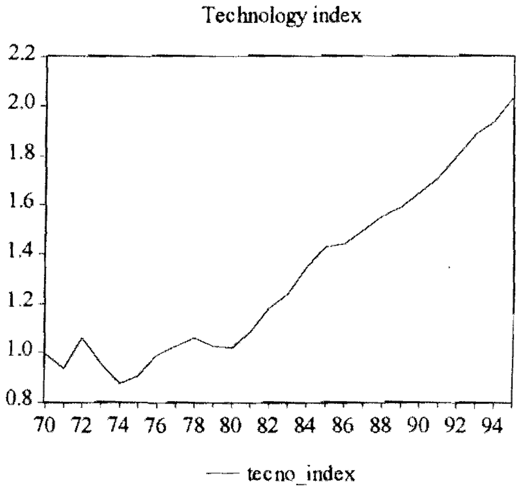
Labour supply

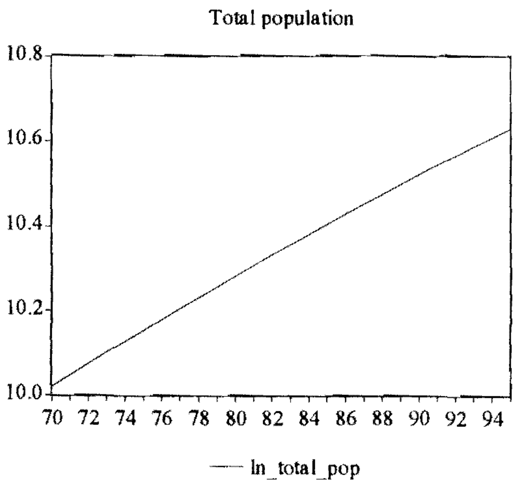


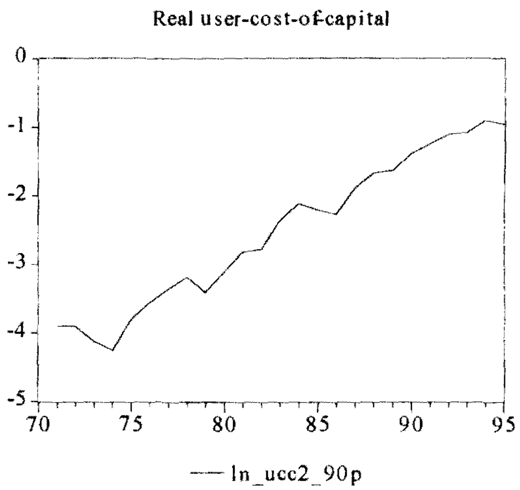

Nominal corporate savings
11
10
9
8
7
6
5
70 72 74 76 78 80 82 84 86 88 90 92 94
— ln_sc_cp


Socio-economic index
0.4
0.2
0.0
-0.2
-0.4
-0.6
70 72 74 76 78 80 82 84 86 88 90 92 94
— ln_socind

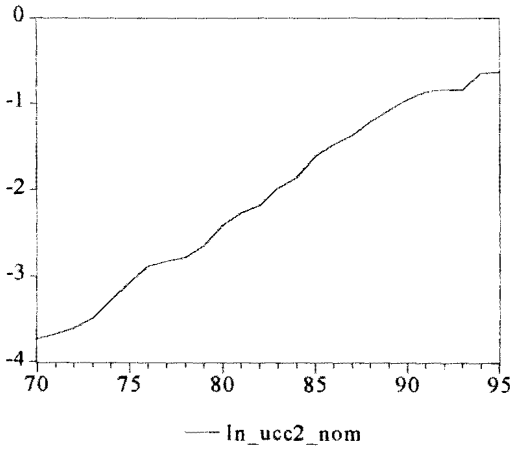

Skilled labour supply
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
70 72 74 76 78 80 82 84 86 88 90 92 94
— ln_ss


Technology index
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
70 72 74 76 78 80 82 84 86 88 90 92 94
— tecno_index

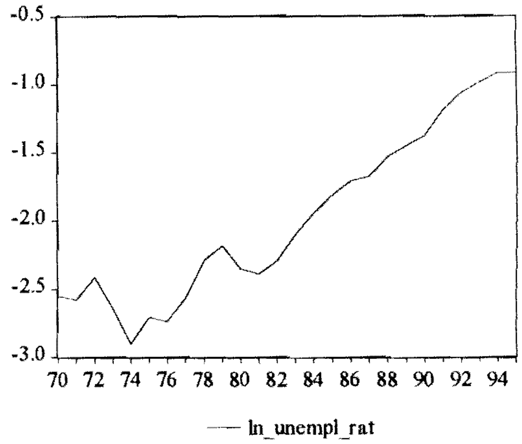

Total population
10.8
10.6
10.4
10.2
10.0
70 72 74 76 78 80 82 84 86 88 90 92 94
— ln_total_pop


Real user-cost-of-capital
0
-1
-2
-3
-4
-5
70 75 80 85 90 95
— ln_ucc2_90p

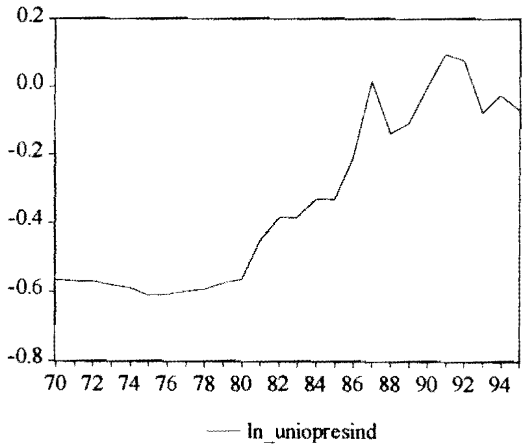
Nominal user-cost-of-capital



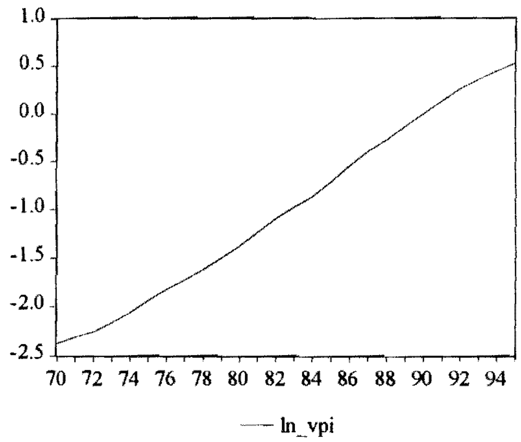
Unemployment rate



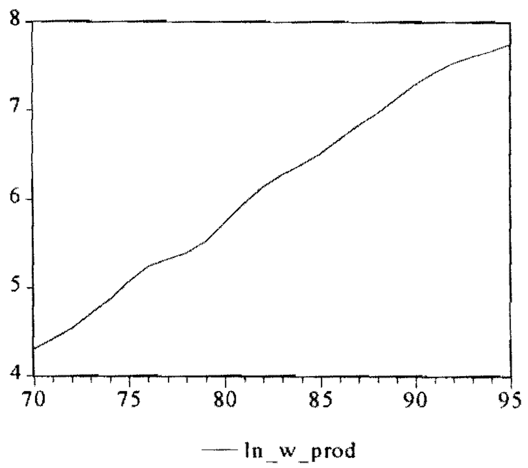
Union pressure index



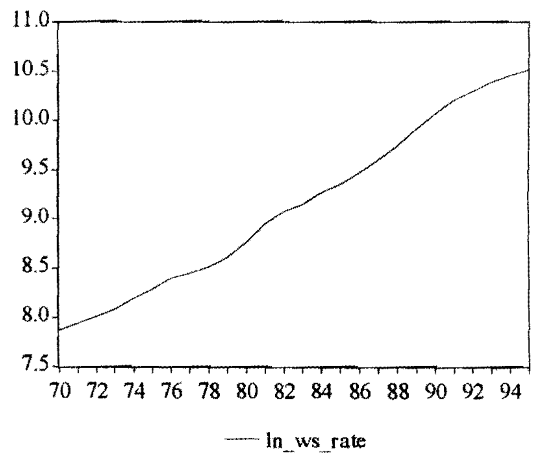
Consumer price index



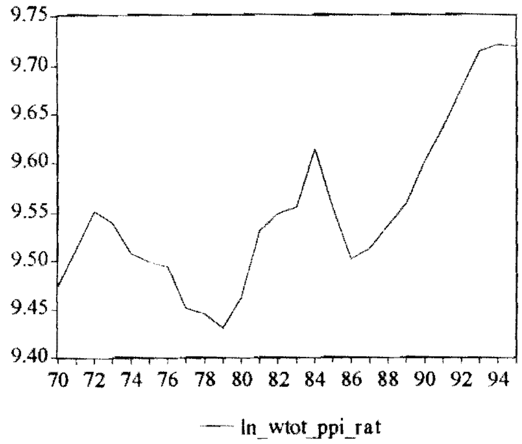
Wage productivity



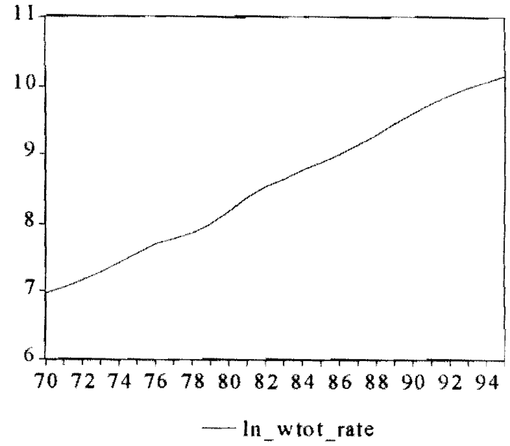
Nominal skilled wage rate



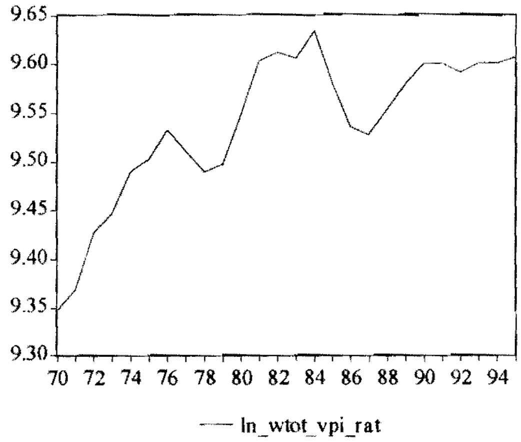
Real total wage rate : PPI deflated



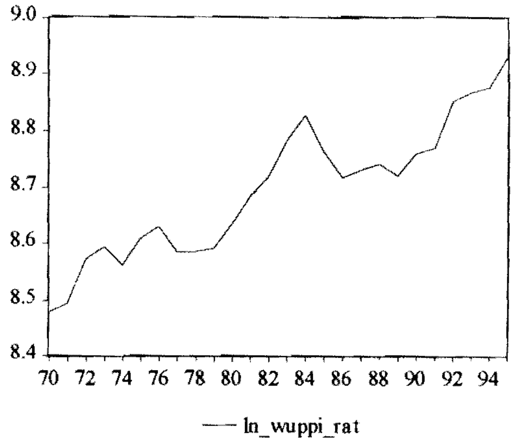
Nominal total wage rate



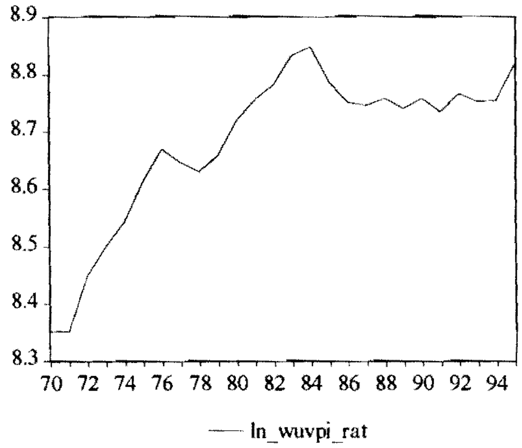
Real total wage rate : CPI deflated



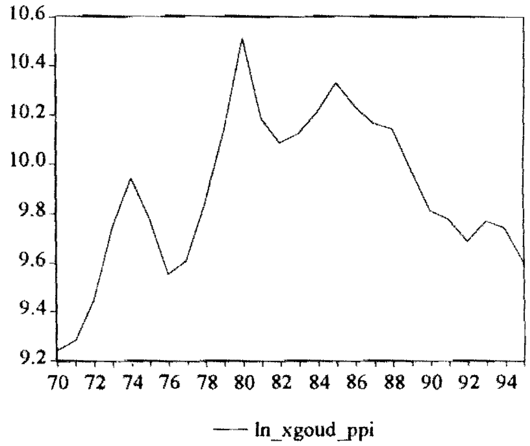
Real unskilled wage rate : PPI deflated

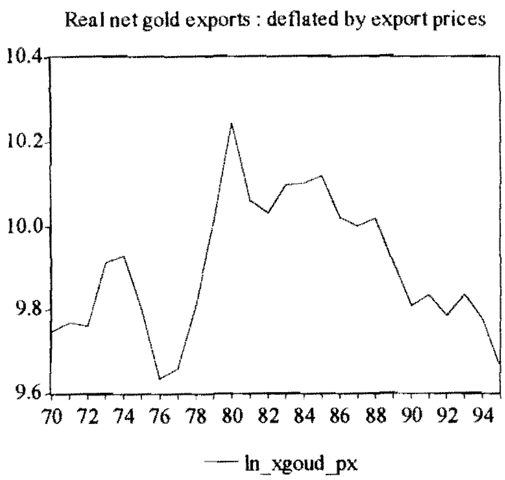


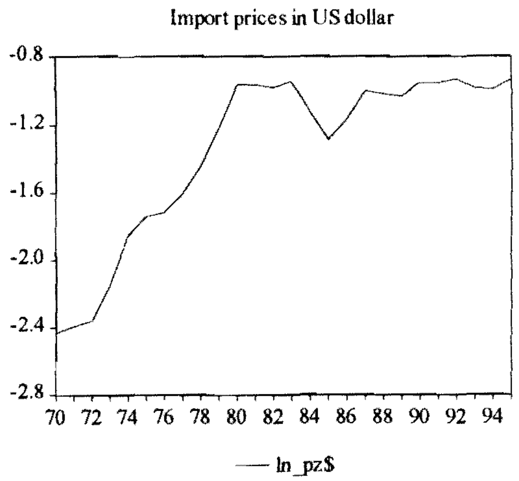
Real unskilled wage rate : CPI deflated



Real net gold exports : PPI deflated




Real net gold exports : deflated by export prices
10.4
10.2
10.0
9.8
9.6
70 72 74 76 78 80 82 84 86 88 90 92 94
ln_xgoud_px


Import prices in US dollar
-0.8
-1.2
-1.6
-2.0
-2.4
-2.8
70 72 74 76 78 80 82 84 86 88 90 92 94
ln_pz$

APPENDIX 10: EVALUATING THE RESPONSE PROPERTIES OF THE MODEL: METHODOLOGY

The dynamic simulation properties of every individual model are investigated and it is tested for stability and robustness simultaneously.

For this purpose, dynamic, *ex-post* and partial simulations are performed on the estimated production function. Two types of dynamic simulations are performed: first, an *ex-post* dynamic simulation on the production function (without any shocks applied) and second, *ex-post* dynamic simulations where each of the explanatory variables are independently increased (shocked).

The initial dynamic simulation (without applying any shocks) is carried out as an indication of the goodness of fit of the model. The response characteristics of the model are evaluated by subsequently subjecting the model to sensitivity testing by changing (shocking) each of the explanatory variables (one at a time). This is done by increasing them by 10 percent. For a model to be stable and robust, shocks applied to it should result in consistent long-run multiplier effects. A consistent long-run multiplier effect means that the difference between the shocked simulated value and the simulated value without a shock must ideally result in approximately 10 percent of the original coefficient of the shocked variable (i.e. the multiplier effect). A shock in short-term explanatory variables should cause an initial movement away from the long-run equilibrium growth path, but eventually the model should converge to the original equilibrium growth path.

Having applied a 10 percent shock to each of the explanatory variable, the dependent variable converged around a new equilibrium, with the adjustment equal to 10 percent of the estimated coefficient of the shocked long-run explanatory variable. In the case of shocked short-run explanatory variables, the dependent variable converged to the original equilibrium growth path.

The results of the adjustment process towards either a new long-run equilibrium (in accordance with the elasticities of the respective cointegration relationships) or the baseline equilibrium (in the case of short-run explanatory variables) are both tabled and graphically illustrated. Vertical axes measure the difference between the outcome of the baseline estimation and the estimation subjected to the exogenous shock, as a percentage of the level of the dependent variable. The speed of adjustment in respective cases is apparent from the graphs. In all instances the adjustment process is completed within the sample range.

APPENDIX 11: KMENTA'S TAYLOR APPROXIMATION OF THE EXPANSION OF THE CES FUNCTIONAL FORM INTO THE TRANSLOG FUNCTIONAL FORM

By using a Taylor series, the CES functional form can be expanded into the Translog functional form. This expansion was first suggested by Kmenta (1967), and has been utilised by Sargan (1971) and Griliches and Ringstad (1971).

Kmenta based his research on the CES function, which was first introduced by Arrow, Chenery, Minhas and Solow in 1961:

$$Q=\gamma\ (\delta V_1^{-\theta}+(1-\delta)V_2^{-\theta})^{-\frac{v}{\theta}} \qquad \text{(A1)}$$

where Q = production; γ = efficiency parameter ($\gamma > 0$); V_i = production factors (inputs) with i = 1,2 ; θ = substitution parameter ($-1 < \theta < \infty$); and δ = distribution (capital intensity) parameter ($0 < \delta < 1$).

By assuming a Taylor series expansion of about $\theta = 0$, Kmenta obtains a linear approximation of the CES function, which can be written as:

$$\ln Q=\ln\gamma+v\delta\ln V_1+v(1-\delta)\ln V_2-\frac{1}{2}v\theta\delta(1-\delta)[\ln(V_1/V_2)]^2 \qquad \text{(A2)}$$

Provided θ is near zero (i.e. provided the elasticity of substitution, $\sigma = 1/(1+\theta)$, is near unity), equation A2 provides a close and convenient approximation of equation A1.[1] This assumption has to be tested in practice.

Kmenta's Taylor approximation to the CES function (equation A2) is, however, of the same form as the Translog production function with imposed restrictions of homotheticity and separability, i.e. a Translog production function exhibiting a constant elasticity of substitution.

The Translog production function of Christensen, Jorgenson and Lau approximates the logarithm of output by a quadratic in the logarithms of the inputs:

$$\begin{aligned} lnQ &= ln\alpha_0+\sum_{i=1}^{2}\alpha_i\ln V_i+\frac{1}{2}\sum_{i=1}^{2}\sum_{j=1}^{2}\beta_{ij}\ln V_i\ln V_j \\ &= ln\alpha_0+\alpha_1\ln V_1+\alpha_2\ln V_2+\beta_{11}(\ln V_1)^2+\beta_{22}(\ln V_2)^2+\beta_{12}\ln V_1\ln V_2 \ . \end{aligned} \qquad \text{(A3)}$$

Restricting the Translog production function to homotheticity and a constant elasticity of substitution, i.e. imposing the restrictions of $\sum\beta_{ij}=\sum\beta_{ji}=0$ and $\beta_{11}=\beta_{22}=-\frac{1}{2}\beta_{12}$, the equation becomes:

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1 If $\theta = 0$ and $\sigma = 1$, then the Translog production function of the form:
$\ln Q = \ln\alpha_0+\alpha_1\ln V_1+\alpha_2\ln V_2+\beta_{11}(\ln V_1)^2+\beta_{22}(\ln V_2)^2+\beta_{12}\ln V_1\ln V_2$,
reduces to the Cobb-Douglas production function of the form:
$\ln Q = \ln\alpha_0+\alpha_1\ln V_1+\alpha_2\ln V_2$.

$$lnQ = ln\alpha_0 + \alpha_1 \ln V_1 + \alpha_2 \ln V_2 - \frac{1}{2}\beta_{12}(\ln V_1 - \ln V_2)^2 \qquad \text{(A4)}$$

which is of the same form as Kmenta's Taylor approximation to the CES function[2].

Hence, if the Translog production function (equation A3) is estimated, the hypothesis of a CES may be tested by checking whether the estimated coefficients obey the restrictions: $\beta_{11} = \beta_{22} = -\frac{1}{2}\beta_{12}$ (Thomas 1993: 329-331).

Griliches and Ringstad (1971) performed this test by using cross-sectional inter-firm data for different Norwegian industries. In order to address the problem of a high degree of multicollinearity between the variables lnV_1, lnV_2 and $[ln(V_1/V_2)]^2$, they rearranged Kmenta's Taylor approximation as:

$$ln\left(\frac{Q}{V_2}\right) = ln\,\gamma + (\nu - 1)lnV_2 + (\nu\delta)\ln\left(\frac{V_1}{V_2}\right) - \frac{1}{2}\nu\theta\delta(1-\delta)\left[\ln\left(\frac{V_1}{V_2}\right)\right]^2. \qquad \text{(A5)}$$

Estimation of equation A5 resulted in estimates for γ, ν, δ and θ and therefore provides information on the properties such as the returns to scale (ν), capital intensity of production (δ) and elasticity of substitution ($\sigma = 1/(1 + \theta)$). The closeness of θ to zero serves as a test whether the Kmenta approximation to the CES function is valid (see equation A2).

As mentioned above this transformation of the CES functional form into the Translog functional form, will be used to test the validity of the Cobb-Douglas functional form as a representation of production technology in South Africa.

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2 Fuss, McFadden and Mundlak (1979: 239) give the following general derivation of the Kmenta Taylor expansion from the Translog function.

Consider the CES equation originally formulated by Arrow in 1961:

$$y^\rho = \alpha_0 + \sum_{i=1}^{n} \alpha_i x_i^\rho$$

with x a vector of inputs or prices, depending on whether a direct or dual form is being considered, y is output, cost or profit.

If $\alpha_0 = 0$ and $\Sigma\alpha_i = 1$ in the CES formula, then a first order expansion in ρ, provides a linear-in-parameters Translog form

$$\ln y = \Sigma\alpha_i \ln x_i + \frac{\rho}{2}[\Sigma\alpha_i(\ln x_i)^2 - \Sigma\alpha_i \ln x_i]^2$$

with second-order terms $\alpha_{ii} = \frac{\rho}{2}\alpha_i(1-\alpha_i)$ and $\alpha_{ij} = \frac{\rho}{2}\alpha_i\alpha_j \quad i \neq j$.

APPENDIX 12: REPRESENTATIONS OF TECHNICAL PROGRESS

Consider a two-factor Cobb-Douglas production structure:

$$Q_t = AK_t^{\alpha} L_t^{B}$$

with Q output, K capital and L labour.

Production models have to allow technology to improve over time in order to explain growth in output with stable populations and growth in the presence of diminishing returns to scale production structures.

A number of alternative representations of technical progress have been proposed.

A12.1 Neutral technical progress

One way of handling technical progress is to make the efficiency parameter A, vary over time so that:

$$Q_t = A(t) K_t^{\alpha} L_t^{B} . \qquad \text{(A12.1)}$$

Before equation A12.1 can be estimated, some form has to be given to the function $A(t)$. The form most frequently used in practice is:

$$A(t) = Ae^{gt}$$

where A and g are constants, so that equation A12.1[1] becomes

$$Q_t = Ae^{gt} K_t^{\alpha} L_t^{B} . \qquad \text{(A12.2)}$$

A, also known as Hicks-neutral productivity, represents the value of $A(t)$ at time = 0. Partially differentiating equation A12.2 with respect to t yields

$$\frac{\partial Q_t}{\partial t} = gQ_t .$$

Hence,

$$\frac{\partial Q_t}{\partial t} \Big/ Q_t = g .$$

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[1] A popular alternative application of this is the labour-augmenting or Harrod-neutral technical progress where $L_t = A(t)L_{at}$, with L_{at} actual labour input. In its simplest case $A(t) = Ae^{gt}$, reflecting an exponential time trend (Hall and Nixon 1997; Turner, Richardson and Rauffet 1993). An extension of this where labour is set to be human capital-augmented, i.e. $A(t) = Ae^{\varphi(S)}$ with $\phi(S)$ reflecting the efficiency of a unit of labour with S years of schooling relative to one with no schooling ($\phi(S) = 0$) (Hall and Jones 1996).

Thus g measures the proportionate change in output per time period when input levels are held constant. Put differently, g is the proportionate change in output that results from technical progress.

It is convenient to estimate equation A12.2 in logarithmic form as it simply requires the inclusion of a time trend in the usual Cobb-Douglas estimation equation:

$$\log Q_t = \log A + gt + \alpha \log K_t + \beta \log L_t . \qquad \text{(A12.3)}$$

Although production functions with neutral specifications of technical progress are most commonly used in practice, they have definite limitations.

(i) *Constancy of g*

The implication of a constant g that technical progress occurs at a constant rate may not be realistic.

(ii) *Neutrality of the technical progress*

The neutrality of the technical progress implies that it has no effect on the marginal rate of substitution of capital for labour[2] and hence for a given ratio of factor prices does not influence the proportions in which capital and labour inputs are combined.[3] Thus, such technical progress does not affect the capital or labour intensity of the productive process, while it is most probable that technical innovations will either be labour-saving or capital-saving.

A non-neutral technical progress will permit the α/β-ratio to vary over time.

(iii) *Technical progress exogenous and disembodied*

Technical progress in this case is exogenous because it has been superimposed on the system. (A is simply assumed to grow over time for no stated reason.)[4]

Disembodied technical progress is a form of exogenous technical progress, implying that all existing factors of production are transformed, no matter how long these factors have

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2 For equation A12.2 it is still true that $\partial Q_t / \partial K_t = \alpha(Q_t / K_t)$ and $\partial Q_t / \partial L_t = \beta(Q_t / L_t)$ so that

$$MRS = \left(\frac{\beta}{\alpha}\right)\left(\frac{K_t}{L_t}\right)$$

The MRS remains constant for any K/L ratio. This occurrence is known as the Hicks-neutral technical progress. It is also Harrod-neutral, since for any Q/K ratio, the marginal product of capital is left unchanged.

3 This form of technical progress means that the isoquants are all shifted towards the origin, but their slopes at the point where they meet any ray from the origin (i.e. for any K/L ratio) remain unchanged.

4 Extensions of this, such as the modelling of effects of learning and of research and development expenditure, have been developed.

been in existence. This is clearly unrealistic, certainly as far as capital inputs are concerned. The occurrence of some new invention does not normally mean that all existing capital machinery, no matter of what age, can now be fully adapted to take advantage of the new technique (Thomas 1993).

A12.2 Alternative representations of technical progress

(i) *Vintage models*

The estimation of the so-called vintage models was an attempt to deal with the disembodied nature of production functions with a neutral technical progress specification.

The first rigorous attempt to formulate a model of embodied technical progress was that of Solow (1960). In the Solow model, technical progress proceeds at a constant rate g, but affects only newly produced capital goods. Separate production functions exist for machines of different vintages. Thus, if Q_v is the output produced by machines of vintage v (i.e. constructed in year v), K_v is the number of machines of that vintage, and L_v is the labour employed on such machines. Then (assuming a basic Cobb-Douglas form) the production function for machines of vintage v is

$$Q_v = Ae^{gv}K_v^{\alpha}L_v^{B} \qquad \text{(A12.4)}$$

where g is the rate of technical progress. Capital stock of vintage v, K_v, is dependent on investment in machines in the year v and the rate (assumed constant) at which machines depreciate. Total output is the sum of all outputs obtained from machines of all vintages and Solow was able to derive an aggregate production function in which the normal capital stock variable was replace by an index of "effective capital stock". This index was a weighted sum of all machines with weights declining with age.

(ii) *Developments based on cointegration*

Budd and Hobbis (1989) have applied cointegration analysis to the UK production function and in particular to address the problem of how best to represent technical progress. They argue that there are two main sources of technical advance. First, it may come through domestic research effort which they proxy by the number of new patents taken out in the US by UK residents. Secondly, new technology can be imported from abroad and this flow is proxied by imports of new machinery and by royalty payments to foreign countries. These flows are converted into "net stock of technology" variables by a simple cumulating process in which given depreciation rates are assumed.

Capital stock figures are adjusted to take into account that proportion which consists of recently imported machinery (which may be assumed to be technically superior, otherwise it would not have been imported). "Quality-adjusted" capital stock, K is defined as $K^* = K(M/K)^{\gamma}$ where M is the net stock of recently imported machinery and K is the unadjusted capital stock.

A technology index, T, is then defined as $T = aP^{\theta}R^{\phi}$ where P and R are the patents and royalties variables respectively.

A Cobb-Douglas production function of the kind $Q = A^*TK^{*\alpha}L^{B}$ is assumed which, after substitution becomes

$$Q = AL^{\beta}[K(M/K)^{\gamma}]^{\alpha}P^{\theta}R^{\phi} \text{ with } A = A^*a. \tag{A12.5}$$

If the technology variables are unimportant, then $\gamma = \theta = \phi = 0$ and the function reduces to the standard Cobb-Douglas form:

$$Q = AK^{\alpha}L^{\beta}. \tag{A12.6}$$

Budd and Hobbis tested standard forms based on equation A12.6 (with and without a time trend included to represent disembodied technical progress) for cointegration. These production functions invariably failed the cointegration tests and frequently had implausible coefficients. It was possible to find a cointegrating vector only when the technology variables were added to the equations. Hence Budd and Hobbis conclude that the long-run production function is of the form (A12.5) rather than (A12.6) and that technical progress is better represented by their proxy variables than by the traditional time trend.

APPENDIX 13: THE NAIRU/NAWRU CONCEPT: THEORETICAL AND MEASUREMENT ISSUES

A13.1 Basic concept and theoretical model

According to modern labour market literature, NAIRU is defined as the rate of unemployment at which inflation stabilises in the absence of wage-price surprises. Conventional thinking about the equilibrium unemployment rate assumes that, in the long-run NAIRU, is determined solely by supply-side factors of the labour market. However, Pichelmann and Schuh introduced an alternative hypothesis where hysteresis-mechanisms could lead to permanent shifts of equilibrium unemployment over time, implying that an unique long-run NAIRU may not even exist.

Consider the following simple formal exposition of equilibrium unemployment given by Pichelmann and Schuh (1997):

Firms set prices as a mark-up over expected wages:

$$p - w^e = \beta_0 - \beta_1 u \qquad \text{(A13.1)}$$

with β_0 denoting "price-push" factors (e.g. oil shocks, productivity slowdown) and with the mark-up depending (at least in the short-run) upon the state in the labour market.

Workers demand wages in relation to existing prices:

$$w - p^e = \gamma_0 - \gamma_1 u \qquad \text{(A13.2)}$$

with $\gamma_1 > 0$ because of union bargaining or efficiency wage considerations, and with γ_0 denoting "wage-push" factors (e.g. unemployment benefits, union power).

Solving for u yields

$$u = (\beta_0 - \gamma_0)/(\beta_1 + \gamma_1) - 1/(\beta_1 + \gamma_1)[p - p^e + w - w^e]\,. \qquad \text{(A13.3)}$$

When there are no wage-price surprises

$$u = (\beta_0 - \gamma_0)/(\beta_1 + \gamma_1) = u^*]$$

with u^* denoting the no-surprise equilibrium rate of unemployment.

Assuming real wages to equal expected real wages and expected inflation equals last year's inflation, give the underlying inflation-unemployment trade-off (standard Phillips-Curve):

$$\Delta\pi = \theta_1 (u^* - u)\,. \qquad \text{(A13.4)}$$

Inflation will only remain unchanged in this setting, when actual unemployment equals u^*. Thus, the effects of aggregate monetary and fiscal policy, as well as of other types of demand shocks, are in the long-run constrained by this fundamental supply-side relationship. From this perspective, the only sustainable way to bring down unemployment is to reduce u^*.

The model is usually closed by introducing a conventional downward sloping aggregate demand schedule whereby lower prices elicit higher demand via real balance effects (and/or lower interest rates, improved competitiveness). Thus, demand disturbances may lead to cyclical unemployment, i.e., deviations of actual unemployment from its equilibrium level as defined above.

In the simple framework outlined above, movements in unemployment can be caused by shifts in aggregate demand giving rise to cyclical unemployment, and by shifts in the price or wage-setting schedules which change equilibrium unemployment.

The textbook theory claims that negative (positive) demand disturbances may temporarily push actual unemployment above (below) its equilibrium level, but over the medium term the ensuing process of disinflation (inflation) will inevitably drive unemployment back to equilibrium. The conventional approach then continues to argue that the degree of nominal inertia is simply not high enough to explain the sustained increase in unemployment in Europe. Thus, the theory concluded there must have been unfavourable shifts in the fundamental supply-side determinants of the NAIRU. The policy implication then, of course, is to press for supply-side reform.

However, despite considerable efforts, it has been hard to identify changes in the basic determinants of equilibrium unemployment large enough to account for the observed trend increase in actual unemployment. Consequently, the alternative hypothesis has been put forward that unemployment may be strongly dependent on its own history (hysteresis). According to this view, current equilibrium unemployment is not independent of past actual unemployment, because of endogenous mechanisms that tend to translate movements in actual unemployment into changes of equilibrium unemployment. The presence of such mechanisms blurs the simple-minded distinction between demand and supply factors because demand shocks eventually have longer-term supply-side consequences.

The distinguishing feature of a process characterised by hysteresis is that the behaviour of the process cannot be described by reference to state variables alone. Instead, in addition to state variables the past history of the process has to be invoked in order to explain its behaviour.

The following simple technical exposition is used to show how traditional economic thinking about the trade-off between unemployment and inflation is altered when the evolution of unemployment is subject to hysteresis effects. As a starting point, consider the following general formulation of the Phillips curve:

$$\pi = \pi^e + \theta_1(u^* - u) \qquad \text{(A13.5)}$$

where π and π^e denote, respectively, the actual and expected rates of inflation and u is the rate of unemployment. Equilibrium unemployment (NAIRU) corresponds to the steady-state situation when actual inflation is equal to expected inflation, so that $u = u^*$. Then, u^* itself is usually assumed to be determined by a set of structural factors affecting the demand and supply-side of the labour market, but to be invariant with respect to business cycle conditions. Thus, denoting the relevant explanatory variables by X:

$$u^* = bX . \qquad \text{(A13.6)}$$

The possibility of hysteresis arises when equilibrium unemployment in a given period also depends on actual unemployment in the past, as e.g. in

$$u_t^* = \alpha u_{t-1} + bX . \qquad \text{(A13.7)}$$

In a steady state, where actual inflation is equal to expected inflation and unemployment is constant, equilibrium unemployment is now given by:

$$u^* = bX/(1-\alpha) . \qquad \text{(A13.8)}$$

Therefore, when last period's actual unemployment is fully translated into equilibrium unemployment in the next period $(\alpha = 1)$, then steady-state equilibrium is no longer uniquely defined. Any change in actual unemployment, e.g. brought about by macroeconomic policies, would also alter the NAIRU by the same amount; such a situation has been labelled as pure hysteresis. When actual unemployment feeds only partly into future equilibrium unemployment $(0 < \alpha < 1)$ there is persistence in unemployment in the sense that the NAIRU evolves only slowly towards its steady state (long-run) level ("speed-limits").

The conventional way to introduce hysteresis mechanisms[1] into the analysis is by adding into the wage equation an additional term denoting the change in unemployment:

$$w - p^e = \gamma_0 - \gamma_1 u - \gamma_2 \Delta u \qquad \text{(A13.9)}$$

where in the case of pure hysteresis it is only the change term that matters. Thus, most explanations for hysteresis generating mechanisms focus on the behaviour of labour market participants, changes in their productive capacity caused by unemployment, and on the resulting consequences for wage bargaining and the matching process between workers and jobs.

A13.2 Measurement issues

The general consensus among economists is that there exists, at least in the long-run, a unique "equilibrium unemployment rate" (i.e. the "NAIRU") which is consistent with stable inflation. In practice, rules for the conduct of monetary policy or programs to reduce unemployment are guided by empirical estimates of the NAIRU. The construction of estimates of the NAIRU,

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1 See Pichelmann and Schuh (1997) for a survey on hysteresis mechanisms.

however, suffers from the fundamental problem that the NAIRU is an unobserved variable, so that there exist leeway for a broad range of plausible methodological approaches for the estimation of the equilibrium unemployment rate.

A13.2.1 Time-series approaches

A widely used method to construct estimates of the NAIRU relies on time-series methods, which are based solely on data of the unemployment rate. Univariate methods proceed by decomposing the unemployment rate into a deterministic and a stochastic component. The deterministic component of the series is then interpreted as the equilibrium unemployment rate whereas the stochastic component represents the cyclical development of the unemployment rate. In order to obtain an estimate of the NAIRU, it has to be ensured that the deterministic part of the unemployment rate is uncorrelated to inflation. This approach has various advantages: it is easy to construct estimates of the NAIRU and theoretical issues (i.e. misspecification of the "model") can be avoided to a large extent.

The simplest univariate specification assumes that the unemployment rate is a realisation of a stationary process, with its expectations being the (time-constant) NAIRU:

$$u_t = \sum_{i=1}^{p} \phi_i u_{t-i} + e_t \qquad \text{(A13.10)}$$

where the random variable $e_t \approx iid$ with mean 0, satisfying:

$$E[u_t] = \bar{u} \qquad \text{(A13.11)}$$
$$E[u_t - u_{t-1}] = 0\,. \qquad \text{(A13.12)}$$

This specification is in accordance to the basic model specified in section 1, which would, in the absence of any change of structural factors of the labour market, imply that the equilibrium unemployment rate is constant over time. A look at various countries' unemployment rates reveals, however, that actual unemployment rates exhibit considerable deviations from the long-run mean over time. According to the previous discussion this could be due to changes in the structural factors of the labour market, so that the equilibrium rate shifts from time to time. This possibility is taken into account when constructing estimates of the NAIRU which allow for "breaks" in the series, so that (A13.11) becomes:

$$E[u_t] = u_i \;\text{ if }\; t_{i-1} < t \le t_i; \quad i = 1,....,I\,. \qquad \text{(A13.13)}$$

A problem arises within this model as the breaks are treated as being known with certainty. In practice however, it is difficult to determine the exact timing when the NAIRU might switch from one regime to another, so that an additional source of imprecision is added to these estimates.

However, since the 1980s a growing number of empirical studies suggest that the equilibrium unemployment rates may be described by non-stationary time-series, i.e. that they follow a stochastic trend so that:

$$E[u_t] = E[u_{i-1}] + \eta_t \tag{A13.14a}$$

or

$$u_t - u_{i-1} = a + \eta_t \tag{A13.14b}$$

with the parameter a representing the deterministic and η the stochastic component of the trend.

This implies that an "equilibrium" value to which the unemployment reverts in the long-run does not exist. This specification of the NAIRU concurs with the theoretical view, described in section 1, that hysteresis factors are at work in the labour market, i.e. that the NAIRU depends on the historical evolution of actual unemployment.

Structural Time Series Models as proposed by Harvey (1989) represent an appropriate methodological tool to construct estimates of the (unobserved) stochastic components of unemployment rates. The models assume that the NAIRU may be driven by simple but flexible stochastic processes. A standard specification of a univariate structural time-series model of the NAIRU is:

$$u_t = u_t^* + uc_t + i_t \tag{A13.15a}$$
$$u_t^* - u_{t-1}^* = a_{t-1} + e_t \tag{A13.15b}$$
$$a_t = a_{t-1} + \eta_t \tag{A13.15c}$$

where u is actual unemployment, u^* represents the trend unemployment rate, which may then be interpreted as the NAIRU, uc is the cyclical unemployment rate, which follows a stochastic cycle.

A13.2.2 Wage-price models

The fundamental drawback of the time-series approach for the estimation of the NAIRU is that it does not provide causal explanations for the development of the "equilibrium" unemployment rate. Estimates based on the univariate time-series methodology therefore form no sound basis for policy interventions as they leave the interactions between the economic variables indeterminate.

Econometric models based on the theoretical model describe in section 1 take the interdependence between economic variables into account. Empirical results obtained form these models thus allow for causal interpretations of the NAIRU estimates. In contrast to time-series models, movements of the NAIRU are explained by various labour market variables (i.e. wage or price pressure elements) which are inserted into the empirical models.

One commonly applied method to estimate the equilibrium unemployment rate is based on the wage equation described in section 1(A13.9), written in log-linear form:

$$\Delta(\log(w_t)-\log(p_t))=\beta_0+\beta_1(L)(\log(\pi_t)-\log(\pi_t^e))-\beta_2(U_t-NAWRU_t)+\beta_3\Delta U_t+\beta_4\log(x_t)+\beta_5\log(A_w)+\omega_t \quad \text{(A13.16)}$$

where NAWRU represents the equilibrium unemployment rate, x depicts productivity and Z_w are variables representing wage pressure elements (such as unemployment benefits, taxation, labour market mismatch, employment protection, etc.) and the change of the unemployment rate is inserted to capture possible hysteresis effects. Thus, the NAWRU may move over time due to changes in wage pressure elements or as a consequence of hysteresis effects. As this specification relates wage inflation rather than price inflation to movements of the unemployment rate, corresponding estimates of the equilibrium unemployment rate are referred to as the NAWRU (non-accelerating wage rate of unemployment). By imposing the long-run homogeneity restriction, namely that real wage growth must be proportional to productivity growth, this specification implies that it is possible to analyse the long-run equilibrium properties of the equilibrium unemployment rate.

In order to construct an estimate of the NAWRU, a model for inflationary expectations has to be developed for the estimation of the equation. A commonly used approach is to use lagged inflation rates as a proxy for "price surprises". Alternatively, some consensus or median forecast of inflation can be used in order to depict "expected inflation". Another commonly used possibility to construct estimates of the NAIRU is to use the standard Phillips-curve relation (A13.4):

$$\pi_t-\pi_t^e=\beta(L)(u_{t-1}-NAIRU_t)+\delta(L)(\pi_{t-1}-\pi_{t-1}^e)+\gamma(L)X_t+e_t \quad \text{(A13.17)}$$

where π^e represents expected inflation, L is the lag operator and X represents additional regressors included in some empirical specifications. As in the case of the NAWRU-estimates described above, the need for a model of inflationary expectations arises. This specification forces the equilibrium unemployment rate, the NAIRU, to satisfy the steady-state condition that expected inflation must equal actual inflation. A drawback of the Phillips-Curve formulation is that "surprises" of nominal wage inflation (deviations of actual wages from their expected values) have to be treated as non-existent.

The discussion in section 1 indicated that both price setting and wage formation incorporate important information on the development of the NAIRU. It should thus be expected that estimates of the NAIRU can be improved by analysing both price and wage setting. This can be achieved by combining the wage setting curve (A13.16) with the price setting schedule (A13.17):

$$D(\log(p_t)-\log(w_t))=a_0-a_1(L)D(\log(w_t-\log(w_t^e))+a_3\log(y_t)-a_4\log(Z_{p_t})+e_t \quad \text{(A13.18)}$$

where y is the level of output market activity and Z_p captures "price pressure" variables as describe in section 1.

The NAIRU is then estimated by simultaneous estimation of equations (A13.16) and (A13.18) and solving for unemployment. This method allows the imposition of homogeneity restrictions both on price setting and on wage formation and thus implies that the estimate of the NAIRU satisfies the necessary conditions for the labour market equilibrium as described in section 1. The estimation of a wage-price system allows for the distinction between the impact of structural factors on wage formation and price setting respectively.

Although there exists a great number of empirical estimates of the NAIRU, there is an apparent lack of discussion about the precision of these estimates. In fact, two fundamental types of uncertainty may contribute to the imprecise measurement of the equilibrium unemployment rate. The first source of uncertainty arises from the fact that the NAIRU is an unobserved variable that leaves room for a number of plausible empirical models for its measurement. Different specifications generally lead to different point-estimates of the level of the NAIRU. The exposition above provided an overview of different possible approaches to the measurement of the equilibrium unemployment, all of which concur with the theoretical model of the NAIRU. The most important difficulty in this context arises from the possibility that in the long-run, the level of the NAIRU may be indeterminate, rendering the NAIRU stochastic in nature. Examples are presented by Pichelmann and Schuh (1997).

APPENDIX 14: COST OF CAPITAL: A NEOCLASSICAL APPROACH

The pioneer of neoclassical theory, Jorgenson (1963), defines the cost of capital as the cost which the firm incurs as a consequence of owning an asset. The cost of capital transforms the acquisition price of an asset into an appropriate rental price. This cost depends on the rates of return and depreciation. The rate of return is the opportunity cost of holding capital goods rather than financial assets. Depreciation arises from the decline in the price of capital goods with age (Jorgenson 1993: 4).

The neoclassical theory of capital accumulation is formulated in two alternative yet equivalent ways. First, the firm may accumulate capital to supply the service to itself. The objective of the firm is to maximise its value, subject to its technical limitations. Secondly, the firm may rent the assets in order to obtain a capital service. In this case the objective of the firm is to maximise its current profit, defined as gross revenue less the cost of inputs less the rental value of capital. The rental can be calculated from the relationship between the price of new capital goods and the discounted value of future services received from these goods (Jorgenson 1993: 4).

According to Jorgenson (1993), in the absence of direct taxes, this relationship takes the form:
$q_t = \int e^{(-r)(s-t)c(s)-\delta(\theta - t)} ds$;
where r is the discount rate, q the price of capital goods, c the cost of capital services and δ the rate of replacement (depreciation). The time of acquisition is given by t and time s is the time during which capital services are supplied (Jorgenson 1993: 4).

Differentiating this with respect to t gives $c = q(r + \delta) - \dot{q}$, which is the rental price of capital services supplied by the firm to itself. Under static expectations about the price of investment goods, the rental price reduces to $c = q(r + \delta.)$.

To extend the formula to allow for taxation, Jorgenson (1993) defines a depreciation formula $D(s)$ to calculate the proportion of the original cost of an asset of age s, which may be deducted from taxes. Jorgenson also assumes a tax credit k that may be deducted from investment expenditure. If the tax rate is constant over time at rate u, the equality between the price of investment goods and the discounted value of capital services is:

$$q_t = \int e^{(-r)(s-t)} [(1-u)c(s)e^{-\delta(\vartheta - t)} + u(1-k)q(t)D(s)]ds + k\, q_t .$$

Allowing the present value of depreciation on one rand's worth of investment to be denoted by z gives:

$$z = \int e^{-rs} D(s)ds .$$

The rental value of capital under static expectations then becomes:

$$c = q(r + \delta) \times \frac{(1 - k)(1 - uz)}{(1 - u)} .$$

There are at least three depreciation formulae, which can be applied when calculating *z*. After calculating the cost of capital, it can be used as one of the most important determinants in a neoclassical investment function and subsequently a production function. By including this variable, any effect of a change in tax, interest rates or depreciation can be investigated. Through this variable, a tax reduction will, for example, influence investment behaviour and eventually aggregate supply (Jorgenson 1993: 4).

The effect of tax policy on investment behaviour enters the investment function through the rental value of capital. This results in a change in the desired level of capital. Such a change leads to net investment (or disinvestment), increasing (or decreasing) capital stock to its new desired level (Jorgenson 1993: 4).

The user-cost-of-capital (*r*) can be expressed as:

$$r = price\ of\ capital\left(\frac{(interest\ rate)-(inflation\ rate)+(rate\ of\ depreciation)}{1-tax\ ratio}\right)$$

To summarise: this measure for user-cost-of-capital combines four effects. The first relates to an opportunity cost to invest and, based on the long-run nature of investment, is approximated by the yield on long-term government bonds. Second, fluctuations in the price of capital may lead to losses or gains for a firm when it sells its capital at the end of a period. A capital gain (loss) would reduce (increase) the user-cost-of-capital. These gains/losses can be approximated by the rate of inflation times the price of capital. A third cost for the owner of capital stems from the depreciation of capital, while the fourth component is taxes, resulting in a difference between the pre-tax and after-tax rates of return on capital.

APPENDIX 15: LONG-RUN RESPONSE PROPERTIES

Figure A15.1(a) Long-run elasticities of the full supply-side model : 10% shock to real GDP at factor cost (actual and smoothed)

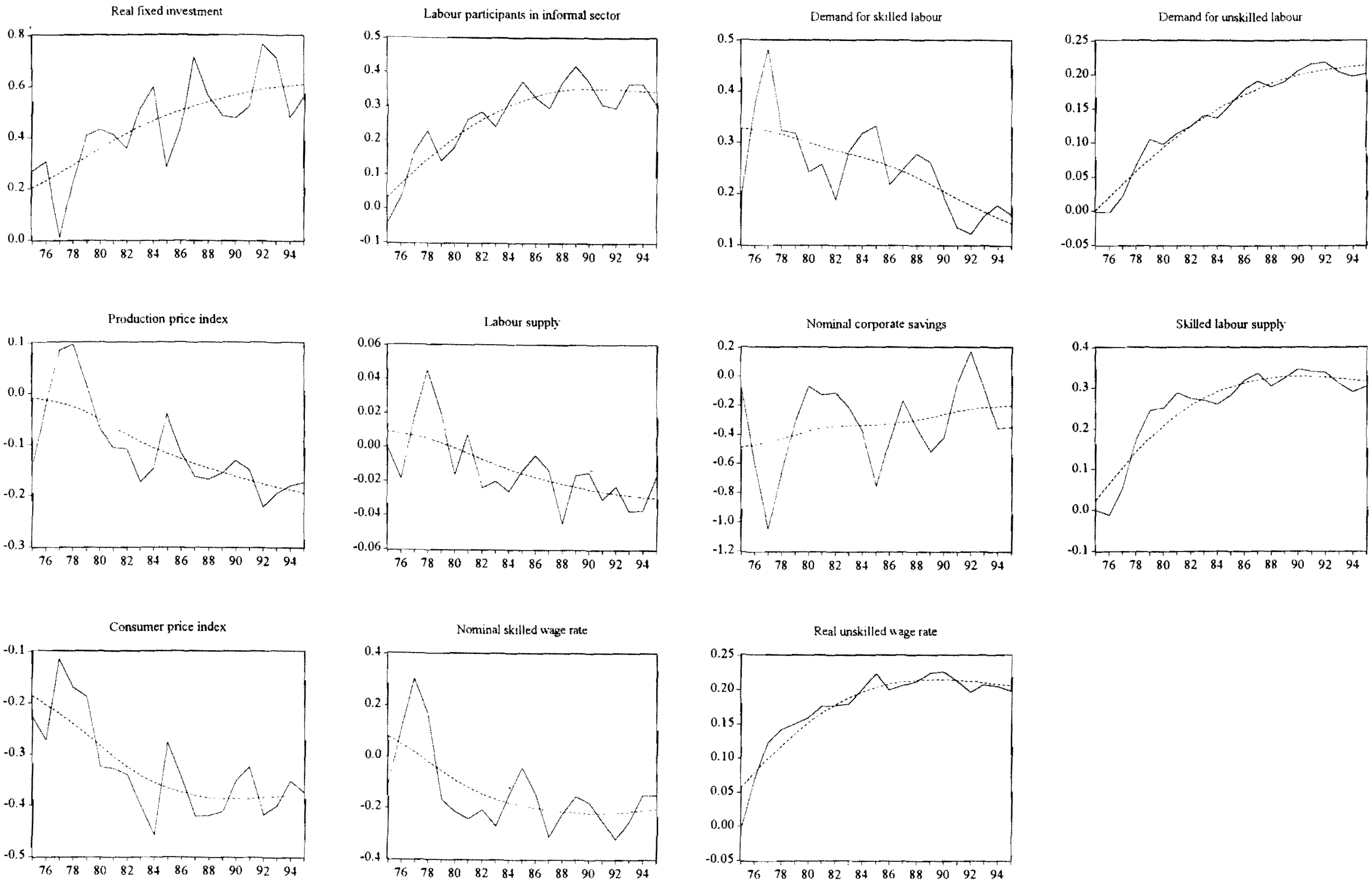


Figure A15.1(b) Long-run multipliers of the full supply-side model : 10 % shock to real GDP at factor cost in 1975 (actual and smoothed)

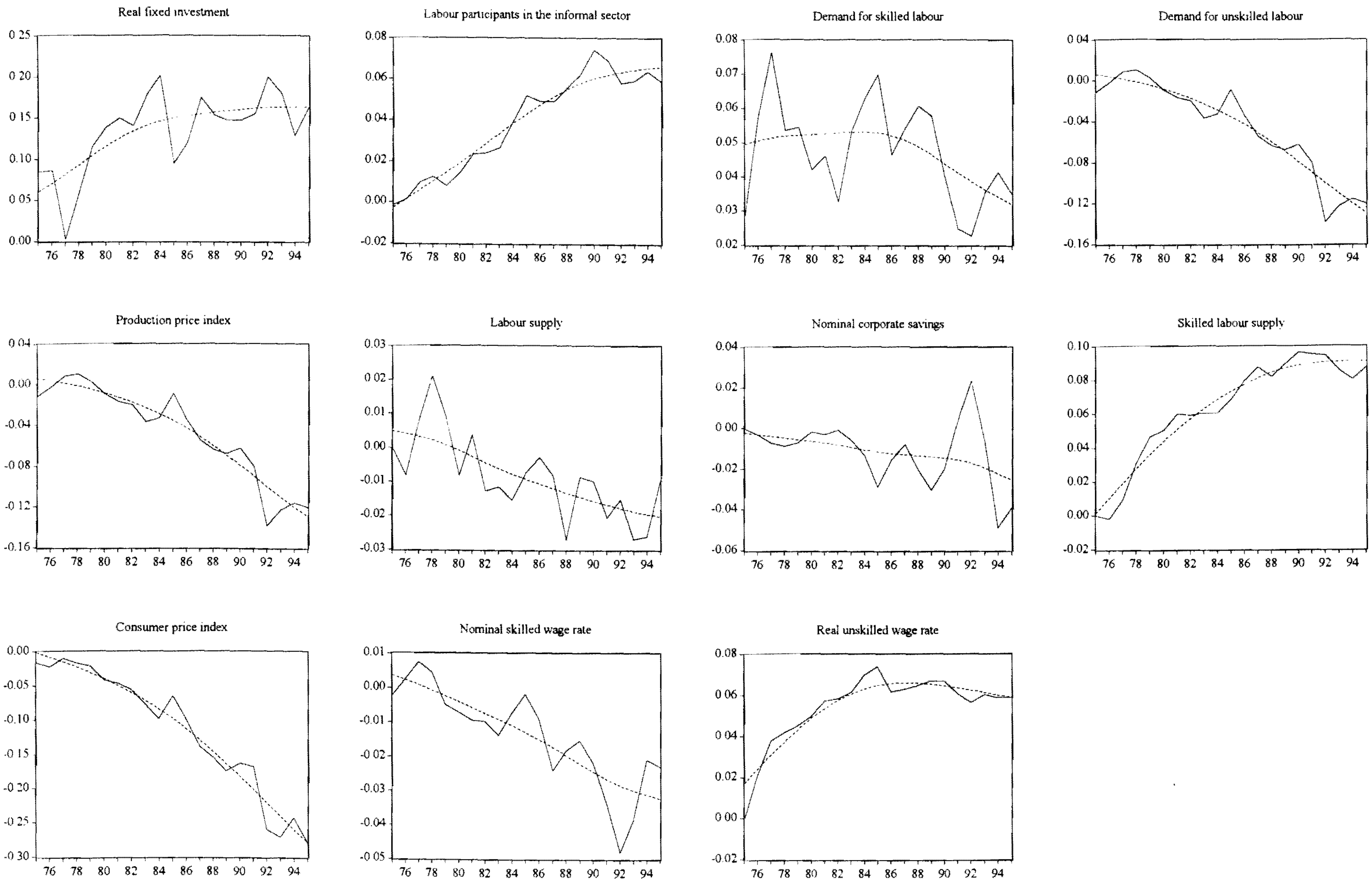


Figure A15.2(a) Long-run elasticities of the full supply-side model : 10% shock to real fixed investment (actual and smoothed)

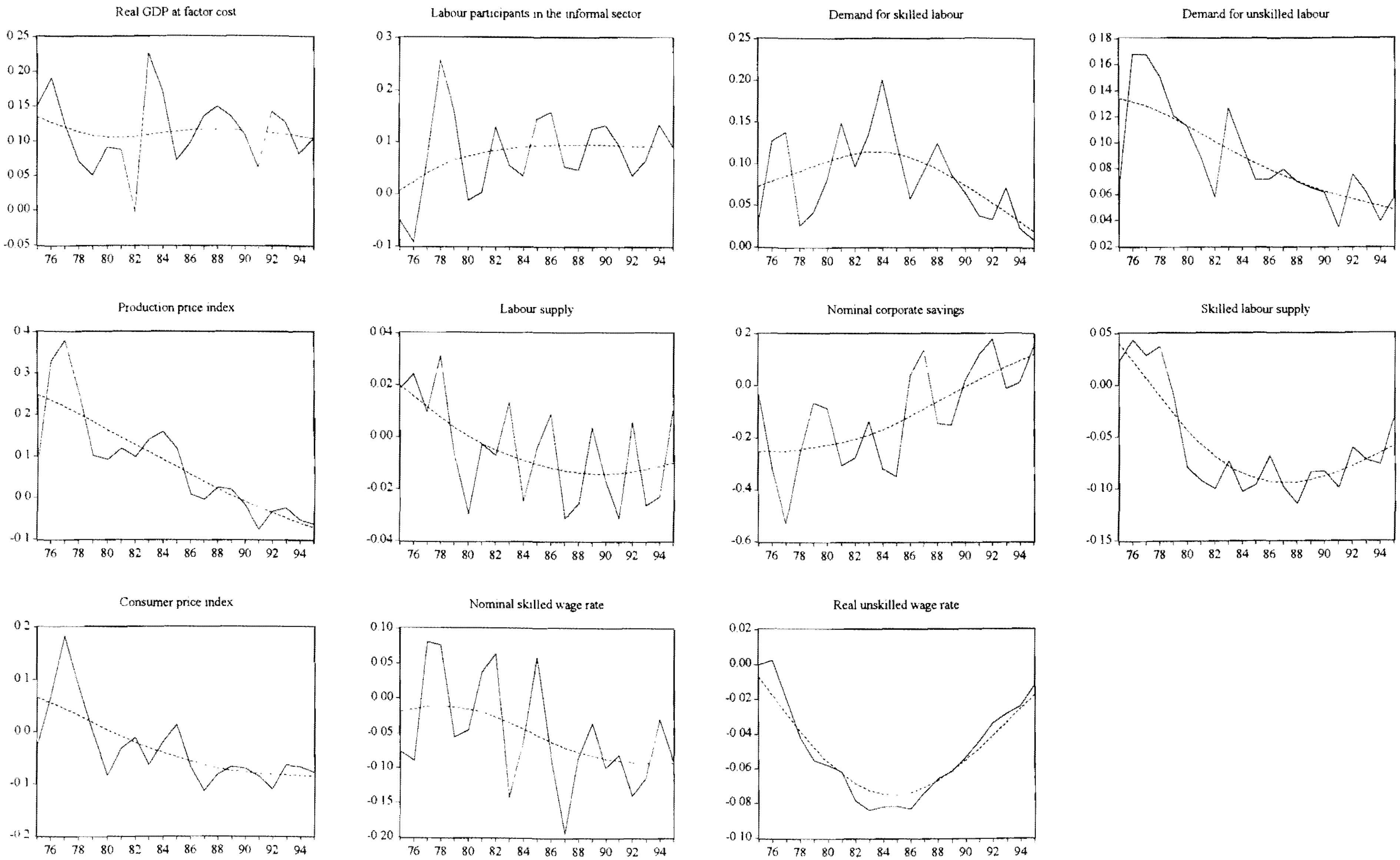


Figure A15.2(b) Long-run multipliers of the full supply-side model : 10% shock to real fixed investment in 1975 (actual and smoothed)

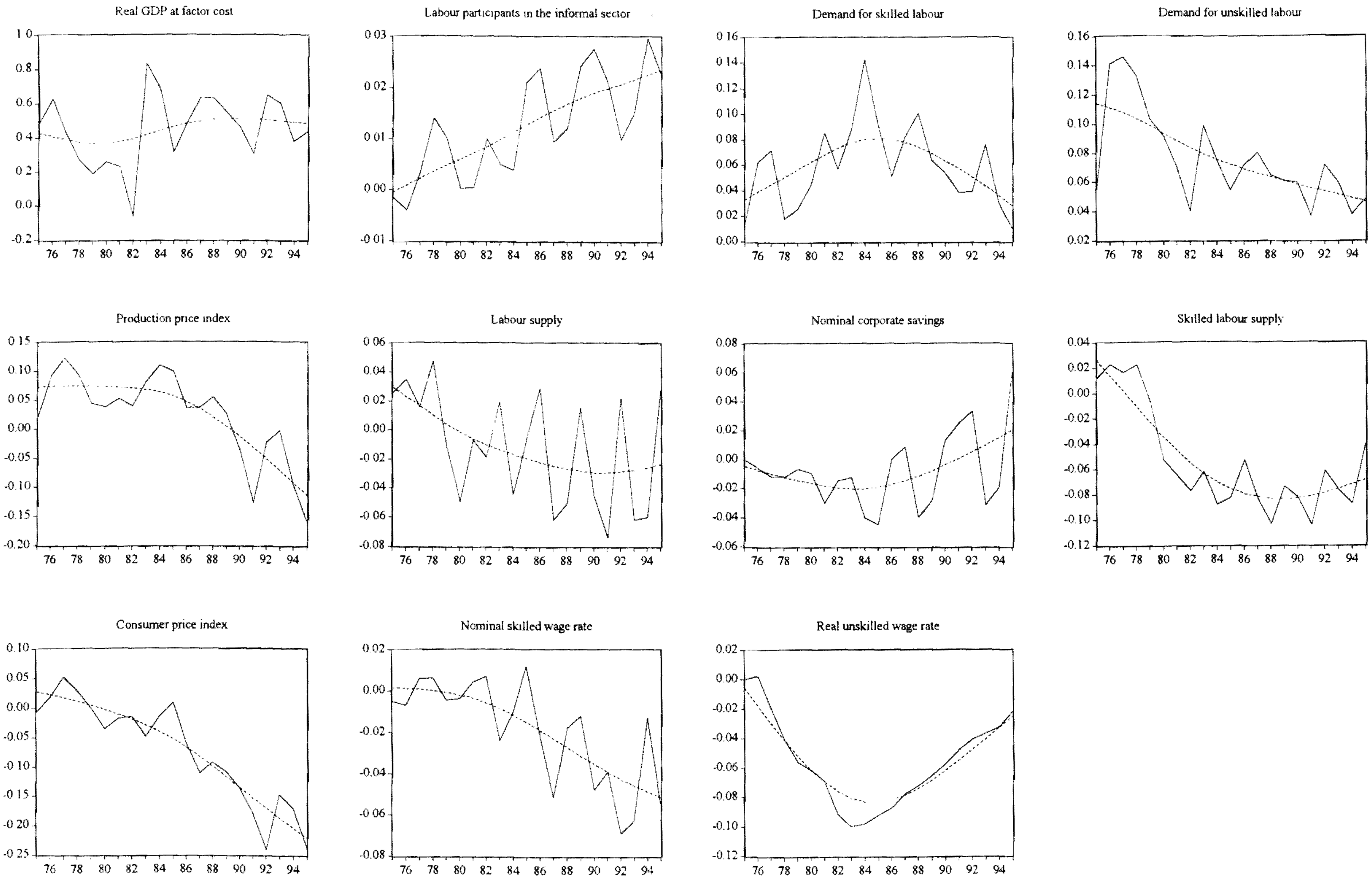


Figure A15.3(a) Long-run elasticities of the full supply-side model : 10% shock to nominal corporate savings (actual and smoothed)

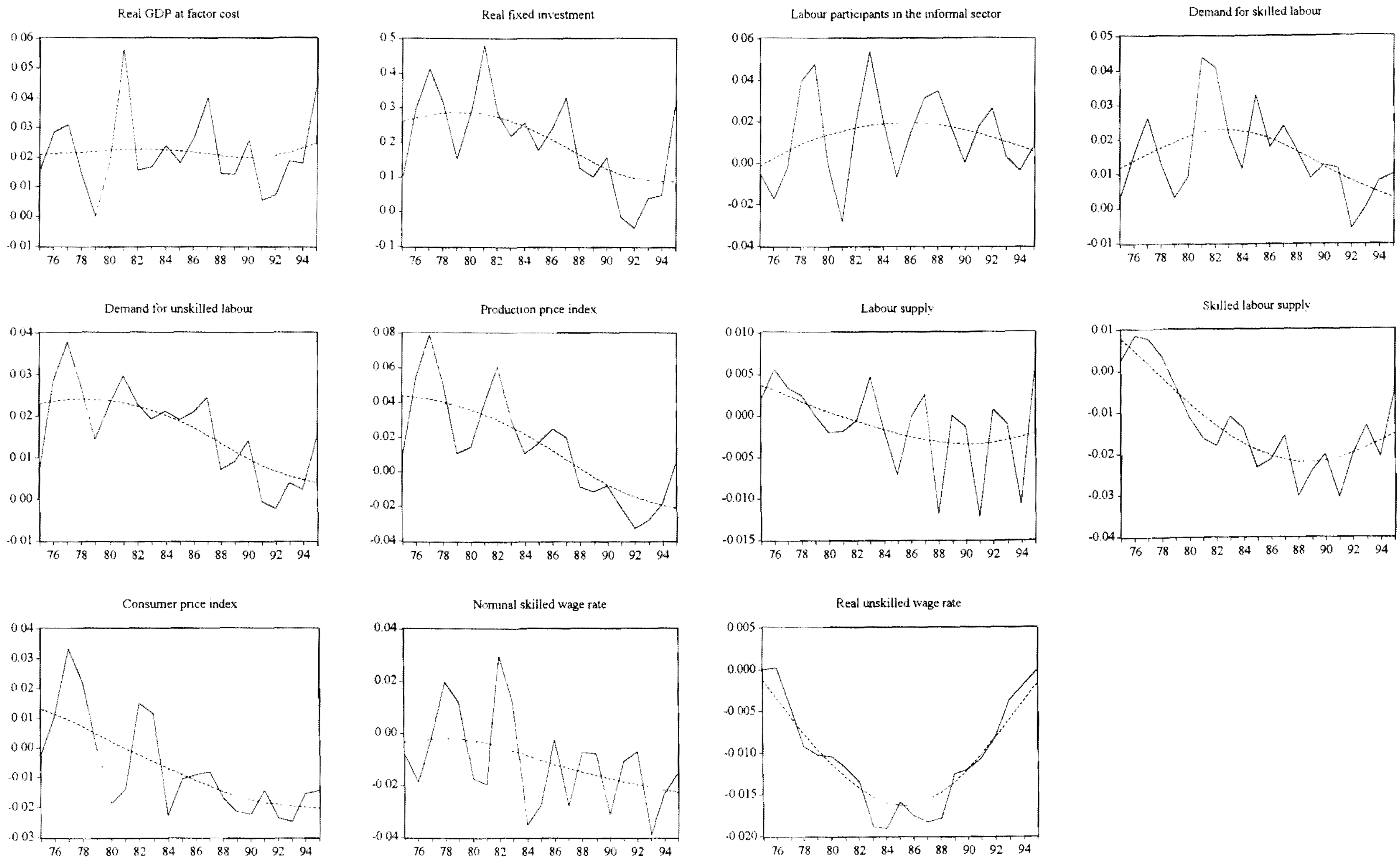


Figure A15.3(b) Long-run multipliers of the full supply-side model : 10% shock to nominal corporate savings in 1975 (actual and smoothed)

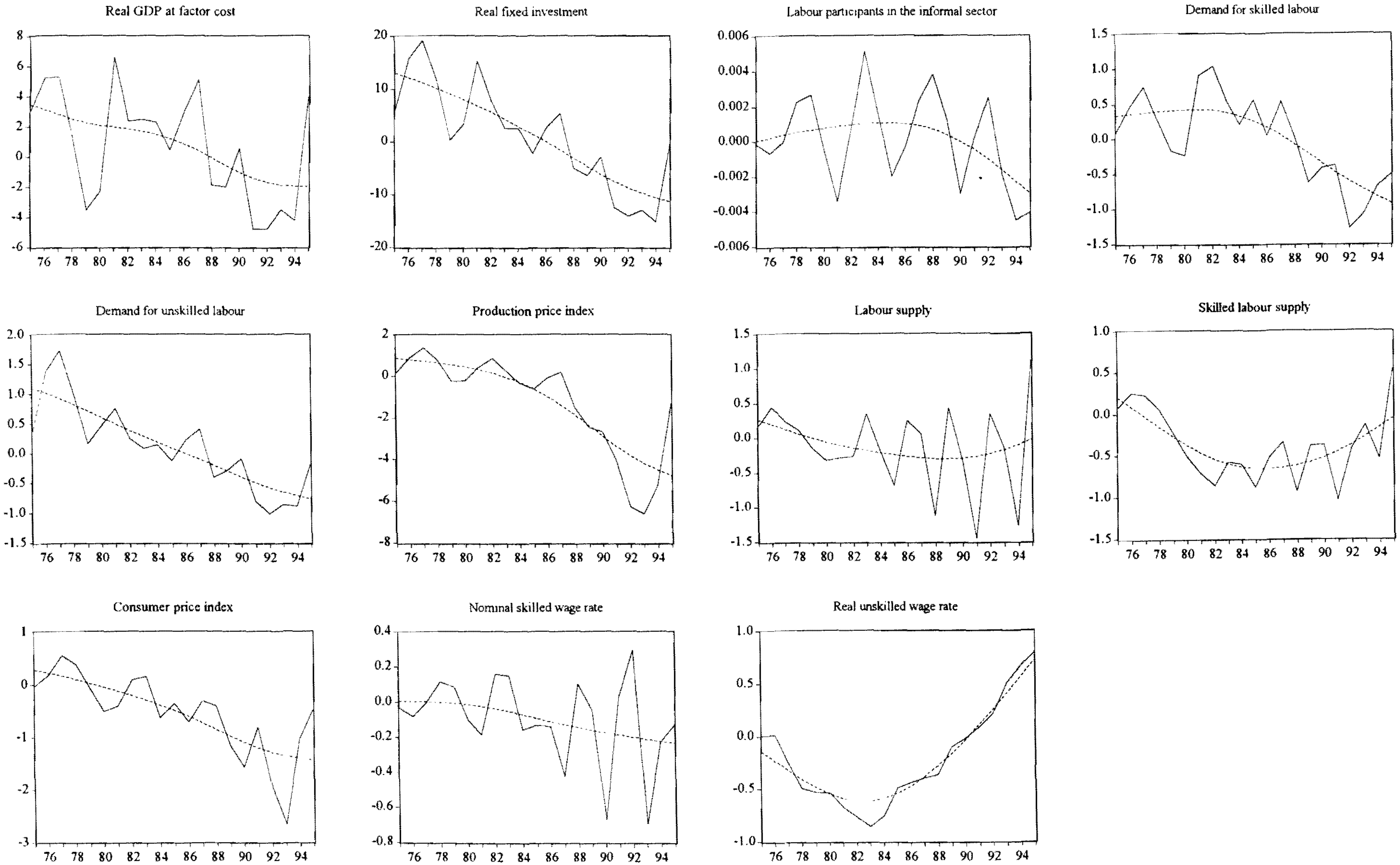


Figure A15.4(a) Long-run elasticities of the full supply-side model : 10% shock to demand for skilled labour (actual and smoothed)

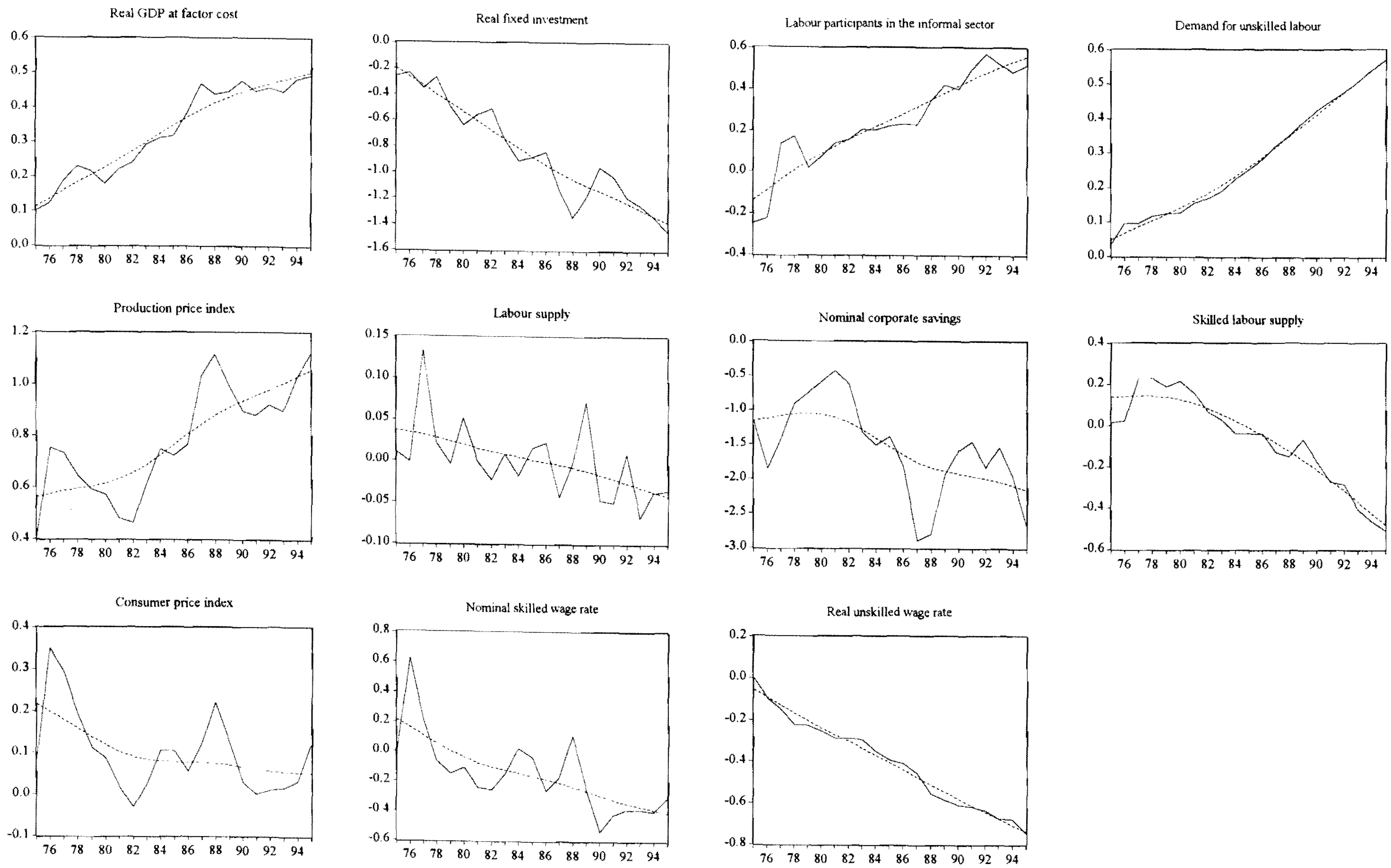


Figure A15.4(b) Long-run multipliers of the full supply-side model : 10% shock to demand for skilled labour in 1975 (actual and smoothed)

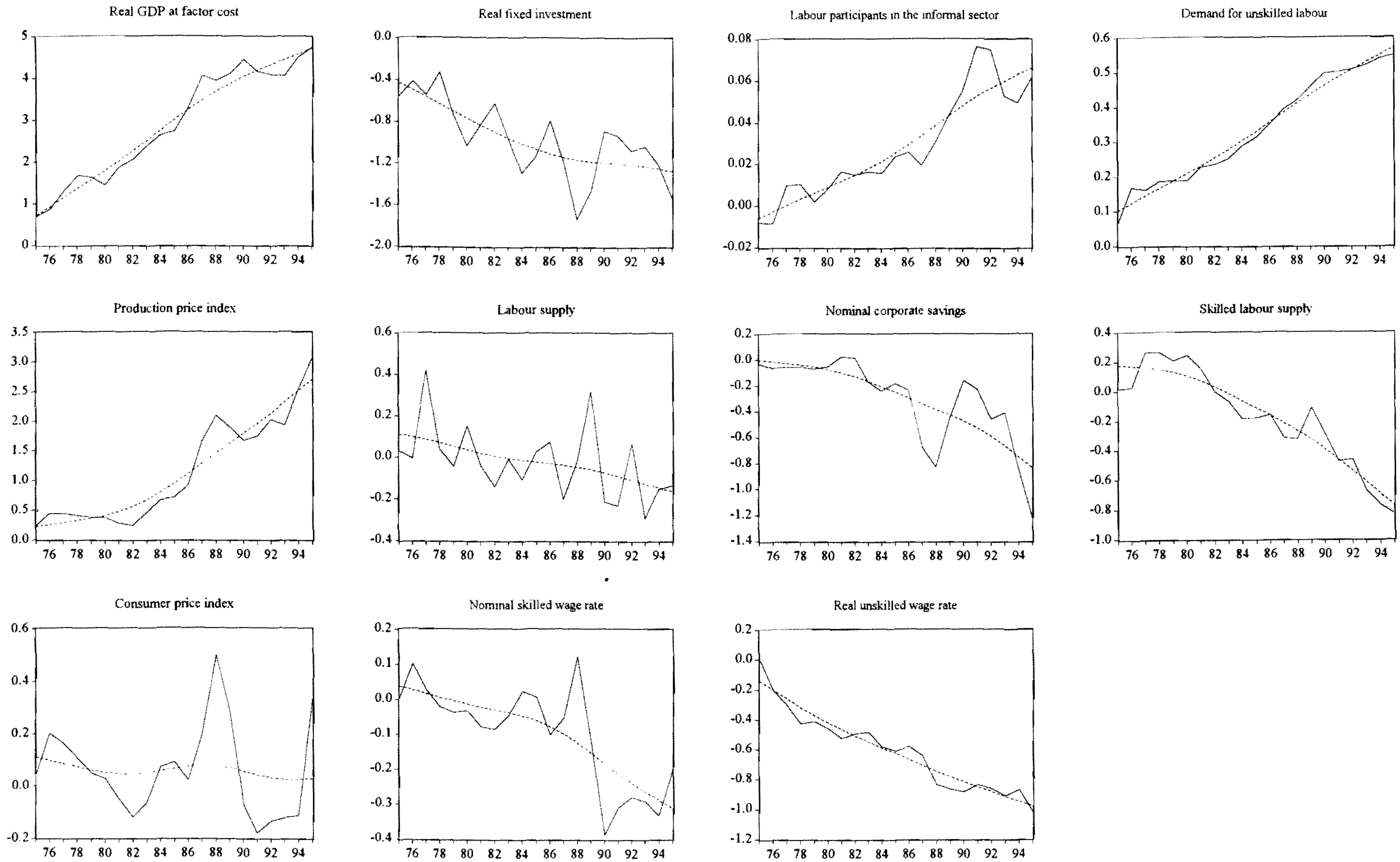


Figure A15.5(a) Long-run elasticities of the full supply-side model : 1% shock to demand for unskilled labour (actual and smoothed)

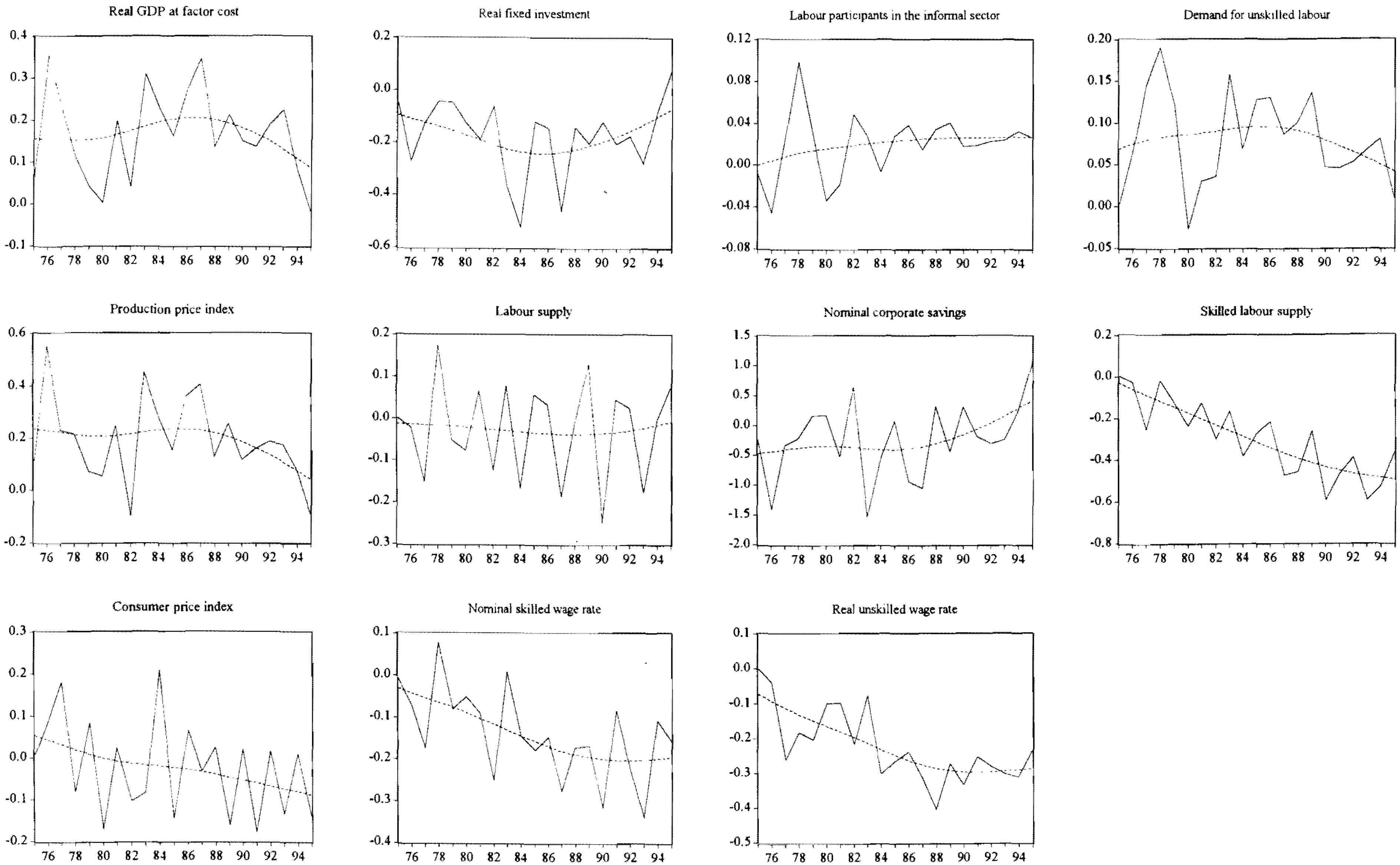


Figure A15.5(b) Long-run multipliers of the ful supply-side model : 1% shock to demand for unskilled labour in 1975 (actual and smoothed)

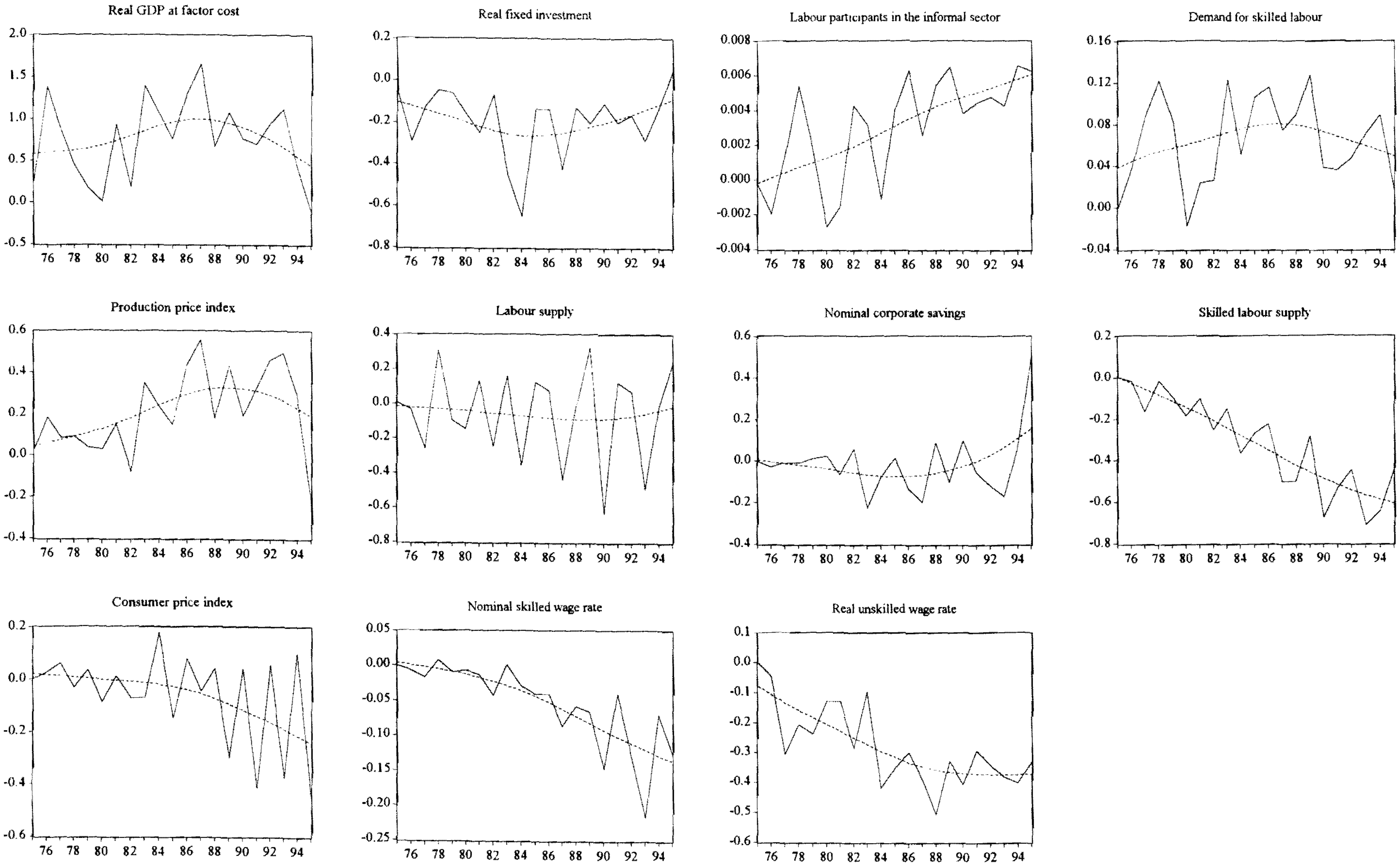


Figure A15.6(a) Long-run elasticities of the full supply-side model : 10% shock to labour supply (actual and smoothed)

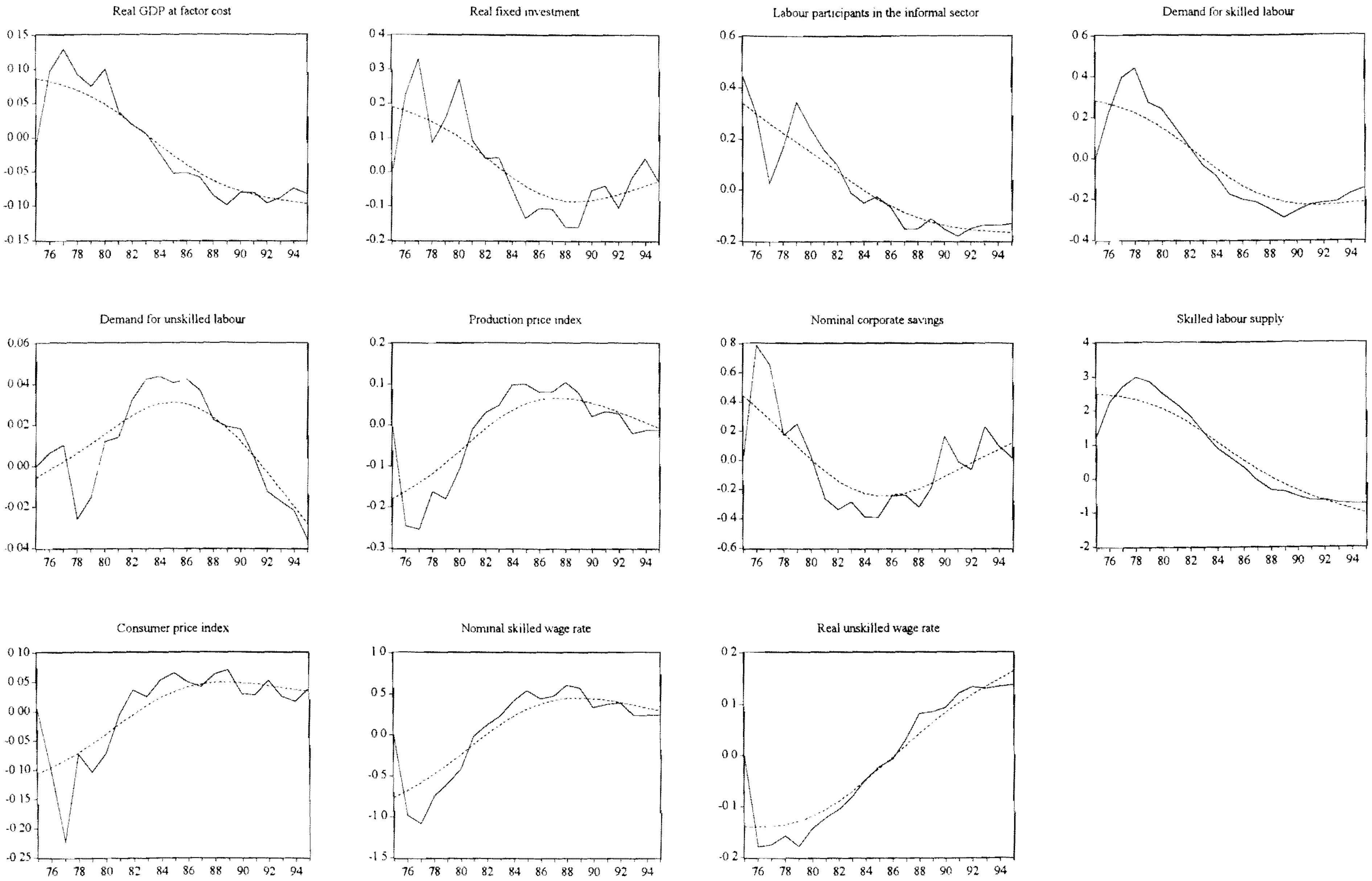


Figure A15.6(b) Long-run multipliers of the full supply-side model : 10% shock to labour supply in 1975 (actual and smoothed)

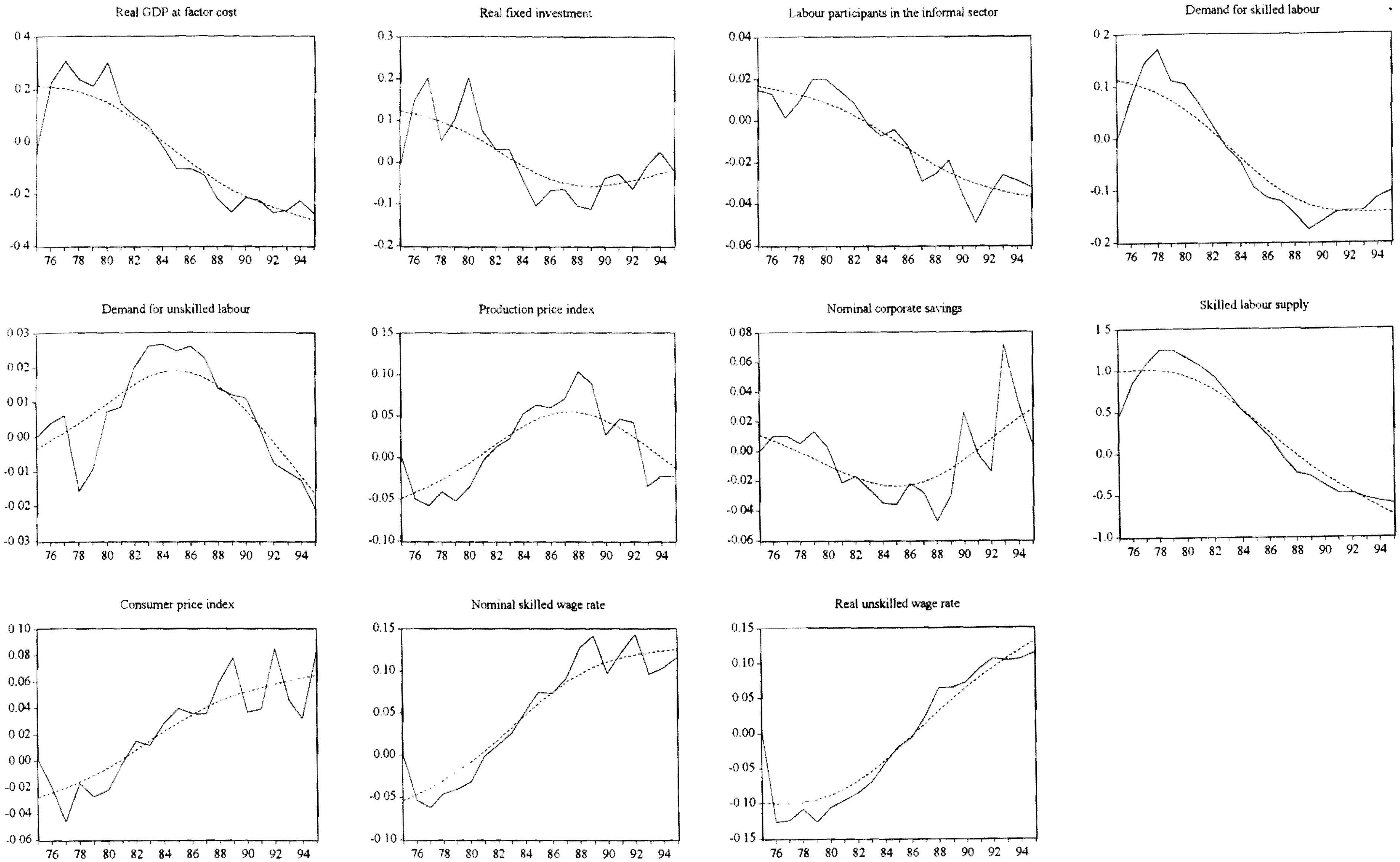


Figure 15.7(a) Long-run elasticities of the full supply-side model : 10% shock to skilled labour supply (actual and smoothed)

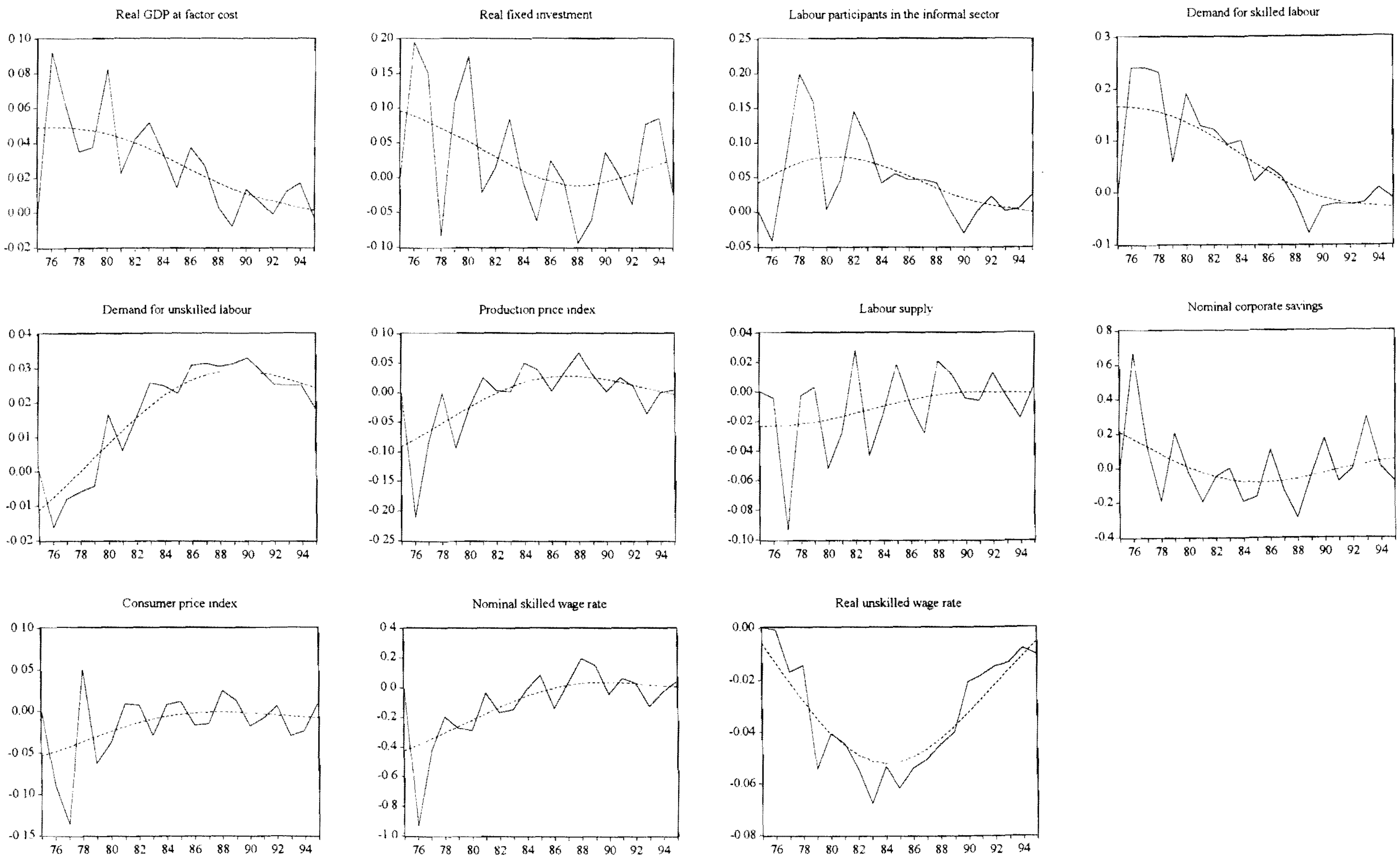


Figure A15.7(b) Long-run multipliers of the full supply-side model : 10% shock to skilled labour supply in 1975 (actual and smoothed)

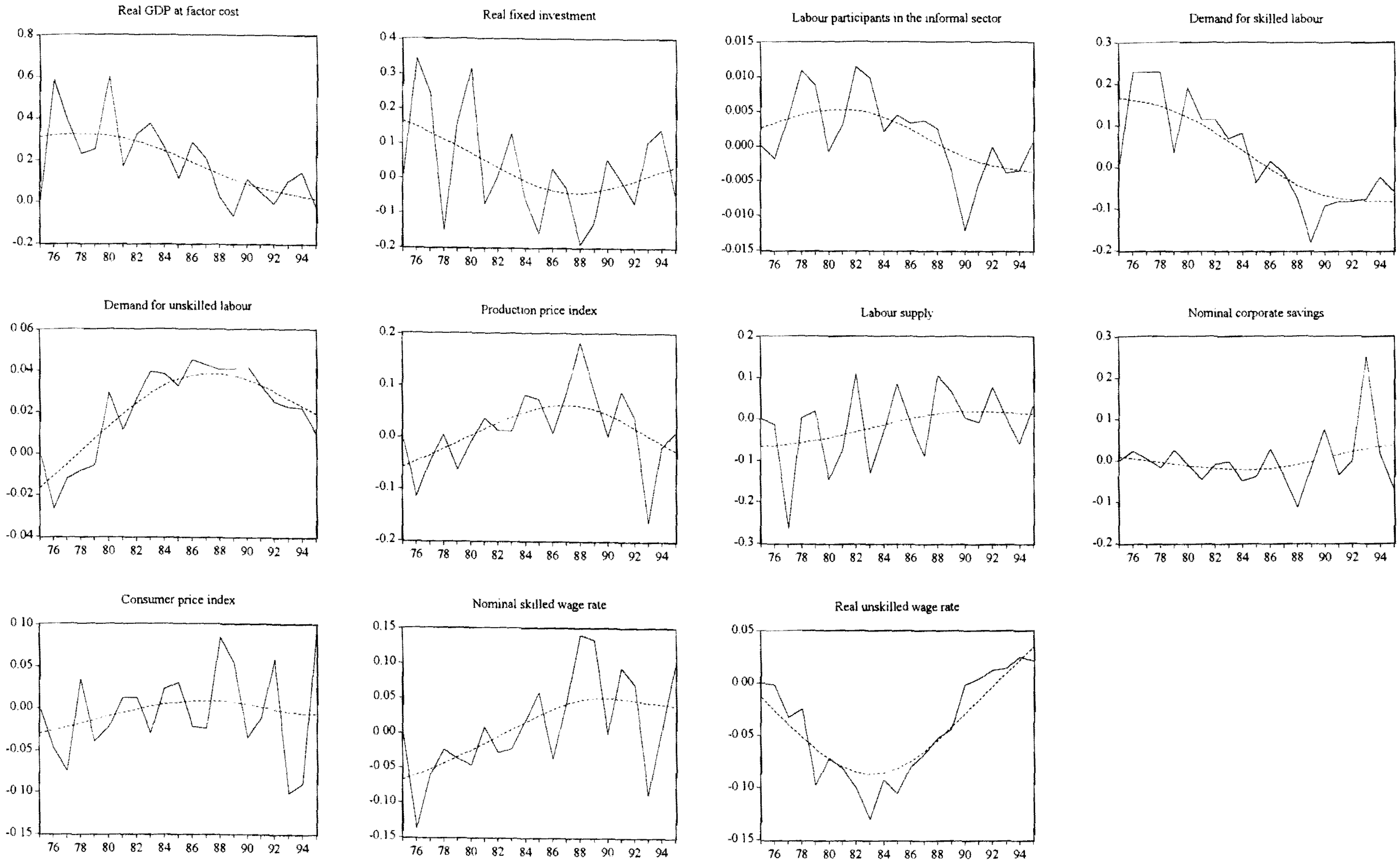


Figure 15.8(a) Long-run elasticities of the full supply-side model : 10% shock to nominal skilled wage rate (acutal and smoothed)

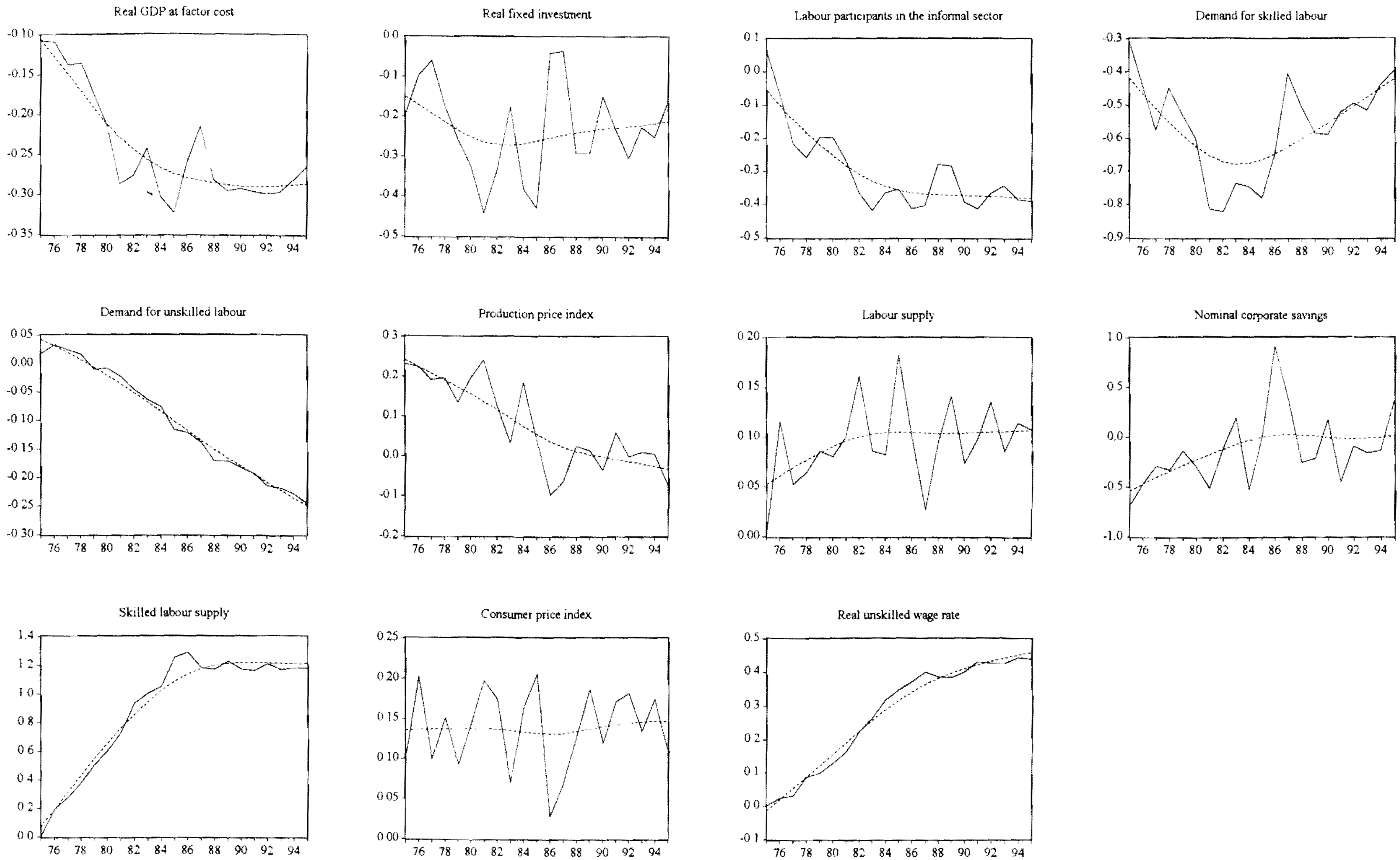


Figure A15.8(b) Long-run multipliers of the full supply-side model : 10% shock to nominal skilled wage rate in 1975 (actual and smoothed)

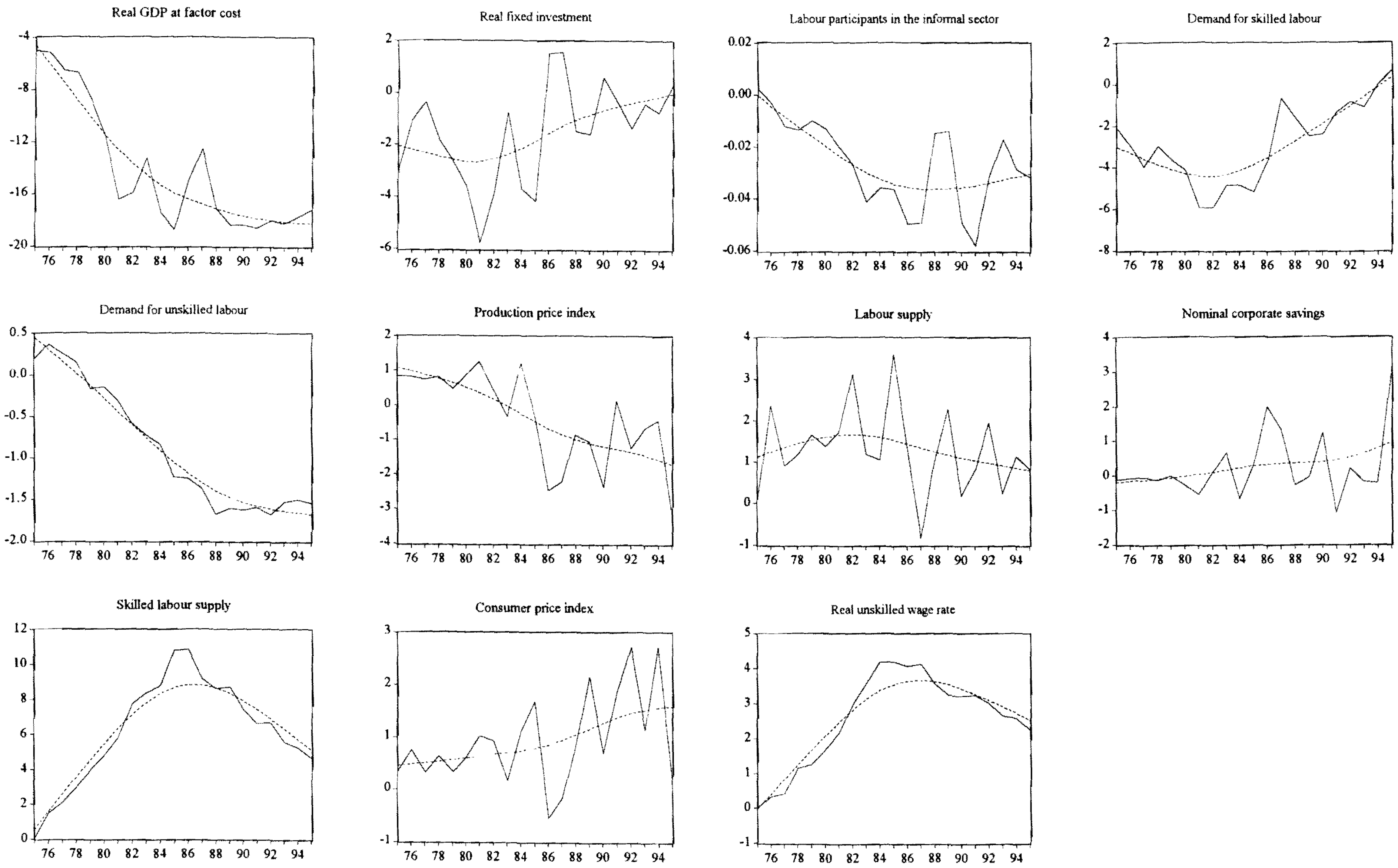


Figure 15.9(a) Long-run elasticities of the full supply-side model : 1% shock to real unskilled wage rate (actual and smoothed)

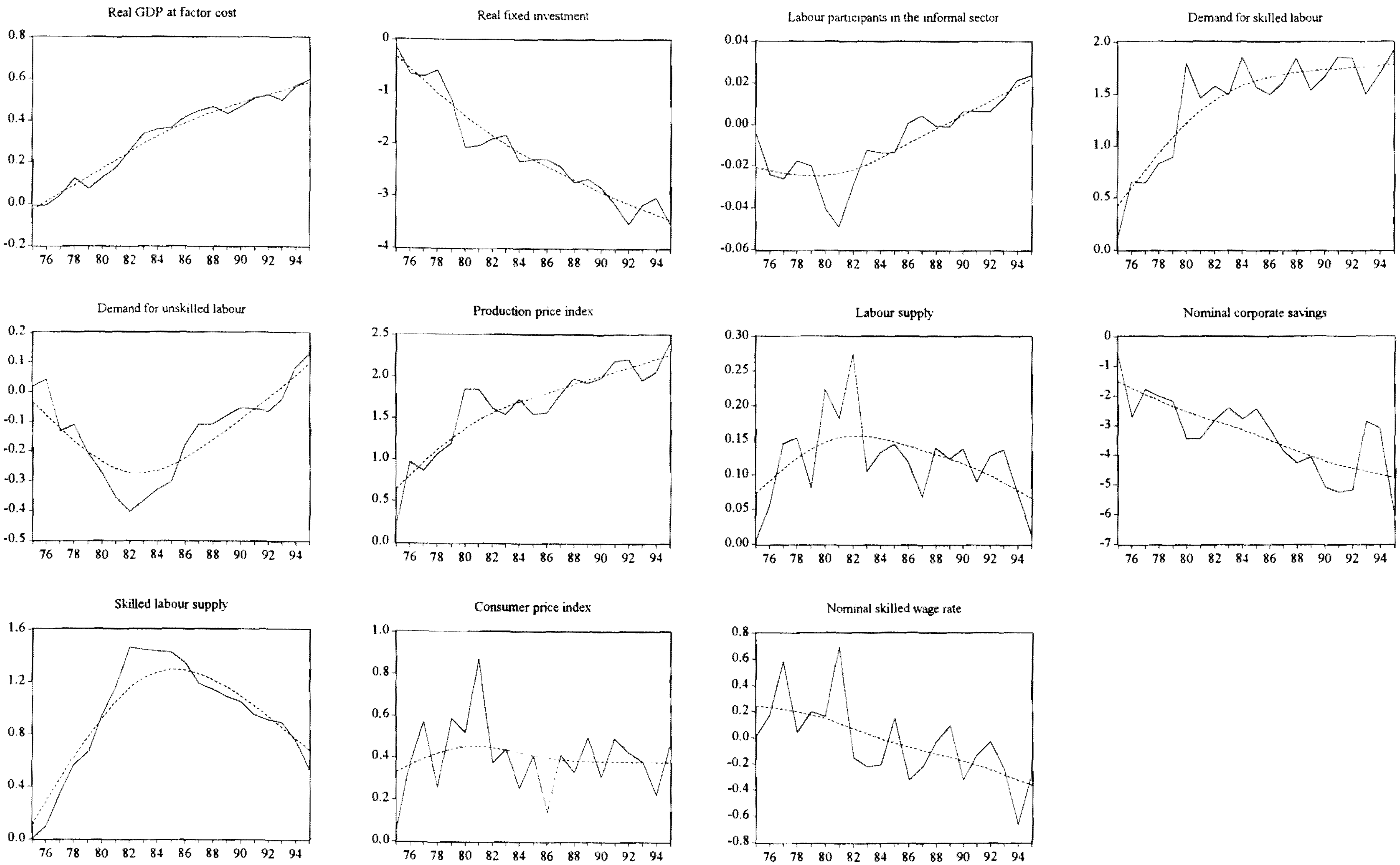


Figure A15.9(b) Long-run multipliers of the full supply-side model : 1% shock to real unskilled wage rate in 1975 (actual and smoothed)

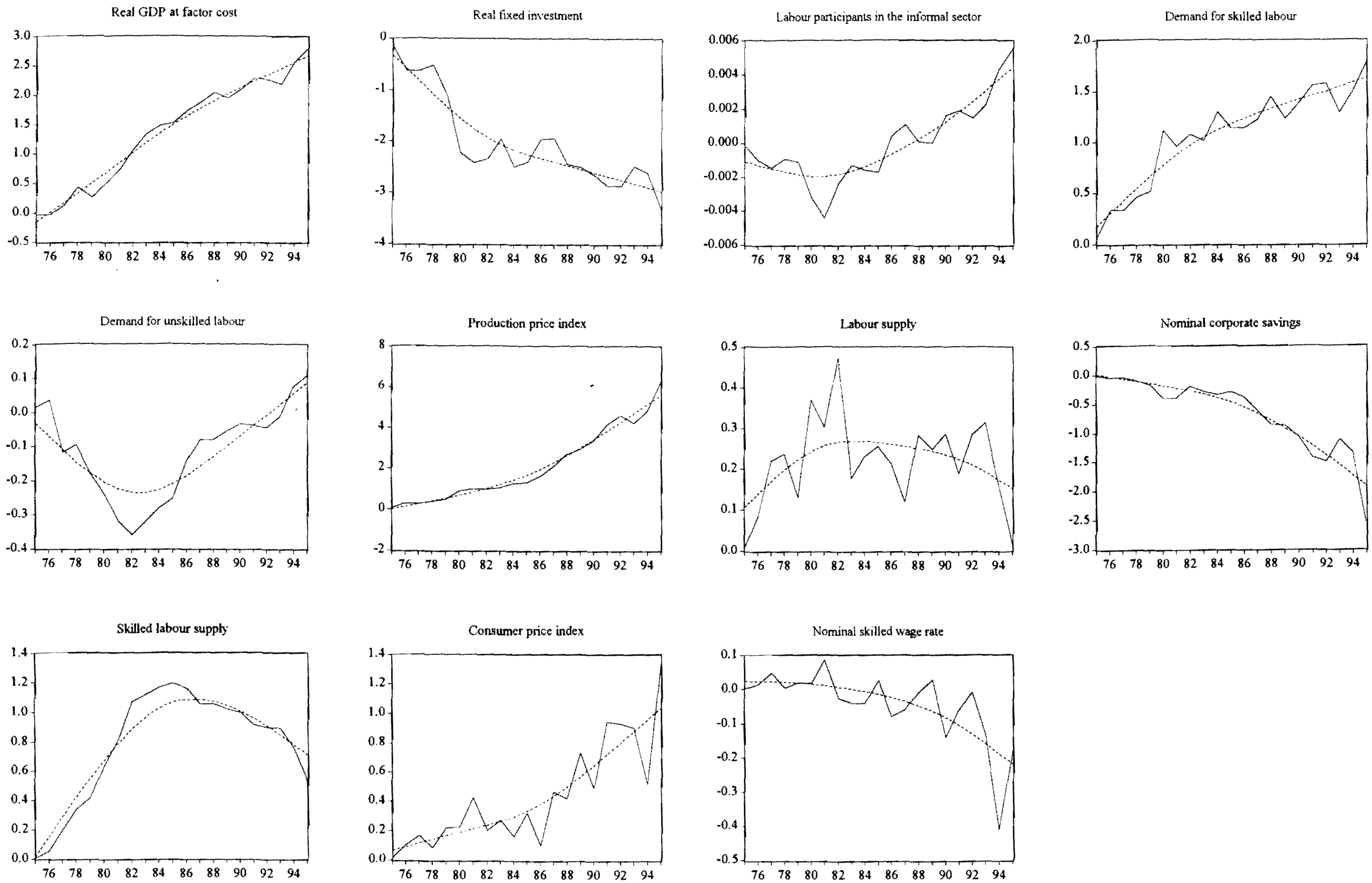


Figure A15.10(a) Long-run elasticities of the full supply-side model : 10% shock to production price-index (actual and smoothed)

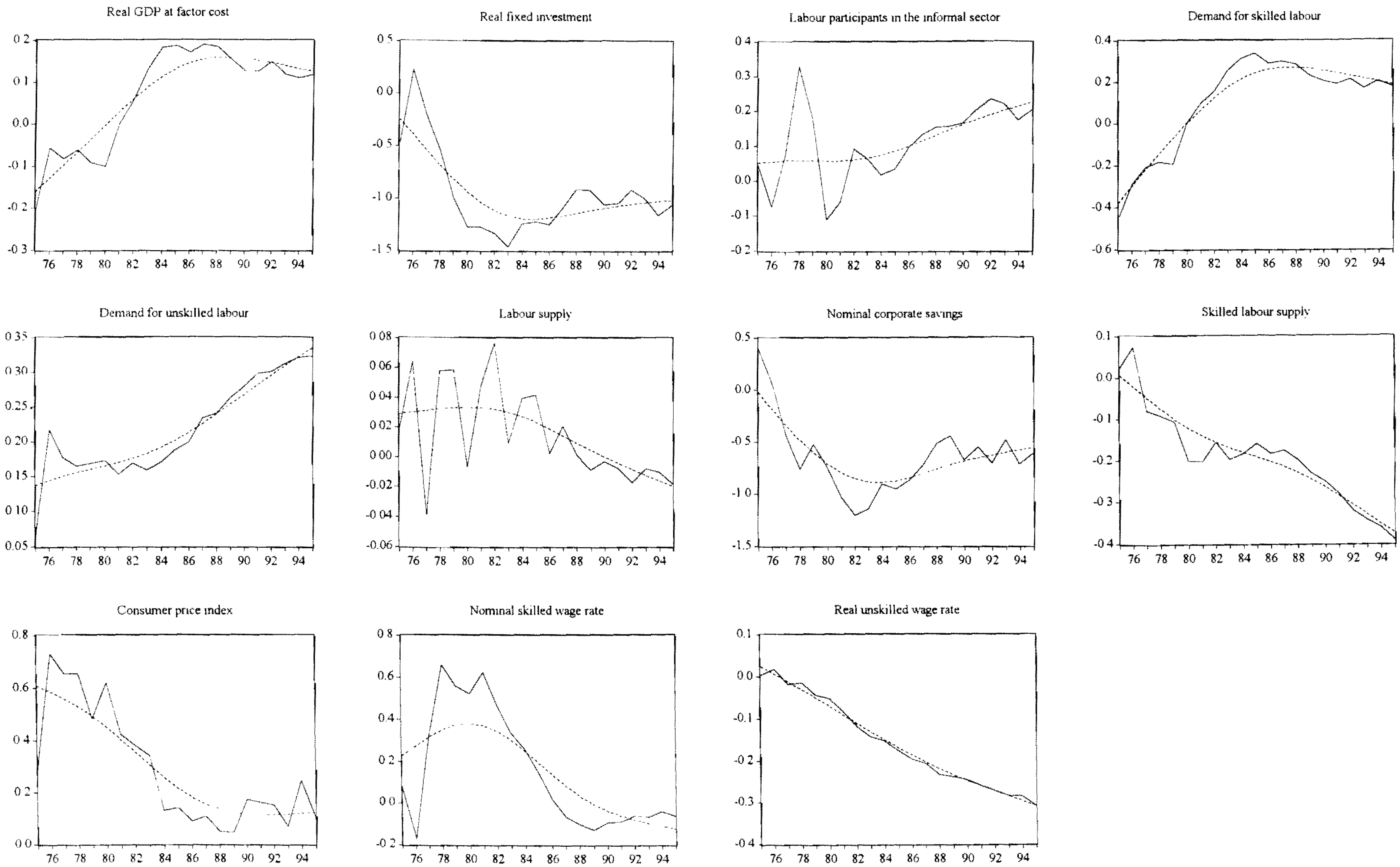


Figure A15.10(b) Long-run multipliers of the full supply-side model : 10% shock to production price index in 1975 (actual and smoothed)

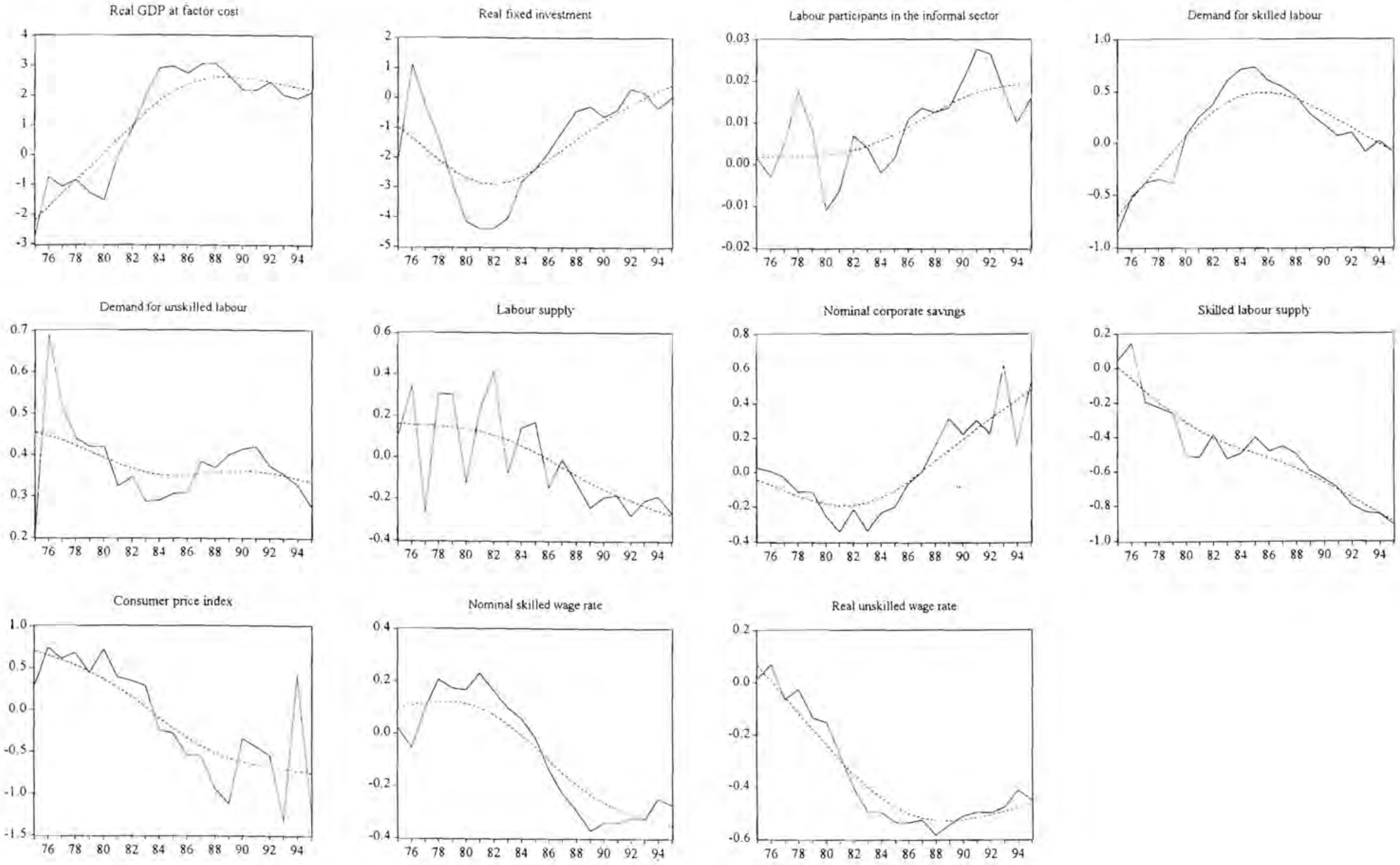


Figure 15.11(a) Long-run elasticities of the full supply-side model : 10% shock to consumer price index (actual and smoothed)

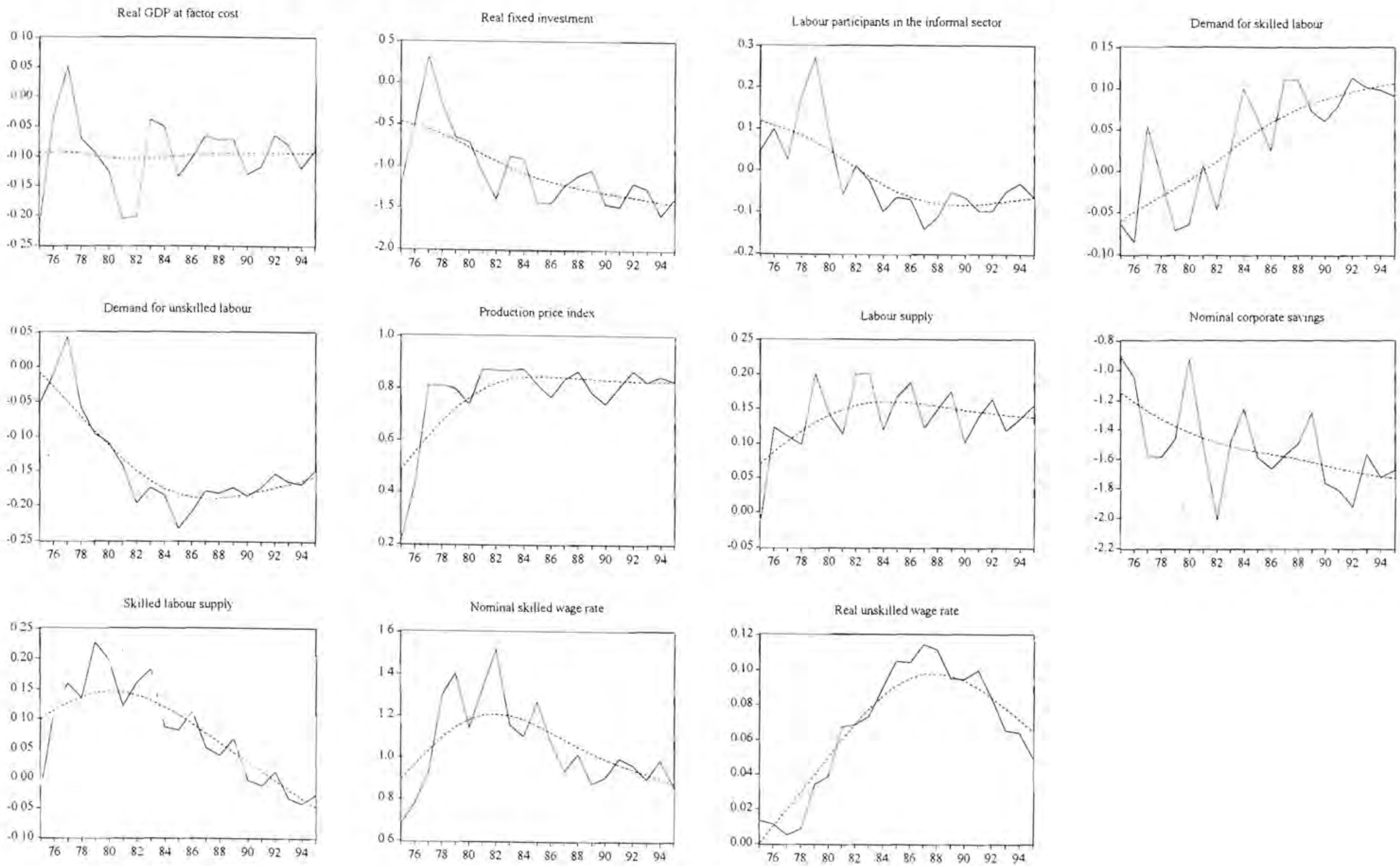


Figure A15.11(b) Long-run multipliers of the full supply-side model : 10% shock to consumer price index in 1975 (actual and smoothed)

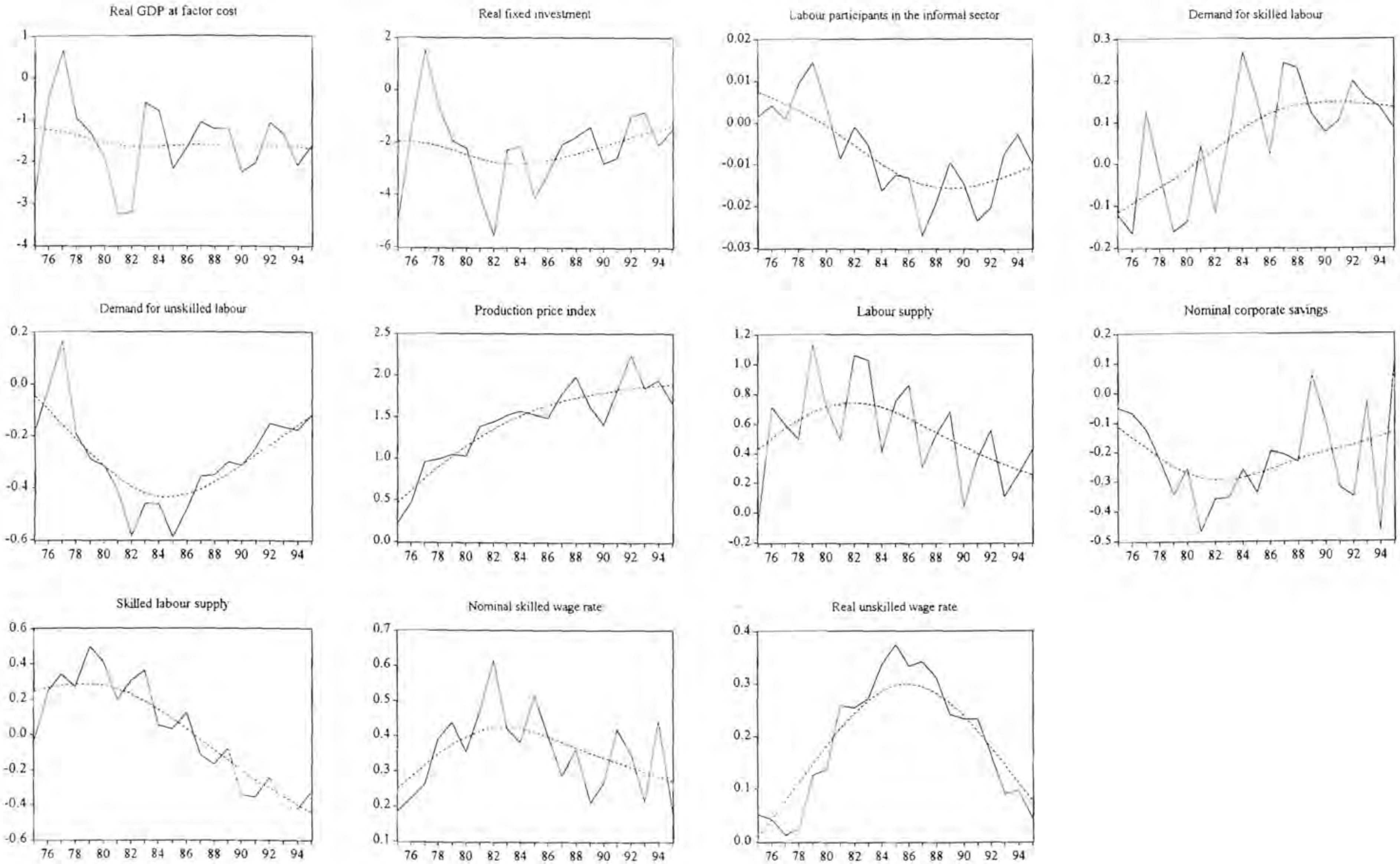


Figure A15.10(b) Long-run multipliers of the full supply-side model : 10% shock to production price index in 1975 (actual and smoothed)

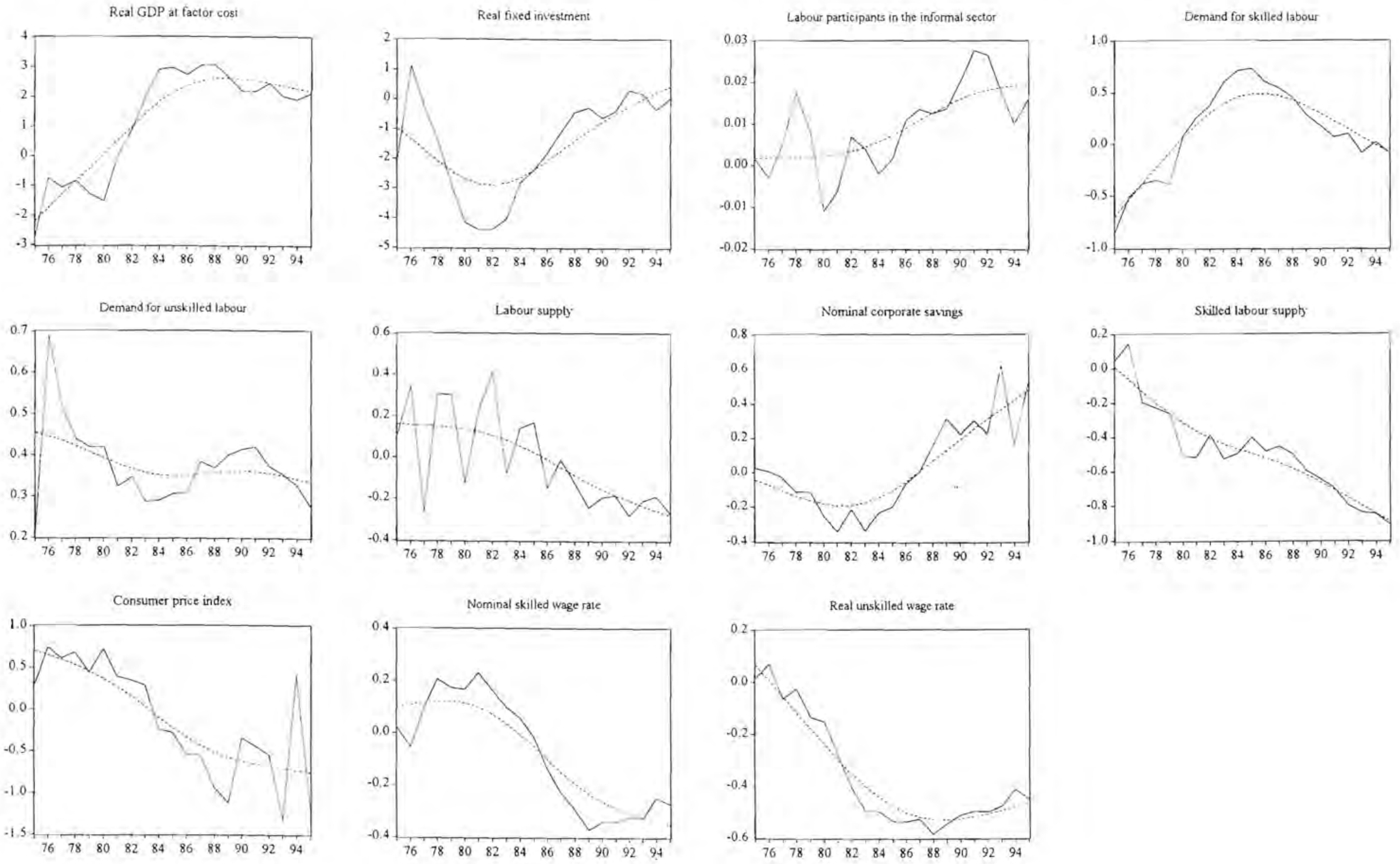


Figure 15.11(a) Long-run elasticities of the full supply-side model : 10% shock to consumer price index (actual and smoothed)

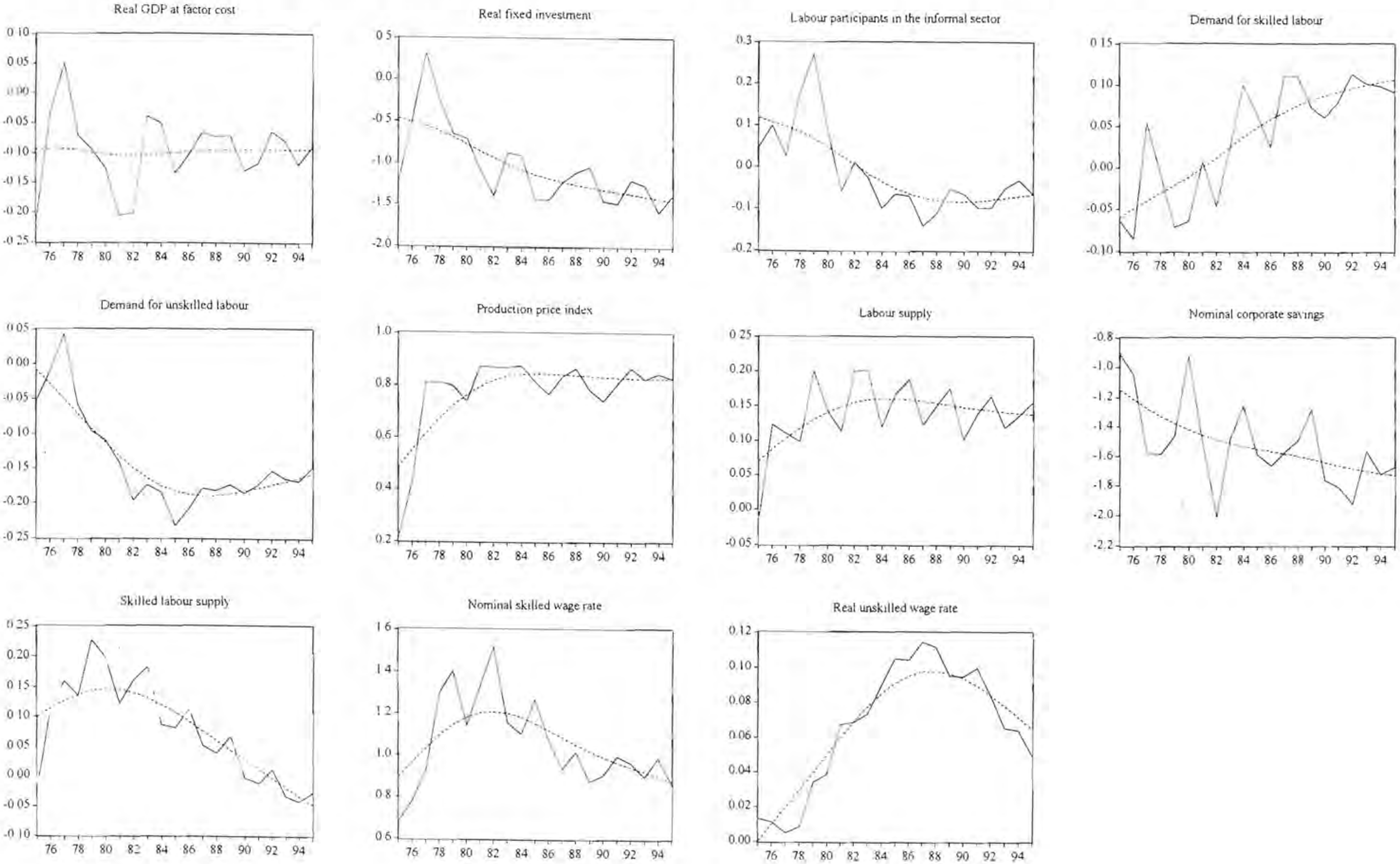
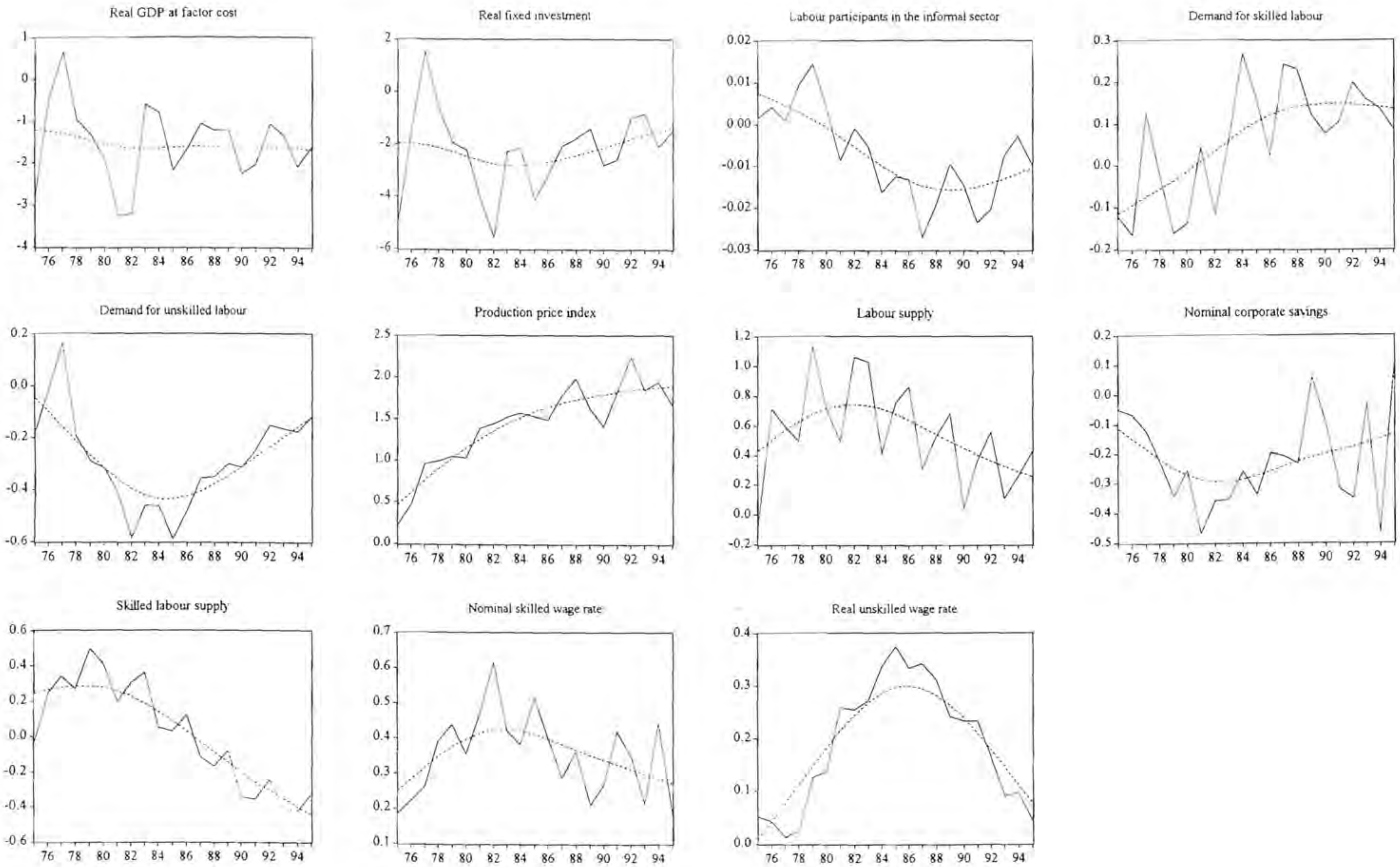


Figure A15.11(b) Long-run multipliers of the full supply-side model : 10% shock to consumer price index in 1975 (actual and smoothed)



APPENDIX 16: POLICY SCENARIOS

Figure A16.1(a) Individual scenario 0: Baseline and shocked simulation paths

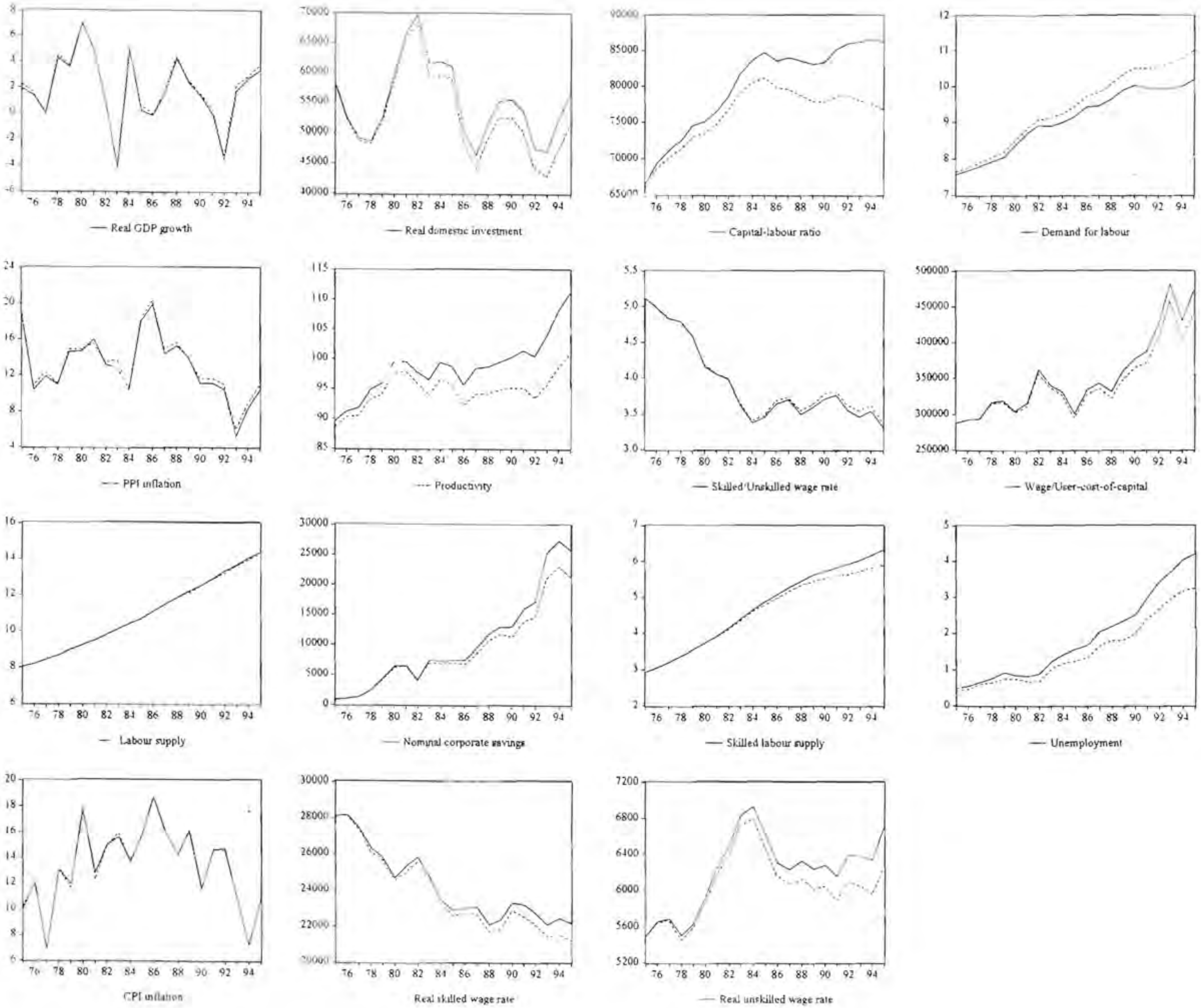


Figure A16.1(b) Individual scenario 0: Percentage differences between shocked and baseline simulation paths

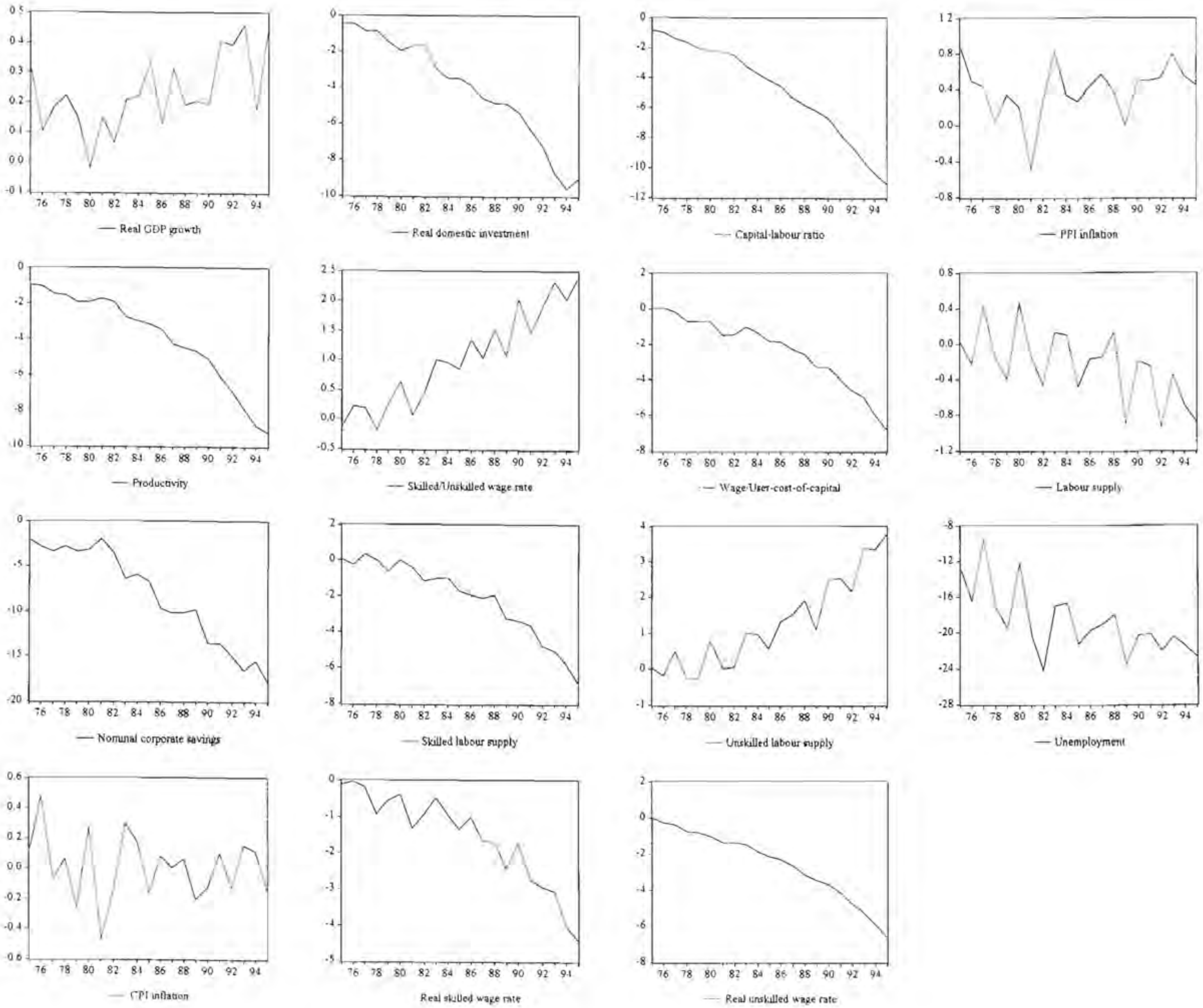


Figure A16.2(a) Individual scenario 1: Baseline and shocked simulation paths

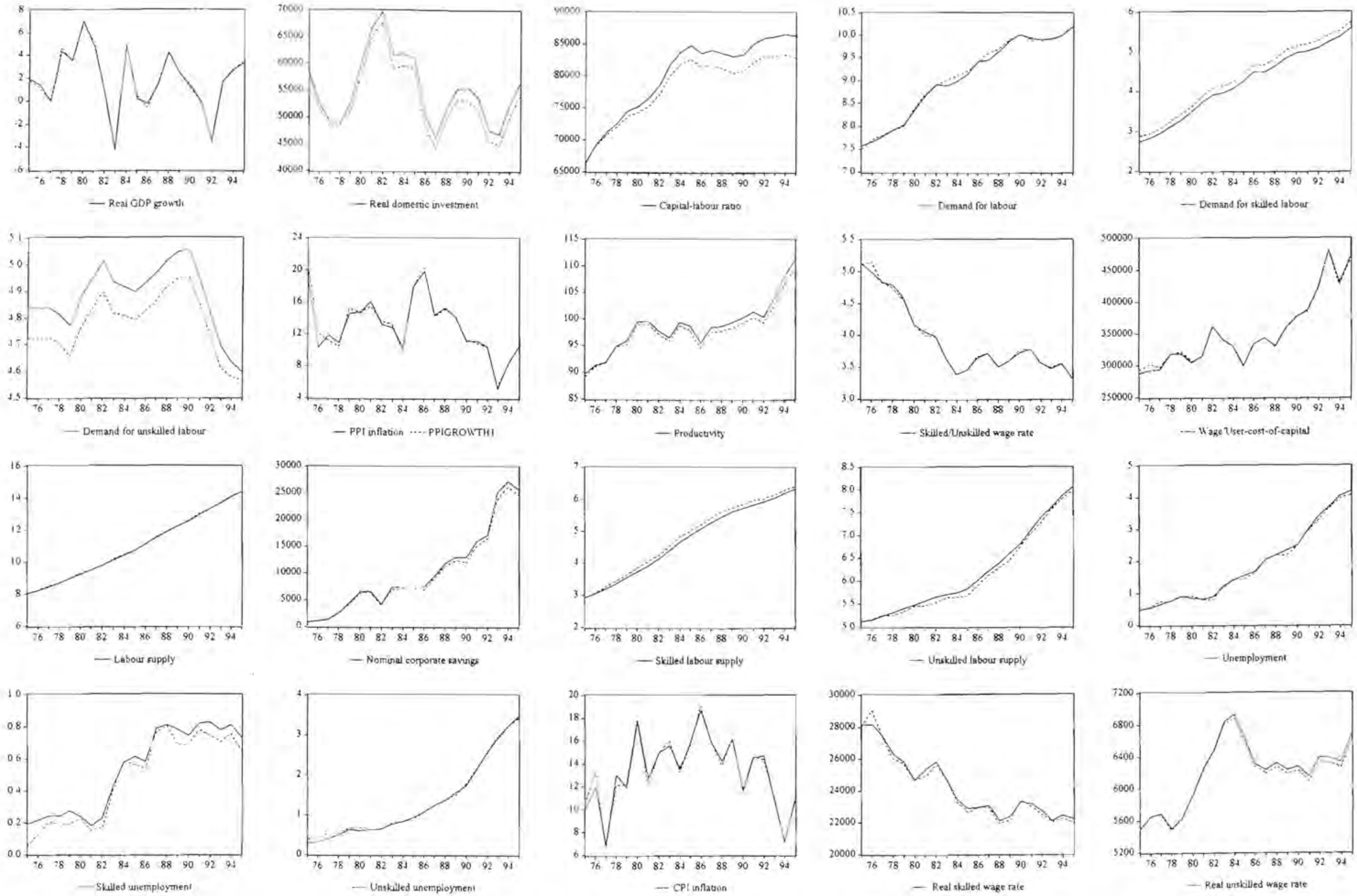


Figure A16.2(b) Individual scenario 1: Percentage differences between shocked and baseline simulation paths

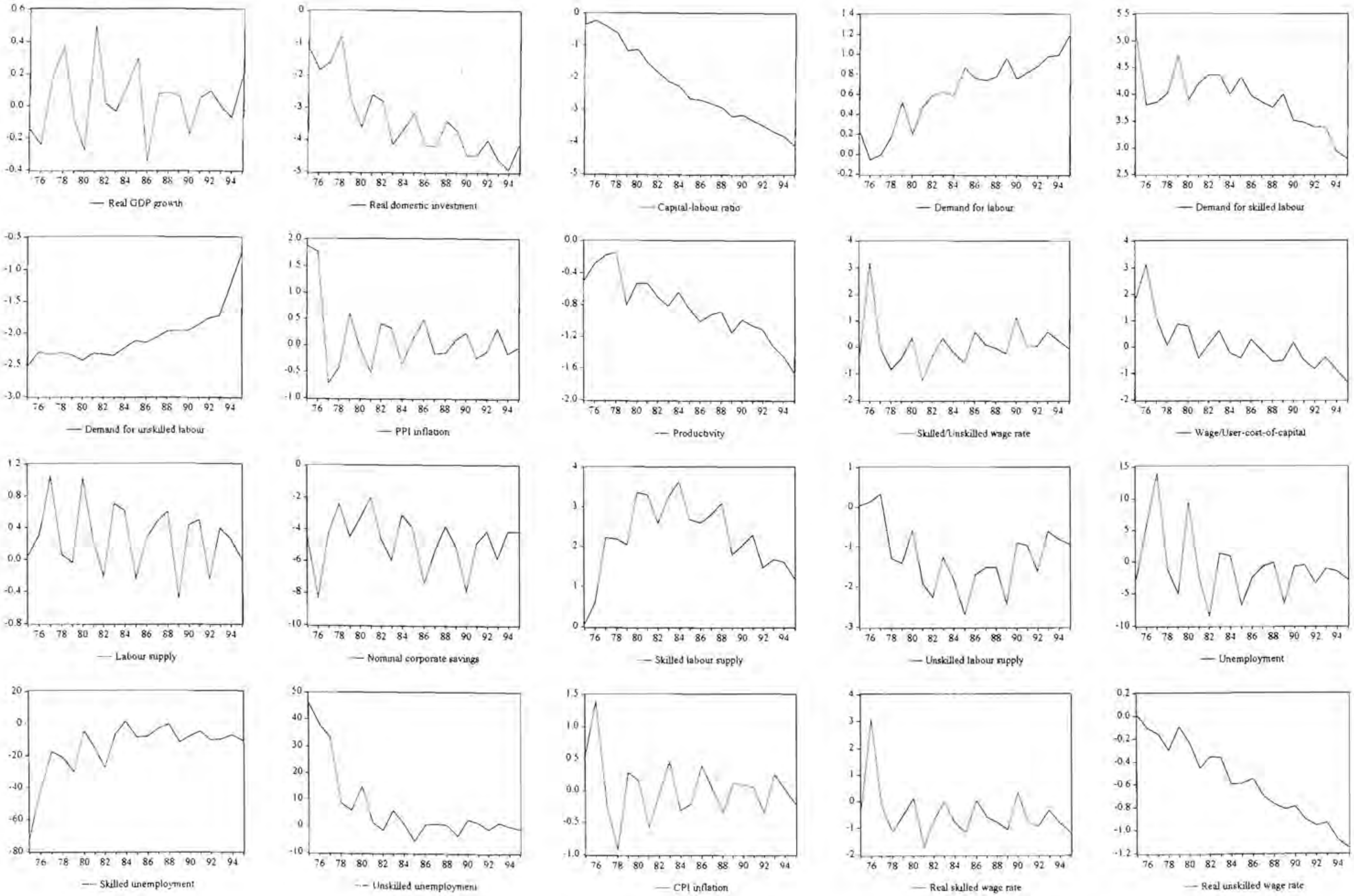


Figure A16.3(a) Individual scenario 2: Baseline and shocked simulation paths

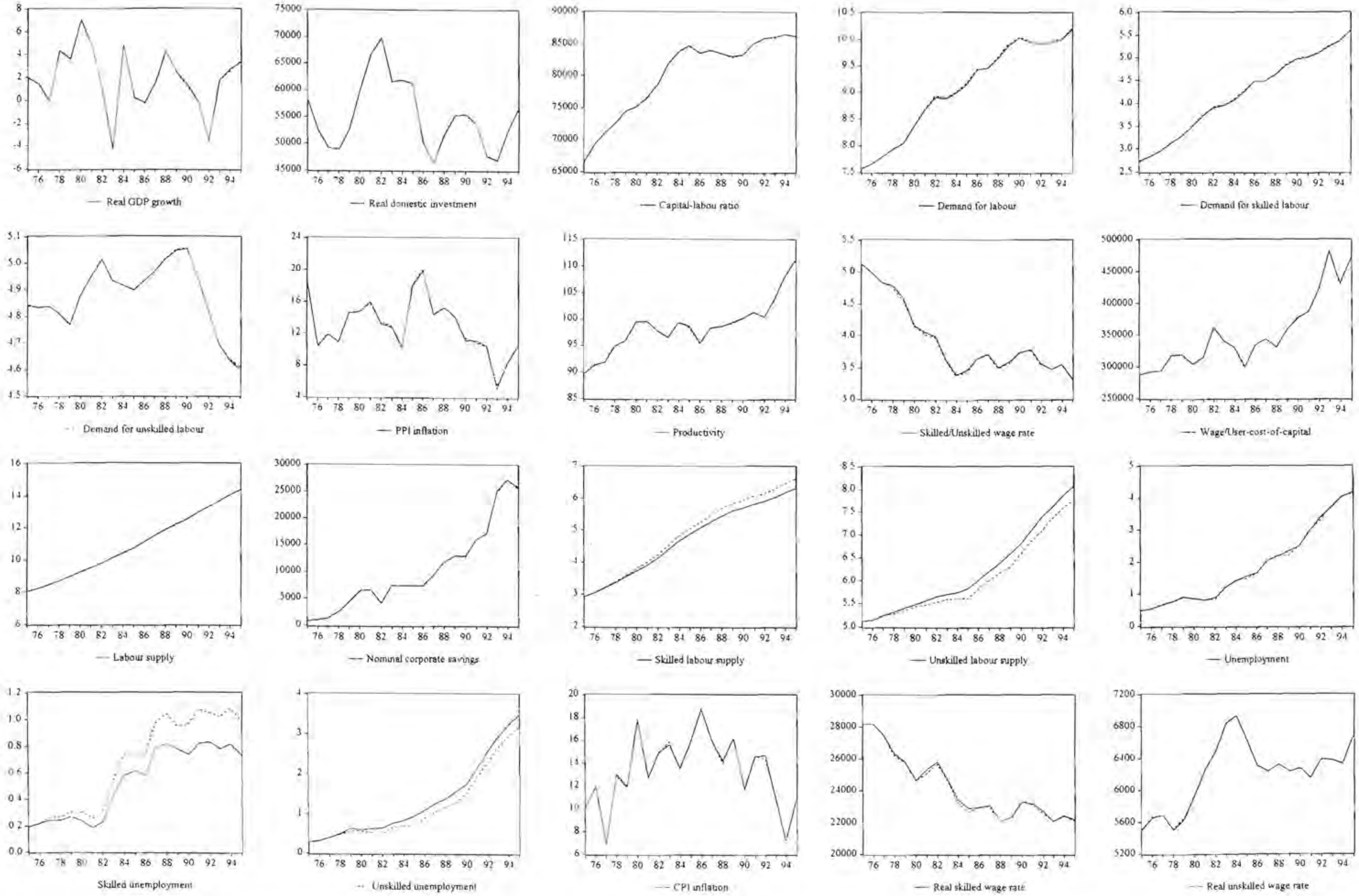
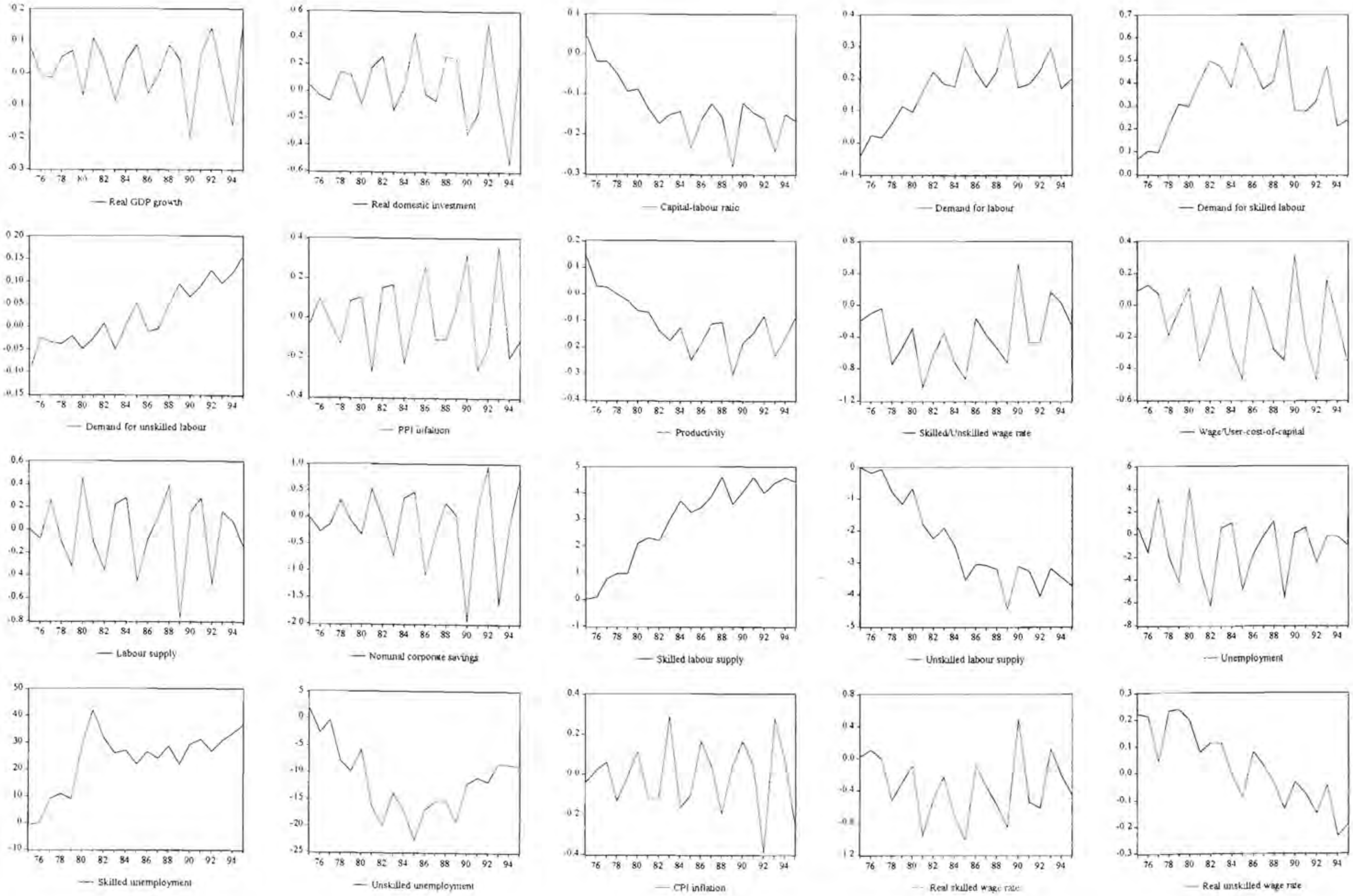


Figure A16.3(b) Individual scenario 2: Percentage differences betwen shocked and baseline simulation paths



FigureA16.4(a) Individual scenario 3: Baseline and shocked simulation paths

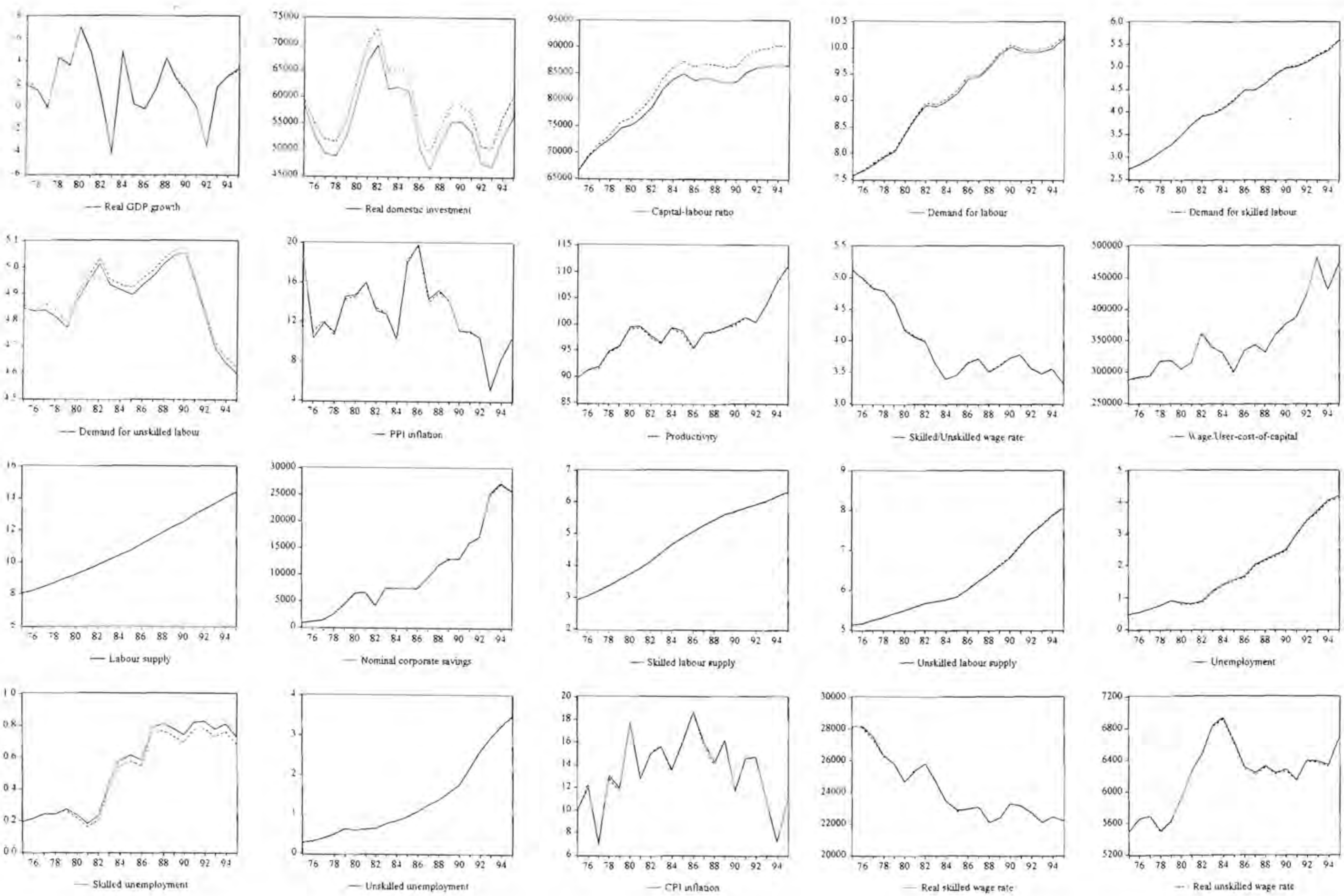


Figure A16.4(b) Individual scenario 3: Percentage differences between shocked and baseline simulation paths

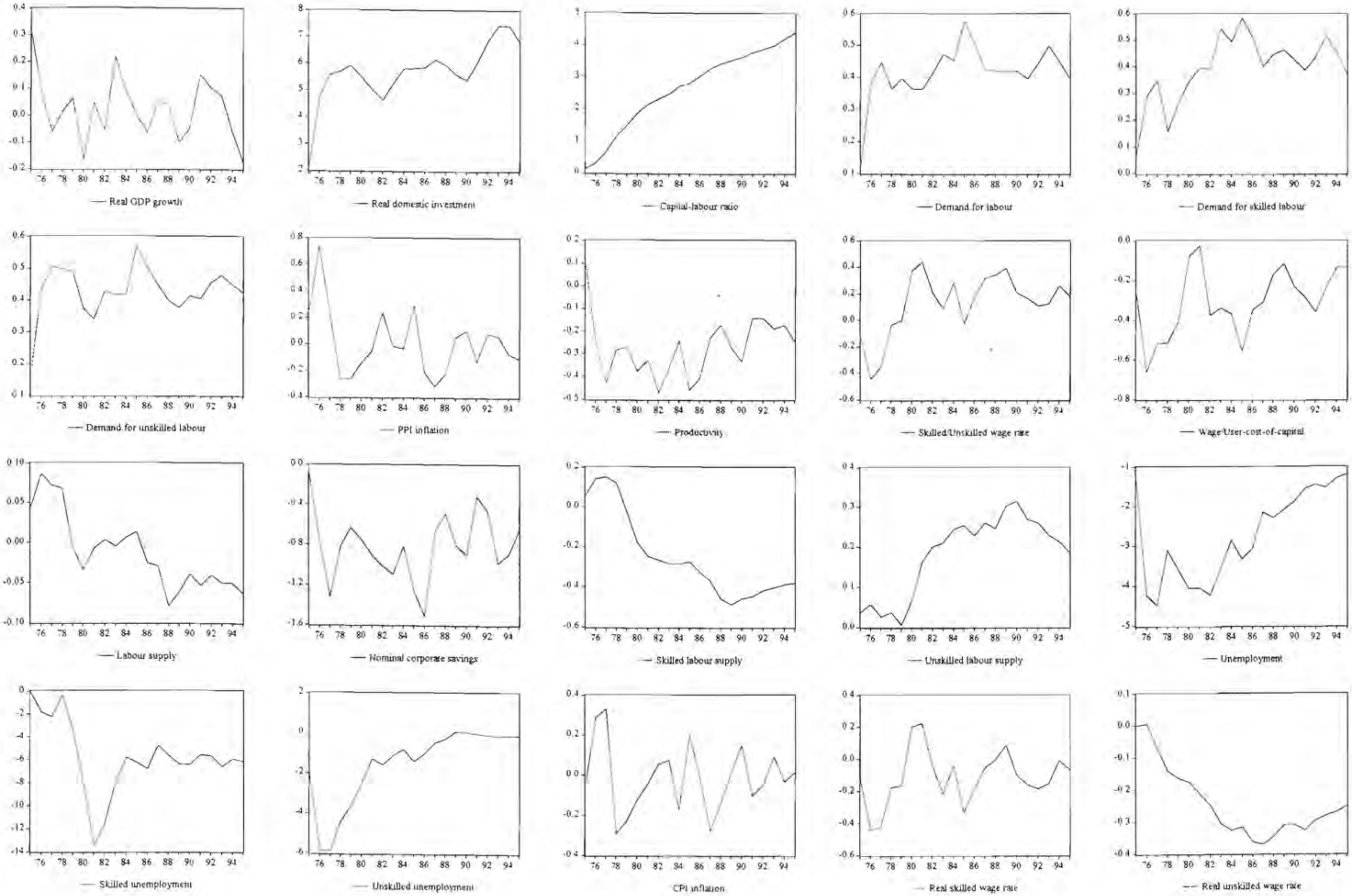


Figure A16.5(a) Individual scenario 4: Baseline and shocked simulation paths

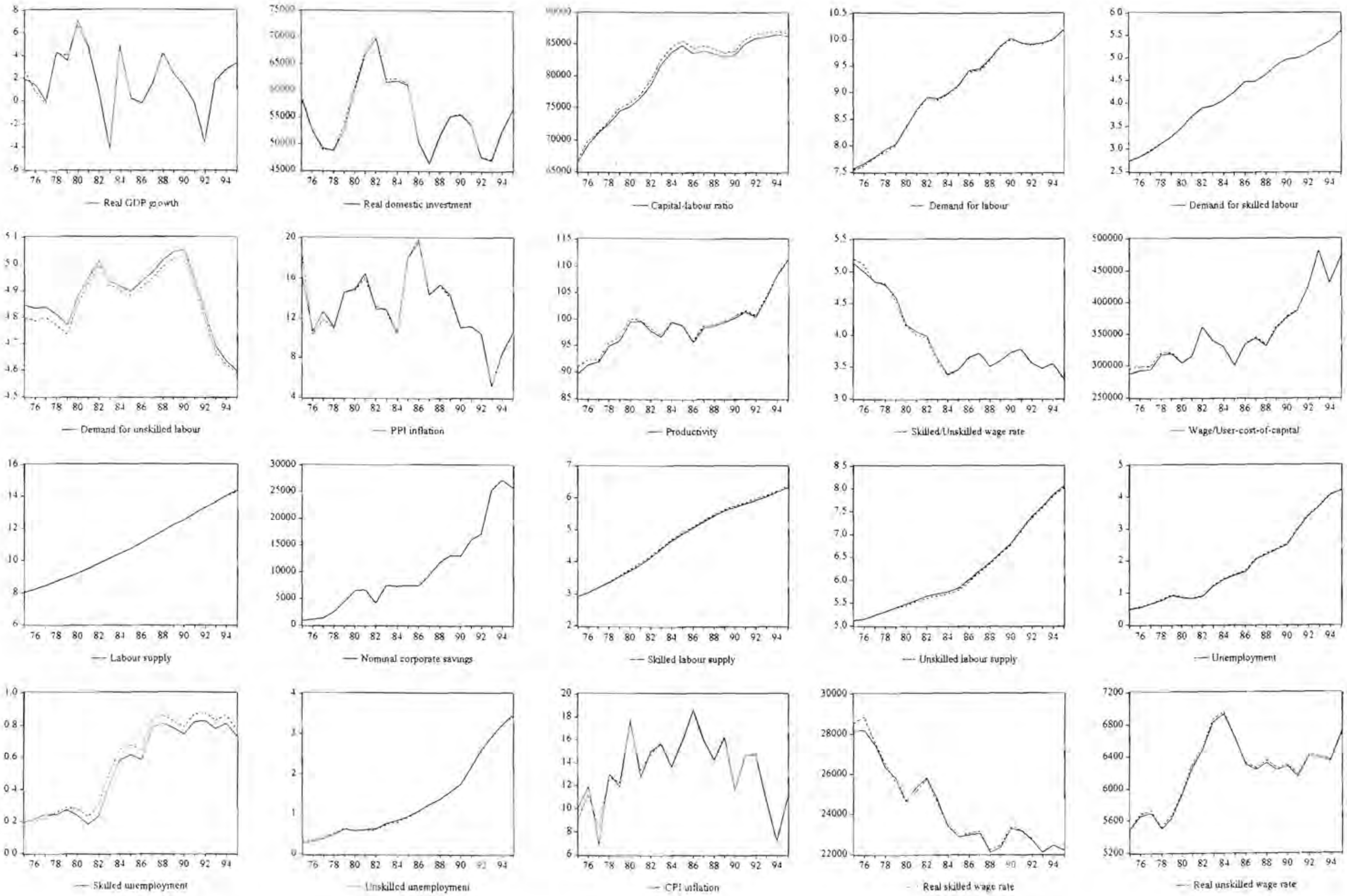


Figure A16.5(b) Individual scenario 4: Percentage differences between baseline and shocked simulation paths

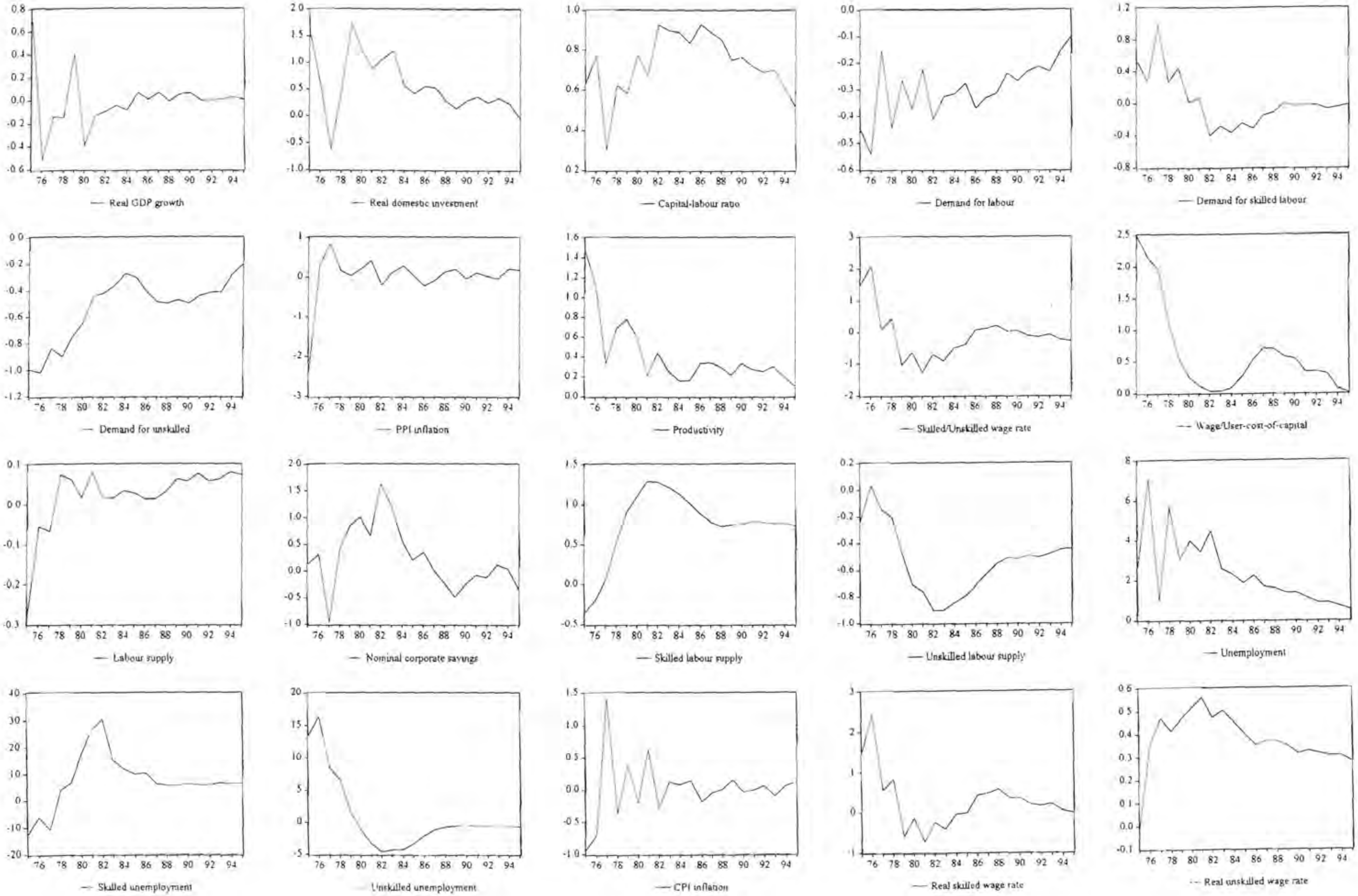


Figure A16.6(a) Individual scenario 5: Baseline and shocked simulation paths

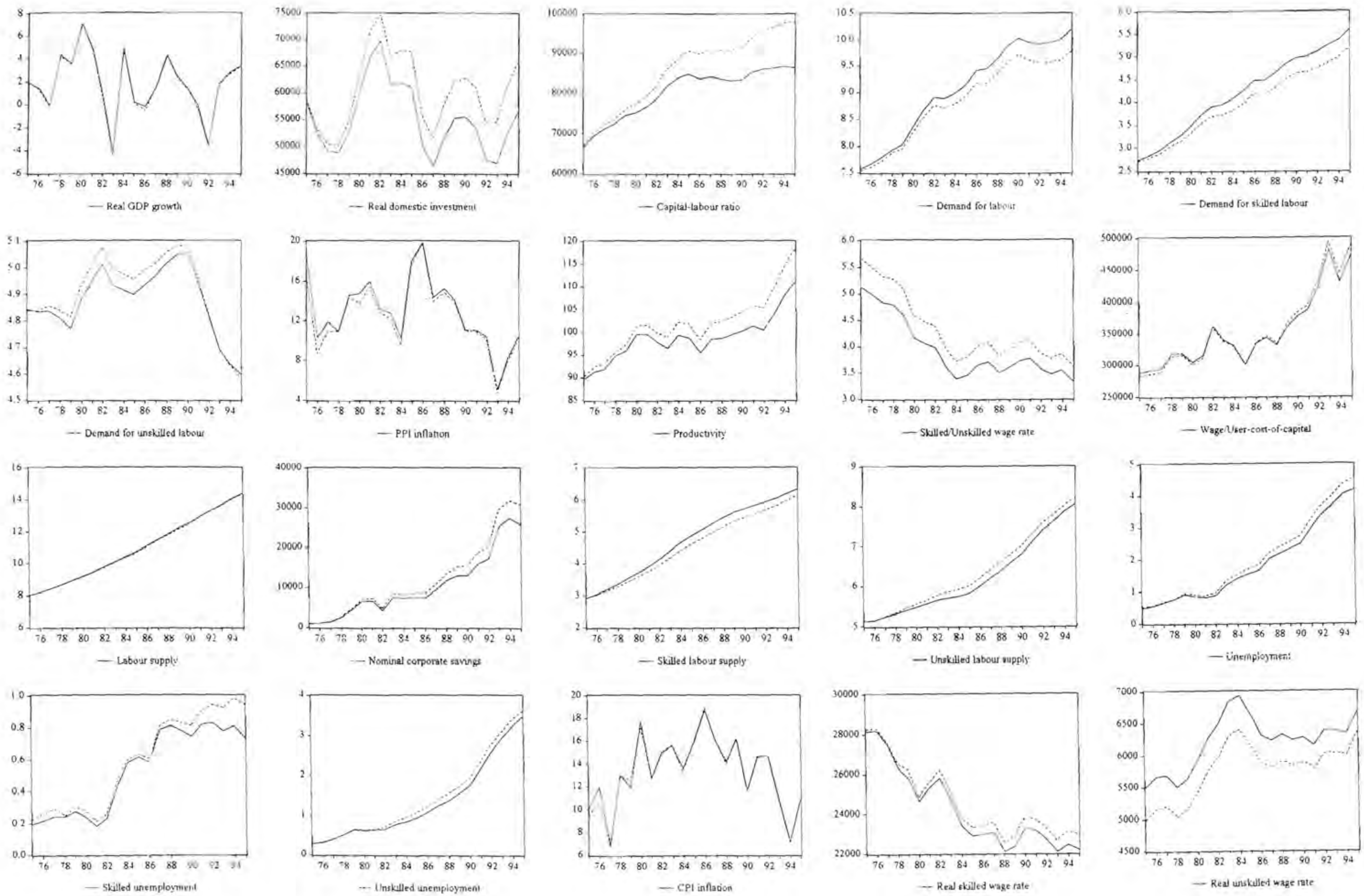


Figure A16.6(b) Individual scenario 5: Percentage differences between baseline and shocked simulation paths

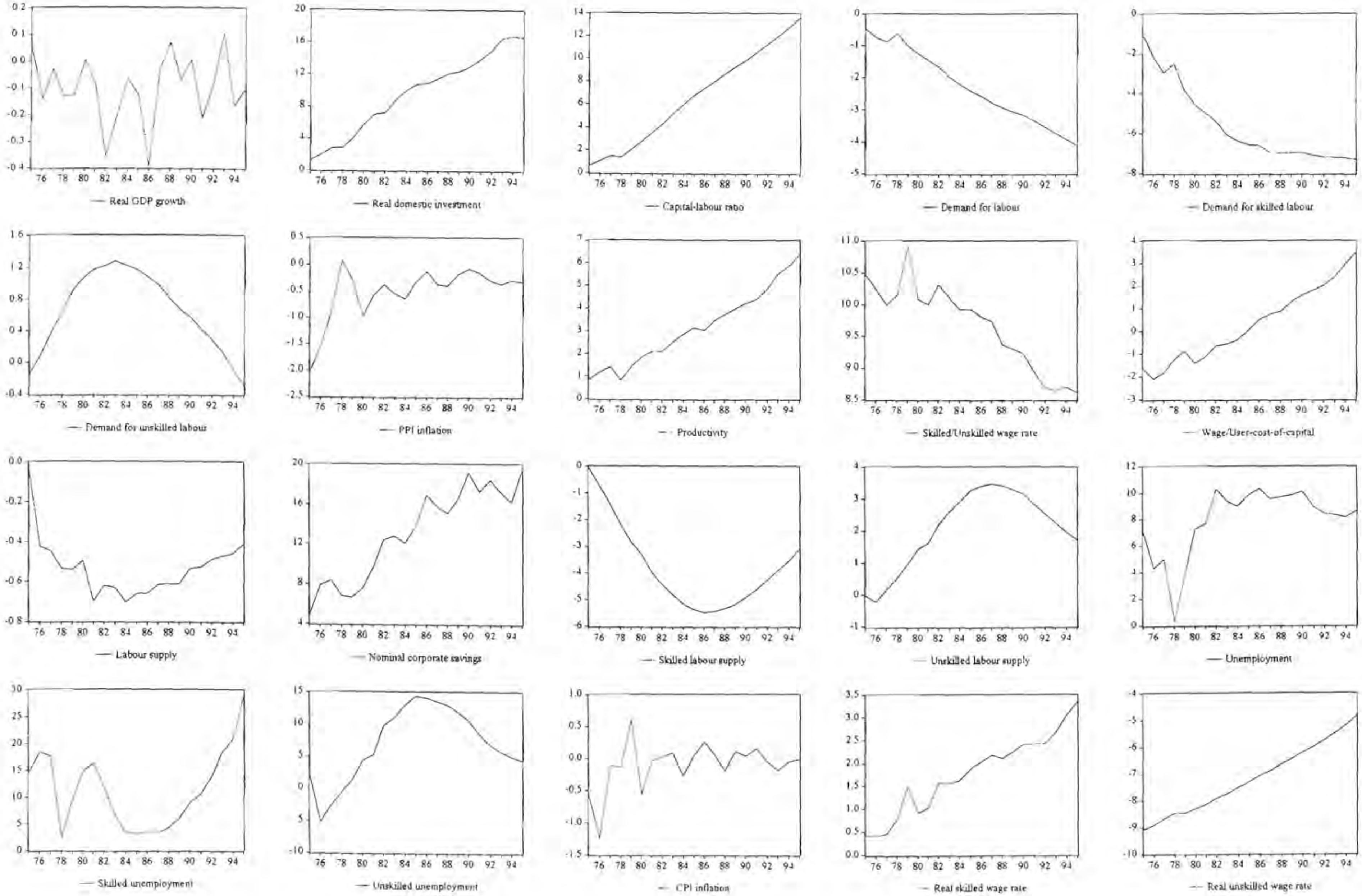


Figure A16.7(a) Individual scenario 6: Baseline and shocked simulation paths

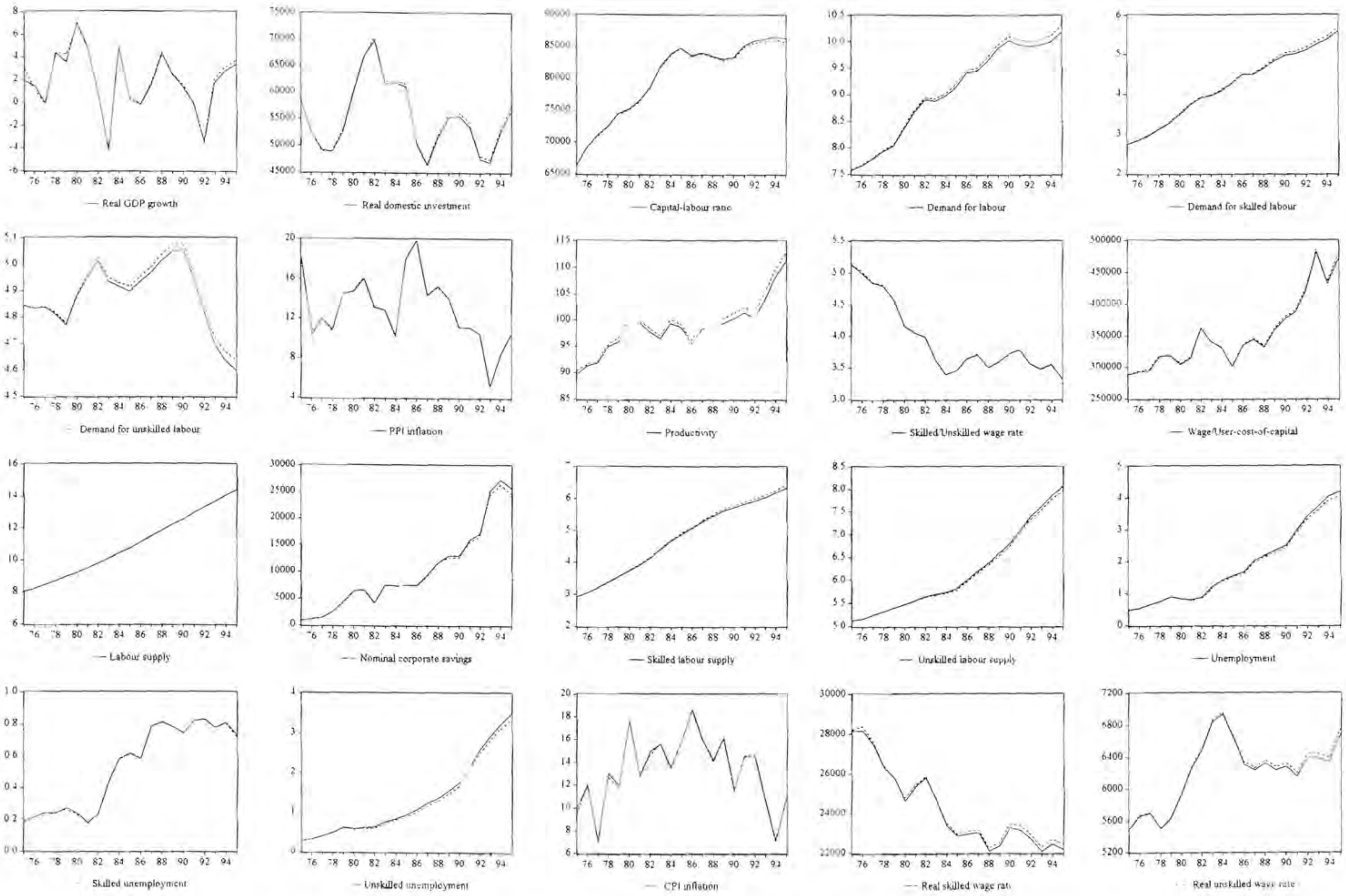


Figure A16.7(b) Individual scenario 6: Percentage differences between baseline and shocked simulation paths

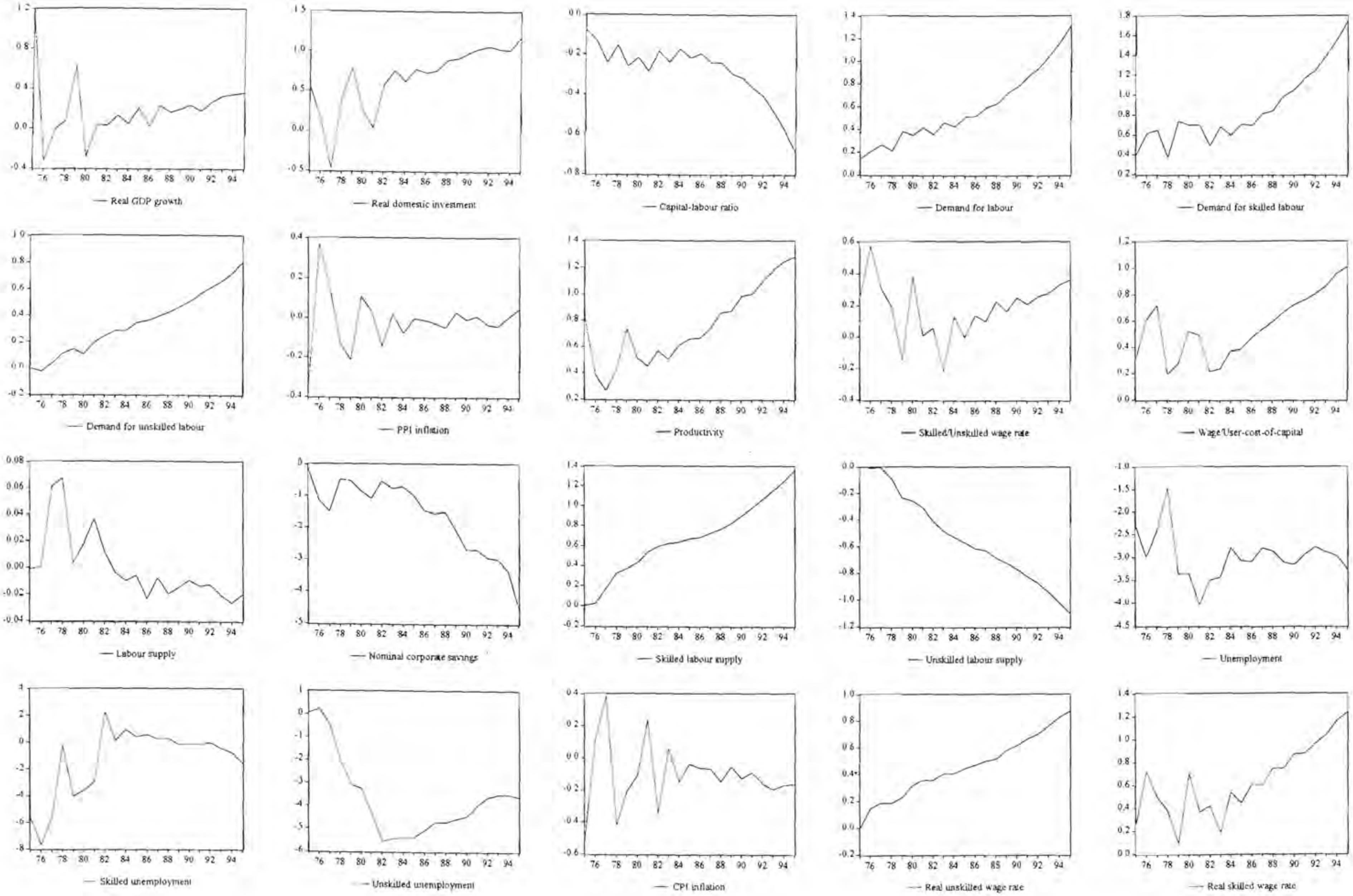


Figure A16.8(a) Individual scenario 7: Baseline and shocked simulation paths

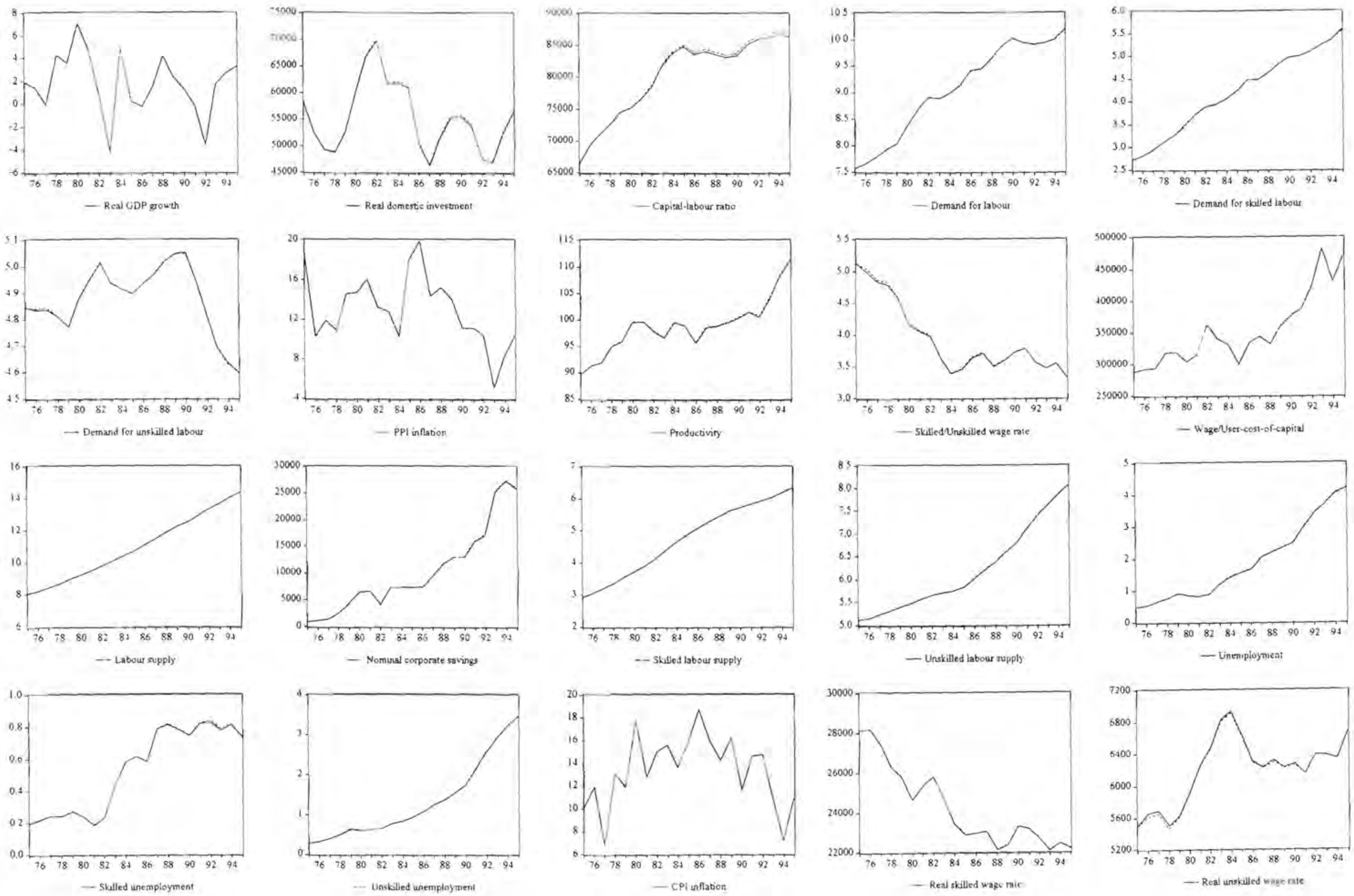


Figure A16.8(b) Individual scenario 7: Percentage differences between baseline and shocked simulation paths

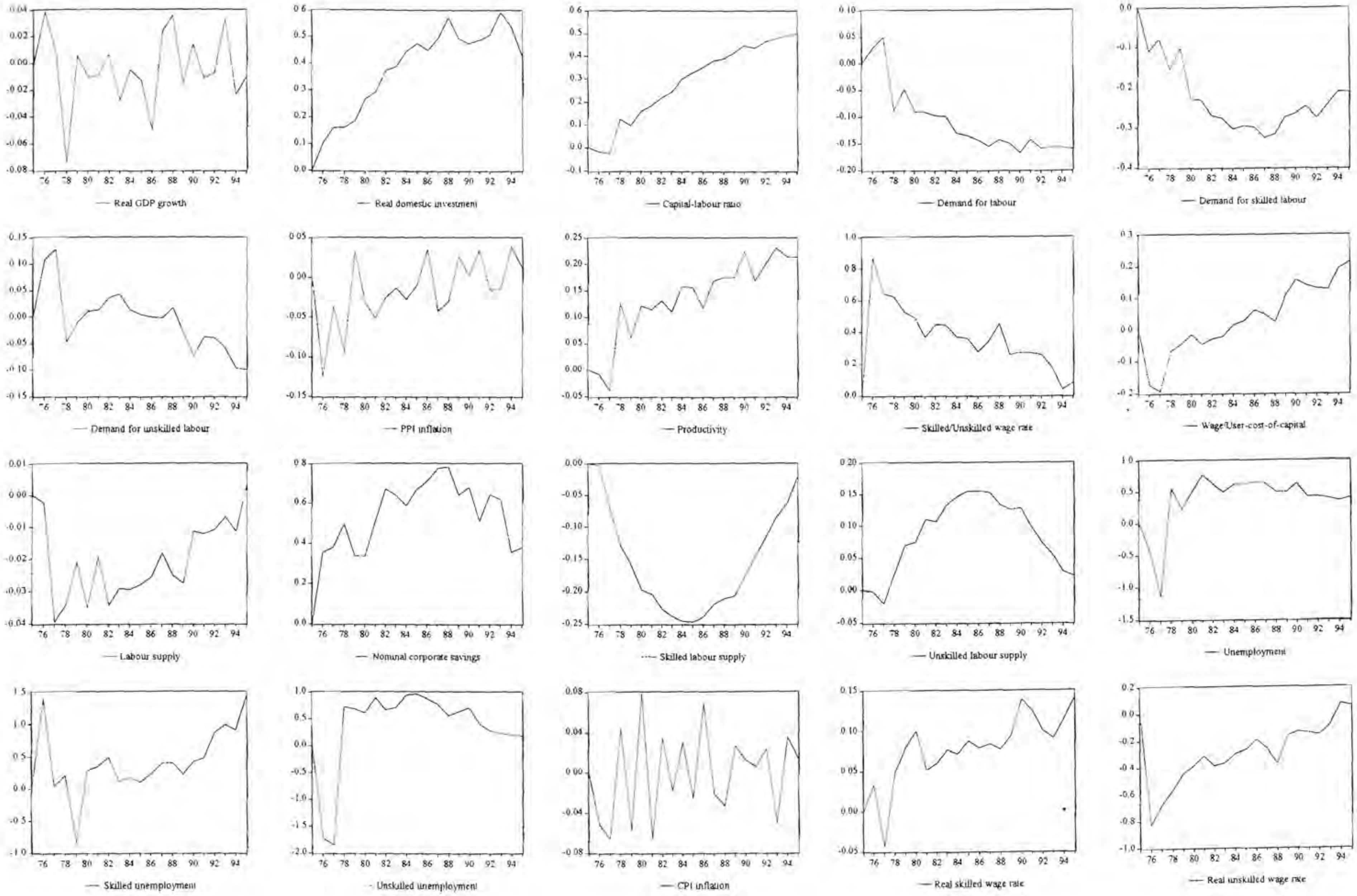


Figure A16.9(a) Individual scenario 8: Baseline and shocked simulation paths

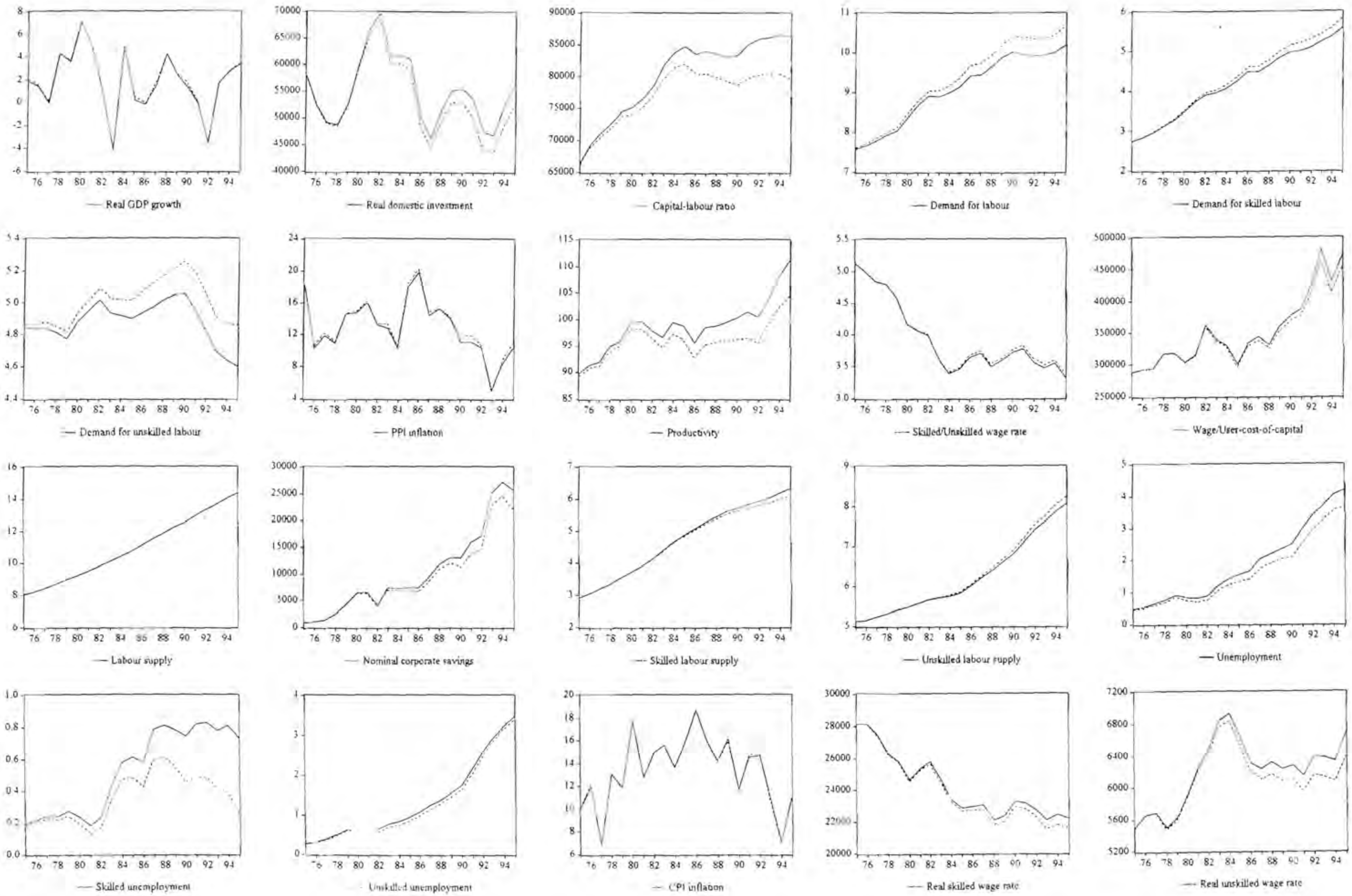


Figure A16.9(b) Individual scenario 8: Percentage differences between baseline and shocked simulation paths

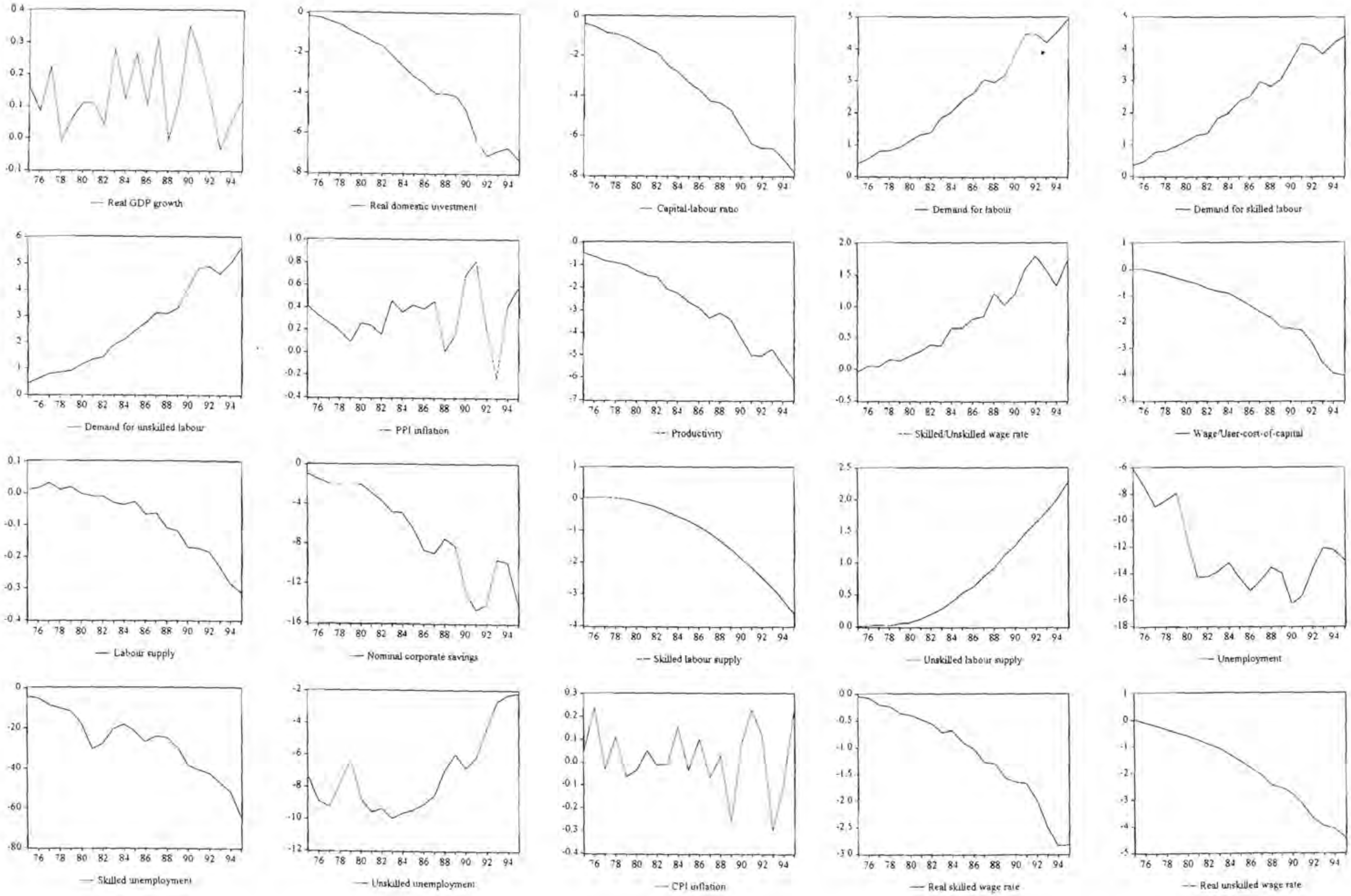


Figure A16.10(a) Individual scenario 9: Baseline and shocked simulation paths

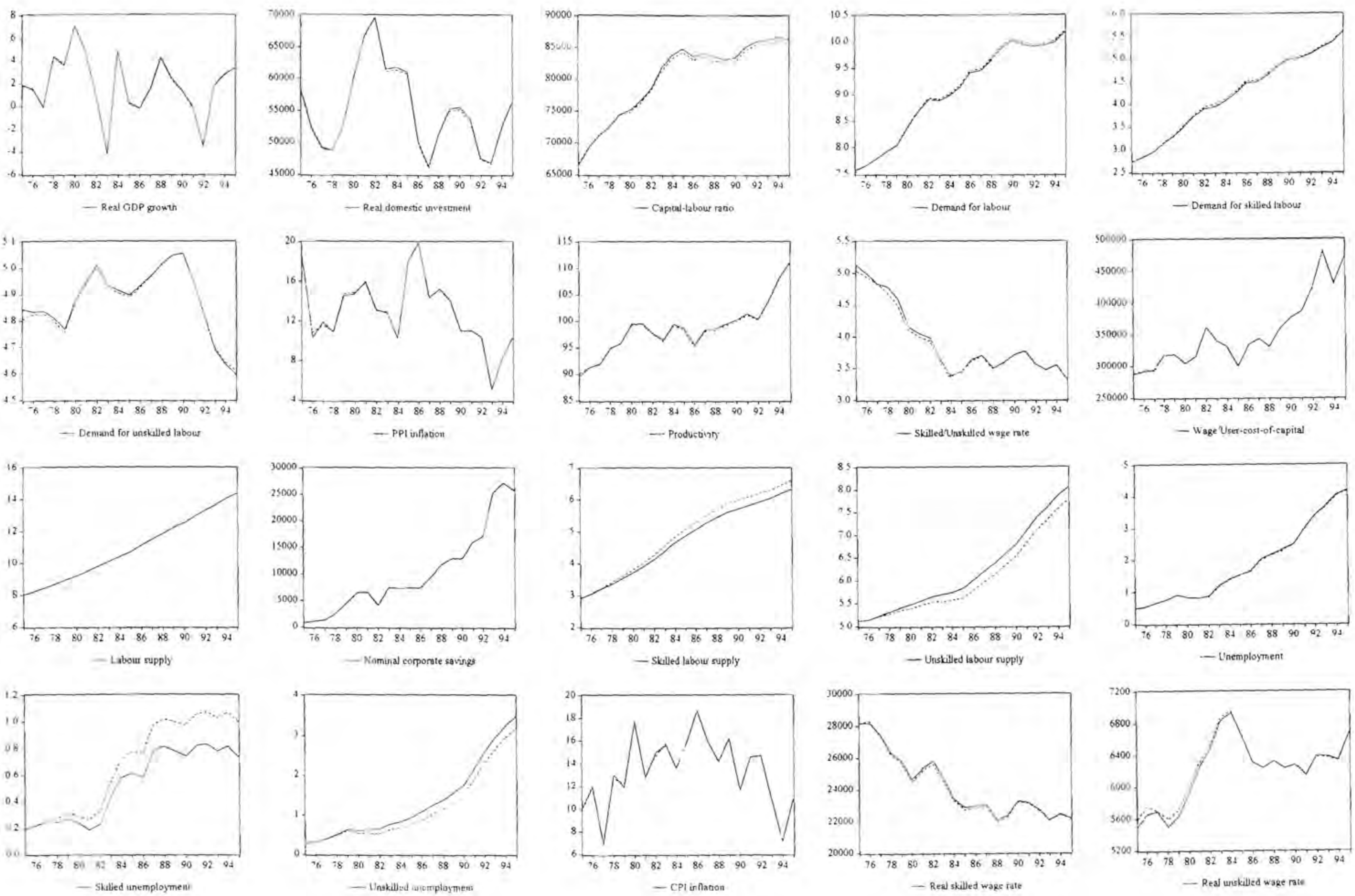


Figure A16.10(b) Individual scenario 9: Percentage differences between baseline and shocked simulation paths

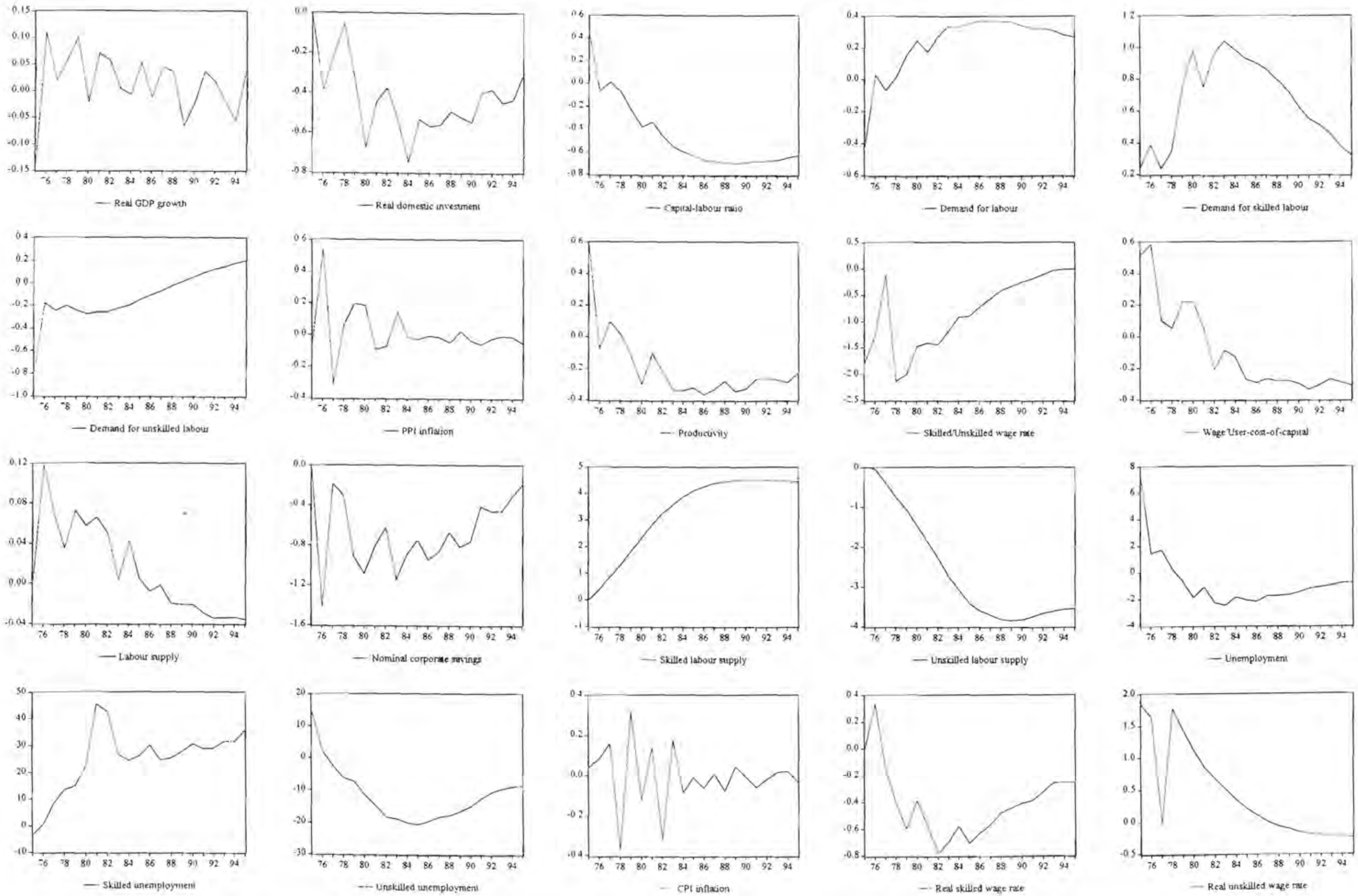


Figure A16.11(a) Combined scenario 1: Baseline and shocked simulation paths

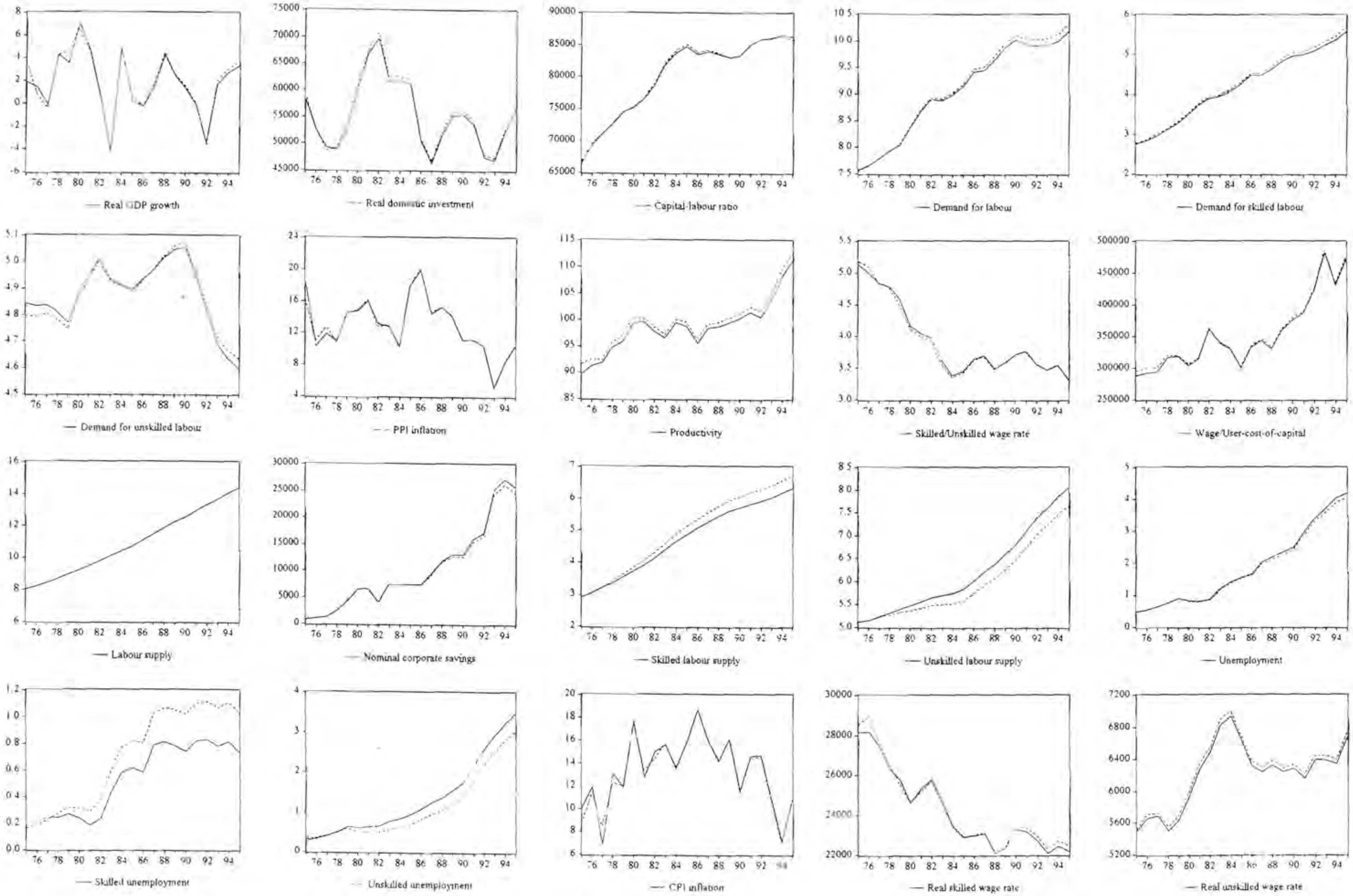


Figure A16.11(b) Combined scenario 1: Percentage differences between baseline and shocked simulation paths

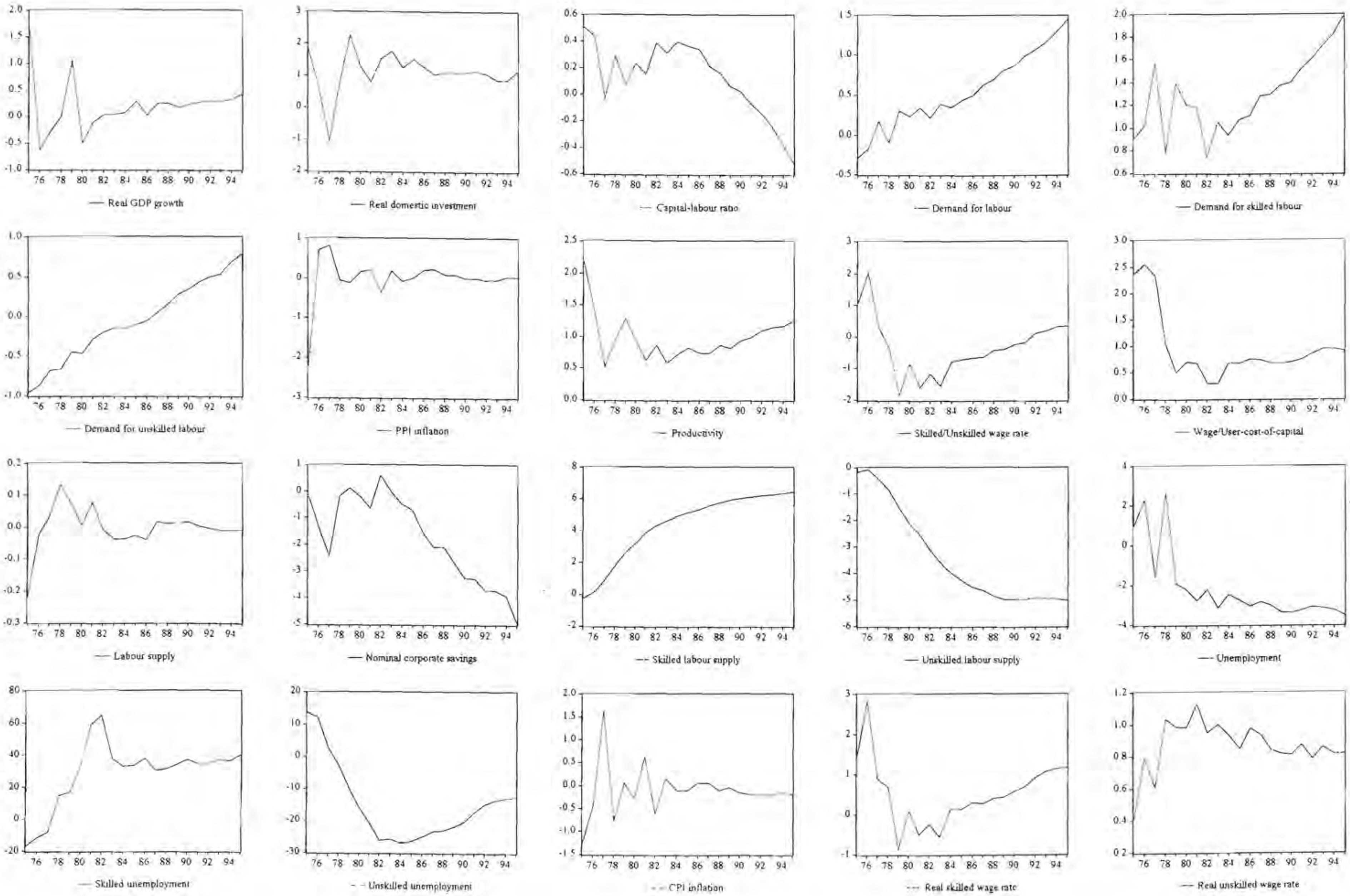


Figure A16.12(a) Combined scenario 2: Baseline and shocked simulation paths

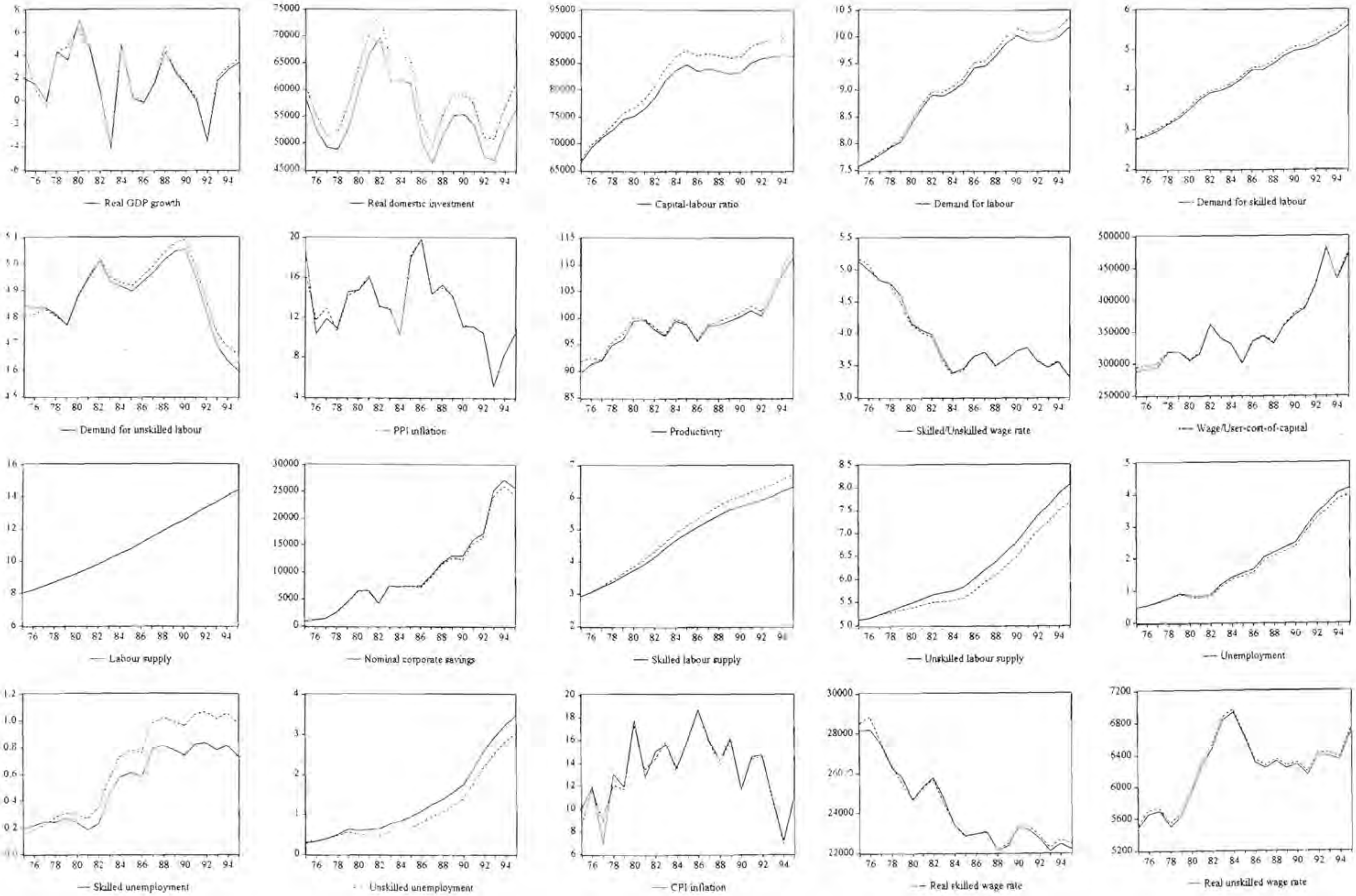


Figure A16.12(b) Combined scenario 2: Percentage differences between baseline and shocked simulation paths

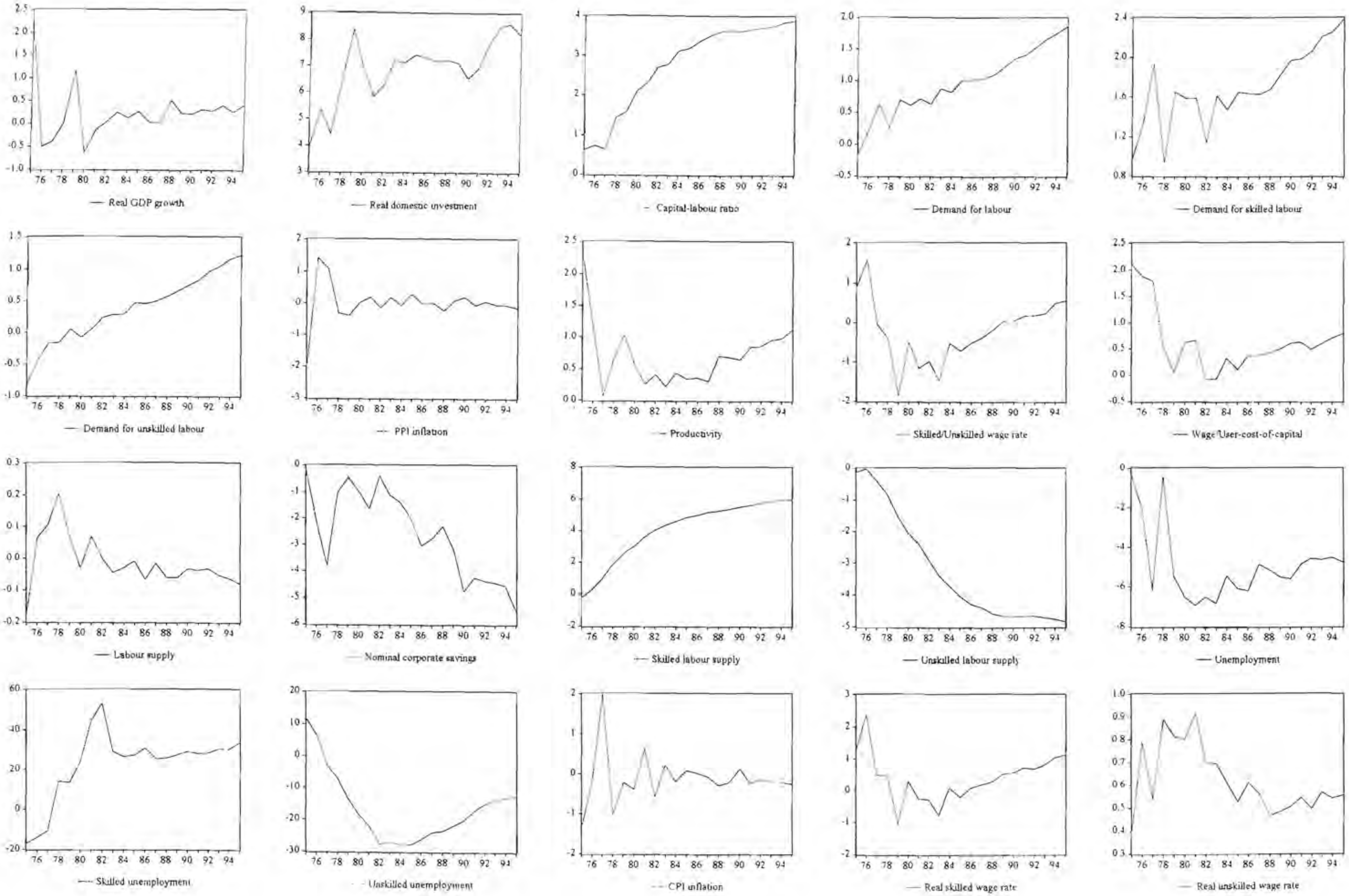


Figure A16.13(a) Combined scenario 3: Baseline and shocked simulation paths

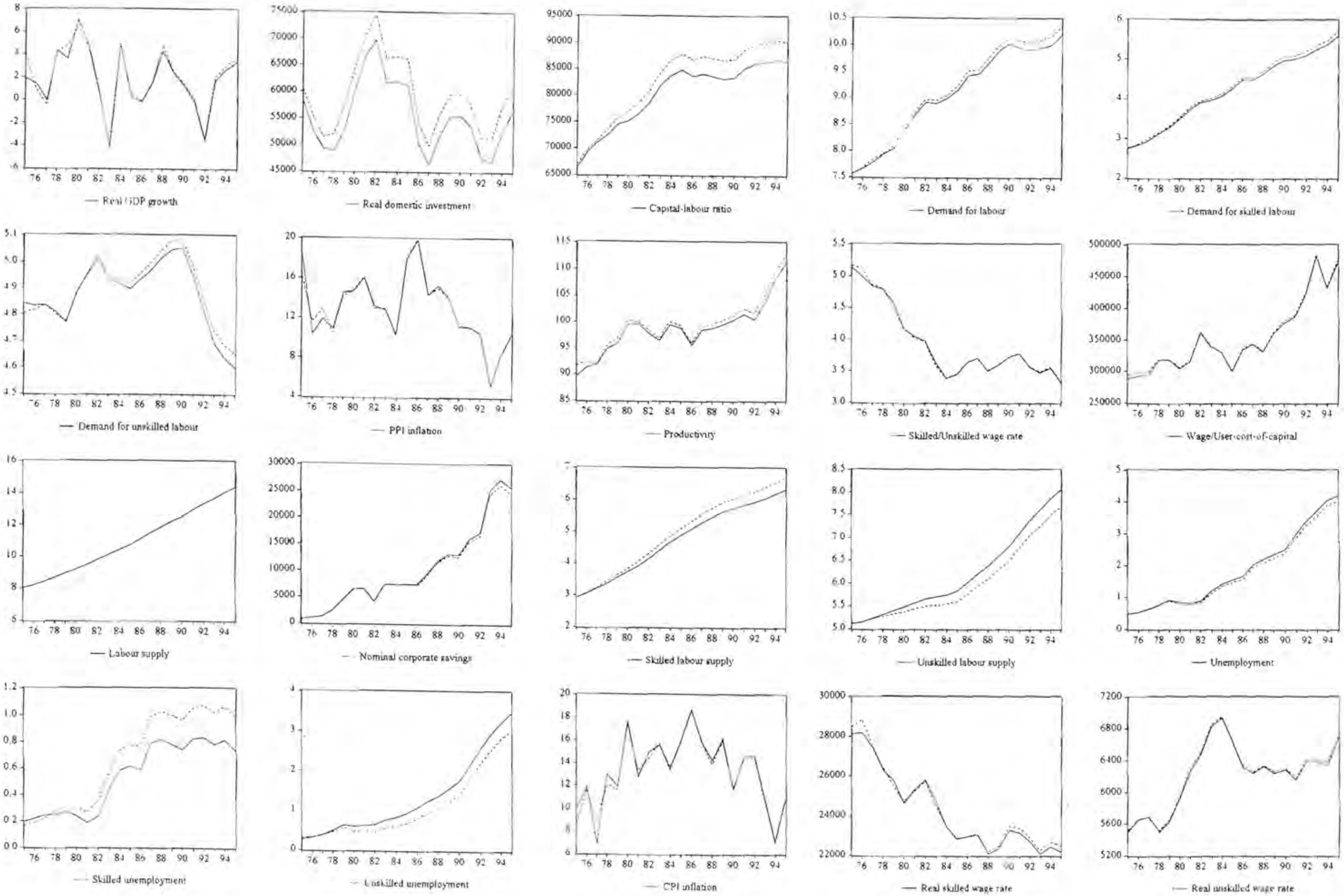


Figure A16.13(b) Combined scenario 3: Percentage differences between baseline and shocked simulation paths

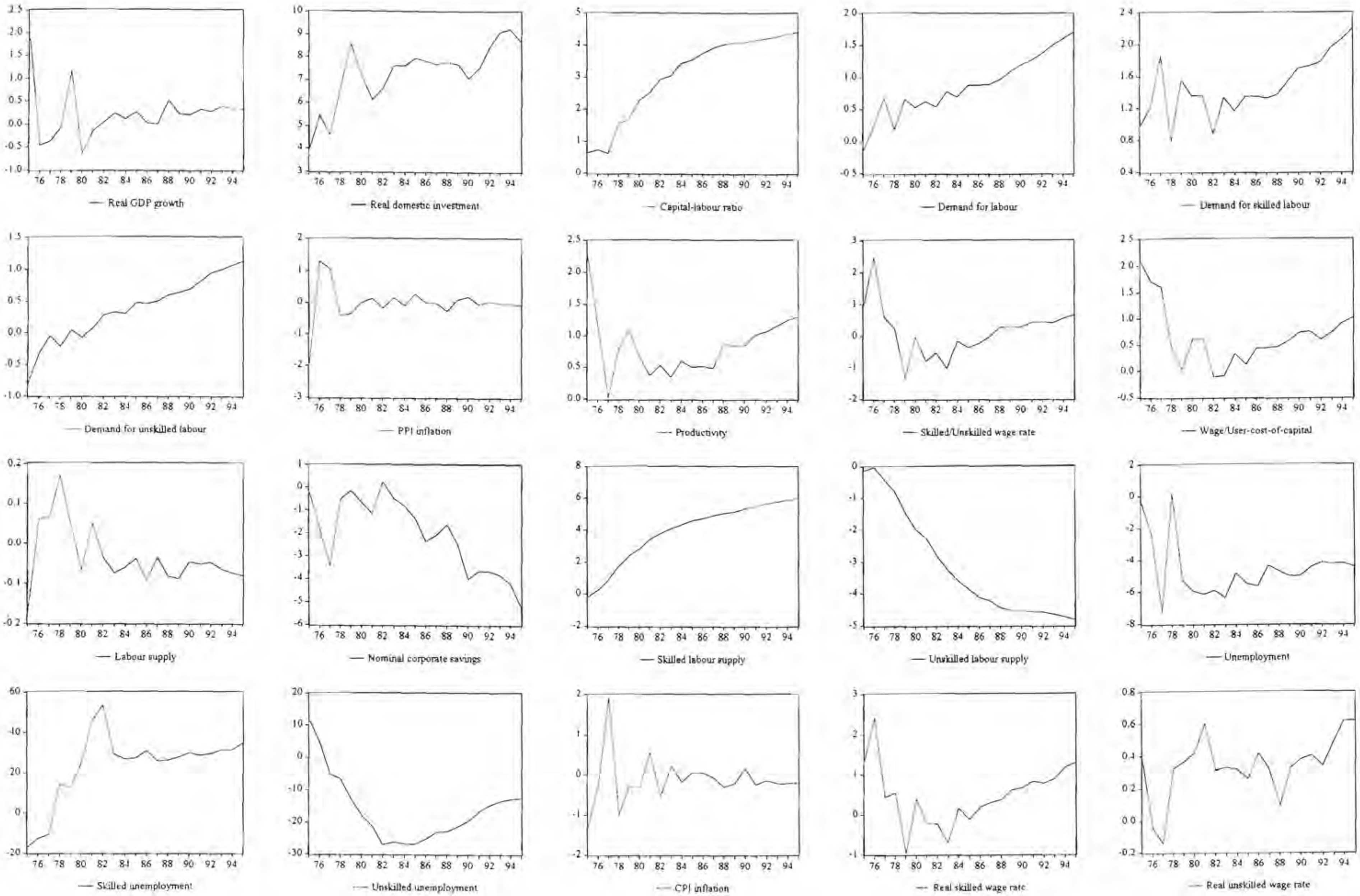


Figure A16.14(a) Combined scenario 4: Baseline and shocked simulation paths

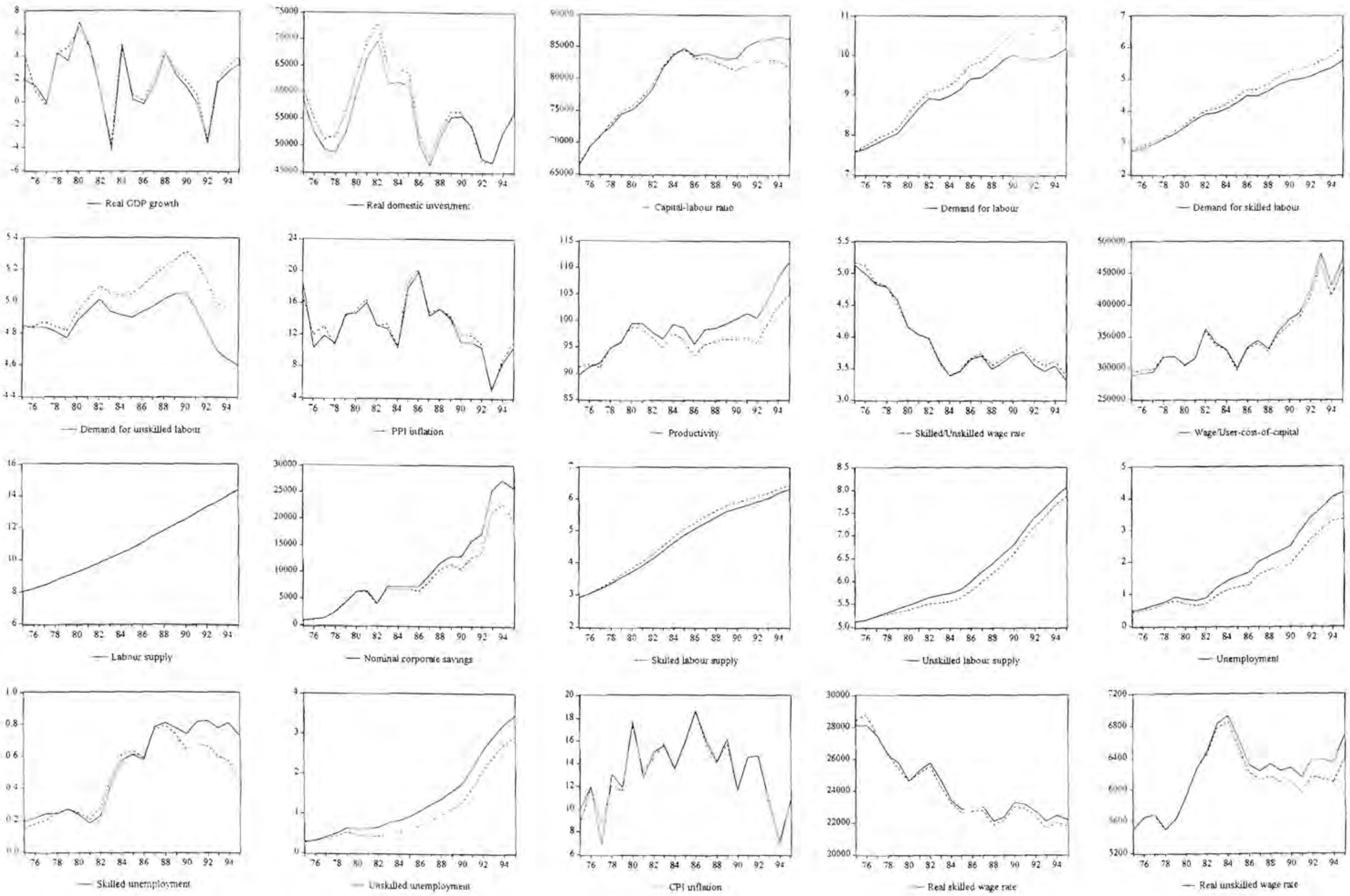


Figure A16.14(b) Combined scenario 4: Percentage differences between baseline and shocked simulation paths

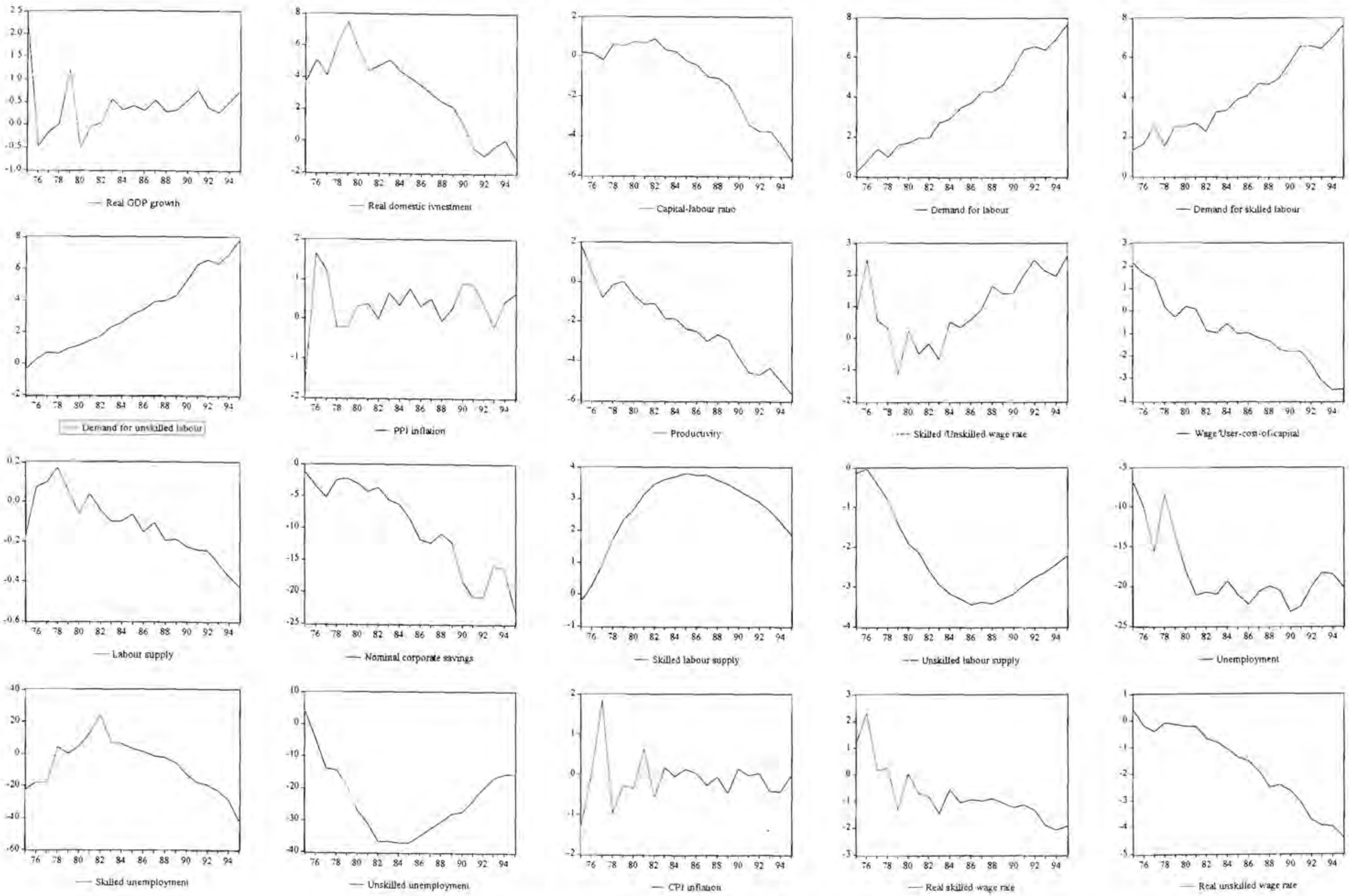


Figure A16.15(a) Combined scenario 5: Baseline and shocked simulation paths

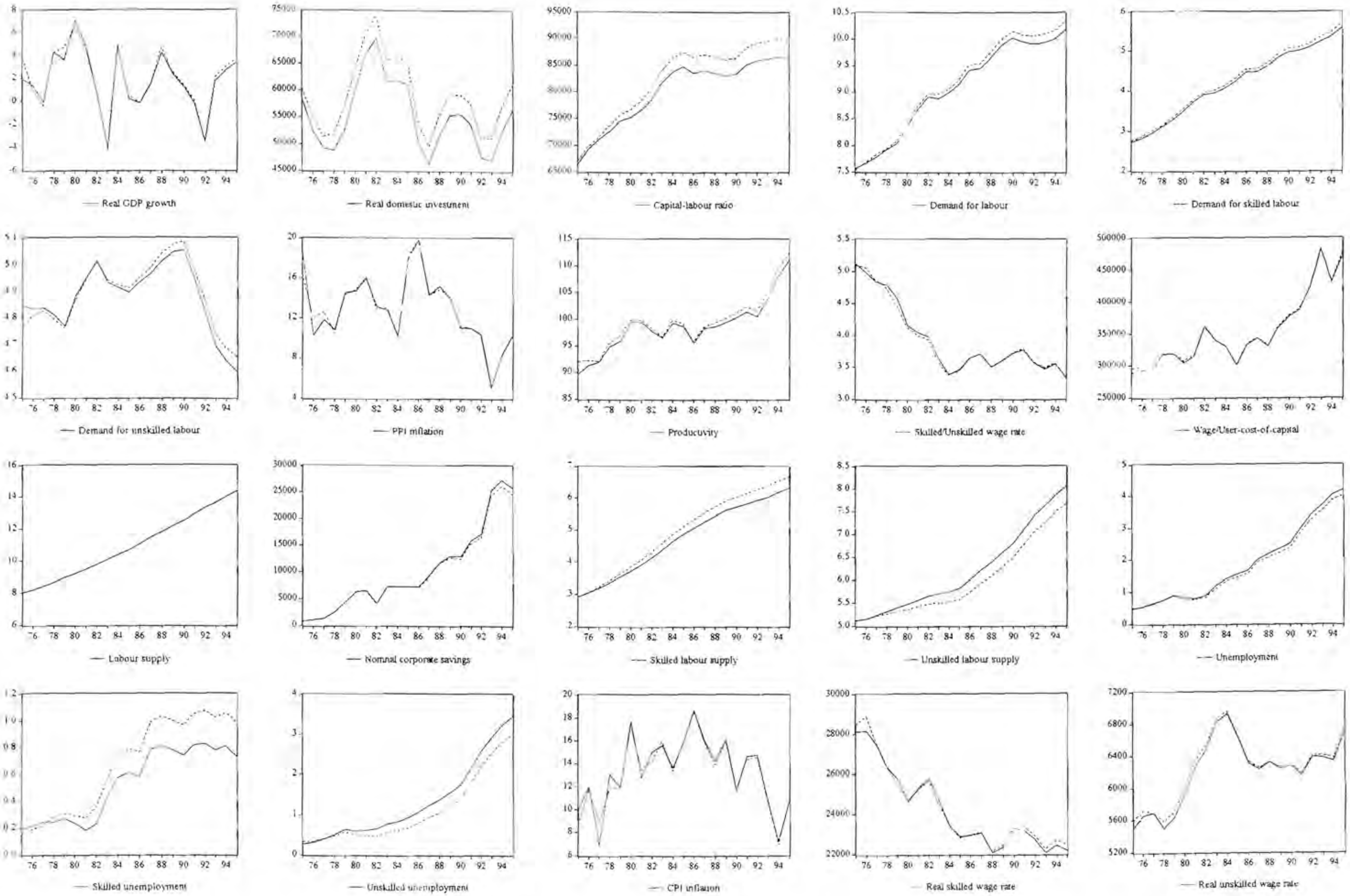


Figure A16.15(b) Combined scenario 5: Percentage differences between baseline and shocked simulation paths

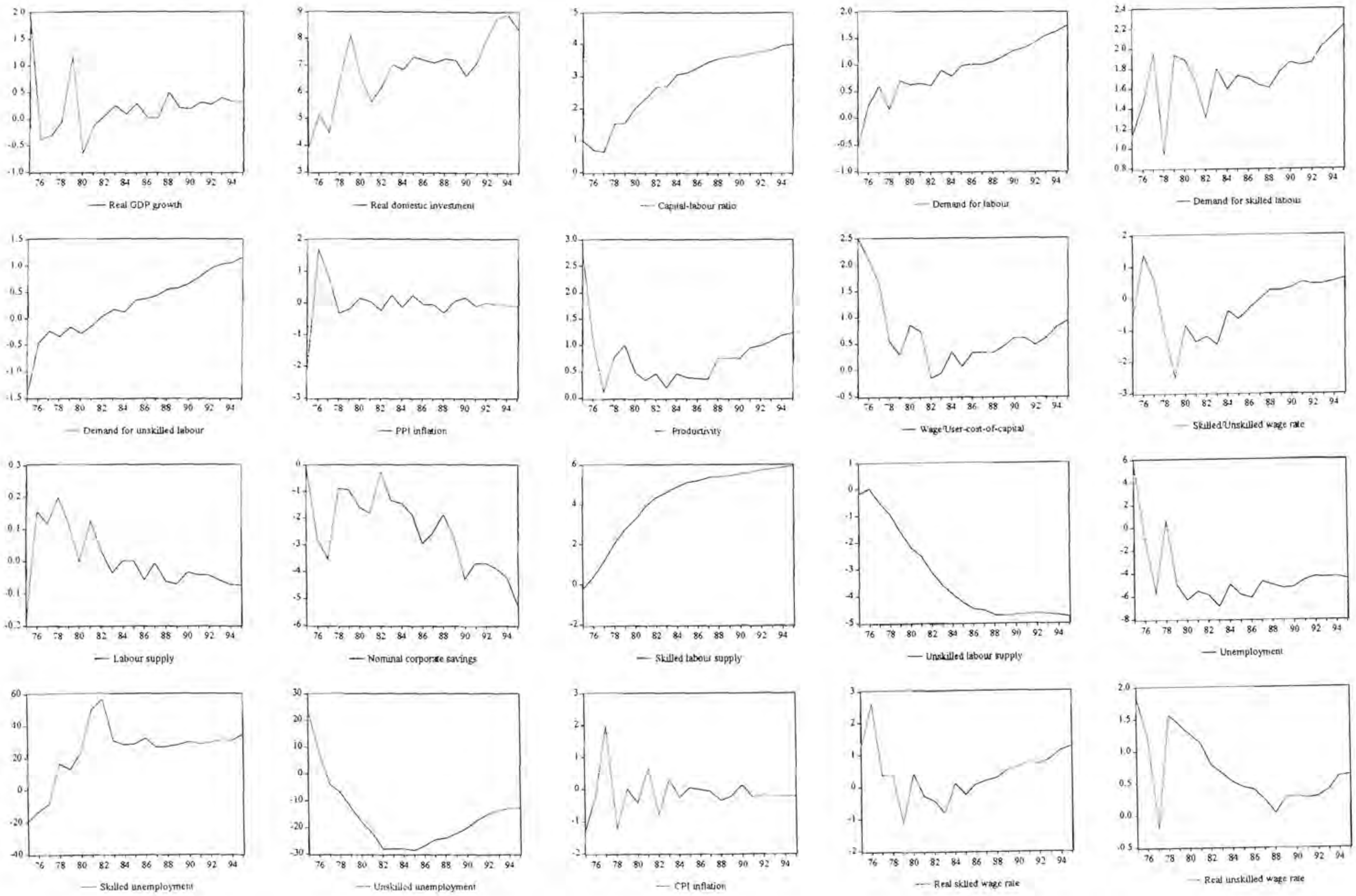


Figure A16.16(a) Combined scenario 6: Baseline and shocked simulation paths

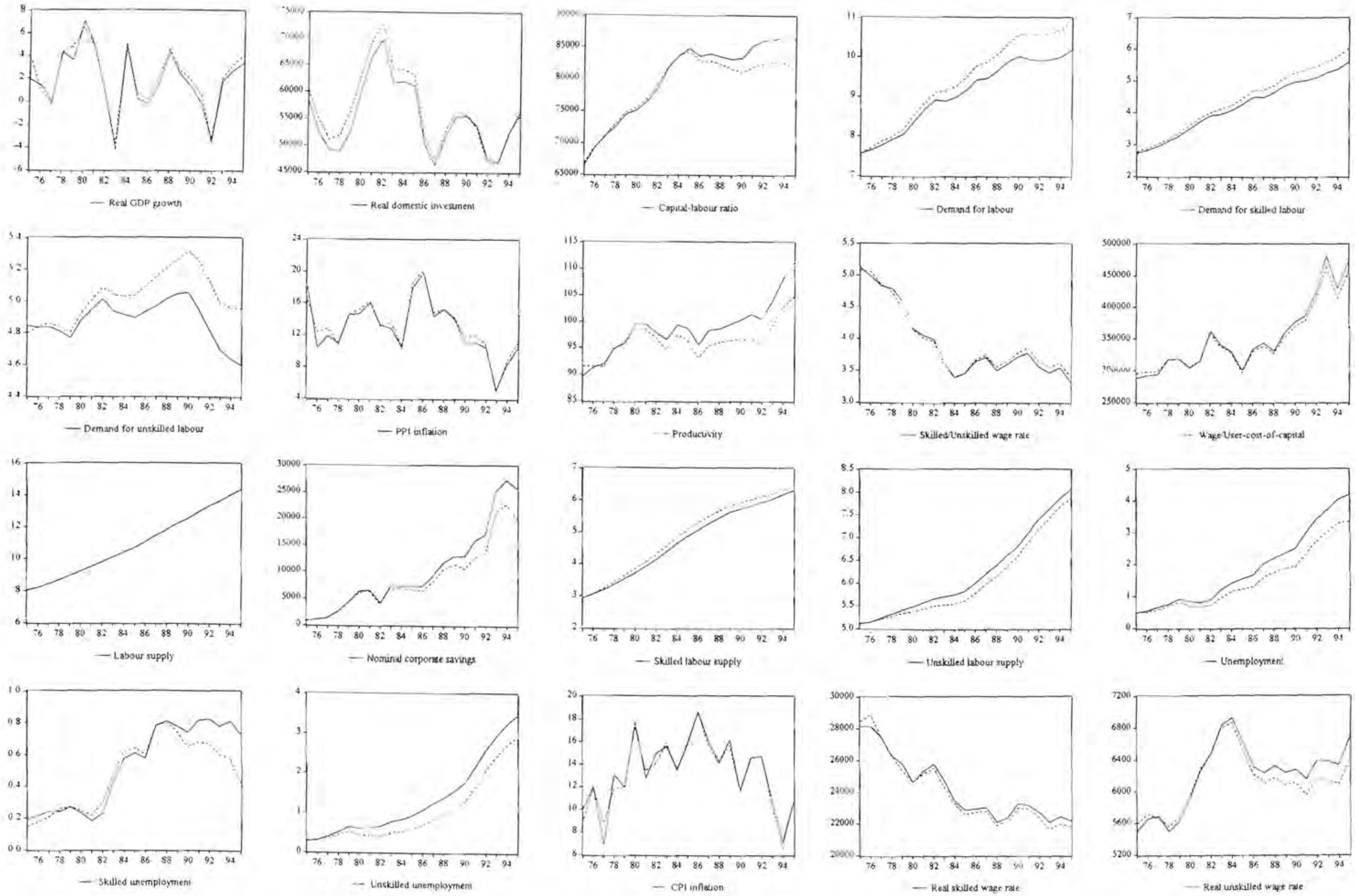
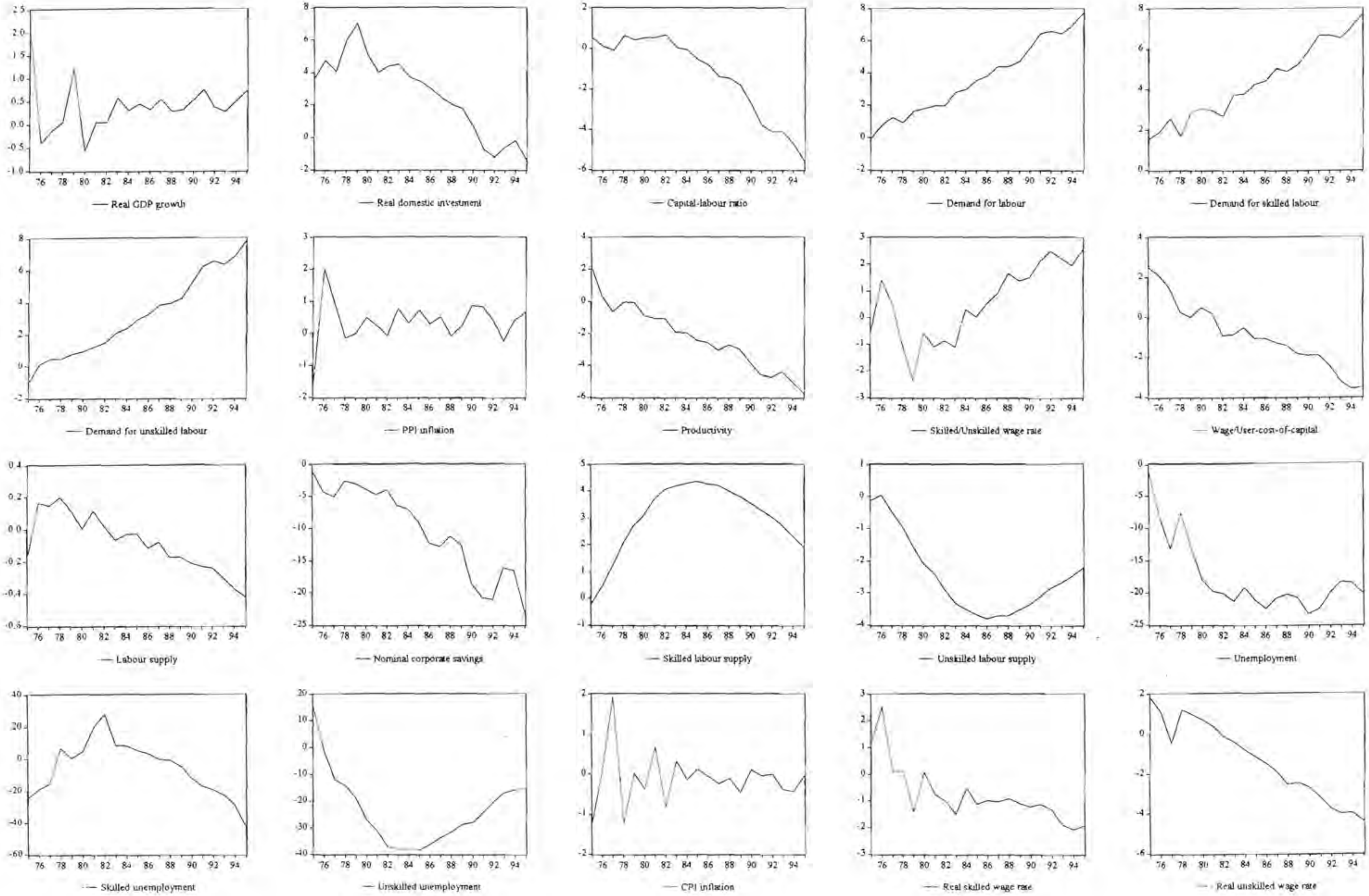


Figure A16.16(b) Combined scenario 6: Percentage differences between baseline and shocked simulation paths



APPENDIX 17: ORDER OF INTEGRATION

The augmented Dickey-Fuller unit root test is employed to test whether the data series are stationary or not. The testing strategy suggested by Dolado *et al.* (1990) and applied by Strum and de Haan (1995) is followed.

The augmented Dickey and Fuller (1981) unit root test is specified as the ordinary least squares estimation of:

$$\Delta Y_t = \eta_0 + \eta_1 \text{Trend} + \eta_2 Y_{t-1} + \sum_{i=1}^{m} \eta_{2+i} \ Y_{t-i} + \varepsilon_t \ . \qquad \text{(A17.1)}$$

where Y_t is the series being tested, m is the number of lags in the testing equation and ϵ_t the residual. The null hypothesis of non-stationarity is rejected in favour of a stationary data series, if the Dickey-Fuller test statistic is significantly less than the relevant critical value.

The test is implemented through the usual t-statistic of $\hat{\eta}_2$, denoted as τ_τ. Under the null hypothesis, τ_τ will not follow the standard t-distribution and the adjusted critical values computed by MacKinnon (1991) are used for evaluation. If τ_τ is significant, the null of non-stationarity is rejected and the data series is stationary.

If τ_τ is insignificant, the joint null hypothesis of $\eta_1 = \eta_2 = 0$, using the F-statistic denoted as Φ_3, is tested. The relevant critical values from Dickey and Fuller are used to evaluate the test statistic Φ_3. If Φ_3 is significant, the unit root test is repeated, now using the critical values of the standard t-distribution.

If the trend is not significant in the maintained model, the next step is to estimate equation 1 without a trend ($\eta_1 = 0$). The unit root test is carried out, now denoting the t-statistic of $\hat{\eta}_2$ as τ_μ and using the relevant critical values from MacKinnon. If the null hypothesis is rejected, the data series is stationary.

If the null of non-stationarity is not rejected, the joint null hypothesis of $\eta_0 = \eta_2 = 0$, using the F-statistic denoted as Φ_1 is tested and the critical values reported by Dickey and Fuller are employed. If Φ_1 is significant, the unit root test is repeated, using the standard normal distribution.

If Φ_1 is insignificant, the Dickey-Fuller τ test is carried out without a constant in the testing equation, testing the joint hypothesis of $\eta_0 = \eta_2 = 0$. If the test statistic (τ) is significantly less than the relevant MacKinnon critical value, the null hypothesis of non-stationarity is rejected and the data series is stationary.

The number of lags used in the estimation equation is determined in similar way as Perron (1989). Perron suggested starting with eight lags. If the last (eighth) lag is insignificant at a 10 percent level of significance (using the standard normal distribution), it is omitted. The test is repeated with seven lags and the last lag tested for significance. The process is repeated until there are no more lags left, in which case the test has reduced to the standard Dickey-Fuller (DF) test. The large level of significance (10 percent) is taken because, as Perron (1989: 1384) pointed out, "...including too many regressors of lagged first-differences does not affect the size of the test but only decreases its power. Including too few lags may have a substantial effect on the size of the test". Furthermore, Molinas (1986) noticed that "…a rather large number of lags has to be taken in the ADF test in order to capture the essential dynamics of the residuals."

The following reasons necessitate the careful evaluation of the ADF integration test results:

(i) In the $DF\tau$ test the presumption is that the data generating process (DGP), stationary or not, has a zero mean (no constant or drift term), and no trend: in effect there are no deterministic components to the series. The implication is that the initial y value is zero, since a DGP without deterministic components and a unit root (i.e. either a true stationary or differenced stationary data series) has its mean determined by its initial observation. Where the mean of a non-stationary series is not zero, i.e. where the DGP has a drift component (constant), the $DF\tau$ test will be inappropriate – it will lead to an over-rejection of the null of non-stationarity (stationarity will too easily be accepted) and therefore generate misleading results[1]. Therefore, if the initial value of y is not certain (i.e. whether the DGP is subject to drift or not), the $DF\tau_\mu$ test need to be employed.

(ii) Under the $DF\tau_\mu$ test: $\Delta y_t = \mu_b + (\rho_b - 1)y_{t-1} + \mu_t$, (only testing for a unit root and drift term), if the series has a unit root $(\rho_b = 1)$, y_t will follow a stochastic trend, drifting upwards or downwards depending on the sign of μ_b.

Alternatively, if the series is stationary (ρ_b [illegible] 1), y_t will have no stochastic trend, and will be stationary around a constant mean of $\mu_b/(1-\rho_b)$. If, however, the true DGP is a trend-stationary process (stationary process with a deterministic trend component): i.e. $y_t = \alpha + \beta t + \mu_t$, y_t will also follow a trend (now of a stationary deterministic and not a non-stationary stochastic nature), drifting upwards or downwards depending on the sign of β. The $DF\tau_\mu$ test will mistaken the stationary deterministic trend for a non-stationary stochastic trend and render the y_t process non-stationary. The $DF\tau_\mu$ test fails to distinguish between a series with a stochastic and a series with a deterministic trend. The τ_τ version of the Dickey-Fuller test ($DF\tau_\tau$) allows for the presence of a time trend. However, there are two points to note here:

- If the $DF\tau_\tau$ test is inappropriately **avoided**, there would be a tendency to **over**-accept the null of non-stationarity for series, which are in fact stationary.
- If the $DF\tau_\tau$ test is inappropriately **used**, there would be a tendency to **under**-accept the null of non-stationarity for series, which are in fact non-stationary.

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[1] $DF\tau$ test: $\Delta y_t = (\rho_a - 1)y_{t-1} + \mu_t$ test whether $\rho = 1$ ($\rho - 1 = 0$) with $\mu_t \sim IID(0,\sigma^2)$.
If $\rho = 1$ (y_t is a non-stationary data series): $\Delta y_t = 0 + \mu_t$ (indicating that $\rho - 1 = 0$ and, although not explicitly testing for it, indicating that Δy_t has a zero mean). Now, if y_t is subject to drift (constant) and the $DF\tau$ test is applied, still only testing for $\rho - 1 = 0$, $\Delta y_t = \delta + \mu_t$ will indicate that $\rho - 1 = \delta \neq 0$. If, by example, $\delta = -1.2 < 0$, then the $DF\tau$ test will wrongly indicate that y_t is stationary due to the outcome of $\rho - 1 = \delta = -1.2$.

(iii) Unit root tests have problems with their "power": in small samples they are likely to accept the null-hypothesis of a unit root when the true DGP is in fact stationary, though close to having a unit root. In effect, standard unit root test will under-reject the presence of a unit root (accept stationarity). With small samples, therefore, special care must be exercised in the application of unit root tests. Effectively, in small (finite) samples some unit root processes appear to behave like trend-stationary processes, while some trend-stationary processes appear to behave like random walk (non-stationary) processes. Unit root tests are likely to be fooled in either event: either rejecting non-stationarity where non-stationarity should be accepted, or accepting non-stationarity where non-stationarity should be rejected. This is obviously a very important problem in the current scenario since the sample size used to test for the presence of a unit root only consists of 25 observations.

(iv) Where (unknown) structural breaks are present in the data, application of "standard" unit root tests would again lead to an under-rejection of the null of the presence of a unit root (i.e. accept stationarity). In the South African context the periods of sanctions, disinvestment, outflow of human capital and changes in monetary policy are of importance and need to be taken in consideration.

An important consequence of the above is that inferences concerning the stationarity properties of data should always be based on a range of evidence, of which the formal ADF (and other) tests are merely one component. Economic theory, structural properties of the data, *a priori* information concerning political and other exogenous shocks to the economy over the sample period, data plots, residual plots, plots of the autocorrelation function, and spectral analysis all form part of the evidence required to draw conclusions on the stationarity of data. These inference guidelines should always be taken in consideration when testing for the presence of a unit root.

Tables A17.1, A17.2 and A17.3 report the outcomes of the ADF tests for all relevant data series employed in the estimations. The series tested are given in the first column. The second column reports whether a trend and a constant (Trend), only a constant (Constant), or neither (None) is included. In the third column, the number of lags recorded is reported. The next column shows the ADF t-statistic, called τ_τ when a trend and constant are included, τ_μ when only a constant is included, and τ when neither occurs. The last column reports the F-statistic, Φ_3 (Φ_1), testing whether the trend (constant) is significant under the null hypothesis of no unit root.

According to table A17.1 there are a couple of variables that seem to be stationary in levels. However, apart from the fact that the test results are not conclusive, taking the problems and inference guidelines associated with the testing for a unit root in consideration, it is obvious that these variables cannot be stationary in their levels. The only variable that can indeed be rendered stationary in levels is *ln_cu*. Table A17.2 indicates that all other variables, except *ln_ss* are integrated of order 1. Although *ln_ss* tested as stationary in second differences, consideration of the inference guidelines makes it is plausible that the variable is integrated of order 1 rather than order 2. The ADF test may recognise the structural break as a trend within a trend, rendering *ln_ss* as an I(2) variable. Due to the nature of construction of the dummy variables, they are all integrated of order 0 and are therefore all stationary in levels.

Table A17.1. Augmented Dickey-Fuller tests for non-stationarity, levels, 1970-1995

Series	Model	Lags	$\tau_\tau, \tau_\mu, \tau$	Φ_3, Φ_1
ln_bbp_90p	Trend	0 *(insign)*	-1.68	3.21
	Constant	0	-2.30	5.29*
	None	0	4.16	
ln_bbp_min_90p	Trend	3	-3.73*	3.46
	Constant	3	-3.72*	3.46
	None	0 *(insign)*	-1.28	
ln_bbpfact_90p	Trend	0 *(insign)*	-1.71	4.04
	Constant	0	-2.70	7.31*
	None	0	4.07	
ln_c90p_lrem5	Trend	3	-4.77**	5.46
	Constant	4	0.15	1.37
	None	4	2.66	
ln_cu	Trend	8	-3.87*	
	Constant			
	None			
ln_educind	Trend	0	-2.81	4.70
	Constant	0	0.45	0.20
	None	0	-2.60*	
ln_empl_rat	Trend	4	-0.24	3.50
	Constant	4	2.04	2.17
	None	4	3.34	
ln_empl_rat_s	Trend	6	-1.24	1.76
	Constant	6	-1.79	2.14
	None	4	0.13	
ln_empl_rat_u	Trend	0 *(insign)*	0.57	23.26
	Constant	0	5.83	33.96
	None	0	9.59	
ln_exces_dem_cp	Trend	0	-2.35	3.37
	Constant	0	-2.65	7.04*
	None	0	-1.77	
ln_fincond_ppi	Trend	1	-3.05	3.26
	Constant	1	-3.15*	5.13
	None	4	0.13	
ln_gostc_cp	Trend	1	-5.09**	8.77*
	Constant	2	-0.38	2.09
	None	2	4.39	
ln_gprys_$	Trend	4	-1.19	2.52
	Constant	4	-2.58	2.72
	None	2	0.89	

*(**) Significant at a 5(1) percent level.

a At a 5(1) percent significance level the MacKinnon critical values are –3.60(-4.38) when a trend and a constant are included (τ_τ), and –3.00(-3.75) when only a constant is included (τ_μ), and –1.95(-2.66) when neither is included (τ). The standard t-distribution critical value is –1.708(-2.485).

b At a 5(1) percent significance level the Dickey-Fuller critical values (for 25 observations) are 7.24(10.61) when a trend and a constant are included (Φ_3), and 5.18(7.88) when only a constant is included (Φ_1).

*** Significant at a 10 percent level.

(insign) Insignificant lag.

Table A17.1 *(cont.)*. Augmented Dickey-Fuller tests for non-stationarity, levels, 1970-1995

Series	Model	Lags	$\tau_\tau, \tau_\mu, \tau$	Φ_3, Φ_1
ln_gprys_r	Trend	4	0.27	4.31
	Constant	4	-3.76**	4.10
	None	1	1.77	
ln_if	Trend	2	-2.32	7.90*
	Constant	2	-2.27	9.42**
	None	2	0.50	
ln_interposind	Trend	6	-3.24	3.44
	Constant	0 *(insign)*	-0.74	0.54
	None	0	-3.91*	
ln_kap_lab_rat	Trend	4	-2.36	8.56*
	Constant	0	-6.32**	39.97**
	None	0	4.51	
ln_kap_r	Trend	2	-1.76	146.30**
	Constant	2	-3.40	187.24**
	None	2	0.69	
ln_n	Trend	4	0.80	3.95
	Constant	0	-3.74*	14.02**
	None	0	6.10	
ln_n_informal	Trend	1	-2.80	3.28
	Constant	0 *(insign)*	-1.11	1.24
	None	0	3.01	
ln_ns	Trend	0 *(insign)*	-1.23	17.33
	Constant	0	-6.01**	36.22**
	None	0	6.68	
ln_nu	Trend	4	1.03	3.89
	Constant	1	-2.08	8.88**
	None	1	-0.21	
ln_p_manuf	Trend	1	-4.01*	18.01**
	Constant	1	-0.61	11.64
	None	1	-1.84	
ln_ppi	Trend	1	-1.91	6.09
	Constant	2	-2.30	6.41*
	None	1	-2.07*	
ln_prime_rate	Trend	3	-3.46	4.23
	Constant	2	-1.48	2.90
	None	0 *(insign)*	0.65	
ln_product	Trend	1	-1.82	2.82
	Constant	0 *(insign)*	1.07	1.13
	None	0	2.24	

*(**) Significant at a 5(1) percent level.

a At a 5(1) percent significance level the MacKinnon critical values are –3.60(-4.38) when a trend and a constant are included (τ_τ), and –3.00(-3.75) when only a constant is included (τ_μ), and –1.95(-2.66) when neither is included (τ). The standard t-distribution critical value is –1.708(-2.485).

b At a 5(1) percent significance level the Dickey-Fuller critical values (for 25 observations) are 7.24(10.61) when a trend and a constant are included (Φ_3), and 5.18(7.88) when only a constant is included (Φ_1).

*** Significant at a 10 percent level.

(insign) Insignificant lag.

Table A17.1 *(cont.)*. Augmented Dickey-Fuller tests for non-stationarity, levels, 1970-1995

Series	Model	Lags	$\tau_\tau, \tau_\mu, \tau$	Φ_3, Φ_1
ln_pz$	Trend	2	-2.07	6.36
	Constant	2	-3.53*	8.93**
	None	2	-2.97**	
ln_r$	Trend	3	-2.23	2.77
	Constant	0 *(insign)*	0.24	0.06
	None	0	2.74	
ln_rel_wscost_u	Trend	6	1.82	2.05
	Constant	4	-1.54	2.03
	None	4	-3.89**	
ln_rel_wsu_rat	Trend	0 *(insign)*	-1.53	2.78
	Constant	6	-1.36	1.09
	None	6	-1.65	
ln_s	Trend	3	-1.27	2.12
	Constant	3	-1.43	2.19
	None	3	-0.79	
ln_ss	Trend	1	0.33	31.27
	Constant	1	-2.54	46.06**
	None	1	-0.03	
ln_sc_cp	Trend	0	-1.99	2.06
	Constant	0 *(insign)*	-0.90	0.81
	None	0	2.47	
ln_socind	Trend	0	-1.50	1.82
	Constant	6	3.43	3.06
	None	5	-0.33	
tecno_index	Trend	0	-2.01	6.14
	Constant	0	1.83	3.36
	None	0	4.02	
ln_total_pop	Trend	4	0.36	12671.24
	Constant	4	-2.94	15012.84**
	None	8	-0.85	
ln_ucc2_90p	Trend	1	-5.06**	8.54*
	Constant	4	-0.78	1.83
	None	7	-1.56	
ln_ucc2_nom	Trend	6	-1.75	1.01
	Constant	0 *(insign)*	-1.07	1.14
	None	5	-1.53	
ln_unempl_rat	Trend	4	-2.58	3.33
	Constant	4	0.76	1.70
	None	6	-4.02**	

*(**) Significant at a 5(1) percent level.

a At a 5(1) percent significance level the MacKinnon critical values are –3.60(-4.38) when a trend and a constant are included (τ_τ), and –3.00(-3.75) when only a constant is included (τ_μ), and –1.95(-2.66) when neither is included (τ). The standard t-distribution critical value is –1.708(-2.485).

b At a 5(1) percent significance level the Dickey-Fuller critical values (for 25 observations) are 7.24(10.61) when a trend and a constant are included (Φ_3), and 5.18(7.88) when only a constant is included (Φ_1).

*** Significant at a 10 percent level.

(insign) Insignificant lag.

Table A17.1 *(cont.)*. Augmented Dickey-Fuller tests for non-stationarity, levels, 1970-1995

Series	Model	Lags	$\tau_\tau, \tau_\mu, \tau$	Φ_3, Φ_1
ln_uniopresind	Trend	7	-1.99	2.36
	Constant	5	2.74	2.32
	None	5	-1.70	
ln_vpi	Trend	4	-0.54	4.02
	Constant	4	-2.11	5.06
	None	4	-3.06**	
ln_w_prod	Trend	2	-0.52	10.84
	Constant	2	-1.74	15.00**
	None	2	2.38	
ln_ws_rate	Trend	1	-2.73	6.88
	Constant	1	-0.35	5.12
	None	1	1.99	
ln_wtot_ppi_rat	Trend	3	-3.24	3.74
	Constant	1	-0.84	1.88
	None	1	0.73	
ln_wtot_rate	Trend	1	-3.59	9.79*
	Constant	2	-0.41	5.20
	None	2	2.41	
ln_wtot_vpi_rat	Trend	1	-3.23	5.56
	Constant	5	-2.20	2.15
	None	0	1.82	
ln_wuppi_rat	Trend	3	-3.34	2.96
	Constant	6	-0.18	1.04
	None	6	2.61	
ln_wuvpi_rat	Trend	0	-1.92	3.87
	Constant	0	-2.82	7.96**
	None	0	2.39	
ln_xgoud_ppi	Trend	4	0.15	2.47
	Constant	5	-1.28	1.86
	None	5	-0.35	
ln_xgoud_px	Trend	0 *(insign)*	-1.29	1.72
	Constant	1	-2.07	2.88
	None	0 *(insign)*	-0.18	

*(**) Significant at a 5(1) percent level.

a At a 5(1) percent significance level the MacKinnon critical values are –3.60(-4.38) when a trend and a constant are included (τ_τ), and –3.00(-3.75) when only a constant is included (τ_μ), and –1.95(-2.66) when neither is included (τ). The standard t-distribution critical value is –1.708(-2.485).

b At a 5(1) percent significance level the Dickey-Fuller critical values (for 25 observations) are 7.24(10.61) when a trend and a constant are included (Φ_3), and 5.18(7.88) when only a constant is included (Φ_1).

*** Significant at a 10 percent level.

(insign) Insignificant lag

Table A17.2. Augmented Dickey-Fuller tests for non-stationarity, first differences, 1970-1995

Series	Model	Lags	$\tau_\tau, \tau_\mu, \tau$	Φ_3, Φ_1
Δln_bbp_90p	Trend	0	-3.81*	7.38*
	Constant	0	-3.65*	13.29*
	None	0	-2.63*	
Δln_bbp_min_90p	Trend	0	-3.78*	7.32*
	Constant	0	-3.90**	15.25**
	None	0	-3.84**	
Δln_bbpfact_90p	Trend	0	-3.85*	7.55*
	Constant	0	-3.58*	12.85**
	None	0	-2.67**	
Δln_c90p_lrem5	Trend	3	-3.26***	3.68
	Constant	3	-3.32*	4.78***
	None	0	-2.82**	
Δln_educind	Trend	0	4.16	9.87
	Constant	0	-4.45**	19.83**
	None	0	-3.28**	
Δln_empl_rat	Trend	3	-4.75**	7.27*
	Constant	0	-2.98*	8.87**
	None	0	-2.21*	
Δln_empl_rat_s	Trend	5	-0.54	2.58
	Constant	3	-3.44*	4.76***
	None	3	-3.53**	
Δln_empl_rat_u	Trend	0	-3.29***	
	Constant			
	None			
Δln_exces_dem_cp	Trend	8	-2.77	4.47
	Constant	3	-4.26**	7.05*
	None	3	-4.35**	
Δln_fincond_ppi	Trend	3	-3.49	5.00
	Constant	3	-3.74*	6.48*
	None	3	-3.85**	
Δln_gostc_cp	Trend	1	-5.06**	9.24*
	Constant	1	-5.20**	14.49**
	None	0	-1.62***	
Δln_gprys_$	Trend	3	-4.53**	6.58
	Constant	0	-3.21*	10.32**
	None	0	-3.02**	

*(**) Significant at a 5(1) percent level.

a At a 5(1) percent significance level the MacKinnon critical values are –3.60(-4.38) when a trend and a constant are included (τ_τ), and –3.00(-3.75) when only a constant is included (τ_μ), and –1.95(-2.66) when neither is included (τ). The standard t-distribution critical value is –1.708(-2.485).

b At a 5(1) percent significance level the Dickey-Fuller critical values (for 25 observations) are 7.24(10.61) when a trend and a constant are included (Φ_3), and 5.18(7.88) when only a constant is included (Φ_1).

*** Significant at a 10 percent level.

(insign) Insignificant lag.

Table A17.2 ***(cont.).*** **Augmented Dickey-Fuller tests for non-stationarity, first differences, 1970-1995**

Series	Model	Lags	$\tau_\tau, \tau_\mu, \tau$	Φ_3, Φ_1
Δln_gprys_r	Trend	3	-6.81**	12.34**
	Constant	0	-3.39*	11.52**
	None	0	-2.45*	
Δln_if	Trend	1	-4.49**	7.33*
	Constant	1	-4.30**	9.90**
	None	1	-4.35**	
Δln_interposind	Trend	0	-3.45***	5.95***
	Constant	0	-3.50*	12.22**
	None	0	-2.26*	
Δln_kap_lab_rat	Trend	7	-1.98	2.54
	Constant	5	-1.33	2.09
	None	5	-2.54*	
Δln_kap_r	Trend	1	-3.48***	7.13***
	Constant	2	-1.12	6.43
	None	2	-2.34*	
Δln_n	Trend	8	-1.51	7.00
	Constant	8	2.22	3.92
	None	5	-1.76***	
Δln_n_informal	Trend	1	-4.36*	6.77***
	Constant	1	-4.57**	10.63**
	None	1	-3.33**	
Δln_ns	Trend	0	-2.95	4.55
	Constant	0	-2.07	4.29***
	None			
Δln_nu	Trend	0	-3.06	4.70
	Constant	0	-2.47	6.09*
	None	0	-2.55*	
Δln_p_manuf	Trend	0	-2.27	3.17
	Constant	0	-2.53	6.38*
	None			
Δln_ppi	Trend	1	-4.57**	7.50*
	Constant	1	-3.75**	7.12*
	None			
Δln_prime_rate	Trend	4	-5.23**	8.24*
	Constant	4	-5.13**	9.67**
	None	3	-3.95**	
Δln_product	Trend	0	-3.24***	5.42
	Constant	0	-2.98	8.89**
	None	0	-2.56*	

*(**) Significant at a 5(1) percent level.

a At a 5(1) percent significance level the MacKinnon critical values are –3.60(-4.38) when a trend and a constant are included (τ_τ), and –3.00(-3.75) when only a constant is included (τ_μ), and –1.95(-2.66) when neither is included (τ). The standard t-distribution critical value is –1.708(-2.485).

b At a 5(1) percent significance level the Dickey-Fuller critical values (for 25 observations) are 7.24(10.61) when a trend and a constant are included (Φ_3), and 5.18(7.88) when only a constant is included (Φ_1).

*** Significant at a 10 percent level.

(insign) Insignificant lag.

Table A17.2 *(cont.)*. Augmented Dickey-Fuller tests for non-stationarity, first differences, 1970-1995

Series	Model	Lags	$\tau_\tau, \tau_\mu, \tau$	Φ_3, Φ_1
Δln_pz$	Trend	1	-4.57**	6.96
	Constant	2	-1.76	5.28*
	None	2	-1.68***	
Δln_r$	Trend	1	-4.12*	6.07***
	Constant	0	-3.81**	14.49**
	None	0	-3.12**	
Δln_rel_wscost_u	Trend	3	-4.31*	8.30*
	Constant	3	-3.93**	9.05**
	None	0	-3.41**	
Δln_rel_wsu_rat	Trend	0	-4.66**	10.87**
	Constant	0	-3.88**	15.05**
	None	0	-2.56*	
Δln_s	Trend	2	-0.90	12.08
	Constant	0	-6.36**	40.47**
	None	9	-7.14**	
Δln_ss	Trend	0	-2.96	4.49
	Constant	0 *(insign)*	-0.94	0.88
	None	0 *(insign)*	-1.33	
Δln_sc_cp	Trend	0	-5.64**	15.94**
	Constant	0	-5.72**	32.75**
	None	0	-4.53**	
Δln_socind	Trend	5	-4.12*	7.89*
	Constant	3	-3.33*	5.86*
	None	0	-3.79**	
Δtecno_index	Trend	0	-5.22**	13.66**
	Constant	0	-4.45**	19.82**
	None	0	-2.92**	
Δln_total_pop	Trend	8	-6.86**	596.94**
	Constant	7	0.04	73.39
	None	7	-4.04**	
Δln_ucc2_90p	Trend	3	-3.96*	7.91*
	Constant	3	-4.05**	10.11**
	None	0	-3.39**	
Δln_ucc2_nom	Trend	0	-4.18*	9.12*
	Constant	0	-3.99**	15.93**
	None			
Δln_unempl_rat	Trend	3	-5.10**	-9.64*
	Constant	3	-5.39**	11.46**
	None	0	-3.42**	

*(**) Significant at a 5(1) percent level.

a At a 5(1) percent significance level the MacKinnon critical values are –3.60(-4.38) when a trend and a constant are included (τ_τ), and –3.00(-3.75) when only a constant is included (τ_μ), and –1.95(-2.66) when neither is included (τ). The standard t-distribution critical value is –1.708(-2.485).

b At a 5(1) percent significance level the Dickey-Fuller critical values (for 25 observations) are 7.24(10.61) when a trend and a constant are included (Φ_3), and 5.18(7.88) when only a constant is included (Φ_1).

*** Significant at a 10 percent level.

(insign) Insignificant lag.

Table A17.2 *(cont.)*. Augmented Dickey-Fuller tests for non-stationarity, first differences, 1970-1995

Series	Model	Lags	$\tau_\tau, \tau_\mu, \tau$	Φ_3, Φ_1
Δln_uniopresind	Trend	4	0.76	6.48
	Constant	0	-4.96**	24.61**
	None	0	-4.72**	
Δln_vpi	Trend	5	-1.89	3.54
	Constant	0	-2.15	4.61***
	None			
Δln_w_prod	Trend	1	-4.80**	9.31*
	Constant	1	-4.31**	11.37**
	None			
Δln_ws_rate	Trend	0	-2.12	2.66
	Constant	0	-2.36	5.55*
	None			
Δln_wtot_ppi_rat	Trend	6	-4.28*	4.38
	Constant	3	-2.89***	4.20***
	None	3	-2.57*	
Δln_wtot_rate	Trend	1	-3.21	3.80
	Constant	1	-3.37*	5.91*
	None			
Δln_wtot_vpi_rat	Trend	0	-3.39	5.75
	Constant	0	-3.23*	10.47**
	None	0	-3.07**	
Δln_wuppi_rat	Trend	0	-3.91	7.69*
	Constant	0	-4.01**	16.05**
	None	0	-3.41**	
Δln_wuvpi_rat	Trend	0	-3.66*	6.73
	Constant	0	-3.19*	10.20**
	None	0	-2.67**	
Δln_xgoud_ppi	Trend	3	-4.81**	6.82
	Constant	0	-3.27*	10.70**
	None	0	-3.34**	
Δln_xgoud_px	Trend	0	-3.73	7.01
	Constant	0	-3.58*	12.82**
	None	0	-3.66**	

*(**) Significant at a 5(1) percent level.

a At a 5(1) percent significance level the MacKinnon critical values are –3.60(-4.38) when a trend and a constant are included (τ_τ), and –3.00(-3.75) when only a constant is included (τ_μ), and –1.95(-2.66) when neither is included (τ). The standard t-distribution critical value is –1.708(-2.485).

b At a 5(1) percent significance level the Dickey-Fuller critical values (for 25 observations) are 7.24(10.61) when a trend and a constant are included (Φ_3), and 5.18(7.88) when only a constant is included (Φ_1).

*** Significant at a 10 percent level.

(insign) Insignificant lag.

Table A17.3. Augmented Dickey-Fuller tests for non-stationarity, second differences, 1970-1995

Series	Model	Lags	$\tau_\tau, \tau_\mu, \tau$	Φ_3, Φ_1
$\Delta\Delta$ln_ss	Trend	1	-5.36**	16.00**
	Constant	1	-5.37**	24.29**
	None	1	-4.78**	

*(**) Significant at a 5(1) percent level.

a At a 5(1) percent significance level the MacKinnon critical values are –3.60(-4.38) when a trend and a constant are included (τ_τ), and –3.00(-3.75) when only a constant is included (τ_μ), and –1.95(-2.66) when neither is included (τ). The standard t-distribution critical value is –1.708(-2.485).

b At a 5(1) percent significance level the Dickey-Fuller critical values (for 25 observations) are 7.24(10.61) when a trend and a constant are included (Φ_3), and 5.18(7.88) when only a constant is included (Φ_1).

*** Significant at a 10 percent level.

(insign) Insignificant lag.