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FORECASTS AND THE IMPACT OF MACROECONOMIC POLICIES: A COMPUTABLE GENERAL EQUILIBRIUM STUDY FOR PAPUA NEW GUINEA

ADDENDUM

p 64 line 13: after "commerce industries." add the sentence "Explicit modelling of margins is not included in the PNG model because data required to support such modelling are unavailable."

p 89 line 3: after "1998 to 2006." add the sentences "The forecast finished in 2006 to allow 5 years of genuine forecast, 2002 to 2006. At the time of preparation of this thesis, published data, if somewhat incomplete, were available for 1998 to 2001.

The chapter describes how we produce annual model-generated baseline forecasts and provides an analysis on the key impacts of each simulation that is undertaken." Then delete "Towards this aim, the chapter describes how we produce annual model-generated baseline forecasts and provides an analysis on the key impacts of each simulation that is undertaken."

p 91 second line of section 3.2: after "forecasting closure." add the sentences "A back-of-the-envelope model is used because it identifies the key economic relationships within PNG-ORAMON. This enables us to decide the appropriate closure changes that are required to absorb forecast data."

p 284 at the end of the last paragraph: after "low inflation rate" add the sentence "Policies to assist exports and constrain imports can be thought of as a low-inflation substitute for devaluation of the exchange rate."

p 285 at the end of the second paragraph: after "low inflation rate" add the sentence "In countries with better developed income-tax systems than that in PNG, increases in income tax might be preferable to increases in tariffs as a way of financing government expenditure programs."

p 333. Replace the first paragraph commencing "To damp the volatility ..." with the paragraph "To damp the volatility in export subsidies, we decided to increase the primary factor substitution for the mineral industries as well as for forestry, the other industry with high volatility in changes in export subsidies. In this way we flatten their short-run supply curves. After some experimentation we found that satisfactory results were achieved by increasing the substitution elasticity for primary factors from 0.5 to 2.0. An intuitive justification for the higher CES for primary factors in the mineral and forestry industries is that they are initially very capital-intensive. There is room for flexibility in their use of labour with the given capital."

p 337. Replace the last paragraph commencing "In our initial model, ..." with the paragraph "In our initial model, the multi-product *smallholding* exporting industries had low constant elasticities of transformation (CET set at 2). This did not allow sufficient flexibility in these industries to switch between commodities. Consequently, when a reduction in copra export was introduced, there could be a small reduction only in copra output in the *smallholding copra* industry because output of the other two goods could not move much given the low CET. Output was given in the *smallholding copra* industry and so most of the variation had to be borne by the *plantation copra* industry. In our revised model, we increased CET to 10 in multi-product agriculture industries. This increase was designed to give *smallholding copra* sufficient flexibility in its copra production to take pressure off the *plantation copra* industry. With the CET parameter at 10, the *plantation copra* industry no longer has to make large changes in its copra output to satisfy an exogenous export change."

FORECASTS AND THE IMPACT OF MACROECONOMIC POLICIES: A COMPUTABLE GENERAL EQUILIBRIUM STUDY FOR PAPUA NEW GUINEA

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PhD

2003

Forecasts and the Impact of Macroeconomic Policies: A Computable General Equilibrium Study for Papua New Guinea

A thesis submitted for the degree of Doctor of Philosophy in Economics

by

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Summary

The aim of this thesis is to examine the transmission of macroeconomic policy shocks in the Papua New Guinea (PNG) economy.

Examination of the pathways through which changes in fiscal and monetary policies transmit economy-wide influences to macro variables as well to as industry-level variables in Papua New Guinea is a key concern of this thesis.

The thesis employs computable general equilibrium modelling (cge) as the tool for economic analysis. An adopted model is adapted for the thesis. The theoretical framework of the adapted model draws heavily on developments and applications of computable general equilibrium models as a tool for policy analysis in Australia.

The first extension to the adopted model is the introduction into the model of the MONASH idea of an investment-capital link for capital accumulation over time. The second addition is the introduction of an equation for the demand for money as a proxy of the monetary sector. With the inclusion of a money demand function, the PNG model can be used to look at the effects of alternative monetary policies. One of the effects of a change in monetary policy is its impact on investment, which is endogenized by making investment dependent on the interest rate, one of the variables in the money demand equation. The third addition to the model is the enhancement of the monetary side of the model by the establishment of a link between the trade account balance and the nominal exchange rate, with the latter being dependent on the former. This new mechanism mimics the effect of a floating exchange rate regime in the PNG economy.

The adapted model was used to derive basecase forecasts (paths without policy shocks) for the PNG economy for the period 1998 to 2006. In deriving the

basecase forecasts, we added shocks for the exogenous variables one at a time sequentially. By proceeding in this way, we were able to learn about the model's behaviour and to detect and correct several weaknesses in its initial theoretical structure and database.

The thesis then examined the deviation from the base path as a result of shocks representing policy changes. It examined the feed-through effect of a change in monetary policy in response to an increase in government spending (recurrent expenditure). Three scenarios were examined. The first involved the combination of an expansionary fiscal policy (an increase in government expenditure without a compensating increase in government revenue) and an accommodating monetary policy (fixed interest rate). The second involved the combination of an expansionary fiscal policy with a tight monetary policy (fixed money supply). In the third, a balanced fiscal policy stance (an increase in government expenditure with a compensating increase in government revenue through higher tariff rates) and tight monetary policy (fixed money supply) are assumed.

It is found that an increase in government spending has costs in all the three policy scenarios. Real exchange rate appreciation occurs in all three. In policy scenario A, exports are squeezed by the real appreciation of the exchange rate. Import-substitution industries are also hurt by the real appreciation. In a nutshell, investment was financed by foreigners and this drove down the trade balance. In policy scenario B, increased government spending took away funds that could otherwise go for investment and consequently investment was crowded out. In policy scenario C, the imposition of taxes has the negative impact of crowding out consumption. On the other hand, the increased tariff rates damp imports as does the reduced level of consumption, and the trade balance improves.

In an environment of ambitious government spending, particularly on consumption, monetary policy has a crucial part to play. As illustrated in the simulations, monetary policy determines the balance between the effects of government spending on macro stability (inflation, the trade balance and the exchange rate) and growth (increases in investment and real GDP). Where growth is sustained through an accommodative monetary policy, there is a sacrifice of economic stability. Where economic stability is sustained through tight monetary policy, there is a sacrifice of growth.

Given an increase in government spending, it is found that: an accommodative monetary policy could allow maintenance of investment growth, but lead to a significant increase in inflation and crowd out the trade sector (specifically exports); a tight monetary policy could allow maintenance of low inflation but crowd out investment; and a tight monetary policy accompanied by increases in taxes on imports could allow maintenance of investment and low inflation but crowd out consumption.

A common result in all three policy simulations is appreciation of the real exchange rate. Under an accommodative monetary policy, real appreciation crowded out exports while investment was sustained through the constant interest rate. Under a tight monetary policy, the increased cost of borrowed-funds crowded out investment (an import-intensive component of demand). The resulting reduction in demand for imports led to real appreciation of the exchange rate. Under a tight monetary policy accompanied by increases in import taxes, there is a double-strength reduction in imports and a double-strength real appreciation.

Declaration

Except where reference is made in the text of the thesis, this thesis contains no material published elsewhere or extracted in whole or part from a thesis presented by me for another degree or diploma.

No other person's work has been used without due acknowledgement in the main text of the thesis.

This thesis has not been submitted for the award of any other degree or diploma in any other tertiary institution.

Exclusive of tables, figures, references and appendices, this thesis is no longer than 100,000 words in length.

[redacted]

Gae Kauzi

August, 2003

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At the technical and professional level, my greatest debt is owed to Professor Peter B. Dixon, the Director of the Centre of Policy Studies and the Impact Project, and my supervisor. Given my weak background in economic modelling, I was very fortunate to have Peter as my supervisor. I am especially grateful for his constant high intellectual guidance, encouragement and unswerving patience with me, in my many shortcomings and low moments throughout the course of the study. Amidst his heavy work load he always seemed to find time to teach me. He has taught me to think through and analyze computable general equilibrium simulation results in a well-structured and concise manner. My future involvement in the development and application of computable general equilibrium modelling as a tool for policy analysis will bear the mark of this academic association with him.

My sincere thanks and appreciation are extended to Dr. Maureen Rimmer for her technical input into the Tablo program of the model and her final editing role of three key chapters of the thesis. Mrs. Jill Harrison was a continuous source of guidance and help on GEMPACK and programming issues, for which I say thank you very much.

The roles played by the above three persons were crucial, without which I would not have advanced in the work for this thesis. My profound appreciation to them.

A one-off occurrence at the beginning of my research proved invaluable. Without my knowing, Professor Ken Pearson pointed out that a computable general equilibrium model of the ORANI type had been constructed by a team at the National Centre for Development Studies (NCDS) of the Australian National University in 1990 (Ken himself had a hand in it in the computing aspect). This led to my adoption of a version of the model from the Centre of International Economics and saved me from starting from scratch. For this I express my gratitude to Ken, and Mr. David Vincent (co-author of ORANI) and Mr Derek Quirke, who kindly agreed to copy to me the model and its database. Derek's early communication with me regarding the database is very much appreciated. Indirectly involved in this was Dr. Theo Levantis. CIE had got the latest model and database from him for their use and application. So, my thanks to Theo too.

Furthermore, my thanks and gratitude are due to: Dr. Glyn Wittwer for his technical input and editorial assistance on one of the chapters; Mrs. Daina McDonald for her thorough editing of the final draft of the whole thesis; and Ms. Louise Pinchen for the meticulous type setting.

Although I was enrolled as a PhD student under the Economics Department (where I did some course work), the full duration of my research time was spent at the Centre of Policy Studies and the IMPACT Project, as this is *the* place for computable general equilibrium (CGE) modelling. It is a place in which there appears to be no distinction between professional staff, support staff and postgraduate students on the use of the research facilities and the coffee room. This aspect in itself constituted a most welcoming and pleasant environment to work in. My deepest gratitude goes to Peter and all his staff for the generous provision to me for the use of the facilities at the Centre and for their friendliness.

Finally, on a personal level, my special word of thanks goes to my beloved wife (Saraim), and our beautiful children (Youngston, Milate, Mary, Ruben and Michael) for their love, understanding, tolerance and support throughout the duration of this study. Just as there are trade-offs in the achievement of economic objectives there have been sacrifices of family-time towards the completion of this thesis. While my nuclear family's support and patience can not be denied, it is to my beloved parents and eldest sister that I dedicate this piece of work, for I would not be here if it was not for their love, recognition of the importance of education and financial support in those early humble days of up-bringing and education in Papua New Guinea.

Chapter 1
Introduction

1.1 *Introduction*

The aim of this thesis is to examine the transmission of macroeconomic policy shocks in the Papua New Guinea (PNG) economy. The underlying motivation for this research is my interest in behavioural relationships between economic variables and the need to better understand the economy. One needs to understand these behavioural relationships in order to understand the mechanisms of the transmission process whereby a change in an economic variable causes a change in other variables. Such relationships can be expressed as mathematical functions, and when put together, they form an economic model. The model can describe an economy. We need an economic model of the PNG economy to enable quantitative investigation into the transmission of macroeconomic shocks in the small open economy.

With this starting premise, this thesis shares the concern of Vincent *et al.* (1990, p.1) that "the pathways through which economic policy changes and other events in the Papua New Guinea economy influence overall performance and that of individual sectors are poorly understood. There is a clear need for a better understanding of these pathways and their influence on policy outcomes. One way of achieving this is by constructing a quantitative model to describe the Papua New Guinea economy."

Examination of the pathways through which changes in fiscal and monetary policies transmit economy-wide influences to macro variables as well to as industry-level variables in Papua New Guinea is the key concern of this thesis.

Our study is anchored in the historical experience of the PNG economy in the late 1980s to 2000. In this period increased government spending, how the budget deficits were financed and the appropriate stance of monetary policy were key concerns of macro policy. At times monetary policy was overburdened with the government's debt management issues. Changes in monetary policy had tend to be in reaction to the national government's fiscal policy. With this recent history in mind, this thesis will analyse the impact of different options for monetary policy, given an increase in government spending. We do not intend to examine options for budget-deficit financing and their impact on the economy nor do we want to discuss government debt management.

The thesis employs computable general equilibrium modelling (cge) as the tool for economic analysis. We draw heavily on developments and applications of computable general equilibrium models as a tool for policy analysis in Australia. A bi-product of the work in this thesis, will be the demonstration and promotion of the usefulness of cge as a practical tool for policy analysis for Papua New Guinea. The use of a cge model lends itself to an economy-wide (macro as well as industry-level) analysis of the impacts of policy shocks. Furthermore, once they have been built, cge models can be applied to analyze a wide range of issues. This is in contrast to the application of macro and macro-econometric models, and other custom-built models, which have a limited range of applications in focusing only on macro and single market analysis or in addressing a particular issue.

The rest of this chapter is organised as follows. Section 1.2 provides a note about the technique of cge modelling in policy analysis. Section 1.3 gives an overview of the development and application of cge modelling in PNG to date. Section 1.4 presents a literature review of cge modelling in general and the development of cge models for PNG in particular. Finally, section 1.5 sketches the skeleton of the rest of this thesis.

1.2 The Technique of Computable (Applied) General Equilibrium Modelling for Policy Analysis

In theoretical and applied economic analysis the term *general equilibrium* refers to an "analytical approach which looks at the economy as a complete system of interdependent components (industries, households, investors, governments, importers and exporters). It explicitly recognizes economic shocks impacting on any one component can have repercussions throughout the system and that accounting for these repercussions may be essential in assessing the effects of the shocks – even on the components upon which they impact initially." (Dixon *et al.* 1992, p.1) It considers "production relationships and demand conditions in totality, the interrelationships between them and the simultaneous determination of prices through the interaction of demand with supply in all markets." (Vincent *et al.* 1990, p.6) A general equilibrium model becomes *computable* when computer is used for its quantitative application for analysis of a specific economic policy problem in specific economies. *Applied general equilibrium modelling* is an alternative term commonly used to describe computable general equilibrium modelling.

In the literature there are two types of computable general equilibrium models: those that are solved in the levels of variables; and those that are solved in changes, percentage changes or logarithmic differentials in variables. The use of the first type is popular at the World Bank and a number of institutions in

North America. The second type is common in Australasia, a number of European countries, and is increasingly now applied in many Asian countries.

We employ the percentage change approach in cge modeling. This approach owes its origin to Johansen (1960). Johansen developed and applied a system of linear equations to study the economy of Norway. In Johansen's system, the variables are changes, percentage changes or changes in the logarithms of the various components of a vector, V, of length n satisfying a system of m equations $F(V)=0$. The equations are based on economic theories such as the neo-classical theory of utility maximization for the household. The number of variables n in the equations is greater than the number of equations m. In solving the model, n-m variables are chosen to be exogenous. Then a linearized version of the m equations is solved to generate the effects of changes in the n-m exogenous variables on the remaining m endogenous variables. The shocks or changes in the exogenous variables represent policy changes and the resulting changes in the endogenous variables represent the effects of the policy changes.

1.3 Overview: Development of CGE Modelling for Papua New Guinea

The proliferation of the Johansen-type of cge modelling in Australia, New Zealand, some Asian countries and one or two South Pacific island countries got its stimulus from ORANI: A Multisectoral Model of the Australian Economy (Dixon, *et al.* 1982), built as part of the IMPACT Project. ORANI's appeal as a valuable tool for assessing and understanding the impact of exogenous changes in the Australian economy soon led to its adoption and adaptation by researchers and institutions in Australia. ORANI and ORANI-lookalike models continue to be applied to a wide range of issues in Australia, in Asia and in South Pacific economies.

Following the ORANI generics, Vincent *et al.* (1990) developed for the Papua New Guinea economy a disaggregated cge model comprising 36 industries producing 33 commodities. This was later revised by Woldekiden (1993). Levantis (1998) developed a another model for PNG, with the major contrasting features compared to the Vincent *et al* (1990) model being the inclusion of: (i) a detail labour market; (ii) an "urban murky"[1] sector made up of industries of informal retail and crime; and (iii) a measure of change in social welfare. Nevertheless, Levantis's model, with 42 industries producing 37 commodities, was similar in structure to the Vincent *et al.* (1990) model, both being ORANI type. A team, led by David Vincent (a co-author of ORANI) of the Canberra based firm Centre for International Economics (CIE), then used Levantis' updated model and data, though in their worth they replaced the 'crime' industry with a potential industry 'LNG Gas' in order to examine the impact of an LNG gas export industry in PNG. We adopt the Levantis-CIE ORANI-type model as a starting point for our work. The listing of industries and commodities in our model is provided in Table A1 in Appendix A. A schematic diagram depicting the input-output data base of the PNG model is shown in Figure B1 in Appendix B.

The Levantis-CIE model in common with other ORANI style models is static. A static general equilibrium model postulates '......neo-classical production functions and price responsive demand functions, linked around an input-output matrix in a Walrasian general equilibrium model that endogenously determines quantities and prices' (Dervis (1975, p.78, also cited in Dixon *et al.* 1982, p.5 and Levantis 1998, p.1). In Chapter 2 of this thesis, additions to the Levantis-CIE model will be introduced. One of the key additions will be inter-temporal dynamics of capital and investment, an important feature of MONASH (the dynamic successor to ORANI, Dixon and Rimmer, 2002). The resulting model will thus be an offspring of ORANI and MONASH.

1.4 Literature Review

In this literature survey we describe previous cge modelling for the PNG economy. We begin with the original ORANI *generics* behind the existing PNG cge models. Then we look at two ORANI-derivative models for PNG, paying particular attention to the Levantis (1998) model which provided the starting point for our own work. Finally, we look at the new dynamic ideas of the MONASH model, some of which is adopted by this thesis.

The main contribution of the work in this thesis is the inclusion in a cge model of PNG of monetary phenomena and inter-temporal dynamics of investment and capital formation. The first area has not been previously researched in a cge framework for PNG and so is not covered in this literature survey. The second area originates from MONASH and so is covered in the context of our brief review of the MONASH Model.

1.4.1 The ORANI Model

We do not give a detailed review of ORANI here because several reviews by experienced researchers have already appeared in the literature [see for example, Pagan (1983), Parmenter and Meagher (1985), Powell and Lawson

1 Cited in Levantis (1998). 'The concept of the 'urban murky' sector was introduced by Fields (1975) and embraces all legitimate and illegitimate informal income earning activities. In Levantis' model the *informal*

(1990), Vincent (1990), Powell and Snape (1993) and Dee (1994)]. For our purpose, we simply point out some of the salient features of ORANI which appeal to us and which have made ORANI a valuable tool for economic analysis.

ORANI was developed in the late 1970s as part of the Australian government-sponsored IMPACT project. The model (Dixon *et al.* 1977 and 1982) and its derivatives are now widely used in Australia and other countries, particularly in Asia, as a tool for practical policy analysis by academics and other researchers in the civil service and the private sector. ORANI is a static multi-sectoral model of the Johansen class.

Some Salient Properties of ORANI

(i) The model has 115 industries producing 113 commodities, which means that some industries produce more than one good and some goods are produced by more than one industry. This is an important departure from a conventional input-output model in which each good is produced by just one industry and each industry produces just one good. The departure reflects reality in many economies. In ORANI, multi-product industries are used to describe Australian agriculture.

(ii) The model uses the input-output tables of the Australian economy as its database. The ORANI modellers show that the input-output table can be viewed as providing the initial solution for the equations of the model. From the input-output table, coefficients of the model, such as cost, revenue and sales shares are computed.

(iii) Demand and supply equations for private sector agents are derived from solutions to the optimization problems (cost minimization, utility maximization, etc.) which underlie the behaviour of agents in conventional neoclassical microeconomics. There are also equations, mainly derived from identities and definitions, for the government

retail industry is taken as the legitimate sector while *crime* is the illegitimate industry.'

and macro variables. The equations describe for some unspecified time period:

- producers' demands for produced inputs and primary factors;
- producers' supplies of commodities;
- demand for inputs to capital formation;
- household demands;
- export demands;
- government demands;
- the relationship of basic values to production costs and purchasers' prices;
- market-clearing conditions for commodities; and
- numerous macroeconomic variables and price indices.

Walrasian general equilibrium quantities and prices are obtained when all the equations depicting the above are solved simultaneously.

(iv) There are two sources for commodities used as inputs to production and for final consumption (either domestic or import). Commodities from the two sources are treated as imperfect substitutes. This was an assumption that the ORANI modellers took on board into cge modelling from the work by Armington (1969, 1970) on macro trade analysis. Via the Armington assumption the ORANI class of models avoids extreme price sensitivity of import-domestic shares.

(v) In handling multi-product industries and multi-industry products as well as import-domestic choice, ORANI employs the concept of separability[2] of functions, which give a structure for consumption, capital formation and production entailing various stages. This greatly simplifies the specification of demand and supply relationships.

(vi) The system of differential equations can be solved by conventional numerical integration techniques. ORANI employs the Euler procedure[3] used in conjunction with simple extrapolation

2 Defined in section 2.2.1 of Chapter 2.

3 The Euler procedure refers to the solution method of conventional numerical integration. It involves a series of Johansen's one step solutions, thereby eliminating linearization errors.

techniques. This is an advance over Johansen's computation method, which corresponds to a one-step Euler procedure. ORANI established the use of the advantageous multi-step Euler solving technique, a technique which eliminates linearization errors.

These salient properties of ORANI will become clear in the next chapter, which sets out the theoretical structure of our PNG cge model.

In our model, we adopt a multi-product multi-industry specification for PNG primary producers; we use input-output tables as the main data input and as the source of the model's initial solution; we derive demand and supply relationships from neo-classical micro foundations; we adopt the Armington assumption; we employ numerous separability assumptions; and we use the Johansen-Euler solution technique. As this is an applied research, we employ the cge modelling ideas of ORANI and make changes where necessary to suit our specific purpose. Some of the changes involve the adoption of ideas from the successor to ORANI, the dynamic MONASH model, reviewed briefly at the end of the section.

1.4.2 The First Computable General Equilibrium Model for Papua New Guinea

The first computable general equilibrium model for Papua New Guinea was developed by Vincent *et al.* (1990) under the auspices of the National Centre for Development Studies (NCDS) of the Australian National University (ANU). This was as an important step in providing analytical, quantitative information for PNG. Up to that time, analysis of economic issues in PNG tended to be descriptive, and analytical, quantitative work was confined to small-scale partial equilibrium studies. The Vincent study aimed at practical application of a cge model to policy issues. The project involved the development and documentation (description) of the model and an illustration of how it can be used to analyze the impact of a shock to the economy. In keeping with its practical nature, the documentation of the work avoided lengthy academic discussion of the theories underlying the model. As described by Vincent *et al.* (1990) the model was "... designed to assist policy advisers and others interested in the Papua New Guinea economy to understand the implications for Papua New Guinea economic performance of a wide range of economic policies and events, both at the macroeconomic and sector level."

The Vincent model has 36 industries producing 33 commodities. The percentage change equations representing the demand and supply conditions of the various agents of the economy are typical of ORANI type equations. The model includes demand equations derived from CES cost-minimization problems and Stone-Geary utility maximization problems, and supply equations derived from CET revenue-maximization problems.

1.4.3 Levantis 1998 Model

The Levantis 1998 model is basically an ORANI type model in structure. The percentage change equations representing the demand and supply conditions of the various agents in the economy are typically of ORANI generics. The derivations of such equations are covered in detail in Chapter 2 and so we do not discuss them in our presentation here. In this sub-section, we summarize the main contrasting features of the Levantis 1998 model to those of Vincent *et al.* 1990. As mentioned earlier, the key differences are (i) a more detailed labour market; (ii) a "urban murky" sector, comprising industries of informal retail and crime; and (iii) a measure of change in social welfare.

A. Sectoral, Industry and Commodity Make-up

The Levantis 1998 model for PNG has a total of 42 industries producing 37 commodities. The 42 industries are divided into four industry sectors: the village sector, the plantation sector, the urban sector and the urban murky sector. These reflect the dual nature (formal and informal sectors) of the economy. Labour is distributed into these sectors so that the labour market structure is that of Harris-Todaro type.[4]

The village sector comprises village-based 'smallholder' industries (producing the main export crops) and a 'traditional agriculture' industry (for villagers solely engaged in subsistence and local market production of fruits and vegetables.) The village sector also includes 'fruits and vegetables', 'fishing', 'forestry', and 'other agriculture' (which comprises beef, poultry and sugar). The plantation sector consists of the largeholder producers of the export commodities. The urban sector covers all modern sector industries, which include mining, manufacturing and service industries. The 'urban murky' sector comprises all legitimate and illegitimate informal-earning activities. In this case, the 'informal retail' industry represents a legitimate side while 'crime' represent an illegitimate side of the 'urban murky' sector. Levantis argues that "the peculiar step of including crime as a separate industry in the model is taken because of its importance in the economy and the labour market" (1998, p3). Going by national accounting standards, the industries of 'commerce' and 'informal retail' are

4 A labour market structure comprising rural, urban formal and informal sectors. Usually there is migration of rural labour to the urban sector in pursuit of higher wages.

considered as margin industries in the model. The village sector, the 'other agriculture' and mining industries are the only multi-product industries.

Levantis employed the concept of 'sources and application of funds' to illustrate the circular flow of funds among residents in the economy. The residents comprise: agents/people who are motivated to source funds by providing their labour or capital as factors of production; owners of production units who earn profit; and the central government which sources its funds from the people in order to provide public goods and services. The total application of funds by various agents to various activities is equal to the total funds from various sources. For Levantis, this is the key condition for Walrasian general equilibrium and it gives rise to what he claims is the central equation of a general equilibrium model. While the equating of the applications and sources of does not in itself explain any variable, Levantis claims that all equations in a cge model are a disaggregation of this fundamental equation. In the context of Levantis' model, the fundamental equation takes the form

$$PX = PX^1 + PX^2 + PX^3 + PX^4 + PX^5 + PX^6 \tag{1.1}$$

where

$P = \{P_{1,1}, \ldots, P_{37,1}, P_{1,2}, \ldots P_{37,2}\}$ is the price vector

of commodity '*is*' before any consumption tax distortions but after production taxes. Hence, for traded goods, it is the world price vector and for imported goods it is c.i.f price vectors,

$X = \{X_{1,1}, \ldots\ldots, X_{37,1}, X_{1,2}, \ldots\ldots X_{37,2}\}$ is the supply vector of commodity '*is*'.

Superscript 1 indicates X for the intermediate-input usage vector of commodity '*is*', superscript 2 indicates the consumer demand vector for commodity '*is*', superscript 3 indicates the private investment demand vector for commodities '*is*', superscript 4 indicates the government consumption vector of commodities '*is*', 5 for government investment demand vector for commodity '*is*' and superscript 6 indicates the export demand vector for commodity '*i1*',

and

the subscript *i* refers to commodities 1 to 37, and

the subscript s = 1 for domestically produced goods and s = 2 for imported goods.

The total source of funds or total supply of goods can be put on the left-hand-side and the total application of funds or demand for goods on the right-hand-side in descriptive form as shown in (1.1a).

$$\text{Production} + \text{imports} = \text{intermediate inputs} + \text{consumption} + \text{investment}$$
$$+ \text{govt consumption} + \text{govt investment} + \text{exports}\,. \qquad (1.1a)$$

Levantis then dissected his Walrasian equilibrium condition of the circular flow funds given by equation (1.1) into four sectors for the PNG economy: the production sector, the household sector, the government sector and the foreign trade sector. For each sector he provided identities for the equality of sources (supply) of funds and application (demand or expenditure) of funds.

To us, Levantis' approach to the circular flow of funds adds little to the essence of an ORANI-type model where the Walrasian equilibrium condition is satisfied by the properties of market-clearing equations (supply equal demand) of consumers and producers and a zero pure profits condition applied to the various agents in the economy. Having note the Levantis circular flow of funds approach, we leave it aside and instead focus on the aspects that distinguish his model from that of Vincent *et al.* 1990.

B. Treatment of Crime as an Industry and Commodity

'Crime' is not an industry/commodity in conventional input-output tables and industry/commodity classifications. In his model, Levantis includes 'crime' as an industry.

The 'crime' industry produces crime as the output. The industry consists of 'self-employed' persons (criminals) engaging in the illegitimate activity of larceny for the purpose of transferring wealth. This rules out other crimes prompted by other motivations. The output of the industry is the payoff (stolen wealth) and the purchasers are the victims of larceny. This is distinguished from a normal transaction where the benefit to a consumer or producer from purchasing a commodity is equal to the outlay. In Levantis' crime industry the victims do not acquire any benefit from purchasing crime. Even though the buyer accrues no benefit from the purchase,[5] this transaction proceeds because it is imposed on the buyer (the victim) against his will.

The victims of crime in the model are households, industries and the government. The activity of crime therefore impacts on household consumption,

5 A benefit to the purchaser is normally a pre-condition for a purchase to occur.

demand for intermediate inputs and government expenditure. The Levantis model accounted for these as follows.

Consumer Demand for Crime

Levantis postulates that the external costs of crime impact directly upon household disposable income. The income or expenditure constraint available for the household consumption decision is thus post-crime income. Hence, the households' optimal voluntary consumption bundle excludes crime as a good. In the model, household demands for commodities are derived from a utility-maximization problem in which the utility function excludes commodity 37(crime).

Crime as an Intermediate Input Demanded Involuntarily by Industries

Similarly, crime-related costs incurred by industries are involuntarily imposed intermediate inputs of crime, the amounts of which accrue to the larcenists. An involuntary purchase of crime-related intermediate inputs does not contribute to production. It impacts directly only upon the surplus to production.

Levantis assumes that losses for businesses due to transfers to criminals are a fixed proportion of the total losses from crime in the community. The output of crime, commodity $i = 37$, produced by the crime industry, $j(crime) = 42$, is a function of crime as an input from criminals. The purchases of crime by industries are assumed to move by a uniform percentage specified by

$$x^{(1)}_{37,1,j} = z_{42} \tag{1.2}$$

where

the superscript 1 refers to intermediate input,

the subscripts 1 and j are for labour and for industries $1,\ldots,42$, respectively, and

z_{42} is the activity or output in industry 42(crime).

The output, z_{42}, can be set exogenously. Through (1.2) an x percentage exogenous increase in output of crime is matched by an x percent increase in the amount of crime purchased by (committed in) various industries. These industries are forced to buy crime as an intermediate input, which adds to their costs and so squeezes their profit.

Involuntary Government Demand for Crime

While all other government expenditure and consumption are exogenous in the model, the government's involuntary consumption of crime is endogenous. The government incurred costs on crime are assumed to be a fixed ratio of the total community expenditure on crime. If the activity level or 'supply' of crime rises by x percent the government purchase of crime also rises by x per cent. Levantis shows this as

$$x_{37,1}^{(4)} = z_{42} \tag{1.3}$$

where the superscript 4 represents government demand.

While this unusual treatment of crime as an industry and a commodity is appealing, the idea can easily be catered for in our model, which does not have crime as an industry and a commodity. Crime adds to the costs of consumers, industries and the government. In our model, this concept and its impact on the economy can be accommodated by treating it as a deterioration in technology. A deterioration in technology reduces households' disposable income, increases cost per unit of purchase or input which reduces industry profit, and reduces the government's budget that could otherwise be spent on worthwhile public goods.

An alternative way to provide for the idea of crime in our model would be to reduce the size of the labour force. Criminals can be viewed as not being part of the effective labour.

C. Labour Market

The Levantis model has two labour types or occupations, unskilled, $q = 1$, and skilled, $q = 2$. Unskilled labour is employed only in the village and urban-murky sectors. Homogeneity is assumed within each skill type. Labour of each type can move freely between industries within a sector. Consequently, the after-tax wage rate for labour of type q is the same for all industries in a given sector. Between sectors, Levantis allows differences in wage rates for a given type of labour. It follows that he can, for example, introduce an exogenous increase (perhaps reflecting a change in legislated minimum wage rates) in the urban unskilled wage rate. Under Levantis' normal assumption that the total supply of unskilled labour is not affected by the change in the urban wage rate, his model can show a reduction in the unskilled wage rate in the non-urban sectors. The reduction in unskilled wage rates outside the urban sector is necessary to maintain total demand for labour equal to the exogenously given supply of labour.

For skilled labour, Levantis assumes exogenously given percentage gaps between wage rates in different sectors. Thus in standard simulations the percentage changes (but not the absolute changes) in skilled wages will be the same across industries and across sectors.

To implement his labour market assumptions, Levantis specifies industry demand functions for labour by skill-type. These functions are of the typical ORANI type. They are derived from a cost-minimizing problem, concerned with the choice of skills subject to a constant-elasticity-of-substitution specification of total labour input as a combination of skills. In percentage change form the labour demand functions are:

$$x_{1qj}^{p} = x_{1j}^{p} - \sigma_{1j}^{p}\left(p_{1qj}^{p} - p_{1j}^{p}\right) \tag{1.4}$$

where

x_{1qj}^{p} = percentage change in demand for labour of skill type q by industry j,

x_{1j}^{p} = percentage change in industry j's demand for labour,

σ_{1j}^{p} = substitution elasticity between skill types of labour,

p_{1qj}^{p} = percentage change in the price of labour of skill type q for industry j, and

p_{1j}^{p} = percentage change in the price of labour for industry j, specified as a weighted average of the percentage changes in the prices of skilled and unskilled labour to industry j.

Levantis specifies the aggregate demand for labour of skill q in sector S as

$$x_{1q}^{p}(S) = \sum_{j \in S} x_{1q,j}^{p} . S_{1q,j}^{p} \tag{1.5}$$

where

$x_{1q}^{p}(S)$ = percentage change in demand for labour of skill type q by sector S (S ranges over village, plantation, urban and urban-murky), and

$S_{1q,j}^{p}$ = industry j's share out of the total demand for labour of type q in the sector to which j belongs.

Given his sectoral and skill breakup Levantis specifies market-clearing conditions for labour of the form

$$x_{1q}^{p}(S) = 100 * dN_q(S) / N_q(S) \quad . \tag{1.6}$$

In (1.6) the percentage change in demand for labour of tvpe q in sector S is equated to the percentage change in the supply of labour (N) of type q in sector S. With the omission of a couple of details that are not relevant to our analysis here, the Levantis specification of the supply of unskilled and skilled labour is then

$$\sum_S dN_q(S) = 0 \quad . \tag{1.7}$$

Finally, Levantis includes equations which allow wage rates for unskilled workers to be set exogenously in the urban sector while wage rates in the other sectors adjust to allow the achievement of (1.7). For skilled workers Levantis assumes that the wage rates in all sector adjust together to achieve (1.7).

Essentially, the aggregate supplies of the two types of labour are assumed to be fixed but labour moves between sectors to satisfy demand. We adopt much the same treatment of labour in our model. However, because we are not particularly concerned with urban-rural issues, we have omitted the Levantis innovation of the assumption of urban unskilled wage rigidity. Instead, in many of our simulations we assume that there is sluggishness in the movements of all wages in PNG. An area for future research would be to add sectoral wage rigidities to our model.

D. Social Welfare

Levantis devoted a section to the modelling of a social welfare variable.

Levantis recognizes that because static CGE models are not inter-temporal there can be complications in measuring gains and losses accruing in future periods from income allocated to investment in the current period. To avoid these complications, Levantis sets real investment expenditure to be exogenously constant in the model so that there are no investment variations to impact upon social welfare. With regard to government activities, in his model, Levantis provides for a change in the budgetary position of the government to be balanced by transfers to the household sector, so that the funds saved (a surplus) or borrowed (deficit) by the government are dealt within the current period. A change in welfare is thus interpreted as that rising from a given budgetary position. Government expenditure can add to social welfare in that it is for the purchase of public goods. Complications associated with the measurement of this contribution to welfare are avoided by the assumption that real expenditure by the government is exogenous, except for the purchase of crime. As mentioned earlier, the government is required to spend an amount of money on crime and the amount spent varies in proportion to the level of crime in the community. Government expenditure on crime reduces welfare by reducing net transfers from government to households, thereby reducing private consumption.

Having avoided the complications inherent in static cge models surrounding the contributions of investment and government spending to welfare, Levantis then uses the standard utility-maximising problem of the consumer as his starting point in deriving a welfare function.

The welfare effect of a policy or other shock to the economy is represented in Levantis' model by the induced change in utility for the typical household. The change in utility for the typical household depends on the change in the household's consumption of commodities. We represent utility for the typical household as

$$U = U(P, Y) \tag{1.8}$$

where

U is the indirect utility function,

$P = \{P_1, ..., P_n\}$ is the vector of consumer prices for commodities, and

Y is the voluntary consumption expenditure available after the imposition of direct expenditure on crime and external losses due to crime.

By totally differentiating (1.8) we obtain the change in utility for the typical household as

$$dU = \frac{\partial U}{\partial P_1} dP_1 + \frac{\partial U}{\partial P_2} dP_2 + ... + \frac{\partial U}{\partial P_n} dP_n + \frac{\partial U}{\partial Y} dY \tag{1.9}$$

To simplify the partial derivatives of the utility function we apply Roy's identity:

$$\frac{\partial U}{\partial P_i} = -\lambda X_i \tag{1.10}$$

where

λ is the marginal utility of consumer spending, that is, the increase in U from a unit increase in Y, and

X_i is the quantity of i that is consumed.

Equation (1.10) says that a unit increase in the price of i is equivalent to loosing X_i units of Y. Translated into utility, a unit increase in the price of i imposes a loss in utility of λX_i. By substituting (1.10) into (1.9) we obtain

$$dU = -\lambda X_1 dP_1 - \lambda X_2 dP_2 - .... - \lambda X_n dP_n + \lambda dY \quad . \tag{1.11}$$

From here we find that

$$\frac{100dU}{\lambda Y} = \frac{X_1 P_1}{Y} \frac{dP_1 * 100}{P_1} + ... + \frac{X_n P_n}{Y} \frac{dP_n * 100}{P_n} + \frac{dY * 100}{Y} \quad , \tag{1.12}$$

that is,

$$w = -\sum_i S_i p_i + y \tag{1.13}$$

where

S_i is the share of good i in the household's budget,

p_i and y are the percentage changes in P_i and Y, and

$$w = \frac{100dU}{\lambda Y} \quad . \tag{1.14}$$

Levantis' measure of the change in welfare is w. It can be understood as follows. First, dU/λ is the amount of extra income that the household would need in order to achieve the same change in utility (dU) as is brought about by the change in policy. Second, this amount of extra income is expressed as a percentage of the initial level of consumption expenditure. Thus, Levantis' measure of welfare change is the percentage increase in consumption expenditure that the typical household would need to maintain its utility given the change in policy.

From (1.13) Levantis' measure of welfare is given by

$$w = y - cpi \tag{1.15}$$

where

$cpi = \sum_i S_i p_i$ = percentage change in consumer price index.

Hence, Levantis' measure of the welfare change associated with a policy or other exogenous shock is the induced percentage effect on real consumption.

Levantis provides two useful disaggregations of aggregate welfare. Specifically, he provides two equations that disaggregate the movement in aggregate real consumption (cr) into parts contributed by movements in other variables. For the purpose of this short literature review, we note these disaggregation without specifying their details. The first disaggregation explains percentage changes in consumption, cr, in terms of: changes in the quantity and productivity of labour; changes in losses due to crime; changes in the terms of trade; and changes in foreign grants. The second disaggregation contains all the elements in the first disaggregation but further disaggregates labour's contribution into urban, village and plantation sectors.

Levantis' main contribution to welfare measurement is the inclusion of crime as a commodity and an industry. This enables him to recognize that involuntary spending or costs due to crime reduce welfare. For example, with a rise in criminal activity, households and industries become more security conscious. Households and industries implement measures to improve their safety. In Levantis' model, such crime-induced expenditures add to costs and thereby reduce consumption of welfare-generating goods. Conversely, a fall in criminal activity translates into a rise in the disposable income of households net of crime-induced expenditures and a reduction in the unit cost of industries. Both these effects increase the consumption of welfare-enhancing goods.

While the allowance for crime in welfare measurement is an important contribution, Levantis' approach to welfare has several limitations. Changes in aggregate real consumption (cr) are adequate measures of welfare changes in a society only under certain conditions. One of these conditions is that income distribution in the society is fair. Where there is a great disparity in income distribution between the rich and the poor members of the society, a change in aggregate real consumption can be a poor (misleading) indicator of the change in social welfare if, for example, the increase in consumption is confined to those who are rich. A second set of problems (mention earlier) with Levantis' approach to welfare concerns the handling of dynamic issues in a comparative setting. For instance, a policy-induced increase in consumption in the current period may be at the expense of the next period's income/wealth.

A dynamic cge model can handle the inter-temporal welfare measurement issues with respect to investment and government spending raised by Levantis. In this thesis, one of the additions we make to the Levantis-CIE model is an inter-temporal investment-capital linkage. This will be discussed in detail in Chapter 2. The inclusion of the inter-temporal investment capital link in our model is not intended to address the welfare-measurement problem, but rather as a tool for our macroeconomic policy analysis. It can be utilized for future research on welfare issues.

1.4.4 The MONASH Model

MONASH is a dynamic cge model, described in the book published by North-Holland in 2002 (Dixon and Rimmer, 2002). It was developed over some twenty years, starting from the comparative-static ORANI model.

In this sub-section, we do not provide a detailed review of MONASH. Instead, for our purpose, we will highlight the key elements in its evolution from ORANI that make MONASH a dynamic model. Some of these advances are employed in our thesis.

While maintaining the strong features of ORANI, a key new premise in MONASH is the idea that there is a path of the economy without a policy shock and there is another path with a policy shock. Policy analysis concerns the deviation of the policy-shock path from the pre-policy path. This is a significant departure from the conventional "what if" analysis that has been the focus of cge models for the last forty years. In "what if" analysis, the path of the economy without a policy shock is not explicit. Implicitly the basecase forecasts (the pre-policy path) is simply zero change from the situation depicted by the initial input-output database.

Entailed in the concept of paths of the economy is the concept of an explicit time period. In contrast to ORANI and other comparative static models in which a period is not explicitly specified in length of time, the dynamic MONASH model explicitly specifies one period as being a year. A time path can thus involve a number of years.

For the idea of pre-policy and post-policy paths of the economy to be implemented, there are two new key advances in MONASH over ORANI. These are the elements of dynamics and additional closure options. We briefly discuss each in turn.

A. The Dynamics of MONASH

MONASH has three types of inter-temporal links: physical capital accumulation; financial asset/liability accumulation; and lagged adjustment process. In this sub-section we describe these briefly in turn. Later, in Chapter 2, the mathematical specifications that we adopt in our model will be covered in detail.

Capital Accumulation

To link capital stock and investment through time, MONASH specifies that the capital stock of an industry at the beginning of each year $t+1$ is equal to the capital stock at the beginning year, t, net of depreciation in year t, plus investment in year t.

MONASH determines investment for each industry in each year as a function of the rate of return that investors require from the industry relative to the expected rate of return (EROR) on the industry capital. MONASH imposes an upward sloping capital supply curve for each industry in order to determine the required rates of return. This curve encapsulates the approach of diminishing availability of investment funds to an industry. The builders of MONASH argue that this approach is more realistic than the often-used alternative of imposing increasing installation costs. With respect to expectations, MONASH allows for either static or forward-looking expectations. Under the static assumption, EROR is determined by current rates of profitability and costs of units of capital. With static expectations, MONASH can be solved by a recursive method whereby the solution for year 1 can be computed from the assumptions for year 1 and data for year 0, the solution for year 2 can be computed from the assumptions for year 2 and data for year 1, and so on. Under the forward-looking assumption, the EROR for an industry is determined by future profitability compared with present costs of units of capital. With forward-looking expectations, the straight-forward recursive solution method does not work because we can not solve year 1 before we know profits and other aspects of the solution for year 2. To address this problem, MONASH employs an iterative solution method, whereby a guess is made about the path for the expected rates of return and the model is solved with these guesses driving investment. The model is then solved once more, with fresh guesses of the expected rates of return based on the revealed rates of return from first simulation. The process is repeated until the guessed EROR and computed EROR equate. However, in most simulations, MONASH adopts static or extrapolative expectations to avoid the computational burden associated with repeated simulations in a very detailed model with more than 100 industries.

Financial Asset/Liability Accumulation

Prompted by public debate in Australia on the current account deficit and the budget deficit in the 1980s and 1990s, MONASH included specifications for the flows in the overseas and government accounts and equations on the related financial assets and liabilities.

In MONASH the level of a financial asset or liability at the start of a year depends on: the level of the asset or liability at the beginning of the previous year; the average rate of interest or dividend rate applying to the asset or liability in the previous year; active accumulation of the asset on liability (new direct investment or borrowed funds) of asset or liability in the previous year; and factors translating the value of the asset or liability from the beginning of the previous year to the start of the current year. The financial assets and liabilities recognized in the model include: public sector debt; foreign debt denominated in foreign currency; foreign debt denominated in domestic currency; foreign equity in domestic industries; and Australian credit and equity assets in foreign countries

Lagged Adjustment Processes

The most important lagged adjustment process in MONASH involves the idea that real wages and thus employment adjust slowly to a policy shock.

MONASH recognizes that real wages are sticky in the short run and flexible in the long run. Wage stickiness is introduced into MONASH by a lagged adjustment equation that relates the policy-induced deviation in the real wage rate in year $t+1$ to the policy-induced deviation in the real wage rate in year t and the policy-induced deviation in employment in year $t+1$. Under this specification, a favourable shock to the economy causes a temporary increase in employment. But in the long run, the gains to employment are choked off by the increases in real wage rates.

Another lagged adjustment process in MONASH relates to disequilibria between levels of investment and rates of return to capital. Such disequilibria are eliminated over time. This is facilitated through equations that set the disequilibrium for an industry in year $t+1$ at half the level of disequilibrium in year t.

B. New Closure Options

MONASH allows flexibility in the choice of a closure to suit the time period to be analyzed, namely, the past, the present or the future. MONASH distinguishes four classes of closures for the $n-m$ exogenous variables, these are the historical, decomposition, forecasting, and policy closures. Historical and decomposition closures are concerned with analysis of a past period. Forecasting and policy closures are used for year-to-year projections of the economy for a future period.

Historical and Decomposition Closures

The main criterion for exogeneity in an historical closure is observability. All the variables in the model for which movements can be readily observed for a past time period are included in the exogenous set. The remainder of the variables in the exogenous set are naturally exogenous variables that are not observed but can be assigned values that do not contradict anything observed about the past. By having the actual observations of the past, historical simulations of the model, can give outcomes for non-observable variables such as changes in technology and changes in household preferences. These are the changes in technology and household preferences that are required for the model to be consistent with the values for observed variables such as outputs and inputs by industry and consumer expenditures by commodity. By combining observed variables as an input and model-generated changes in technology and preference variables as an output, a historical simulation becomes a powerful tool to update the database of a model to a more recent year.

For a decomposition closure the exogenous set includes all naturally exogenous variables. These are variables that are not normally explained in a cge model. They may be observables such as tax rates or unobservables such as a technological change. Using a decomposition closure, simulations of the model can explain to what extent movement in these naturally exogenous variables were the driving factors behind movements in naturally endogenous variables such as output, employment and investment by industry, and consumer expenditure by commodity.

Forecast and Policy Closures

Adopting a forecasting closure in MONASH allows the model to generate forecasts of industry, occupational and regional variables that are consistent with what is thought to be known about the future. Thus, in the forecasting closure, the exogenous set includes variables for which reputable forecasts are available from organizations specializing in the study of particular parts of the economy. For Australia, MONASH forecast simulations have often incorporated Treasury forecasts as shocks to macro variables, which become part of the exogenous set. MONASH forecast simulations have also incorporated forecasts of prices and volumes of exports from the Australian Bureau of Agricultural and Resource Economics. In turn, the exogenization in forecast simulations of variables such as the prices and volumes of exports requires the endogenization of variables such as export demand shifters and export-supply-affecting technological changes.

In a policy closure, naturally exogenous variables are in the exogenous set. Most of the exogenous variables in a policy simulation are assigned the values that they had (either endogenously or exogenously) in the forecast simulations. Only the variables of policy interest are assigned different values. For example, if we are interested in the effects of moving tariff rates away from their basecase forecast paths, then only the tariff rates are assigned different values in the policy simulation than they had in the forecast simulation. In this way, the policy closure enables the model to simulate policy-induced deviated growth paths of variables away from the paths of the basecase forecasts.

For this thesis we embrace the MONASH innovations in the modelling of dynamics and in closure setting. In particular, we employ the inter-temporal link of investment and capital for the process of capital accumulation to make the adopted ORANI type model dynamic. This is covered in detail in Chapter 2. We apply the technique of forecasting closure to get our simulated basecase forecasts. We then switch to a policy closure for the simulations that yield policy-induced deviations in variables for the analysis on the impacts of policy shocks. These are covered in detail in Chapter 3 (forecasting) and Chapter 4 (policy analysis).

With the reliance on the generics of the ORANI and MONASH CGE models we name our model PNG-ORAMON (PNG for the country and ORAMON comprises the first three letters of the two parent models)

1.5 Outline of the Study

The rest of this thesis is divided into four chapters.

In Chapter 2 we provide the theoretical foundations of the cge model for the PNG economy. As done in ORANI, we derive the simultaneous equations for the PNG cge model from a number of fundamental ideas. The first is the use of neoclassical microeconomic theoretical foundations for the two main agents in the economy, specifically: the utility-maximization problem for the representative consumer (household); and the cost-minimization problem for the producers (industries). Second, the equilibrium conditions that supply equals demand is applied to commodities and primary factors. Third, pricing equations are built on the ideas of zero pure profit (accruing to any agent) and uniform basic prices across users and industries. The fourth idea is the use of Armington elasticities, as defined earlier in the section on ORANI.

In Chapter 2 we also outline the additions we made to the model of PNG that we adopted as our starting point. The first addition is the introduction into the model of the MONASH idea of an investment-capital link for capital accumulation over time. The second addition is the introduction of an equation for the demand for money as a proxy of the monetary sector. With the inclusion of a money demand function, the PNG model can be used to look at the effects of alternative monetary policies. One of the effects of a change in monetary policy is its impact on investment, which is endogenized by making investment dependent on the interest rate, one of the variables in the money demand equation. A third addition to the model is the enhancement of the monetary side of the model by establishing a link between the trade account balance and the nominal exchange rate, with the latter being dependent on the former. This new mechanism mimics the effect of a floating exchange rate regime in the PNG economy. Our treatment of monetary phenomena is similar to that of Rees and Tyers (2002) where they include functions for regional real demand for money in their model. Each region's real demand for money is a function of GDP and the interest rate. Real demand for money is equated with the region's real supply of money. Rees and Tyers model also has a nominal exchange rate variable defined as the quotient of two exchange rates to facilitate international transactions. Rees and Tyers find that the inclusion of money demand equations in a cge framework leads to interesting conclusions about the effects of monetary policy in the short run. We also find interesting results in our simulations in Chapter 4.

In all the above, we apply the mathematical technique of linearization to derive the Johansen-type percentage change equations. To solve the model we use the GEMPACK computer programs developed at the Centre of Policy Studies and the IMPACT Project, Monash University (Pearson 1988, Codsi and Pearson 1988, Codsi *et al.* 1992, Harrison and Pearson 1996, Harrison *et al.* 1996).

Chapter 3 is about developing a reasonable set of model-generated forecasts for the PNG economy. The genuine forecasting period is 2002 to 2006.

Because we inherent a database that is for 1997, we have to update the database to 2001 as the base year for our policy simulations. For both the update period (1997 to 2001) and the genuine forecasting period (2002 to 2006) we use a forecast closure in which most of the macroeconomic variables are exogenous. For the update period (realized years), these variables are shocked with their year-to-year observed movements. For the genuine forecast period, annual shocks are applied reflecting macro forecasts made by the PNG Central Bank and the PNG Treasury and simple extrapolations from recent history. In developing the forecasting closure, we start from a plain closure in which all the exogenous variables are naturally exogenous. In moving from this plain closure to the forecasting closure we employ a back-of-the envelope model to justify each swap that is made. (A swap effects the exogenization of a variable that was previously endogenous through the enodgenization of a previously exogenous variable).

In pursuit of a reasonable set of forecasts, we ran two sets of simulations, Set A and Set B. With one exception, the exogenous variables in the two sets of simulations are the same. In Set A simulations, the nominal exchange rate is exogenous, depicting a fixed exchange rate system whereas in set B simulations the nominal exchange rate is endogenous, depicting a floating exchange rate system. With both sets we want to eventually get a whole forecast story for the economy when all the relevant exogenous variables are shocked. We could get straight to that by running just one simulation incorporating all the shocks, which is the usual approach. Instead, we introduce each of the shocks one at a time sequentially with a simulation run for each shock. An advantage in proceeding in the step-by-step manner is that we are able to isolate the impact of each shock and by doing so better understand the mechanisms in our model and the characteristics of the database that together drive the results. The macro results in Set A simulations were satisfactory. While the industry-level results were satisfactory to some extent, careful analysis in the step-by-step simulation approach helped us identify few problems in the industry results, particularly in the industries of the agricultural and mineral government sectors. To get over these problems, we made a number of adjustments/rectifications to the original model. The adjustments/rectifications relate to primary-factor intensity and usage and to capital accumulation in some sectors. With these adjustments/rectifications in place, we ran the Set B simulations, again introducing one shock at a time, sequentially. We found satisfactory industry-level as well as macro results.

A motivation for the research in this thesis is to have a sound, formal, empirical technique for policy analysis. This will enable us to examine the economy-wide transmission or feed-through effect of policy shocks. It can also contribute to economic literature and aid sound macroeconomic policy formulation and management in PNG.

Chapter 4 encapsulates the motivation and overall aim of the thesis. In the chapter we examine the impact on the PNG economy of changes in fiscal and monetary policies. We look at three policy-change scenarios. In each case, the fiscal change involves an increase in government spending. In the first policy scenario, the increase in government spending is accompanied by an accommodating monetary policy (fixed interest rate). In the second, the increase in government spending is accompanied by a tight monetary policy (fixed money supply). In the third, we assume a (more or less) balanced fiscal stance, with a compensating increase in government revenue (through increase in taxes) matching the increase in government spending. This is accompanied by a tight monetary policy (fixed money supply). For the policy simulations we use a policy closure, which is the basic closure covered in Chapter 3. The impacts of the policy changes are the deviations away from (or disturbances to) the basecase forecasts for 2002 to 2006 (of Chapter 3) prior to the policy changes. So the simulated macro and industry-level results for the three policy scenarios are presented as percentage deviations in variables away from a control solution. (the basecase forecasts for 2002 to 2006 generated in Chapter 3).

Chapter 5 summarizes the key findings of the study.

Chapter 2

The Theoretical Structure of the CGE Model of the Papua New Guinea Economy

2.1 Introduction

The theoretical framework underpinning the applied computable general equilibrium model of the Papua New Guinea (PNG) economy draws heavily on the generics of, first, the static ORANI model of the Australian Economy (Dixon, Parmenter, Sutton and Vincent, 1982) and, second, the subsequent dynamic MONASH model of Australia (Dixon and Rimmer, 2002). Changes to the assumptions, parameters, and the structure of the model are made where appropriate to reflect the unique features of the PNG economy.

An economy-wide model of the Papua New Guinean economy based on the ORANI prototype was constructed by Vincent, Weisman, Pearce and Quirke in 1990. We are adapting their model for the purpose of this thesis.

The applied general equilibrium modelling of the PNG economy for this thesis follows the Johansen (1960) school of modelling and adopts the economic ideas, theories and practices used in ORANI and MONASH.

The adaptation that I have made to the Vincent *et al.* (1990) model involves two broad areas. The first area is the introduction of a monetary segment to capture my interest in monetary policy. This imposes a macroeconomic phenomenon into the model, which is enhanced by the introduction of a linkage between the exchange rate and the trade account. The second area is the introduction of an inter-temporal link that facilitates the dynamics of capital formation over time, thus enabling the model to be dynamic. The first modification enables the conduct of simulations involving the response of monetary policy to changes in fiscal policies. The second area of change, adopted from the MONASH model, enables the model to perform year-to-year simulations. These changes render the model a hybrid of ORANI and MONASH CGE models, hence the model name is PNG-ORAMON.

An attractive feature of the PNG model is the inclusion of fiscal details of the national government as adopted from Vincent *et al.* 1990 (ANU). The government entity is represented not only by "other demand" but also a series of government revenue and expenditure equations.

All the equations representing these features of the model are presented in subsequent sections of this chapter.

The PNG model, being of the Johansen type, employs the technique of linearization by total differentiation of equations and is solved by logarithmic differentials or in percentage changes. This is in contrast to the other category of CGE models that are solved in the levels of the variables. The Johansen approach generates results that are linear approximations to the non-linear system. However, computing advances have enabled multi-step calculations to be made that eliminate linearization errors and so provide accurate solutions even in cases where the experiment involves large changes (Dixon *et al.* 1982 pp. 204-207). The Johansen approach has a number of advantages. These include the separation of the solution algorithm from the model and consequently the solution technique is unaffected by changes in model design; the ease with which to explain the mechanism underlying the results to policy makers; and the separation of or decomposition of results for several policy changes (Vincent *et al.* 1990, p. 7).

As presented in Dixon, Parmenter, Powell and Wilcoxen (1992) and Dixon *et al.* (1982), the Johansen class of general equilibrium models is one in which an equilibrium is a vector, V, of length n variables satisfying a system of equations,

$$F(V)=0 \qquad (2.1)$$

F is a vector of functions of length m, where n > m. The Johansen approach is to derive from (2.1) a system of linear equations in which the variables are changes, percentage changes or changes in the logarithms of the components of V. Since the system (2.1) contains more variables than equations, we need to assign exogenously values to *(n-m)* variables and solve for the remaining *m* endogenous variables. To enable this, we need to obtain the linearized version, which we can derive as a differential form from (2.1)

$$A(V)v=0 \qquad (2.2)$$

where

$A(V)$ is an $m \times n$ matrix whose components are functions of V; and

v is an $n \times 1$ vector showing percentage changes or changes in the log of the variables v.

2.2 *The Theoretical Structure*

The PNG economy is structured and modelled into these segments:

- production functions
- household demands
- export demands
- "Other" (government) demands
- the pricing system (or zero pure profit conditions)
- demand for inputs for capital formation
- the market-clearing equations

- the government budget
- capital, investment and rates of return
- money demand
- the trade account
- link between the exchange rates and the trade account.

In the ensuing sections I present the derivation of the linearized percentage change equations for the above segments of the economy. The derivations are, first, by the economic method of maximization and minimization of certain objective functions under particular economic theory/ies and second, by linearization of equations as given by economic theory and by identity and definition (e.g., the gross domestic product identity) that are used in the PNG model.

2.2.1 The Structure of Production

It is assumed that industries can produce several commodities, using as inputs domestic and imported commodities, and primary factors (labour, capital and land).

This multi-input, multi-output production specification is possible under the assumption of separability[6] of functions.

Consider first the initial stage of production, shown at the bottom of the structure depicted in Figure 2.1. At the initial stage of production, domestic and imported intermediate inputs are combined by an industry in a constant elasticity of substitution (CES) combination to yield a composite a good. Primary factor inputs are also a CES aggregation of labour, capital and land. All industries in the CGE model share this common production structure. However, input proportions and behavioural

6 This assumption, in layman's language, refers to a whole structure comprising different stages for which there are functions that can be distinguished and solved separately. For example, choice of primary factors is made in CES combination and then composite primary and composite intermediate inputs are made in a Leontief combination for an output. See Dixon, Parmenter, Powell and Wilcoxen (1992, p. 142) for a technical definition.

parameters may vary between industries. The labour that is used with land and capital is a CES aggregation of the different types of labour or occupations.

At the second stage (middle), each commodity composite and primary factor composite and "other costs" (introduced at this stage) are combined using a Leontief production function[7] for each industry's activity level. The Leontief production function is equivalent to a CES production function if the substitution elasticity is equal to zero. These composites of intermediate inputs and primary factors are demanded in direct proportion to an industry's activity level.

At the third and final (top) stage, the Leontief-induced activity levels (for industries producing more than good) are disaggregated via a constant elasticity of transformation (CET) function[8] to yield the final outputs, good 1 to good n.

These stages of the production story are illustrated in Figure 2.1.

The subsequent sub-sections provide the mathematical functional form and derivation of the linearized percentage change form equations necessary for each stage.

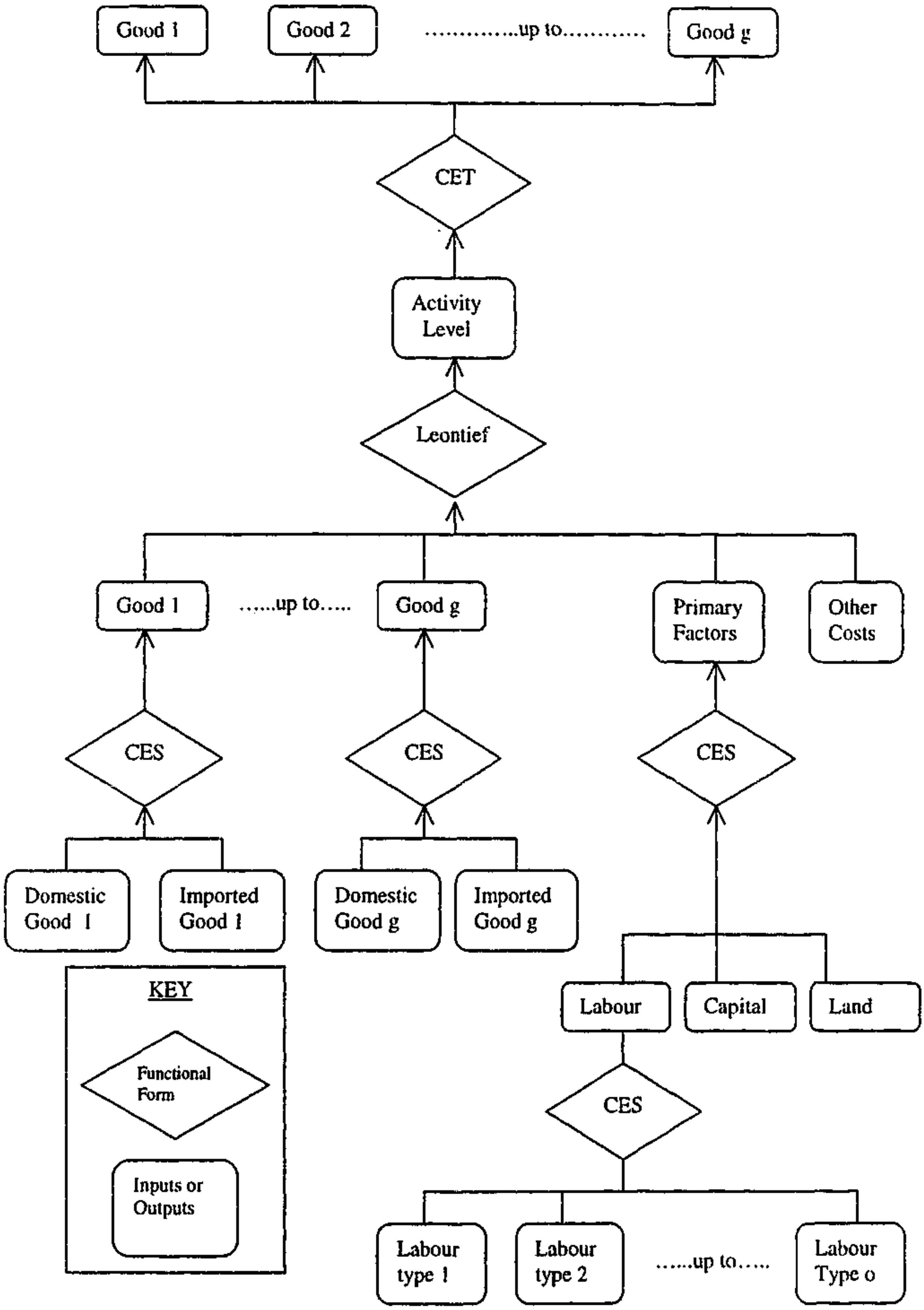
2.2.1(a) Derivation of the General Linearized Percentage-Change Input-Demand Function

For notational and presentational conveniences we will first derive a linearized percentage change demand equation for inputs in general. We will then apply appropriate notations to the derived demand function to represent types of inputs and outputs, users, sources and purposes.

---

7 The Leontief production functional form is $Y = \min_i \left\{ \frac{X_i}{b_i} \right\}$, where Y is output, X_i is input and b_i is a parameter.

Figure 2.1: Structure of Production



8 Refers to a production possibility frontier where the transformation elasticity between the production of goods by industry *j* does not change.

It is assumed that an industry j faces given input prices, P_i, $i = 1, \ldots, n$, for the required inputs. It chooses certain amounts of the inputs, X_i, $i = 1, \ldots, n$, so as to minimize its cost, $\sum_i P_i X_i$, of producing its output (or producing at an activity level), Y, subject to a constant returns to scale CES (constant elasticity of substitution) production function

$$Y = A\left[\sum_{i=1}^{n} \delta_i X_i^{-\rho}\right]^{-\frac{1}{\rho}} \tag{2.3}$$

where the parameters satisfy the restrictions

$A > 1$;

$0 < \delta < 1$ with $\sum \delta_j = 1$; and

$-1 < \rho \neq 0$ (ρ is greater than -1 but not equal to zero).

We follow Dixon, Bowles and Kendrick (1980) in solving the industry's cost minimization problem.

The Langragian function for the industry's problem is

$$L = \sum_i P_i X_i - \Lambda\left(Y - A\left[\sum_i \delta_i X_i^{-\rho}\right]^{\frac{-1}{\rho}}\right) \quad . \tag{2.4}$$

The first-order condition with respect to the k^{th} input is

$$\frac{\partial L}{\partial X_k} = P_k - \Lambda A(-1/\rho)\left[\sum_i \delta_i X_i^{-\rho}\right]^{-(1/\rho)-1} \delta_k(-\rho) X_k^{-\rho-1} = 0,\ k = 1, \ldots\ldots, n \quad .$$

That is,

$$P_k - \Lambda A\left[\sum_i \delta_i X_i^{-\rho}\right]^{-(1+\rho)/\rho} \delta_k X_k^{-(1+\rho)} = 0\,,\ k = 1,\ldots\ldots,n \quad .$$

Thus,

$$P_k = \Lambda A\left[\sum_i \delta_i X_i^{-\rho}\right]^{-(1+\rho)/\rho} \delta_k X_k^{-(1+\rho)} \quad . \tag{2.5}$$

Similarly, the first-order condition with respect to the n^{th} input is

$$P_n = \Lambda A\left[\sum_i \delta_i X_i^{-\rho}\right]^{-(1+\rho)/\rho} \delta_n X_n^{-(1+\rho)} \quad . \tag{2.6}$$

Hence,

$$\frac{P_k}{P_n} = \frac{\Lambda A\left[\sum_i \delta_i X_i^{-\rho}\right]^{-(1+\rho)/\rho} \delta_k X_k^{-(1+\rho)}}{\Lambda A\left[\sum_i \delta_i X_i^{-\rho}\right]^{-(1+\rho)/\rho} \delta_n X_n^{-(1+\rho)}} \quad .$$

Therefore,

$$\frac{P_k}{P_n} = \frac{\delta_k X_k^{-(1+\rho)}}{\delta_n X_n^{-(1+\rho)}} \quad , \quad \text{for all } k \quad . \tag{2.7}$$

From equation (2.7), we can solve for X_n,

$$X_n = \left(\frac{P_n \delta_k}{P_k \delta_n}\right)^{-(1/(1+\rho))} .X_k \ , \quad \text{for all } k\,. \tag{2.8}$$

Substitute equation (2.8) for X_i, into the original production function to obtain

$$Y = A\left[\sum_i \delta_i \left(\frac{P_i \delta_k}{P_k \delta_i}\right)^{(\rho/(1+\rho))}\right]^{-\frac{1}{\rho}} .X_k \quad . \tag{2.9}$$

From equation (2.9), we find that the input demand functions have the form

$$X_k = \frac{Y}{A\left[\sum_i \delta_i \left(\frac{P_i \delta_k}{P_k \delta_i}\right)^{\frac{\rho}{1+\rho}}\right]^{-\frac{1}{\rho}}}$$

or

$$X_k = Y * \frac{1}{A}\left[\sum_i \delta_i \left(\frac{P_i \delta_k}{P_k \delta_i}\right)^{\frac{\rho}{1+\rho}}\right]^{\frac{1}{\rho}} \tag{2.10}$$

or

$$X_k = Y * \frac{1}{A}\left[\left(\frac{\delta_k}{P_k}\right)^{\rho/(1+\rho)} \sum_i \delta_i \left(\frac{P_i}{\delta_i}\right)^{\rho/(1+\rho)}\right]^{\frac{1}{\rho}}, \; k = 1, \ldots\ldots., n. \quad .$$

that is,

$$X_k = Y\left(\frac{1}{A}\right)\delta_k^{(1/(1+\rho))} . P_k^{-(1/(1+\rho))}\left[\sum_i \delta_i^{(1/(1+\rho)} . P_i^{(\rho/(1+\rho))}\right]^{1/\rho}, \; k = 1, \ldots\ldots., n. \tag{2.11}$$

By logarithmic differentiation we have

$$x_k = y + p_k\left(-\frac{1}{1+\rho}\right) + \frac{1}{\rho}\sum_i \left(\frac{\rho}{1+\rho}\right) p_i S_i$$

or

$$x_k = y - \left(\frac{1}{1+\rho}\right)p_k + \frac{1}{\rho}\sum_i S_i\left(\frac{\rho}{1+\rho}\right)p_i \tag{2.12}$$

where

$$S_i = \frac{\delta_k^{(1/(1+\rho))}.P_k^{(\rho/(1+\rho))}}{\left[\sum_i \delta_i^{(1/(1+\rho))}.P_i^{(\rho/(1+\rho))}\right]} \quad .$$

The S_k can be interpreted as the cost share of input k in the industry's total inputs cost. To see this we note from equation (2.11) that

$$\frac{P_k X_k}{\sum_i P_i X_i} = \frac{Y\left(\frac{1}{A}\right)\delta_k^{(1/(1+\rho))}.P_k^{-(1/(1+\rho))}\left[\sum_i \delta_i^{(1/(1+\rho))}.P_i^{(\rho/(1+\rho))}\right]^{1/\rho}.P_k}{Y\left(\frac{1}{A}\right)\sum_i \delta_i^{(1/(1+\rho))}.P_i^{-(1/(1+\rho))}\left[\sum_i \delta_i^{(1/(1+\rho))}.P_i^{(\rho/(1+\rho))}\right]^{1/\rho}.P_i}$$

or

$$\frac{P_k X_k}{\sum_i P_i X_i} = \frac{\delta_k^{(1/(1+\rho))}.P_k^{(\rho/(1+\rho))}}{\left[\sum_i \delta_i^{(1/(1+\rho))}.P_i^{(\rho/(1+\rho))}\right]} \quad .$$

Hence, $S_k = \dfrac{P_k X_k}{\sum_i P_i X_i}$, which is the cost of input k as a proportion of the total cost of all the inputs, $i = 1,........,n$ for the industry.

Equation (2.12) can be rewritten as

$$x_k = y - \sigma\left(p_k - \sum_i S_i p_i\right), \text{ for } k = 1,......,n \,. \tag{2.13}$$

where,

$\sigma = \dfrac{1}{(1+\rho)}$ is the substitution elasticity between domestic good k and imported good k;

x_k is the percentage change in the demand for good k as an input;

y is the percentage change in output;

p_k is the percentage change in the price of good k; and

$\sum_i S_i p_i$ is the cost share-weighted price index of the required inputs.

Equation (2.13) is the percentage-change-form of the input-demand function. There are two important interpretations from the equation. First, in the absence of changes in relative input prices, the percentage change in the volume of input k will be the same as the percentage change in output. This stems from the linear homogeneity or constant returns to scale property of the production function, equation (2.3). Second, if the price of input k rises relative to a cost-share-weighted index of all input prices, then the use of k will fall relative to output, that is, $\dfrac{X_k}{Y}$ will decline.

A Note on Notations

The PNG model has 42 industries and 37 commodities. There is thus an industry dimension and a commodity (as an output or input for production) dimension to contend with in modelling. Within the commodity-input dimension, an input can be a good, a primary factor or an element of "other costs". Primary factors consists of labour, capital and land. Final consumers are aggregated together as a household. There are one-dimensional macro variables. Use of notations to represent these various dimensions and items within a dimension can be daunting. Therefore, at the mercy of the ORANI tradition, we introduce the main notations here to guide our presentation.

(i) The percentage change in any variable will be denoted by a lower case letter of the corresponding upper case letter. For example, the percentage change in the activity level is $z = (dZ/Z)*100$.

(ii) Commodities are denoted by subscript i, with $i = 1, \ldots\ldots\ldots, g$ commodities.

(iii) Industries are denoted by subscript j industries, with $j = 1, \ldots\ldots\ldots\ldots, h$ industries.

(iv) The purposes for which inputs are put to use are denoted by superscript k. There are five purposes:

$k = 1$ for current production,

$k = 2$ for capital creation,

$k = 3$ for household consumption,

$k = 4$ for export, and

$k = 5$ for other demand (government).

(v) There are two sources, denoted by subscript s, of intermediate inputs, $s = 1$ for domestic goods as inputs and $s = 2$ for imported goods as inputs into production.

(vi) Primary factor inputs are represented by subscript $(g+1, v)$, with $v = 1$ for labour, $v = 2$ for fixed capital, and $v = 3$ for land.

(vii) Labour types or occupations are represented by subscript v. There are two types of labour in the model, $v = 1$ for unskilled labour and $v = 2$ for skilled labour.

(viii) Other costs such as administration (telephone, stationery, etc) come under the heading of "other costs" and is denoted $X^{1}_{(g+2)j}$.

2.2.1(b) *Intermediate Inputs*

The derivation of equation (2.13) can be applied, first, to the combined use of domestic good and imported commodities as intermediate inputs, by each industry facing a CES production function for current production. That is, an industry can use as inputs domestic and imported commodities of the same commodity classification, which can be substitutes. This is the Armington (1969, 1970) assumption; imports are imperfect substitutes for domestic inputs. Applying equation (2.13) and the notations presented earlier, demand by an industry j for an intermediate input i for current production, $x^{(1)}_{(is)j}$, which is sourced domestically or imported, can be shown as,

$$x^{(1)}_{(is)} = z_j - \sigma^{(1)}_{ij}\left(p_{is} - \sum_{s=1}^{2} S^{(1)}_{(is)} p_{is} \right) \tag{2.14}$$

where

the superscript (1) denotes demand of inputs for current production;

z_j is now used (instead of y) to represent the percentage change in output or activity level in industry j;

p_{is} is the percentage change is the price of good i from source s;

$S^{(1)}_{(is)j}$ is the cost-share-weighted price index of the required inputs for industry j for current production; and

$\sigma^{(1)}_{ij}$ is the substitution elasticity between domestic good i and imported good i in industry j.

2.2.1(c) Primary Factors

Second, the derivation of equation (2.13) can be applied to a CES aggregation of labour, fixed capital and land, (to yield a primary factor composite) demanded by each industry. An industry's demand for a primary factor, $x^{(1)}_{(g+1,v)j}$, is shown as

$$x^{(1)}_{(g+1,v)j} = z_j - \sigma^{(1)}_{j}(p^{(1)}_{(g+1,v)} - \sum_{v=1}^{3} S_{(g+1,v)} p^{(1)}_{(g+1,v)j}) \tag{2.15}$$

where

$S_{(g+1,v)}$ = cost share of primary factor v in total primary factor cost for industry j.

(Similar interpretations as those presented earlier can be made of the rest of the function.)

2.2.1(d) *Different Types of Labour*

Within the factor labour there can be various types or occupations of labour. For the PNG model, there are two types of labour. It is assumed that the two types of labour are combined in a CES manner to yield the aggregate labour that is then used with land and capital by each industry. So, following the derivation of equation (2.13), an industry's demand for a certain type of labour, $x^{(1)}_{(1+g,1,q)j}$, is given by

$$x^{(1)}_{(g+1,1,q)j} = x^{(1)}_{(g+1,1)j} - \sigma^{(1)}_{1j}(p^{(1)}_{(g+1,1,q)j} - \sum_{r=1}^{o} S_{(g+1,1,r)j}\, p^{(1)}_{(g+1,1,r)j}) \tag{2.16}$$

where

$S_{(g+1,1,q)j}$ is the weighted cost share of labour type q in the total labour cost of industry j.

2.2.1(e) *Composite Goods, Composite Primary Factors and Other Costs for Activity Level*

The commodity composites and primary-factor composites and "other costs" (which come in at this stage) are then combined in a Leontief production function to yield the activity level of each industry. They are all demanded in direct proportion to each industry's activity level (holding technology constant), measured by an index of industry activity, Z_j.

The linearized percentage change equation of the demand for composite (combination of domestic and import) good i, $X^{(1)}_{(i.)j}$, is in direct proportion to each industry's activity level, Z_j, and can be expressed as

$$x^{(1)}_{(i.)j} = z_j \quad . \tag{2.17}$$

The percentage change form of the demand for a composite primary factor, $X^{(1)}_{(g+1,.)j}$, is

$$x^{(1)}_{(g+1,.)} = z_j \ . \qquad (2.18)$$

An industry also incurs costs for things other than intermediate inputs of goods and primary factors. These include overhead costs such as administration and storage of output. These costs come under the heading of "other costs", denoted $X^{1}_{(g+2)j}$. The demand for other costs is also in direct proportion to the industry's output or activity level, Z_j,

$$x^{(1)}_{(g+2)j} = z_j \ . \qquad (2.19)$$

2.2.1(f)   Commodity Supplies

At the third stage (the top) of the production structure each producing industry will choose the commodity-output combination that will maximize its revenue for any level of activity. For each industry j it will be assumed that

$$X^{0}_{(i1)j,} \text{ for } i = 1,\ldots\ldots, g$$

(outputs of commodities)

are chosen to maximize

$$\sum_{i=1}^{g} P^{0}_{(i1)} X^{0}_{(i1)j,} \qquad (2.20)$$

subject to a constant ratio of elasticities of transformation (CET), a homothetic commodity transformation production possibilities frontier

$$Z_j = \beta\left[\sum_{i=1}^{m}\gamma_i X_{(i1)j}^{0\ -\rho}\right]^{-1/\rho} \tag{2.21}$$

where

B and the γs are positive parameters with $\sum_i \gamma_i = 1$, and

$\rho < -1$.

The first-order conditions are that there exists Λ such that Λ and the Y_k s jointly satisfy

$$P_k = \Lambda B\left[\sum_{i=1}^{m}\gamma X_{(i1)j}^{0\ -\rho}\right]^{-(1+\rho)/\rho} \gamma_k X_{(k1)j}^{0\ -(1+\rho)} \quad , \quad \text{for } k = 1,\ldots\ldots,m$$

and equation (2.21).

By following the same steps (as was done) for the derivation of an industry's demand for intermediate inputs and primary factors, the eventual percentage form equation is

$$x_{(i^*)j}^{(0)} = z_j + \sigma_{(i1)j}^{(0)}\left(p_{i1} - \sum_{i=1}^{g} C_{(i1)j}\, p_{i1}\right) \tag{2.22}$$

where

$C_{(i1)j}$ is the revenue share of product i in the total revenue of industry j, mathematically represented as

$C_{(i1)j} = \dfrac{P_k Y_k}{\sum_i P_i Y_i}$, for all k.

Each industry's supplies of composite commodities depends on the industry's overall activity level and the relative prices of the different composite commodities.

2.2.2 *The Structure of Consumer (Household) Demand*

The nesting structure for consumer (household) demand is shown in Figure 2.2. At stage 1 (bottom of the structure) consumers can choose between domestic good i and the imported equivalent, which is an imperfect substitute of good $i, 1, ..., g$. The domestic good and the imperfect import substitute are combined in a CES aggregation to give a composite of that good i. These commodity composites, good 1 to good g, are then aggregated by a *Stone-Geary* function at stage 2 (top of the structure) to yield the household utility.

The total number of households, who are the consumers, in the PNG economy is denoted Q. The interest of Q is to maximize total utility. This can be represented by an average household whose utility is derived from a consumption-bundle of effective inputs (goods and services consumed). The average household's utility function is strictly quasi-concave. The objective of the average household then is to choose a consumption bundle, X_i / Q, $i = 1, ..., g$ of effective units so as to maximise the strictly quasi-concave utility function

$$U\left(X_1/Q, X_2/Q, ... X_n/Q\right) \tag{2.23}$$

subject to

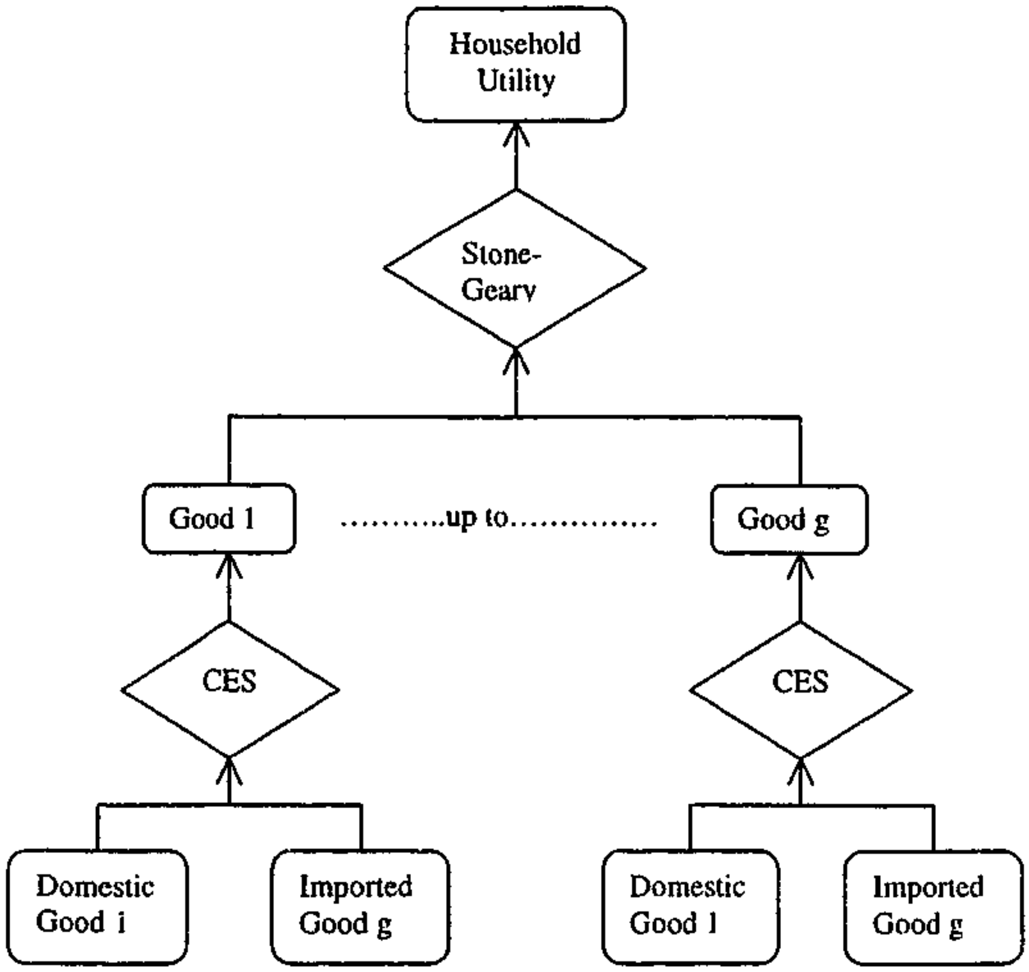
$$X_i = A\left[\sum_i \delta_i X_{is}^{-\rho}\right]^{-\frac{1}{\rho}}, \text{ for } i = 1, ..., g \text{ and } s = 1, 2 \tag{2.24}$$

and

$$\sum_{i=1}^{n} \sum_{s=1}^{2} P_{is} X_{is} = C \tag{2.25}$$

where the restrictions on the parameters in equation (2.24) are the same as before.

Figure 2.2: Structure of Consumer Demand



2.2.2(a) Consumer Demand for Commodities by Source (in CES Combination)

If the average household is to maximise utility subject to a budget constraint then it must spend as little as possible to achieve whatever the optimal levels of *effective inputs* are. From the derivations (2.3) to (2.13) we get a CES expression for household demand by source (where the superscript $^{(3)}$ denotes sales to households)

$$x_{is}^{(3)} = x_i^{(3)} - \sigma_i^{(3)} (p_{is}^{(3)} - \sum_{s=1}^{2} S_{is}^{(3)} p_{is}^{(3)}) \quad \text{for } i = 1, \ldots\ldots, g . \tag{2.26}$$

where

$x_i^{(3)}$ is the percentage change in the household demand for good i undifferentiated by source;

$p_{is}^{(3)}$ is the percentage change in the household purchase price of good i from source s;

$S_{is}^{(3)}$ is the value share of good i from source s in the total household purchase of good i for consumption; and

$\sigma_i^{(3)}$ is the substitution elasticity between domestic and imported source of good i consumed by households.

2.2.2(b) *Stone-Geary Aggregation of the CES Commodity Composites (by the Household)*

The demanded commodity composites are then combined in a Stone-Geary[9] manner for the derivation of the household's total utility. In the PNG model we have imposed the restrictions of a Stone-Geary utility function without the use of an explicit derived equation. The specifications suit our purpose. The restrictions of a Stone-Geary utility function are that: there is a lack of specific substitutability between the commodity composites derived from the CES aggregation; and there are no inferior goods. An advantage of the Stone-Geary specification is that it requires only the estimates of expenditure elasticities and a Frisch parameter.

Although, the Stone-Geary utility function is not explicitly used in the model, a general demand form is used in which the restrictions imposed on the parameters follow the Stone-Geary form.

The general form (ignoring taste-change terms) is;

9 Also referred to as Klein-Rubin utility functional form. The functional form is $U(X_1^{(3)} \ldots X_r^{(3)}) = \sum_{i=1}^{r} \delta_i \ln\left(X_i^{(3)} - \theta_i\right)$. The maximization of this utility function subject to a budget constraint $\sum_{i=1}^{r} P_i X_i = C$ would give rise to a linear expenditure function of the form $P_i^{(3)} X_i^{(3)} = \theta_i + \delta_i (C - \sum_{i=1}^{r} P_i^{(3)} \theta_i)$. Total differentiation and algebraic manipulation of these equations would yield a percentage change form of the Stone-Geary demand for good $x_i^{(3)}$ by the household.

$$x_i^{(3)} = \varepsilon_i c + \sum_{k=1}^{g} \eta_{ik} p_k^{(3)} \tag{2.27}$$

where

$c =$ aggregate nominal expenditure;

$\varepsilon_i =$ expenditure elasticity of good i, the effect on household consumption of effective units of good i arising from a 1.0 per cent rise in average household expenditure; and

$\eta_{ik} =$ own-price and cross-price elasticities, the effect on household consumption of effective units of good i arising from a 1.0 per cent increase in the general price of good k.

The expenditure and, own-price and cross-price elasticities satisfy the usual restrictions of homogeneity, symmetry and Engel's aggregation.

The restrictions on the parameters on the general demand function to yield a Stone-Geary utility form are as follows.

$$\eta_{ik} = KD_{ik}\frac{\varepsilon_i}{F} - \varepsilon_i\left[S_k^{(3)} + \frac{\delta_k}{F}\right]$$

where

$\varepsilon_i =$ $\dfrac{\delta_i}{S_i^{(3)}}$;

$F =$ Frisch parameter is the (negative of the) ratio of total to luxury expenditure;

$S_i^{(3)} =$ share of household expenditure for good i;

$\delta_i =$ marginal budget share; and

$KD =$ Kroneker's delta: $KD_{ij} = 0$ for $i \neq j$, $KD_{ii} = 1$

The lack of specific substitutability between commodity composites is a property of an additive utility function where the household behaves as if its marginal utility of good i is independent of its consumption of good j for all $i \neq j$. Arising out of the additive utility function is the notion of the *Frisch* parameter, which is interpreted as own elasticity of the marginal utility of expenditure with respect to increases in expenditure. As mentioned already, the only estimated parameters needed in the Stone-Geary system are the expenditure elasticities (or marginal budget shares) for the commodities and the Frisch parameter.

2.2.3 Demand for Inputs for Capital Formation

The capital creation function has the same nested structure that governs intermediate inputs to current production. This is represented by Figure 2.3.

At the first stage, capital is assumed to be produced with inputs of domestically-produced and imported commodities, combined through a CES function. It follows that the resulting linearized equation is the same in structure as that obtained for the production function.

$$x_{(is)j}^{(2)} = y_j - \sigma_{ij}^{(2)}(p_{is} - \sum_{s=1}^{2} S_{(is)j}^{(2)} p_{is}) \tag{2.28}$$

where

the superscript (2) denotes demand for capital formation;

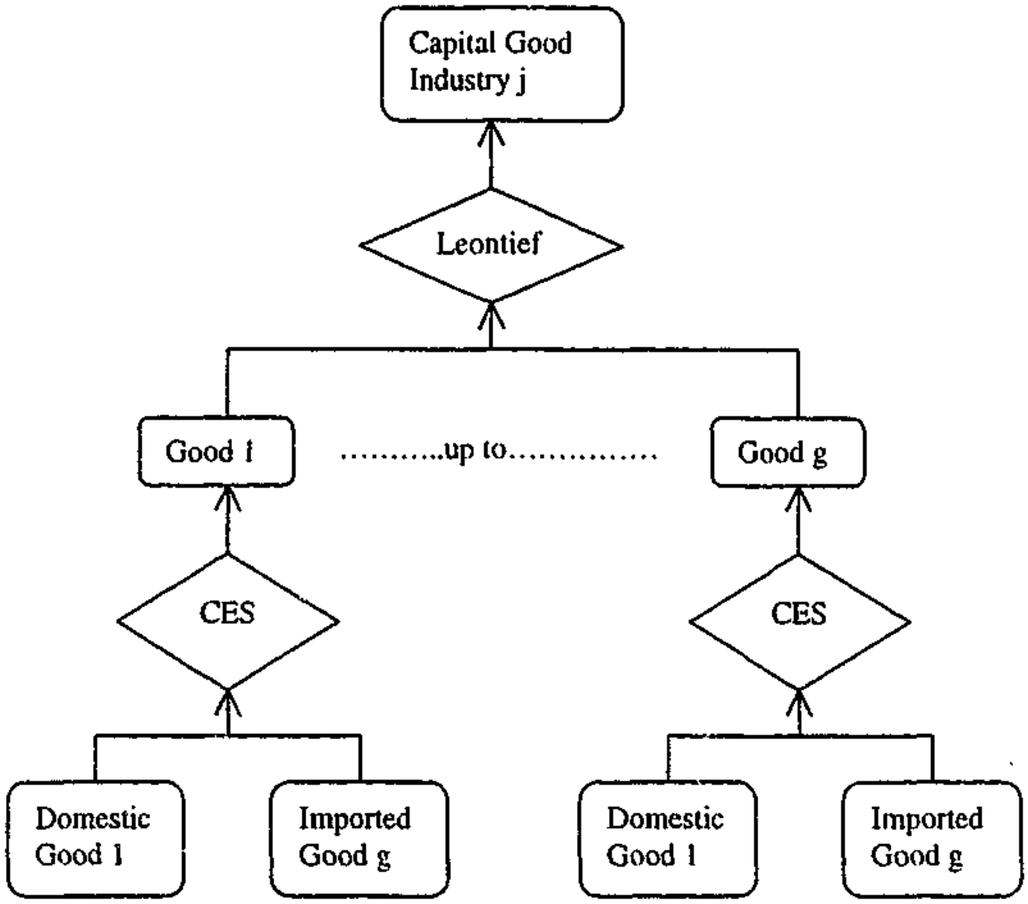
y_j is percentage change in investment level in industry j;

p_{is} is the percentage change is the price of good i from source s;

$S_{(is)j}^{(2)}$ is the cost-share-weighted price index of the required domestic and imported inputs for the industry for capital creation; and

$\sigma_{ij}^{(2)}$ is the substitution elasticity between domestic good i and imported good i.

Figure 2.3: Structure of Investment



Equation (2.28) says that demand for inputs to capital creation depends on the level of investment being undertaken by each industry and the relative prices between domestic and imported inputs into this investment.

At the second stage the commodity composites (combination of domestic and import) good i, $X_{(i.)j}^{(2)}$, are combined in a Leontief production function to yield the investment level of each industry. They are all demanded in direct proportion to each industry's investment level (holding technology constant), measured by an index of industry activity, Y_j.

This can be expressed in linearized percentage change form as

$$x_{(i.)j}^{(2)} = y_j \quad . \tag{2.29}$$

2.2.4 Export Demand

Following Dixon *et al.* (1982, p104) it is assumed that the f.o.b foreign-currency price per unit of export of good i, $P^{e}_{(i1)}$, is a function of the export volume of the good i, $X^{(4)}_{(i1)}$, and a shift variable representing changes in overseas demand for the good i from PNG, $F^{e}_{(i1)}$.

$$P^{e}_{(i1)} = g_i(X^{(4)}_{i1})F^{e}_{i1}\text{, for } i = 1,\ldots\ldots,n$$

where

g_i is a non-increasing function of $X^{(4)}_{(i1)}$

The linearized percentage form of this equation is

$$p^{e}_{i1} = -\gamma_i x^{(4)}_{i1} + f^{e}_{i1} \tag{2.30}$$

where

$$-\gamma_i = \frac{\partial g_i}{\partial X^{(4)}_{i1}} \frac{X^{(4)}_{i1}}{g_i}\ .$$

Note γ is non-negative and is the reciprocal of the foreign elasticity of demand for PNG exports of good i.

The interpretation of the equation is that a rise in the export volume of good i comes about through a fall in its foreign currency f.o.b price. If the supply of good i does not affect world prices of good i the value of γ is set at zero.

2.2.5 *Other Demand*

As in ORANI (Dixon *et al*, 1982, p.105) *Other Demand* consists mainly of government demand for both imported and domestically produced goods and services. The equation for this category of demand, which has no theoretical basis, is simply

$$x_{is}^{(5)} = c_R h_{is}^{(5)} + f_{is}^{(5)} \quad , \quad i = 1,\ldots\ldots,g, \;\; s=1,2 \tag{2.31}$$

where

$x_{is}^{(5)}$ is the percentage change in "other" demand for good i from source s; and

c_R is the percentage change in real aggregate household consumption, defined as

$$c_R = c - \xi^{(3)} \, , \tag{2.32}$$

(where c is the percentage change in nominal aggregate household consumption and $\xi^{(3)}$ is the consumer price index.); and

$h_{is}^{(5)}$ and $f_{is}^{(5)}$ are parameters and shift variables.

If the $h_{is}^{(5)}$ parameters are all set at one and the $f_{is}^{(5)}$ shift variables are set at zero, "*other*" demand will move in line with real household expenditure. Other scenarios can be applied, however, such as having the $h_{is}^{(5)}$ set at zero and $f_{is}^{(5)}$ set at 5.0 per cent to represent a fiscal policy of an increase in all real current government spending.

2.2.6 *Zero Pure Profits*

We follow the convention entailed in input-output tables and normally applied in CGE modelling as in ORANI and make two important initial assumptions. First, in all economic activities (producing, importing, exporting, transporting, etc.) there are zero pure profits. That is, all factors of production are paid their marginal product so that there is no economic profit left (Euler's Theorem). Second, basic values are uniform across users and across producing industries in the case of domestic goods and importers in the case of foreign goods.

2.2.6(a) Zero Pure Profits in Production

With the above two assumptions, the total basic value of the final output of good i, $X_{(i,1)j}^{(0)}$, of industry j can be written as being equal to the total payment for all necessary inputs (as defined earlier in *note on notations*) for current production: domestic and imported intermediate inputs, $X_{(is)j}^{(1)}$; labour input by type $X_{(g+1,1,m)j}^{(1)}$; other factor (capital and land) inputs $X_{(g+1,s)j}^{(1)}$ and other costs $X_{(g+2)j}^{(1)}$, all valued at their respective prices. In levels form this can be shown as

$$\sum_{i=1}^{g} P_{i1}^{(0)} X_{(i1)j}^{(0)} = \sum_{i=1}^{g} \sum_{s=1}^{2} X_{(is)j}^{(1)} P_{(is)j}^{(1)} + \sum_{m=1}^{M} P_{(g+1,1,m)j}^{(1)} X_{(g+1,1,m)j}^{(1)} + \sum_{s=2}^{3} P_{(g+1,s)j}^{(1)} X_{(g+1,s)j}^{(1)} + P_{g+2,j}^{(1)} X_{g+2,j}^{(1)} \qquad j = 1,\ldots\ldots,h \quad . \tag{2.33}$$

In percentage change form, equation (2.33) reduces to

$$\sum_{i=1}^{g} p_{i1}^{(0)} H_{(i1)j}^{(0)} = \sum_{i=1}^{g} \sum_{s=1}^{2} p_{(is)j}^{(1)} H_{(is)j}^{(1)} + \sum_{m=1}^{M} p_{(g+1,1,m)}^{(1)} H_{(g+1,1,m)j}^{(1)} + \sum_{s=2}^{3} p_{(g+1,s)j}^{(1)} H_{(g+1,s)j}^{(1)} + p_{g+2,j}^{(1)} H_{g+2,j}^{(1)} \tag{2.34}$$

where

the H's are revenue and cost shares. $H_{is,j}^{1}, H_{ij}^{1}$ and $H_{(g+1,1,m)j}^{1}$ are the shares of j's costs accounted for by inputs of is, by inputs of i from all sources and by inputs of labour of skill m.

Based on Dixon *et al.* (1980, p. 110), "Under constant returns to scale in production, both revenue and costs per unit of activity are independent of the activity level. They are influenced only by changes in prices and technology", the x's are eliminated.

2.2.6(b) Zero Pure Profits in Capital Creation

In the zero pure profit condition for capital formation, the value of new capital must equal the cost of its production. With the notations as defined earlier, in levels form this can be written as

$$\Pi_j Y_j = \sum_{i=1}^{g} \sum_{s=1}^{2} P_{(is)j}^{(2)} X_{(is)j}^{(2)} \quad . \tag{2.35}$$

Following the procedure described in Dixon *et al.* (1982 pp. 109 to 111), the percentage change form of the above equation can be written as:

$$\pi_j = \sum_{i=1}^{g} \sum_{s=1}^{2} p_{is,j}^{(2)} H_{is,j}^{(2)} \tag{2.36}$$

where

πj	is the percentage change in the price of a unit of capital for industry j; and
$H_{(is)j}^{2}$	is the share of good i from source s.

Note that in the PNG CGE model, there is no industry technical change term. If there were, there would be some a's appearing in the RHS of the equation.

Equation (2.36) "implies that the percentage change in the cost of a unit of capital for industry j is a weighted average of the percentage changes in the prices of the inputs, the weights being cost shares" (Dixon *et al.* 1982, p. 111).

2.2.6(c) Zero Pure Profits in Importing

The basic price of imported good $i, P_{i2}^{(0)}$ (i.e. the price received by PNG importers, excluding transport and other margins costs) is equal to the foreign-currency c.i.f price of imported good *i*, P_{i2}^{m}, converted into the local currency price by the nominal exchange rate Φ, multiplied by the power of the tariff, T_i, imposed on the good. In levels, this can be written as

$$P_{i2}^{(0)} = \frac{P_{i2}^m}{\Phi} . T_i \tag{2.37}$$

where

$$\Phi = \frac{Dollar_f}{Kina_d} \quad .$$

In percentage change form equation (2.37) can be written as

$$p_{i2}^{(0)} = p_{i2}^m - \phi + t_i \quad . \tag{2.38}$$

2.2.6(d) *Zero Pure Profits in Exporting*

The fourth zero pure profit equation relates the basic prices of domestic goods to f.o.b. export prices. The PNG Kina price paid by foreigners for units of good $i1$ at PNG ports, i.e., the f.o.b. price, converted to local currency via the exchange rate, Φ, is equal to the basic price, $P_{i1}^{(0)}$ of the good multiplied by the power of the export subsidy, V_i,

$$P_{i1}^{(0)} = \frac{P_{i1}^e}{\Phi} . V_i \tag{2.39}$$

In percentage change form, equation (2.39) can be written as

$$p_{i1}^{(0)} = p_{i1}^e - \phi + v_i \quad . \tag{2.40}$$

In contrast to ORANI, in the PNG model there are no costs of taxes and margins involved in delivering good (i1) to foreigners at the PNG ports of exit. Therefore, we have not accounted for such items in equations (2.39) and (2.40).

2.2.7 *Market Clearing Conditions*

We need an equation that equates supply $X_{i1}^{(0)}$ and demand for each of the domestically produced goods, $i1, i = 1, ..., g$. The subscript (1) denotes domestically produced good i. Total supply is the sum of the output i from all the industries producing the good. Total demand is made up of

(i) demand for intermediate inputs to current production ($X_{(i1)j}^{1}$);

(ii) demand for inputs to the production of capital equipment ($X_{(i1)j}^{2}$);

(iii) demand for consumption goods ($X_{(i1)}^{3}$);

(iv) export demand (X_{i1}^{4}); and

(v) other (government) purchases (X_{i1}^{5});

Again, there is no explicitly defined storage, wholesale and other margins services in the PNG model. There is the implication that margins are already accounted for in transportation and commerce industries. The main implication of having no specific margins is that if there were no taxes, the model would not distinguish between basic and user prices. As it is, the PNG model does include various taxes such as the excise tax and these drive a wedge between basic prices and user prices.

The equation depicting the above can be written as

$$X_{i1}^{(0)} = \sum_{j=1}^{h} X_{(i1)j}^{(1)} + \sum_{j=1}^{h} X_{(i1)j}^{(2)} + X_{i1}^{(3)} + X_{i1}^{(4)} + X_{i1}^{(5)} \quad , \; i = 1, ..., g \qquad (2.41)$$

where

$$X_{i1}^{(0)} = \sum_{j=1}^{h} X_{(i1)j}^{(0)} \, , \; i = 1, ..., g$$

Similarly, a market-clearing equation is required for the primary factors.

The equation depicting equality of supply and demand for:

labour of skill m, L_m is

$$L_m = \sum_{j=1}^{h} X_{(g+1,1,m)j}^{(1)} \quad , \quad m = 1,\ldots\ldots,M \quad ; \tag{2.42}$$

start-of-year capital $K_j(0)$ is

$$K_j(0) = X_{(g+1,2)j}^{(1)} \quad ; \text{and} \tag{2.43}$$

land N_j is,

$$N_j = X_{(g+1,3)j}^{(1)} \quad . \tag{2.44}$$

In percentage-change form, equations (2.41) to (2.44) can be written, respectively, as

$$x_{i1}^{0} = \sum_{j=1}^{h} x_{(i1)j}^{1} B_{(i1)j}^{1} + \sum_{j=1}^{h} x_{(i1)j}^{2} B_{(i1)j}^{2} + x_{(i1)}^{3} B_{(i1)j}^{3} + x_{(i1)}^{4} B_{(i1)}^{4} + x_{(i1)}^{5} B_{(i1)}^{5} \quad , \tag{2.45}$$

$$l_m = \sum_{j=1}^{h} x_{(g+1,1,m)j}^{(1)} B_{(g+1,1,m)j}^{(1)} \quad , \tag{2.46}$$

$$k_j(0) = x_{(g+1,2)j}^{(1)} \quad , \tag{2.47}$$

$$n_j = x_{(g+1,3)j}^{(1)} \quad ; \text{and} \tag{2.48}$$

where the Bs are the relevant shares in total demands.

2.2.8 *Government Sector*

The PNG model adopted from Vincent *et al.* (NCDS 1990) contains equations for government revenue, government expenditure and the net budgetary position of the government. The percentage change equations are derived from identities rather than behavioural theory. The definitions are taken from Vincent *et al.* (1990, pp. 21-24). The equations are a tool for explaining the effects on the economy of changes in government revenue, expenditure and the net budgetary position.

2.2.8(a) *Government revenue from personal taxes*

Personal tax revenue is given by the sum across all industries of the product of the average tax rate for each industry and labour payments (gross wage costs to a firm) of each industry. An average tax rate is assumed to apply to wages paid in each sector.

$$r_1^t = \sum_{j=1}^{h} S_{1j}^t \left(t_{ij} + p_{1j}^p + x_{(g+1,1)j}^p \right) \tag{2.49}$$

where

r_1^t is government revenue from personal taxes;

S_{1j}^t is share of the total government revenue from personal taxes that accrues from industry j;

t_{ij} is tax rate on industry wage payments;

p_{1j}^p is price of labour in industry j; and

$x_{(g+1,1)j}^p$ is demand for labour in industry j.

2.2.8(b) *Government revenue from company taxes*

Revenue from company taxes depends on the sum across industries of the product of company tax on profits and profit levels,

$$r_{2,3}^{t} = \sum_{j=1}^{h} S_{(2,3)j}^{t}\left(t_{(2,3)j} + p_{(g+1,2)j}^{(1)} + x_{(g+1,2)j}^{(1)}\right) \tag{2.50}$$

where

$r_{2,3}^{t}$ is government revenue from company taxes;

$S_{(2,3)j}^{t}$ is the share of the total government revenue from company taxes that accrues from profits in industry j;

$t_{(2,3)j}$ is the tax rates on industry profits;

$p_{(g+1,2)j}^{(1)}$ is rental price of capital in industry j; and

$x_{(g+1,2)j}^{(1)}$ is industry demand for capital.

2.2.8(c) Government revenue from import duties

Revenue raised from import duties is a function of import prices in local currency, import volumes and the rate of import duty levied on each commodity import.

$$r_{t}^{t} = \sum_{i=1}^{g} T_{i}^{t}\left(s_{i}^{t} t_{i} + p_{i2}^{m} + x_{i2} - \phi\right) \tag{2.51}$$

where

r_{t}^{t} is government revenue from import duties;

T_{i}^{t} is the share of total tariff revenue accounted for by tariff revenue from good i;

s_{i}^{t} is the ratio of the power of the tariff on good i to the *ad valorem* rate;

t_{i} is one plus the *ad valorem* tariff or tariff equivalent; and

other variables are as defined earlier in the chapter.

2.2.8(d) Government revenue from excise duties

Excise duties are estimated as the product of the rate of tax and the value of excisable goods consumed (price times quantity) from domestic and imported sources.

$$r_c^t = \sum_{i=1}^{g} \sum_{s=1}^{2} T_{is}^c \left(t_i^c + p_{is} + x_{is}^{(3)} \right) \tag{2.52}$$

where

r_c^t is government revenue from excise duties;

T_{is}^c is the share of government revenue from excises on commodity i from source;

t_i^c is the tax rate on excisable good i; and

other variables are as defined earlier in the chapter.

2.2.8(e) Government revenue from other taxes

Revenue from other taxes (a residual item) is assumed to move in line with nominal GDP.

$$r_0^t = gdp \tag{2.53}$$

where

r_o^t is government revenue from other taxes.

2.2.8(f) Government revenue from mining royalties, dividends

Revenue from mining dividends and royalties is a product of a specified yield per unit of rent and the resource rent from each mine.

$$r_m^t = \sum_{j=1}^{h} M_j^t \left(t_j^m + p_{(g+1,3)j}^{(1)} + x_{(g+1,3)j}^{(1)} \right) \tag{2.54}$$

where

r_m^t is government revenue from mining royalties and dividends;

M_j^t is the share of total government revenue from mining royalties obtained from industry j;

t_j^{m} is the tax yield per unit of mining rent;

$p_{(g+1,3)j}^{(1)}$ is the rental price of land; and

$x_{(g+1,3)j}^{(1)}$ is industry demand for land.

2.2.8(g) *Government revenue from other non-tax sources (excluding foreign aid payments) and foreign aid payments*

Other non-tax revenue, r_o^{nt}, excluding foreign grants, moves in line with nominal GDP. Foreign aid grants r^{fg} moves in line with the nominal exchange rate.

$$r_0^{nt} = gdp \tag{2.55}$$

2.2.8(h) *Nominal government consumption expenditure*

Aggregate nominal consumption expenditure of the government is defined as the sum of the government's current spending on goods and services supplied by each industry.

$$g^c = \sum_{i=1}^{g} \sum_{s=1}^{2} S_{is}^{(5)} \left(x_{is}^{(5)} + p_{is} \right) \tag{2.56}$$

where

g^c is nominal government consumption expenditure;

$S_{is}^{(5)}$ is the share of total other demand accounted for other demand for good i from source s; and

$x_{is}^{(5)}$ is other demand for good i from source s.

2.2.8(i) *Nominal government capital expenditure*

This is defined as the sum of government capital spending on each type of capital good. Provision is made in the industry investment equation (2.65) through industry j's investment shifter variable, f_j^2, for this capital expenditure to be shifted exogenously. Capital spending by the government is only in the public sector industries of *education, health, government administration* and *electricity & garbage.*

$$g^I = S^I_{gj} \sum_{j=1}^{h} \left(y_j + \pi_j \right) \tag{2.57}$$

where

S^I_{gj}	is the share of total government investment (capital) spending represented by government investment spending in industry j;
y_j	is industry investment; and
π_j	is the cost of industry capital.

2.2.8(j) *Total government revenue and expenditure*

The summation of the various components of government revenue and expenditure yield totals for the two items respectively.

$$g^r = R_1 r_1^t + R_2 r_{2,3}^t + R_3 r_t^t + R_4 r_c^t + R_5 r_c^t + R_6 r_m^t + R_7 r_0^{nt} + R_8 r^{fg} \tag{2.58}$$

This r_c^t should be r_o^t

where

$R_1 = 0.145$, $R_2 = 0.065$ [illegible] $= 0.039$, $R_6 = 0.060$, $R_7 = 0.359$ and $R_8 =$ [illegible] ares[10] of total government revenue obtained from [illegible] taxes, import duties, excise duties, other taxes, mining royalties, other non-tax revenues and foreign grants.

$$g^e = E_1 g^c + E_2 g^I + E_3 g^0 \tag{2.59}$$

10 Quoted from Vincent *et al.* 1990 (original source of the share figures was AIDAB (former name for AUSAid)), 1989.

industry j's investment shifter variable, f_j^2, for this capital expenditure to be shifted exogenously. Capital spending by the government is only in the public sector industries of *education, health, government administration* and *electricity & garbage.*

$$g^I = S_{gj}^I \sum_{j=1}^{h} \left(y_j + \pi_j \right) \tag{2.57}$$

where

S_{gj}^I is the share of total government investment (capital) spending represented by government investment spending in industry j;

y_j is industry investment; and

π_j is the cost of industry capital.

2.2.8(j) *Total government revenue and expenditure*

The summation of the various components of government revenue and expenditure yield totals for the two items respectively.

$$g^r = R_1 r_1^t + R_2 r_{2,3}^t + R_3 r_i^t + R_4 r_c^t + R_5 r_e^t + R_6 r_m^t + R_7 r_0^{nt} + R_8 r^{fg} \tag{2.58}$$

where

$R_1 = 0.145$, $R_2 = 0.065$, $R_3 = 0.143$, $R_4 = 0.007$, $R_5 = 0.039$, $R_6 = 0.060$, $R_7 = 0.359$ and $R_8 = 0.182$ are respectively the shares[10] of total government revenue obtained from personal taxes, company taxes, import duties, excise duties, other taxes, mining royalties, other non-tax revenues and foreign grants.

$$g^e = E_1 g^c + E_2 g^I + E_3 g^0 \tag{2.59}$$

10 Quoted from Vincent *et al.* 1990 (original source of the share figures was AIDAB (former name for AUSAid)), 1989.

where

g^0 is other government demand and $E_1 = 0.37$, $E_2 = 0.18$ and $E_3 = 0.45$ are respectively the shares[11] of government expenditure on consumption, capital creation and other spending.

2.2.8(k) The budget position of the government

The net budgetary position of the government is defined as the difference between aggregate government revenue and aggregate government expenditure.

$$100\Delta G^B = G^R g^r - G^E g^e \tag{2.60}$$

where

ΔG^B is the change in the government's budget position;

G^R is total government revenue; and

G^E is total government expenditure.

2.2.9 Investment and Capital Stock

It is in this area that the adopted static CGE model of PNG is transformed into a dynamic one. This is a key change, with the generic ideas coming from the dynamic MONASH model, and it is fundamental to understanding and interpreting the simulations that follow in later chapters.

Given that we started from a static framework, the inherited theoretical structure for investment and capital are presented first. We then introduce the inter-temporal dynamic linking of investment and capital. We further link the industry investment in the static framework to the dynamic investment-capital equation, enabling a circular flow.

2.2.9(a) *Rates of Return, Investment and Capital Stocks in Comparative Statics*

The theory of investment in the comparative static part of the model is a straight ORANI feature. It is concerned with the allocation of aggregate private investment across using industries, not the determination of the level of aggregate private investment. The allocation or re-allocation of aggregate investment comes about as a result of a policy change, say an exogenous change in the tariff rate. The re-allocation of investment then affects investment by industry and the trade balance. For example, it would drive down the trade balance if investment were shifted towards industries whose capital structure is very import-intensive. The adopted theory has six components (see Dixon *et al.* 1982, pp. 118 to 122), which, for expositional purposes, we reduce to three.

The first is concerned with the current net rate of return on fixed capital in industry (j). It is defined as

$$R_j(0) = \frac{P^{(1)}_{(g+1,2)j}}{\Pi_j} - d_j \qquad (2.61)$$

where

d_j is the rate of capital depreciation (assumed fixed) in industry j;

$P^{(1)}_{(g+1,2)j}$ is the rental value of a unit of capital industry j; and

Π_j is the cost of a unit of capital in industry j.

In percentage change form equation (2.61) is

$$r_j = Q_j\left(p^{p}_{(j+1,2)j} - \pi_j\right) \;,\; j = 1,\ldots\ldots h \qquad (2.62)$$

11 Quoted from Vincent *et al.* 1990 (original source of the share figures was Dept of Finance and Planning, PNG, 1989.)

where

Q_j is the ratio of the gross rate of return in industry j to the net rate of return.

The second component is the assumption that total private investment expenditure, Y, is allocated across industries so as to equate the expected rates of return. Embedded in this is the notion that the expected rate of return to capital for one period ahead, $R_j(1)$, is an inverse function of capital. This notion underlies the behaviour of investors. If investment plans in the current period will lead to an increase in capital stock by the end of the next period so that $K_j(1)/K_j(0)$ is greater than one, businessmen would expect the rate of return to capital to fall. Given this notion, in the allocation of total investment across industries there should exist a rate of return Ω in the one period ahead that equates all the industries expected rates of return such that

$$\left(\frac{K_j(1)}{K_j(0)}\right)^{-\beta_j} R_j(0) = \Omega \ , \quad j \in J \tag{2.63}$$

where

J is a subset of $\{1, \ldots\ldots, h\}$ consisting of industries whose investment can be treated as endogenous. The subset J would normally exclude government-dominated industries; and

β_j is a positive parameter.

In percentage change form equation (2.63) can be expressed as

$$\omega = -\beta_j \left(k_j(1) - k_j(0)\right) + r_j(0) \ . \tag{2.64}$$

The third component involves the assumption that the current capital stock and the current level of investment are the only variables that influence the level of capital stock at the end of one period (in comparative statics, the length of a time period is not clearly specified),

$$K_j(1) = K_j(0)\left(1 - d_j\right) + Y_j \ , \ j = 1, \ldots, h \ . \tag{2.65}$$

In percentage change form equation (2.65) is

$$k_j(1) = k_j(0)\left(1 - G_j\right) + y_j G_j \ , \ j = 1, \ldots, h \tag{2.66}$$

where

$G_j = Y_j / K_j(1)$ is the ratio of gross investment in industry j to its future capital stock.

We can then find an expression for industry j's investment by substituting equation (2.66) for k_j in (2.64) and solving for y_j.

$$-\beta\left\{\left(1 - G_j\right)k_j(0) + G_j y_j - k_j(0)\right\} + r_j(0) - \omega = 0$$

which yields

$$y_j = k_j(0) + \frac{1}{\beta G_j}\left(r_j(0) - \omega\right) \ . \tag{2.67}$$

Aggregate real investment is then the summation of investment in all the industries.

$$i_R = \sum_{j=1}^{h} T_j y_j \ , \ j = 1, \ldots, h \tag{2.68}$$

where

T_j is the share of total investment accounted for by industry j.

The underlying ideas behind equation (2.67) are first, that investors are cautious so behave as if they expect that expansions in the capital stock in any industry will lower the rate of return on the industry's capital, and second, that investment plans are set (via the endogenously-determined value for ϖ) to equate expected rates of return across industries. This means that an industry with a high rental rate on capital relative to the rental rate on capital in the economy as a whole will attract high investment growth relative to investment growth in the economy as a whole. This theory may not be appropriate for some industries, particularly public sector industries. Investment in public sector industries is usually set exogenously.

In our model there is an alternative provision (as done in ORANI) for investment in those industries ($j \notin J$) for which the rate of return theory is considered inappropriate. The equation for this is

$$Y_j = (I_R)^{h_j^{(2)}} F_j^{(2)} \quad , \; j \notin J \tag{2.69}$$

where

$$I_R = I / \Xi^{(2)} \tag{2.70}$$

where

$\Xi^{(2)}$ is the capital goods price index;

I is the nominal level of private investment;

I_R is the real level of private investment; and

F_j^2 is a shift variable.

In percentage change form these two equations are, respectively:

$$y_j = h_j^{(2)} i_R + f_j^{(2)} \text{ , and} \tag{2.71}$$

$$i = i_R + \xi^{(2)} \ . \tag{2.72}$$

When h_j^2 is set equal to one and $f_j^{(2)}$ is set exogenously at zero, then equation (2.71) implies that investment in industry j moves by the same percentage as aggregate investment. Alternatively, non-zero shocks can be given to $f_j^{(2)}$ to introduce changes in the ratio of investment in industry j to aggregate investment. Equation (2.72) defines aggregate nominal investment.

2.2.9(b) Dynamics of Capital Stocks, Investment and Rates of Return

In the year-to-year simulations, it is assumed that capital growth rates and thus investment in industries are determined by investors willingness to supply increased funds to each industry in response to changes in the industry's expected rate of return to capital, represented by specified functions. The basic idea is that the capital stock of an industry at the end of a year $(t-1)$ becomes the starting capital stock for the following year (t). Investment in the year (t) depends on the rate of return to capital in an industry. The investment flow during the year (t) adds to the capital stock at the end of the year (t). After allowing for depreciation, capital stock at the end of year (t) becomes the starting capital stock for the next year $(t+1)$, and so on.

The idea postulated by equation (2.65) and its percentage change version, equation (2.66), is the starting point for our inter-temporal dynamic presentation. Capital accumulation throughout a forecast year is related to the investment flow during the year. Capital stock at the end of a year can be represented by

$$K_{j,t+1} = K_{j,t} * (1-\delta) + Y_{j,t} \tag{2.73}$$

where

$K_{j,t}$ corresponds to $K_j(0)$ (used earlier) and is the capital stock at the beginning of year t;

$K_{j,t+1}$ corresponds to $K_j(1)$ (used earlier) is the capital stock at the end of year t;

$Y_{j,t}$ is investment during year t; and

δ corresponds to d (used earlier) and is the depreciation rate parameter.

In percentage change form, equation (2.73) can be written as

$$K_{j,t+1} * k_{j,t+1} = K_{j,t} * k_{j,t} * (1-\delta) + Y_{j,t} * y_{j,t} \tag{2.74}$$

where

$k_{j,t+1}$, $k_{j,t}$, and $y_{j,t}$ are percentage deviations in the values of $K_{j,t+1}$, $K_{j,t}$ and $Y_{j,t}$ from their values in the initial solution for year t.

Following a modelling technique in MONASH we then introduce a coefficient called *TINY* on the left-hand-side to avoid indeterminacy problems that arise if capital stock at the beginning of year t+1 is zero. Equation (2.74) becomes

$$(K_{j,t+1} + TINY) * k_{j,t+1} = K_{j,t} * k_{j,t} * (1-\delta) + Y_{j,t} * y_{j,t} \tag{2.75}$$

where y_j is determined by equation (2.67).

Equation (2.75) is used in the PNG model to relate capital accumulation to investment in a forecast year.

2.2.9(c) *Linkage of Investment and Capital*

In the PNG CGE model (in tablo code), the start of year (t) industry capital $K_{t,j}$ $(KBASE_t)$ is set equal to the end-of-year $(t-1)$ industry capital, initial base $K_{j,t-1}$ $(KBASE_{t-1})$. The growth in the start-of-year (t) capital base is then linked to the growth (percentage change) in industry capital stock k_j, which is in the equation for investment, equation (2.67). Industry investment y_j in equation (2.67) then feeds into the capital accumulation equation (2.75).

The level of investment and the rate of growth in capital impact on the activity level, on employment and on output of industries in each year. These year-to-year simulations trace out the paths of variables for years t, $t+1$, $t+2$, etc, over a chosen period.

2.2.9(d) *Linking of End-of-Year Capital Stock to the Start-of-Year Capital Stock for the Following Year*

We need an equation to enable the capital stock at the end of a year $(t-1)$ to become the stock at the start of year (t). We follow the MONASH approach whereby the initial solution for an indı ıtry's capital stock for the start of year (t) is the opening capital stock in the previous year $(t-1)$. In the year (t), the accumulation of capital through investment will result in a percentage change k from the opening capital stock K. This can be represented as

$$k = 100*(KBASE_{t+1} - KBASE_t)/KBASE_t \qquad (2.76)$$

or equivalently by

$$k = 100*(IBASE_t - \delta * KBASE_t)/KBASE_t \qquad (2.77)$$

where

$KBASE_t$, $KBASE_{t+1}$ and $IBASE_t$ are the initial solutions for K_t, K_{t+1} and I_t.

If k is exogenous, the percentage deviation from the initial solution capital can be worked out outside the model using (2.76) or (2.77). However, we will follow the convention adopted by MONASH, which is to compute k inside the model. This can be done by considering the equation

$$K - KBASE = (IBASE - \delta * KBASE) * UNITY + F \qquad (2.78)$$

where

K, $UNITY$ and F are variables and $KBASE$, $IBASE$ and δ are parameters.

The initial solution in (2.78) can be satisfied with $UNITY$ and F being zero and K and $KBASE$ being equal. If we then keep F at zero and move $UNITY$ to one, the correct deviation $IBASE - \delta * KBASE$ in the opening capital stock for year t from its initial solution value can be obtained. Therefore, we solve equation (2.78) for a percentage change version, which entails the linkage shown in equations (2.76) and (2.77).

In percentage change terms, equation (2.78) is

$$K * k = 100 * (IBASE - \delta * KBASE) * del\_unity + 100 * del\_f \quad . \qquad (2.79)$$

Applying the notations used in our model, equation (2.79) becomes

$$(K_{t,j} + TINY) * k_{j,t} = 100 * \{I_j - DEP * K_j\} * del\_unity + 100 * d\_f\_k_j \ . \ (2.80)$$

Equation (2.80) enables the end-of-year capital stock in a year to be equal to the capital stock at the start of the next year adjusted for a deviation by the movement of *del_unity* between zero and one. The variable *del_unity* is an homotopy variable and it is the key enabling the linkage to work. Its role is to equate opening values of capital stock at the start of year t with the closing stock value at the end of year $t-1$ (see Dixon and Rimmer, 2002, pp. 22, 24, 43-49,68-70,244).

In sum, capital accumulation depends on investment during a year which yields an end-of-year capital stock through equation (2.75). Equation (2.80) (which takes on board the ideas in equations (2.76) and (2.77)) allows the end-of-year capital stock to be carried into the following year. This mechanism enables forecasts of capital stock and investment to be made in a dynamic manner.

2.2.10 Monetary Sector or Money Market Represented by a Money Demand Function

This is our own contribution to the model. Our interest in this part of the theoretical framework is on how to model the monetary sector's (central bank's) decisions on monetary policy and its influence in the economy. We use the concept of demand for money in an equation to represent of the monetary sector or the money market. In effect, we impose a small macro model in the PNG CGE model to cater for monetary phenomena. This enables us to introduce monetary policy shocks and to capture their effects. Together with the government budget equations presented earlier, this enables explanation of the endogenized investment. In so doing, we depart from ORANI's premise of exogenous aggregate investment under implicit macroeconomic policy changes in policy analysis.

It is not our intention to contribute to intellectual discussions about the theoretical framework of money demand, the appropriate functional form for the demand for money and the explanatory variables which should be included in the money demand function. These are outside the ambit of this thesis. For our purpose we take the practical line that changes in monetary policy, captured broadly by changes in interest rates and money supply in the money demand function, affect saving and investment decisions in an economy. Changes in interest rates in the PNG economy affect the level of borrowed investment funds and perhaps to a lesser extent saving decisions. One cannot disregard the common story that a small man in fishing or agriculture is refused bank lending because it is deemed that he would not be able to repay the loan, or the idea that the high interest rates of mid-1990s to 2000 were not conducive to investment.

The interest rate as a crucial variable in influencing investment growth and thus economic activity in the economy, and the importance of this monetary mechanism is the central theme for the inclusion of a money demand function in our model.

We follow the norm set by the pioneering work of Friedman (1970)[12] and Baumol-Tobin inventory theory in our selection of the explanatory variables to include in our money demand function. We include nominal income to capture the transaction and precautionary motives for holding money as postulated by the portfolio theory and the interest rate to capture the cost of holding money, consistent with the Baumol-Tobin inventory theory. The demand for money is a declining function of the opportunity cost of holding money, (the nominal interest rate) and an increasing function of nominal income. In the literature on demand for money, it is often argued that financial markets in developing economies are not fully developed

12 See Friedman, M.A. (1970), "A Theoretical Framework for Monetary Analysis", *Journal of Political Economy*, March, 193-238.

and key interest rates are not sufficiently market driven to be a good indicator of the opportunity cost of holding real balances. Therefore, inflation is usually used as a measure of the opportunity cost of holding money in a money demand equation[13]. We however exclude inflation so as not to complicate the pathway of the transmission process in the model and to give emphasis to the link between the interest rate, the required rate of return to capital and investment.

The inclusion of an interest rate in our money demand function is not intended to capture the influence of interest rate differentials in foreign exchange markets and on securities market: in PNG the domestic financial market is still in infancy and securities do not feature prominently as an alternative investment. In any case, we do not have foreign exchange and securities markets in the PNG model. In the model, the nominal exchange rate plays the conversion linkage of transactions between PNG and the rest of the world. The inclusion of the interest rate is intended to capture its influence on investment in domestic industries. Related to this, there are no rational expectation variables in our money demand function: studies such as Pesaran (1987) and Fair (1984) found the processes of expectation formation in developing countries to be quite different from those in developed countries. Expectations in developing countries are naïve (Kannapiran, 2001).

In levels form our money demand function for our purpose can be expressed as

$$M^d = \mathrm{A}Y^{B_1} * e^{-B_2 R} \tag{2.81}$$

13 For instance, Aghevli, B.B. and Khan, M.S., (1999) "Government deficits and Inflationary Process in Developing Countries", in *The Monetary Approach to Balance of Payments*, IMF, 1980, cited by Kannapiran C.A in his study on money demand for PNG.

where

M^d = nominal demand for money;

Y = nominal income or GDP;

R = the nominal interest rate; and

A , B_1 and B_2 are positive parameters.

Taking the log of variables on both sides, with the exception of for R which is already expressed in percentage terms, gives

$$\ln M^d = A + B_1 \ln Y - B_2 R \quad . \tag{2.82}$$

The percentage change form of this equation is

$$m^d = \beta_1 y - \beta_2 Rr \quad . \tag{2.83}$$

In the model, the path of the impact of interest rate on investment involves a simple mechanism. A change in the interest rate, being a change in the price or cost of borrowed investment funds, causes a change in the cost of capital for industries. The change in the cost of capital in turn has a bearing on the economy-wide rate of return to capital required to sustain the current level of (industry/economy) investment and therefore output or to achieve a certain level of investment and output. At a given output level, an increase in the interest rate would lead to an increase in the economy-wide required rate of return.

In modelling the path, the percentage change in the nominal interest rate, r, caused by a change in monetary policy, is linked to the economy-wide required (expected) rate of return to capital, ω (omega)[14], which appears in equation 2.67.

14 In the actual model, the tablo code used for the economy-wide required rate of return is *lambda*. We use *omega* here to illustrate that it is linked to the investment equation derived in equation (2.67) (i.e., for consistency).

$$omega = \alpha r \tag{2.84}$$

In the simplest form, the economy-wide rate of return to capital is set equal to the nominal interest rate. If the parameter $\alpha = 1$ then $omega = r$.

The economy-wide required rate of return then influences investment in equation (2.67). Subsequently, the percentage change in investment impacts on capital stock in equation (2.75). In this way, a change in monetary policy through a change in the interest rate impacts on investment via the influence of interest rate on the economy-wide required rate of return.

2.2.11 Aggregate Imports, Exports and the Balance of Trade

Aggregate demand for imported good i, $i = 1,\ldots\ldots, g$, is represented by

$$X_{i2}^{(0)} = \sum_{k=1}^{2}\sum_{j=1}^{h} X_{(i2)j}^{(k)} + X_{(i2)}^{(3)} + X_{(i2)}^{(5)} \quad , \quad i = 1,\ldots\ldots, g \quad . \tag{2.85}$$

Equation (2.85) can be expressed in percentage form as

$$x_{i2} = \sum_{j=1}^{h} B_{(i2)j}^{(1)} x_{(i2)j}^{(1)} + \sum_{j=1}^{h} B_{(i2)j}^{(2)} x_{(i2)j}^{(2)} + B_{(i2)}^{(3)} x_{(i2)}^{3} + B_{(i2)}^{5} x_{(i2)}^{5} \quad , \quad i = 1,\ldots\ldots, g \tag{2.86}$$

where

the $B's$ are the shares of imported good i absorbed by industries as intermediate inputs, as inputs to capital creation and for consumption by households.

The foreign-currency value of aggregate imports, M, can be defined as:

$$M = \sum_{i=1}^{g} P_{(i2)}^{m} X_{(i2)}^{(0)} \tag{2.87}$$

where

$P^{m}_{(i2)}$ is the foreign-currency price of imported good i.

In percentage form, equation (2.87) can be written as:

$$m = \sum_{i=1}^{g} \left(p^{(m)}_{(i2)} + x^{(0)}_{(i2)} \right) M_{(i2)} \quad , \tag{2.88}$$

where

$M_{(i2)}$ is the share of imported good i in the total foreign-currency cost of commodity imports.

Aggregate foreign-currency value of exports, E, is defined as

$$E = \sum_{i=1}^{g} \left(P^{e}_{(i1)} X^{(4)}_{i1} \right) \quad , \tag{2.89}$$

where

P^{e}_{i1} is the foreign currency price of export good i;

In percentage-change form equation (2.89) can be expressed as

$$e = \sum_{i=1}^{g} \left(p^{e}_{i1} + x^{4}_{i1} \right) E_{i1} \tag{2.90}$$

where

E_{i1} is export good $i's$ share in aggregate export value.

From the above the balance of trade can be defined as

$$BoT = E - M \quad . \tag{2.91}$$

In change form this gives

$$100 \Delta BoT = Ee - Mm \tag{2.92}$$

where

ΔBoT is the change in the trade balance expressed in Kina million (not as a percentage change). (The trade account can have zero balance and the sign of the balance can change. So to avoid problems these can cause in using a percentage change equation for the trade balance an equation for the Kina amount of change is used.)

2.2.12 *Linking the Exchange Rate to the Trade Account*

In a closure that includes the nominal exchange rate in the exogenous set (for example, in a policy closure depicting a fixed exchange rate regime), the feed-through effects of a change in economic policy such as an expansionary fiscal policy or an external shock that impinges on the nominal exchange rate and other variables such as inflation, are not fully transmitted. This is not appropriate when we are modelling a floating exchange rate regime. We therefore, have to establish a mechanism in our model to endogenize the nominal exchange rate. This will enable the nominal exchange rate to change in response to policy shocks and will enable the subsequent transmission of impacts to other variables.

Being open and small, the PNG economy is very vulnerable to external financial and economic as well as domestic macroeconomic changes. These changes easily affect the balance of payment flows. With the current floating exchange rate system, the flows in the external sector impact significantly on the nominal exchange rate. We therefore allow the nominal exchange rate to become endogenous by constructing an equation, in the model, linking the exchange rate to the trade account. The inclusion of the equation enables policy simulations to generate deviations in the nominal exchange rate from its basecase forecast path.

The structure of the equation linking the exchange rate and the trade account is based on the idea embedded in the employment-wage relationship in the MONASH model, which postulates that real wages are sticky in the short run and flexible in the long run. In policy simulations with MONASH it is usually assumed that "the deviation in the real wage from its basecase forecast level increases at a rate which is proportional to the deviation in aggregate hours of employment from its base forecast level" (Dixon *et al.* 2002, p. 205). Applying this principle in linking the nominal exchange rate to the trade account, we assume that the deviation in the nominal exchange rate from its basecase forecast is proportional to the difference between the ratio of trade balance to GDP in the policy simulation and the ratio of trade balance to GDP in the basecase forecast simulation. The speed of the change depends on the exchange rate sensitivity (proportionality) parameter.

Algebraically, the exchange rate-trade balance specification, in levels form, can be expressed as

$$\left[\frac{\Phi_P}{\Phi_F}-1\right]=\mathrm{A}\left[\left(\frac{BT}{GDP}\right)_P-\left(\frac{BT}{GDP}\right)_F\right]+F_{PHI} \quad . \tag{2.93}$$

In percentage change form, the equation becomes

$$\frac{\Phi_P}{\Phi_F}*\left(\phi_p-\phi_f\right)=100*\alpha\left[\Delta(BT/GDP)_p-\Delta(BT/GDP)_f\right]+f_{phi} \tag{2.94}$$

where

Φ_P = level of the nominal exchange rate after a policy change;

Φ_F = base forecast level of exchange rate;

ϕ_p and ϕ_f are percentage changes in the exchange rate policy-change and base forecast simulations respectively;

$\Delta(BT/GDP)_p$ and $\Delta(BT/GDP)_f$ are the changes in the trade balance to GDP ratio (change in BT/GDP) in the policy change and base forecast simulations respectively;

$$\Delta\left(BT/GDP\right)_p = \frac{\Delta BT}{GDP_{base\_year}} - 0.01(BTGDP * gdp)$$

where

GDP_{base_year} is the GDP level in the base year, and

$BTGDP$ is a coefficient representing the balance of trade to GDP ratio;

f_{phi} is a shifter variable; and

α = exchange rate sensitivity parameter.

In essence, equation (2.94) captures the following economic logic. If the trade balance to GDP (BT/GDP) ratio in the policy simulation is greater than that in the base forecast, then that represents an improvement in the trade account as a result of the introduction of a policy change. This should induce an appreciation of the exchange rate, depicted on the LHS of the equation. Conversely, a net decline in the RHS of the equation would lead to a depreciation of the exchange rate.

All the derivations covered in Sections 2.2.1 to 2.2.12 are programmed in the Tablo part of the GEMPACK computer programs. This is presented in Appendix C, in which all the variables, coefficients and equations are defined in Tablo language.

Chapter 3

Baseline Forecasts for the Papua New Guinea Economy: 1998 to 2006

3.1 Introduction

Our aim in this chapter is to find a reasonable set of forecasts for the Papua New Guinea economy for the nine years 1998 to 2006. Towards this aim, the chapter describes how we produce annual model-generated baseline forecasts and provides an analysis on the key impacts of each simulation that is undertaken. The model we use is a computable general equilibrium (CGE) model of the PNG economy (PNG model). The starting point from which the forecasts are generated is the Levantis-CIE database for 1997, adopted as the database for PNG-ORAMON.

The forecasting closure we use is developed from the basic closure for PNG-ORAMON by appropriate swaps. In the basic closure all variables not normally explained in CGE models are set exogenously. These include observable policy variables such as tax rates and unobservables such as technology and taste/preference variables. For the forecasting closure we exogenise variables whose value we know. We use the word "know" broadly, in that we include in this category not only published data (for the realized years of the period) but also variables for which forecasts are made by agencies such as the Treasury and the Central Bank (Bank of Papua New Guinea) and variables for which we consider that we can make reasonable "guesstimates' by extrapolation. The exogenous variables in the forecasting closure include the real demand-side components of gross domestic product, the inflation rate, and the foreign-currency prices of exports and imports.

There are few by-industry or by-commodity exogenous variables in our forecasting closure. Consequently, the technical change/taste variables to be endogenised through the swaps are broad variables such as the economy-wide factor-saving technical change, the preference between imported and domestic products, *a1primgen* and *twistimp*.

The nine-year forecast period (1998 to 2006 inclusive) can be sub-divided into three sub-periods. We are more confident about the forecasts for the first than the second sub-period and more confident about the second than the third. For each of the three sub-periods we have a different way of obtaining the exogenous shocks. For the first sub-period, the years 1998 and 1999, we use actual data published by the Papua New Guinea National Statistical Office (NSO) and the Bank of PNG. The second sub-period comprises the years 2000 and 2001 and for these years we have some actual data and for other variables we can make reasonable "guesstimates" by simple extrapolation from recent data. For the third sub-period, the five years 2002 to 2006 inclusive, we use forecasts provided by government and non-government agencies as well as simple extrapolators.

The rest of this chapter is organised as follows. Using a back-of-the-envelope version of the model, Section 3.2 describes the development for the forecasting closure from a starting closure. Section 3.2 also includes a list of the variables in the PNG model, indicating the swaps made in the exogenous variables in moving first from the starting to the basic closure and then to the forecasting closure. Section 3.3 presents our forecasting simulations and results. It constitutes the bulk of Chapter 3. We describe in detail two sets of simulations. In the first, simulations A, the nominal exchange rate is exogenous and in the second, simulations B, the nominal exchange rate is endogenous. In both sets of simulations we apply the shocks sequentially and describe and interpret the results at each step. The sequential application and interpretation of the results in the simulations constituted a learning exercise and adjustments/rectifications were made to the PNG model in light of what had been learnt from the set A simulations. The exogeneity or endogeneity of the nominal exchange rate and the adjustments/rectifications to the model underlie the differences between the results of forecasting simulations in sets A and B. In the event, we prefer our second simulation (B) which is the one generated by the adjusted/improved model. Section 3.4 sets out the industry results for the final forecasting simulation of set B simulations (B11). Concluding remarks for the chapter are contained in Section 3.5.

The chapter has two appendices. The first discusses problems we perceived in the industry results in the set A simulations. The second appendix contains tables of results for simulations that are less important in our analysis of results but are still referred to in the text. In this way, we do not have too many tables in the way of the discussion.

3.2 Development of the Forecasting Closure

We will use a stylized or back-of-the-envelope version of PNG-ORAMON to develop and explain the derivation of the forecasting closure.

3.2.1 Back-of-the-Envelope Model

In the back-of-the-envelope (BOTE) model we assume that (i) the economy has two factors of production, capital and labour, and (ii) the costs per unit of employing capital and labour equal the values to the employer of the marginal products of capital and labour. We specify fourteen equations representing total output, labour and capital demands, export and import demands, investment creation and the money market. These are:

GDP identity:

$$Y = C + I + G + (X - M) \tag{3.1}$$

Production function:

$$Y = \frac{1}{A} F(K, L) \tag{3.2}$$

Foreign demand for PNG exports:

$$P_e = G(X, F_4) \tag{3.3}$$

Domestic price is related to export price:

$$P_d = \left[\frac{P_e}{\theta}\right] V \tag{3.4}$$

Rate of return on capital equals rental price divided by asset price or real rental price divided by real asset price:

$$ROR = \left(\frac{Q}{P_d}\right)\left(\frac{P_d}{\Pi}\right) \tag{3.5}$$

Asset price depends on prices of domestic and imported inputs to capital creation:

$$\Pi = \Pi\left(P_d, {}^{P_m}\!\!/_{\theta}\right) \tag{3.6}$$

Real wage rate equals marginal product of labour. Marginal product of labour depends on technology, the K/L ratio and the twist in K/L choice:

$$\left(\frac{W}{P_d}\right)=\frac{1}{A}\ F_l\left(\frac{K}{L},TWISTLK\right) \tag{3.7}$$

Real rental rate equals marginal product of capital. Marginal product of capital depends on technology, the K/L ratio and the twist in K/L choice:

$$\left(\frac{Q}{P_d}\right)=\frac{1}{A}F_k\left(\frac{K}{L},TWISTLK\right) \tag{3.8}$$

Public consumption depends on GDP:

$$G=APCG*Y \tag{3.9}$$

Private consumption depends on GDP:

$$C=APC*Y \tag{3.10}$$

Investment depends on the rate of return to capital (ROR) compared with the interest rate (R). Investment can also move independently of ROR and R via the shift variable (F_I):

$$I=I(ROR,R,F_I) \tag{3.11}$$

Imports are a function of GDP, relative prices of domestically-produced and imported goods and the twist variable for the import/domestic mix:

$$M=M\left(\frac{P_d}{P_m/\theta},TWISTIMP,Y\right) \tag{3.12}$$

The real wage rate is the ratio of the nominal wage rate to the domestic price:

$$W_R=\frac{W}{P_d} \tag{3.13}$$

Demand for money depends on GDP and the rate of interest:

$$M^d = M^d(P_d * Y, R) \tag{3.14}$$

In these equations:

Y	is real gross domestic product (GDP);
C, I, G, X, M	are aggregate real private consumption, aggregate real investment, aggregate real government consumption, aggregate real exports and aggregate real imports respectively;
K and L	are the capital stock and labour;
P_d and P_e	are the domestic price of the country's output and the foreign-currency export price;
P_m	is the foreign-currency import price;
APC	is the private, broad average marginal propensity to consume;
$APCG$	is the government average marginal propensity to consume;
ROR	is the rate of return to capital;
Q and Π	are the rental on capital and the asset price of capital respectively;
W	is the nominal wage rate;
W_R	is the real wage rate;
$\frac{Q}{P_d}$	is the real rental rate on capital;
θ	is the nominal exchange rate expressed as $ foreign per Kina;
A	is a technology coefficient allowing for Hicks-neutral technical change;
TWISTLK	is a twist variable that either favours or disadvantages labour relative to capital. If *TWISTLK* increases by one per cent, then there will be a one per cent increase in K/L at any given wage-rental ratio with no change in overall costs;
TWISTIMP	is a twist variable for imports. If *TWISTIMP* increases by one per cent, then industries, households and investors will increase their use of imported goods relative to their use of domestic goods by

	one per cent, with no change in overall costs;
F_4 and F_I	are export and investment shifters respectively;
V	is the power (one plus the rate) of the export subsidy;
M^d	is money demand (which equals money supply); and
R	is the nominal interest rate.

A starting closure for the fourteen-equation model is set out below:

Exogenous	*Endogenous*
A	Y
F_4	C
θ	F_I
V	G
P_m	X
APC	M
APCG	W_R
I	P_e
K	P_d
L	*ROR*
TWISTLK	Q
TWISTIMP	Π
R	W
	M^d

The model has fourteen equations and so fourteen variables can be determined endogenously. We show the derivation of the fourteen endogenous values by explaining the starting solution.

- With K and L exogenous, equation (3.2) can solve for the real gross domestic product Y.
- Given the solution for Y from equation (3.2), equation (3.9) can solve for G and equation (3.10) can solve for C.
- Given solutions for Y, C and G, and with I exogenous, equation (3.1) generates $(X - M)$.

- Now from (3.3), (3.4) and (3.12) we can solve for P_d, P_c, X and M. This can be done by guessing P_d, computing P_c from (3.4), computing X from (3.3) and M from (3.12), and checking to see if we get the right answer for $(X-M)$. If we do not, we vary our guess for P_d until we do get the right answer for $(X-M)$.
- Equation (3.7) solves for the real wage, $\frac{W}{P_d}$.
- Equation (3.8) solves for the real rental on capital $\frac{Q}{P_d}$.
- Equation (3.6) solves for Π
- Equation (3.5) solves for ROR.
- Equation (3.11) can solve for F_I.
- Equation (3.13) solves for W_R (which is same as the solution for equation (3.7)).
- With P_d implied above (see earlier discussion about guessing values for P_d until the guess is consistent with (X-M)) equation (3.13) or (3.7) can solve for W and equation (3.8) can solve for Q.
- Equation (3.14) solves for M^d.

Note that in this starting closure, F_I and W_R are endogenous. In a basic closure, a closure in which all variables not normally explained in CGE models are set exogenously, F_I and W_R should be exogenous. We therefore make two swaps to obtain the basic closure from the starting closure. The first is to exogenize F_I and endogenize I. The second is to exogenize W_r and endogenize L.

3.2.2 The Forecasting Closure

We develop a closure for forecasting from the basic closure by some appropriate swaps. In the context of the *BOTE* model, the swaps are shown in Table 3.1 below. In terms of the actual model, Table 3.2 shows the starting, basic and forecasting closures and the swaps involved.

The first five swaps connecting the basic and forecasting closures in Tables 3.1 and 3.2 configure the model to accept shocks for the components of real gross domestic product from the demand side, namely, real aggregate consumption, investment, government spending, exports and imports.

In the context of the *BOTE* model, we can endogenize APC by exogenizing C, endogenize $APCG$ by exogenizing G, endogenize *TWISTIMP* by exogenizing M and endogenize F_I by exogenizing I (rows 1, 3, 5 and 2 in Table 3.1).

Correspondingly, in the actual model, the scalar shifter variables *fc*, and *f5* (representing the private, broad average marginal propensity to consume and the government's average marginal propensity to consume, respectively), are endogenized to allow for the exogenization of aggregate real consumption *cr* and other aggregate demand (government) *chie*. For exogenizing aggregate real investment, *ir* , we endogenize the position of the demand curve for investment with the scalar shifter, *f2*, in the investment functions. The import-domestic goods-mix variable, *TWISTIMP*, is endogenized to allow the exogenization of aggregate real imports.

With C, I, G, M exogenized in BOTE, equation (3.1) can determine X through $X = Y - (C + I + G - M)$ or $X = \frac{1}{A}F(K,L) - (C + I + G - M)$. The swap in row 12 of Table 3.1 enables us to accept shocks for labour. Given that K and L are now both exogenous, this implies a certain level of technology for Y to be realised. Technology-related variables are thus endogenous in a forecasting closure. If the state

Table 3.1: Exogenous Variables in the Starting, Basic and Forecasting Closures of the BOTE Model

	Starting Closure		Basic Closure		Forecasting Closure
1	APC		APC	swap	C
2	I	swap	F_I	swap	I
3	$APCG$		$APCG$	swap	G
4	A		A	swap	X
5	$TWISTIMP$		$TWISTIMP$	swap	M
6	F_4		F_4	swap	P_d
7	θ		θ		θ
8	V		V	swap	P_e
9	P_m		P_m		P_m
10	K		K		K
11	L	swap	W_R		W_R
12	$TWISTLK$		$TWISTLK$	swap	L
13	R		R		R

of technology coefficient A is to be endogenized, in the BOTE model we exogenize aggregate exports. In the actual model, we endogenize the technology coefficient *a1primgen* by exogenizing *efcreal* (aggregate real exports).

Our next task is to make it possible for the model to accept forecasts for the domestic price level. In terms of the BOTE model we must exogenize P_d. In deciding what must be endogenized we noted that exports are related to domestic prices and the exchange rate via equations (3.4) and (3.3), which imply that

$$\left(\frac{P_d.\theta}{V}\right)=G(X,F_4) \qquad (3.15)$$

With the exogenization of X and the exogeneity of V and θ, exogenization of P_d requires that F_4 is free to move. Thus, the scalar export shifter F_4 in the export function (equation (3.3)) is swapped with the domestic price level, P_d. In the actual

Table 3.2: Exogenous Variables in the Starting, Basic and Forecasting Closures in the Actual PNG-ORAMON Model and the Swaps Involved

Starting Closure		Basic Closure		Forecasting Closure
fc *(consumption shifter)*		fc *(consumption shifter)*	*swap*	cr *(agg real hh conptn)*
ir *(agg real inv)*	*swap*	f2 *(scalar inv shifter)*	*swap*	ir *(agg real inv)*
f5 *(scalar shifter for other Dd)*		f5 *(scalar shifter for other Dd)*	*swap*	chic *(agg real other demand)*
a1primgen *(primary factor saving tech change)*		a1primgen *(primary factor saving tech change)*	*swap*	efcreal *(agg real exports)*
twistimp *(tech coeff for m-d mix)*		twistimp *(tech coeff for m-d mix)*	*swap*	mfcreal *(agg real imports)*
f4 *(scalar exports shifter)*		f4 *(scalar exports shifter)*	*swap*	epsilon3 *(consumer price index)*
vi 4-14 16 *(export subsidy)*		vi 4-14 16 *(export subsidy)*	*swap*	pei1 4-14 16 *(fob export price)*
f4i1 *(ind exports shifter)*		f4i1 *(ind exports shifter)*	*swap*	x4obs *(observation of forecast of exports)*
f_obs *(shifter for forecast of exports)*		f_obs *(shifter for forecast of exports)*	*swap*	f4 *(scalar exports shifter)*
aggl *(aggregate employment)*	*swap*	realwage *(real wage)*		realwage *(real wage)*
twistlk *(labour twist variable)*		twistlk *(labour twist variable)*	*swap*	aggl *(aggregate employment)*
foj *(ind oth cost shifter)*		foj *(ind oth cost shifter)*		foj *(ind oth cost shifter)*
f2j *(ind inv shifter)*		f2j *(ind inv shifter)*		f2j *(ind inv shifter)*
f5is *(other dd shifter)*		f5is *(other dd shifter)*		f5is *(other dd shifter)*
f1q *(occup wage shifter)*		f1q *(occup wage shifter)*		f1q *(occ wage shifter)*
rn *(nominal interest rate)*		rn *(nominal interest rate)*		rn *(nominal interest rate)*
q1 *(# of households)*		q1 *(# of households)*		q1 *(# of households)*
pmi2 *(cif fc import price)*		pmi2 *(cif fc import price)*		pmi2 *(cif fc import price)*
ti *(1+ad valorem tariff)*		ti *(1+ad valorem tariff)*		ti *(1+ad valorem tariff)*
phi *(exchange rate)*		phi *(exchange rate)*		phi (nominal *exchange rate)*
nj *(land & mine rebates)*		nj *(land & mine rebates)*		nj *(land & mine rebates)*
tci *(excise tax rate)*		tci *(excise tax rate)*		tci *(excise tax rate)*
refg *(foreign grants)*		refg *(foreign grants)*		refg *(foreign grants)*
go *(other gov't expd)*		go *(other gov't expd)*		go *(other gov't expd)*
x4i1 1-3 15 17-37 *(export Dd)*		x4i1 1-3 15 17-37 *(export Dd)*		x4i1 1-3 15 17-37 *(export Dd)*
a3 *(h/hold basic taste change)*		a3 *(h/hold basic taste change)*		a3 *(h/hold basic taste change)*
rk *(absolute rate of return)*		rk *(absolute rate of return)*		rk *(absolute rate of return)*
f_phi *(shifter for future exchange rate equation)*		f_phi *(shifter for future exchange rate equation)*		f_phi *(shifter for future exchange rate equation)*
del_unity *(homotopy variable for k formation)*		del_unity *(homotopy variable for k formation)*		del_unity *(homotopy variable for k formation)*
d_f_kj *(shifter for opening k stock in k fortn eqtn)*		d_f_kj *(shifter for opening k stock in k fortn eqtn)*		d_f_kj *(shifter for opening k stock in k fortn eqtn)*
del_ff_btgdp *(shifter for del_btgdp eqtn)*		del_ff_btgdp *(shifter for del_btgdp eqtn)*		del_ff_btgdp *(shifter for del_btgdp eqtn)*
ff_kj *(adjustment shifter for start-of-yr k stock)*		ff_kj *(adjustment shifter for start-of-yr k stock)*		ff_kj *(adjustment shifter for start-of-yr k stock)*

model, the corresponding swap is the endogenization of $f4$ and the exogenization of $epsilon3$.

The next swap in Table 3.1 concerns the foreign-currency export price, P_e. Referring to equation (3.4), we see that $\left(\frac{P_d.\theta}{V}\right) = P_e$. With P_d and θ exogenous, in the BOTE model the exogenization of P_e requires the endogenization of V. The corresponding swap in the actual model is the exogenization of most export prices ($pei1$) and the endogenization of the corresponding export subsidies (vi).

The remaining extraneous forecasts are for import prices (which are already exogenous) and for individual export volumes. Export volumes for individual commodities are not variables in the BOTE model but they are explicitly defined in the actual model. To introduce extraneous forecasts for individual export volumes, we use shocks to the variable $x4obs$. Thus, we must exogenize $x4obs$. As can be seen from Table 3.2 we do this by endogenizing the shifters for foreign demands for various exports, $f4i1$. With *f_obs* exogenous, actual exports ($x4i1$) are tied down by the shocks to $x4obs$. But the sum of actual exports determined in this way may contradict the exogenous setting for aggregate exports, *efcreal*. To avoid this problem, we endogenize *f_obs* and exogenize the scalar shifter ($f4$) in the export demand equations. In effect we believe our forecasts for aggregate exports but we believe only the structure for individual exports.

In the BOTE model, the swap in row 12 of Table 3.1 allows for extraneous forecasts of aggregate employment. With the real wage rate already exogenous, the exogenization of aggregate employment requires an adjustment in the demand for labour so that equation (3.7) holds. The adjustment required can be taken care of by the variable *TWISTLK* in equation (3.7). If the extraneous forecast of aggregate employment is not what the exogenous real wage rate can generate (given the labour demand function), the labour twist variable *TWISTLK* can be allowed to adjust to reconcile labour with the wage rate. In other words, the exogenization of aggregate employment, L, can be facilitated by the endogenization of the variable *TWISTLK*. Correspondingly, in the actual model, aggregate employment, $aggl$, is exogenized through the endogenization of the labour twist variable, $twistlk$.

Finally, for the BOTE model there is no swap in row 13 of Table 3.1, the row which concerns the exogeneity/endogeneity settings for the monetary sector. The interest rate is exogenous in both the basic and forecasting closures. In the actual model, our choice of the exogeneity/endogeneity settings of the money demand (money supply), M^d, and the interest rate, R, (*mn* and *rn* respectively) in the forecasting closure reflects the availability in PNG of monetary instruments and the conduct of monetary policy via open market operations. For the forecasting closure, we have chosen the interest rate to remain exogenous because to some extent the central bank can affect the direction and magnitude of changes in the interest rate by its decisions on the Kina auction facility and by Treasury Bill auctions.

3.3 Forecasting Simulations and the Results

Having established the forecasting closure, we run forecasting simulations[15] using PNG-ORAMON, the actual model, in search for a reasonable model-generated forecasts for the PNG economy. Appropriate exogenous variables are shocked one at a time, additively, and a simulation is run after each additional shock. In this way we can identify the impact of each additional shock on the endogenous outcome. This enables us to attribute particular results to particular shocks and allows us to analyse better the results when all the shocks are introduced simultaneously.

Our discussion will focus initially on the macro results. Once a reasonable and plausible set of macro results is found, the industry results underlying that macro picture will be discussed.

3.3.1 Set A Simulations: Exogenous Nominal Exchange Rate

The forecasting closure we developed and described in section 3.2 is used for Set A simulations.

In set A simulations, the nominal exchange rate is exogenous. For presentational convenience, in our discussion of the forecast results we concentrate on one year, 1998. In general, the discussion holds for other years also, and where it does not we note reasons for differences.

Simulation A1: Price Homogeneity Shock (Exchange Rate under Endogenous Inflation)

In order to ensure that the model works, we begin with a simulation that tests for price homogeneity. In such a simulation the inflation rate (consumer price index) is endogenous, and aggregate real exports *efcreal* is exogenized via the endogenization of the shifter *f_obs*. Note that the swap between primary-factor saving technical change, *a1primgen,* and aggregate real exports, *efcreal,* is conditional on the exogenization of the consumer price index via the endogenization of the scaler export shifter, *f4*. The *nominal exchange rate* is shocked by the forecast percentage changes in the exchange rate in each year of the forecast period.

15 We use the Euler method of solution with an 8-step iteration.

As expected, all the price variables increased (decreased) by exactly the same rate as the devaluation (appreciation) of the exchange rate. There was no change in any of the real variables apart from the trade account (*deltabn*), the current account (*deltac*), the change in total subsidy (*d_totsub*) and the net government budget position (*deltagb*). These four variables are not expressed in percentage changes and have non-zero Kina figures.

The trade account, which in PNG is typically in surplus, moves further into surplus in the years whe. there is exchange rate depreciation and moves towards deficit in 2006 when there is a forecast appreciation in the exchange rate.

Simulation A2: Nominal Exchange Rate Shock (with Exogenous Inflation)

In the years since the floating of the Kina in 1994, the local currency has depreciated against the major currencies, including the US dollar and the Australian dollar. There is no reason at this stage to believe that the Kina will appreciate against the major currencies in the foreseeable future. Therefore, devaluation in the exchange rate is forecast for all the years, with the exception of 2006.[16] In years when the exchange rate is depreciating, devaluation should encourage growth in exports as they become cheaper for foreign buyers. Diagrammatically, depreciation would move the supply curve of output outwards (to the right).

However, in the simulation, y is tied down by the demand/expenditure side components of GDP, which are all exogenous and not yet shocked. Capital and labour are tied down as well. Exports, both in aggregate and by commodity are exogenous and are not shocked and therefore the export supply curve does not move out.

Moreover, given that the consumer price index is exogenous and not shocked, domestic Kina prices do not respond relative to world prices. Hence, there has to be some compensatory effect to explain why the difference between world prices and domestic prices does not lead to a change in exports. This compensatory role is played by the *artificial* or *phantom* export subsidy. A devaluation causes a surplus and an appreciation causes a deficit in the trade and current accounts. In 1998 there is a decline in the export subsidy for all commodities and this offsets any favourable impact the devaluations might have had. The same story goes for 1999 to 2005. The magnitude of the decline is more pronounced in the first two years compared with 2000 to 2005 because the rate of depreciation is greater in those years. Table 3.3 shows the changes in the powers of export subsidy for the 37 commodities in the model.

Who pays the tax or, to put it another way, who is made worse off by the (negative) subsidy? It is not labour because, as we can see in Table 3.4, column 1, there is no change in the price of labour *(ppvj, "labour")*. The tax (or reduced subsidy) is borne by profit to capital through a reduction in the rental price of capital *(ppvj, "capital")*, which makes capital cheap. (Table 3.4 shows the percentage changes in the prices of labour, capital and land for 1998 caused by the exchange rate appreciation in 1998.) With an increase in the wage rate relative to the rental price of capital, a technological twist in favour of labour is required to maintain the given level of employment. The labour twist variable, *twistlk*, increases by 39.28 per cent in 1998. (See Table 3.5, row 26).

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16 In our forecasts we include one year of appreciation of the Kina for two reasons. First, the Kina does occasionally appreciate, and it can not go on depreciating forever. Second, we wanted to study the behaviour of our model in the context of an appreciation as well as a devaluation.

Table 3.3: Percentage Changes in Powers of Export Subsidies when the Nominal Exchange Rate is Shocked (by a depreciation of 22.12 percent) in Simulation A2

		1998	1999	2000	2001	2002	2003	2004	2005	2006
	Commodity					*(percentage change)*				
1	Fruit_Vegs	-21.20	-19.82	-0.88	-1.06	-1.09	-1.13	-1.21	-1.35	1.37
2	NonRLivestk	-22.47	-21.30	-0.94	-1.12	-1.14	-1.16	-1.20	-1.30	1.32
3	Coffee	-21.11	-19.00	-0.78	-0.93	-0.95	-0.98	-1.03	-1.10	1.12
4	Cocoa	-21.65	-19.76	-0.82	-0.97	-0.98	-0.98	-1.00	-1.04	1.04
5	PalmOil	-17.35	-13.83	-0.49	-0.57	-0.57	-0.56	-0.56	-0.54	0.54
6	Copra	-17.44	-13.87	-0.49	-0.58	-0.57	-0.57	-0.57	-0.60	0.60
7	OthTCrops	-19.49	-16.87	-0.65	-0.77	-0.77	-0.77	-0.78	-0.78	0.78
8	OthAgric	-29.17	-29.53	-1.43	-1.68	-1.63	-1.58	-1.56	-1.65	1.68
9	Fishing	-25.57	-24.13	-1.00	-1.16	-1.15	-1.12	-1.09	-1.03	1.02
10	Forestry	-26.45	-25.47	-1.11	-1.31	-1.32	-1.33	-1.34	-1.34	1.34
11	Copper	-33.99	-35.14	-0.64	-0.54	-0.60	-1.03	-1.26	-1.31	1.31
12	Gold	-34.68	-49.82	-6.77	-13.72	-19.07	-20.55	-17.92	-12.36	12.84
13	OthMinerals	-34.58	-44.59	6.14	45.28	18.25	9.99	4.32	2.19	-1.95
14	CrudeOil	-35.66	-55.89	-4.82	-5.83	-5.98	-6.08	-6.10	-6.01	6.28
15	Quarrying	-29.18	-30.03	-1.41	-1.65	-1.65	-1.63	-1.61	-1.56	1.56
16	TimbProcess	-25.11	-23.59	-1.00	-1.17	-1.17	-1.18	-1.18	-1.19	1.20
17	FoodProcess	-32.66	-27.98	-0.93	-1.07	-1.03	-1.00	-0.96	-0.91	0.91
18	Bever_Tobaco	-29.47	-30.46	-1.41	-1.64	-1.62	-1.59	-1.54	-1.44	1.43
19	Metals_Engin	-26.08	-18.84	-0.59	-0.69	-0.68	-0.67	-0.67	-0.66	0.66
20	Machinery	-38.98	-41.09	-1.93	-2.27	-2.28	-2.26	-2.20	-2.16	2.18
21	Chemical_Oil	-34.59	-29.88	-0.94	-1.07	-1.05	-1.02	-0.99	-0.92	0.91
22	Petroleum_Re	-20.53	-17.78	-0.70	-0.86	-0.94	-1.06	-1.21	-1.43	1.47
23	OthManufact	-32.82	-24.72	-0.73	-0.84	-0.82	-0.80	-0.78	-0.74	0.73
24	RoadTrans	-34.19	-36.39	-1.81	-2.12	-2.13	-2.14	-2.14	-2.09	2.10
25	WaterTrans	-27.20	-24.71	-0.98	-1.14	-1.12	-1.11	-1.08	-1.04	1.03
26	AirTrans	-28.56	-25.93	-0.99	-1.15	-1.13	-1.11	-1.07	-1.02	1.01
27	Education	-29.64	-30.07	-1.41	-1.66	-1.65	-1.62	-1.59	-1.52	1.52
28	Health	-24.84	-23.43	-1.00	-1.17	-1.16	-1.15	-1.13	-1.10	1.09
29	Elect_Garbge	-32.26	-38.81	-2.37	-2.83	-2.87	-2.88	-2.85	-2.74	2.77
30	Build_Cons	-20.47	-21.68	-1.15	-1.39	-1.43	-1.48	-1.56	-1.69	1.72
31	Commerce	-32.54	-34.16	-1.68	-1.98	-1.99	-2.00	-2.01	-1.98	1.99
32	Finance_Inv	-36.14	-44.78	-2.97	-3.58	-3.67	-3.75	-3.79	-3.72	3.80
33	GovtAdm	-30.40	-32.02	-1.61	-1.90	-1.90	-1.90	-1.88	-1.85	1.85
34	OthServ	-34.23	-35.98	-1.78	-2.10	-2.11	-2.11	-2.09	-2.01	2.02
35	Security	-24.38	-23.35	-1.03	-1.21	-1.21	-1.22	-1.22	-1.22	1.22
36	InforRetail	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	1.00
37	LNGPlant	-40.05	-47.40	-2.90	-3.45	-3.46	-3.44	-3.36	-3.18	3.21

Table 3.4: Percentage Changes in the 1998 Prices of Labour (wage), Capital (rental) & Land (rental) when the Nominal Exchange Rate is Depreciated by 22.12% in 1998 (Simulation A2)

	Industry	labour	capital	land
			(percentage change)	
1	TradAgric	0.00	-49.84	2.03
2	SmallHCoffee	0.00	-50.80	0.24
3	SmallHCocoa	0.00	-50.45	0.90
4	SmallHPoil	0.00	-50.29	1.18
5	SmallHCopra	0.00	-49.90	1.90
6	SmallOther	0.00	-48.43	4.63
7	PlantCoffee	0.00	-46.87	0.81
8	PlantCocoa	0.00	-45.62	3.26
9	PlantPOil	0.00	-49.63	-3.96
10	PlantCopra	0.00	-70.09	-40.24
11	PlantOther	0.00	-51.17	-8.17
12	PlantFruit_V	0.00	-31.16	24.16
13	OthAgric	0.00	-63.22	-23.04
14	Fishing	0.00	-49.54	-23.57
15	Forestry	0.00	-48.92	-8.51
16	PorgeraMine	0.00	-36.60	-25.08
17	OkTediMine	0.00	-47.83	-36.21
18	OtherMine	0.00	-41.61	-25.26
19	Oil	0.00	-36.53	-27.95
20	Quarrying	0.00	-48.13	-21.63
21	TimbProcess	0.00	-50.47	-5.04
22	FoodProcess	0.00	-61.82	-40.55
23	Bever_Tobaco	0.00	-46.86	-19.91
24	Metals_Engin	0.00	-72.88	-54.93
25	Machinery	0.00	-52.65	-48.25
26	Chemical_Oil	0.00	-59.84	-45.81
27	Petroleum_Re	0.00	-48.78	3.97
28	OthManufact	0.00	-70.58	-49.33
29	RoadTrans	0.00	-49.35	-23.31
30	WaterTrans	0.00	-54.63	-30.56
31	AirTrans	0.00	-55.06	-31.15
32	Education	0.00	-49.22	-12.60
33	Health	0.00	-50.99	-7.62
34	Elect_Garbge	0.00	-41.66	-12.83
35	Build_Cons	0.00	-35.85	-5.00
36	Commerce	0.00	-49.05	-22.89
37	Finance_Inv	0.00	-43.76	-15.69
38	GovtAdm	0.00	-48.73	-17.51
39	OthServ	0.00	-52.60	-27.76
40	Security	0.00	-49.76	-1.58
41	InforRetail	0.00	-49.87	1.96
42	LNGPlant	0.00	-49.04	-22.88

Table 3.5: Selected Macro Results when the Nominal Exchange Rate is Shocked in Simulation A2

	Variable *Model Name*	*Economic Name*	1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
1	alprimgen	Tech Coefficient	0.97	1.54	0.07	0.07	0.03	-0.03	-0.10	-0.21	0.22
2	aggl	Agg Employment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	cr	Agg Real Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	d_avesub	Change in Ave Subsidy	-0.35	-0.37	-0.02	-0.02	-0.03	-0.02	-0.02	-0.02	0.02
5	d_totsub	Change in Total Subsidy*	-1238	-1645	-84	-117	-131	-126	-110	-93	90
6	deltab	Change in Real Trade Balance*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	deltabn	Change in Nom Trade Balance*	139.06	127.15	4.82	5.67	5.67	5.67	5.67	5.67	-5.63
8	deltac	Change in Current A/C Balance*	141.49	129.89	4.96	5.84	5.84	5.84	5.84	5.84	-5.80
9	efcreal	Agg Real Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Epsilon1	GDP Deflator	-0.63	-1.76	-0.14	-0.17	-0.19	-0.20	-0.23	-0.26	0.27
11	Epsilon2	K Goods Price Index	4.70	-0.46	-0.36	-0.48	-0.56	-0.67	-0.84	-1.11	1.15
12	Epsilon3	Consumer Price Index	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	f2	Investment Shifter	71.32	286.18	0.15	1.56	3.25	4.88	7.29	11.03	-10.38
14	gdp	Nominal GDP	-0.63	-1.76	-0.14	-0.17	-0.19	-0.20	-0.23	-0.26	0.27
15	gdpr	Real GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	in	Agg Nominal Investment	4.70	-0.46	-0.36	-0.48	-0.56	-0.67	-0.84	-1.11	1.15
17	ir	Agg Real Investment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	lw	Wage-Weighted Emp	2.06	2.95	0.16	0.19	0.17	0.16	0.17	0.23	-0.24
19	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	mn	Money Demand	-0.63	-1.76	-0.14	-0.17	-0.19	-0.20	-0.23	-0.26	0.27
21	phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	1.00
22	realwage	Real Wage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	-1.00
24	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	twistimp	Import Twist	134.86	154.31	4.56	5.42	5.12	4.80	4.62	4.96	-4.77
26	twistlk	Labour Twist	39.28	595.57	-15.84	-13.69	-10.58	-8.51	-6.97	-5.68	5.76
27	xi4	Export Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99
28	xig	Other Dd Price Index	-8.73	-11.37	-0.57	-0.67	-0.67	-0.66	-0.64	-0.60	0.60
29	xim	Import Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99

* in Kina Million

With both aggregate capital, K, and aggregate employment, L, fixed, we at first would not expect any change in the technology-augmenting factor A in the production function $Y = \frac{1}{A}F(K,L)$, given that in this simulation Y is also fixed. But in this simulation the technology coefficient, *a1primgen*, has changed. For 1998, the technology coefficient increases[17] by 0.97 per cent (first row of Table 3.5). This in turn implies that either capital or labour in the production function must have increased because otherwise we cannot explain the decline in technology. On closer examination of our results we find that while aggregate person-weighted employment, *aggl*, is exogenous and not yet shocked (Table 3.5, line 2), there is an increase of 2.06 per cent in wage-weighted employment, *lw* (Table 3.5, line 18). A change in wage-weighted employment can occur with a constant number of persons employed if there is a change in the composition of employment either away from or towards occupations or industries with high wage rates.[18] With an increase in wage-weighted employment of 2.06 per cent, technology had to deteriorate by 0.97 per cent to ensure that total output remains constant.

There are two contributing reasons for the 2.06 per cent increase in aggregate wage-weighted employment. The first is that the composition of employees between industries has changed. Employees in low-wage-paying industries moved to high-wage-paying industries, so that there are more employees on high wage rates and less on low wage rates even though total person-weighted employment, *aggl*, remains constant. The second reason is that labour in the *traditional agriculture* industry as well as in the five *smallholding* agricultural export industries is made up of

17 Because we have written the technology coefficient as *1/A*, a percentage increase in *a1primgen* means deterioration and a percentage decline means an improvement in technology.

subsistence farmers who are relatively immobile between industries. In this simulation, demand for labour by these industries increased by around 1.0 per cent. Although labour in these industries is not employed and paid in the formal sense, labour demand for these industries is included in the definition of wage-weighted employment. Thus, the increase in labour demand in these industries contributed to the increase in *lw*.

The industry *other manufacturing,* which is a low-wage, import-competing industry, was very adversely effected by the devaluation in 1998. The domestic-imported weighted-price of *other manufacturing* goods increased by 18.8 per cent despite a 13.0 per cent fall in the price of domestic goods. This was because import prices (which have a high weight) increased by 27.43 per cent (Table 3.5, line 29), over the amount of the devaluation. This rise in import prices led to a 10.6 per cent fall in household demand for the import-domestic composite of these goods. All other things equal, there would be a substitution by households away from more expensive imports and towards cheaper domestic goods. However, in our simulation results there is a big twist in favour of imports (indicated by a large increase in *twistimp*, 134.86 per cent, Table 3.5, line 25) so that aggregate real imports can remain constant. Given the twist in favour of imports, household demand for domestically-produced other manufacturing goods declined by 19.6 per cent. In view of this, demand for labour by the industry in 1998 fell by 20.4 per cent and activity and output levels declined by 15.5 per cent.

As explained earlier, the *phantom* tax is paid out of the profit to capital and consequently, the rental price of capital and rate of return to capital declined,

18 For example, assume a total of 10 persons employed. If 5 persons earn $10.00 each and 5 earn $20.00 each, this gives a total of 150 wage units. If 4 persons earn $10.00 each while 6 earn $20.00 each, this gives a

particularly in the first two years, 1998 and 1999. Rates of change in industry investment in the two years are volatile. There are some big increases despite significant declines in the rate of return to capital in the agriculture industries in 1998 while there are large declines in investment in response to falls in the rate of return to capital in manufacturing industries in 1999. The big changes in the rate of return on capital and in investment flowing from the exchange rate shock appear implausible in the light of the dynamics in our model of investment and capital creation. Intuitively, it does not make sense to have large exchange rate changes without there being changes in the domestic price level.

Consider now the impact of an appreciation of one per cent in the exchange rate in 2006. We would expect exports to decline but they do not because they are exogenous and they are not shocked. Consistent with this, export subsidies increase, so compensating for the fixed domestic price levels and notionally offsetting any damping effect on exports that the appreciation of the exchange rate might have had.

Given that the results of this simulation (A2) produced implausible results for capital and investment, and because we would expect price changes to flow from changes in the exchange rate, in our next simulation (A3) we introduce a price shock.

Simulation A3: Inflation Shock

Inflation, as measured by the consumer price index, is now shocked. For the years 1998 to 2001 the actual realized CPI inflation rates are used while for 2002 to 2006 inflation is shocked at the underlying annual rate of 9.0 per cent. PNG has a floating exchange rate regime but, as already noted, in our set A simulations, exchange rate is exogenous.

different total, namely 160 wage units.

The change in inflation causes domestic prices to increase relative to world prices. In 1998 the exogenous price shock is an increase of 13.6 per cent. This is not so large as to eliminate the gain in competitiveness experienced by trading industries from the exchange rate depreciation of 22.12 per cent (Table 3.8, line 21). Consequently, "phantom" subsidies still have a compensatory role to play, but not as large a role as in the last simulation. In this simulation, export subsidies in 1998 increase relative to the subsidies in the last simulation. Table 3.6 sets out the results for the changes in the powers of the export subsidy for the 37 industries in our model.

Compare Tables 3.6 and Table 3.3, which show percentage changes in the powers of export subsidies by industry for this and the previous simulation. Recall that exports are not shocked in either simulations A2 or A3 and that aggregate real exports, *efcreal*, are the same. We see that in simulation A3 capital still pays for the export tax (negative subsidy) in 1998, but the subsidy plays a smaller role than in the previous simulation. Table 3.7 shows that in simulation A3 the rental price of capital declines by less than it did in simulation A2 (see Table 3.4).

Because aggregate real investment, *ir*, is exogenous and not yet shocked, aggregate capital stock, *ksnew*, which is endogenously dependant on *ir*, does not change. L is fixed in $Y=\frac{1}{A}F(K,L)$. With Y fixed as well, A has to remain unchanged for the production function to hold. However, by comparing the results in Tables 3.8 and 3.5, we see that the technology coefficient, *a1primgen*, has deteriorated in 1998 by less than in the previous simulation (0.42 per cent now compared to 0.97 per cent earlier). This is so because wage-weighted employment now has gone up by 0.91 per cent compared to the 2.06 per cent in the previous simulation. The increase in the wage-weighted employment in this simulation

Table 3.6: Percentage Change in the Powers of Export Subsidies when CPI is Shocked Additively (Simulation A3)

		1998	1999	2000	2001	2002	2003	2004	2005	2006
	Commodity					*(percentage change)*				
1	Fruit_Vegs	-10.69	-7.82	13.91	7.83	7.56	7.58	7.6	7.62	9.72
2	NonRLivestk	-11.33	-8.34	14.93	8.33	8.01	8.01	8	8	10.17
3	Coffee	-10.68	-7.76	13.82	7.84	7.6	7.63	7.66	7.69	9.82
4	Cocoa	-10.95	-7.99	14.25	8.04	7.77	7.79	7.81	7.82	9.97
5	PalmOil	-8.88	-6.19	10.86	6.48	6.44	6.62	6.77	6.92	8.98
6	Copra	-8.95	-6.23	10.92	6.5	6.47	6.64	6.79	6.92	8.96
7	OthTCrops	-9.89	-7.09	12.53	7.23	7.07	7.16	7.23	7.3	9.36
8	OthAgric	-14.82	-11.19	20.7	11.17	10.59	10.45	10.33	10.22	12.88
9	Fishing	-12.93	-9.65	17.53	9.61	9.14	9.02	8.92	8.82	11.1
10	Forestry	-13.39	-10.02	18.29	9.98	9.48	9.35	9.24	9.13	11.48
11	Copper	-16.73	-13.72	25.93	12.58	11.24	10.54	9.97	9.5	11.57
12	Gold	-16.97	-14.08	26.71	12.76	11.35	10.61	10.02	9.54	11.6
13	OthMinerals	-16.95	-14.03	26.59	12.75	11.34	10.61	10.02	9.55	11.62
14	CrudeOil	-16.72	-14.92	28.31	12.31	10.47	9.47	8.74	8.2	9.86
15	Quarrying	-14.65	-11.3	20.88	10.98	10.22	9.91	9.63	9.39	11.68
16	TimbProcess	-12.72	-9.44	17.11	9.45	9.02	8.94	8.86	8.79	11.09
17	FoodProcess	-16.93	-12.67	23.88	12.97	12.24	11.98	11.71	11.44	14.23
18	Bever_Tobaco	-14.79	-11.43	21.14	11.09	10.32	10.01	9.74	9.5	11.83
19	Metals_Engin	-13.8	-9.6	17.51	10.37	10.22	10.34	10.37	10.35	13.11
20	Machinery	-20.13	-15.72	30.71	15.75	14.63	14.2	13.82	13.49	16.85
21	Chemical_Oil	-17.93	-13.57	25.85	13.84	13.02	12.73	12.45	12.19	15.25
22	Petroleum_Re	-10.42	-7.51	13.34	7.64	7.43	7.48	7.52	7.55	9.65
23	OthManufact	-17.43	-12.55	23.7	13.46	13.02	13	12.92	12.8	16.17
24	RoadTrans	-17.35	-13.54	25.71	13.26	12.27	11.84	11.47	11.14	13.81
25	WaterTrans	-13.89	-10.3	18.86	10.41	9.92	9.8	9.68	9.55	12
26	AirTrans	-14.63	-10.88	20.06	11.02	10.49	10.35	10.22	10.08	12.67
27	Education	-14.98	-11.45	21.23	11.28	10.57	10.31	10.07	9.86	12.31
28	Health	-12.57	-9.33	16.89	9.33	8.91	8.83	8.76	8.69	10.98
29	Elect_Garbge	-16.01	-12.8	23.99	12.05	11.02	10.55	10.17	9.86	12.2
30	Build_Cons	-10.16	-7.59	13.45	7.4	7.05	6.99	6.93	6.89	8.71
31	Commerce	-16.48	-12.78	24.04	12.52	11.63	11.25	10.92	10.62	13.17
32	Finance_Inv	-18.02	-14.63	28.04	13.75	12.43	11.79	11.27	10.83	13.29
33	GovtAdm	-15.32	-11.82	21.99	11.54	10.75	10.43	10.15	9.91	12.32
34	OthServ	-17.4	-13.55	25.73	13.31	12.32	11.89	11.5	11.15	13.78
35	Security	-12.31	-9.14	16.51	9.12	8.71	8.64	8.58	8.52	10.77
36	InforRetail	-11.17	-8.19	14.63	8.22	7.92	7.92	7.92	7.92	10.08
37	LNGPlant	-20.23	-16.51	32.4	15.71	14.12	13.3	12.61	12.03	14.67

Table 3.7: Percentage Change in the 1998 Prices of Labour (wage), Capital (rental) & Land (rental) when CPI is Shocked Additively in Simulation A3

		labour	capital	land
	Industry		*(percentage change)*	
1	TradAgric	13.60	-11.54	14.67
2	SmallHCoffee	13.60	-12.27	13.75
3	SmallHCocoa	13.60	-11.99	14.10
4	SmallHPoil	13.60	-11.94	14.17
5	SmallHCopra	13.60	-11.66	14.51
6	SmallOther	13.60	-10.51	15.96
7	PlantCoffee	13.60	-9.30	14.19
8	PlantCocoa	13.60	-8.43	15.40
9	PlantPOil	13.60	-11.47	11.57
10	PlantCopra	13.60	-26.83	-7.38
11	PlantOther	13.60	-12.57	9.42
12	PlantFruit_V	13.60	0.40	24.56
13	OthAgric	13.60	-22.04	1.50
14	Fishing	13.60	-11.15	1.98
15	Forestry	13.60	-10.94	9.32
16	PorgeraMine	13.60	-3.27	2.06
17	OkTediMine	13.60	-8.98	-3.12
18	OtherMine	13.60	-5.73	2.09
19	Oil	13.60	-1.77	2.26
20	Quarrying	13.60	-10.20	3.04
21	TimbProcess	13.60	-11.96	11.15
22	FoodProcess	13.60	-19.88	-7.72
23	Bever_Tobaco	13.60	-9.18	4.16
24	Metals_Engin	13.60	-29.75	-17.80
25	Machinery	13.60	-13.97	-11.70
26	Chemical_Oil	13.60	-18.36	-10.56
27	Petroleum_Re	13.60	-10.90	15.47
28	OthManufact	13.60	-27.54	-13.84
29	RoadTrans	13.60	-11.28	1.84
30	WaterTrans	13.60	-14.93	-2.21
31	AirTrans	13.60	-15.05	-2.35
32	Education	13.60	-11.14	7.28
33	Health	13.60	-12.35	9.81
34	Elect_Garbge	13.60	-6.06	7.63
35	Build_Cons	13.60	-2.31	11.79
36	Commerce	13.60	-11.04	2.11
37	Finance_Inv	13.60	-7.49	6.04
38	GovtAdm	13.60	-10.76	4.88
39	OthServ	13.60	-13.61	-0.74
40	Security	13.60	-11.56	12.76
41	InforRetail	13.60	-11.65	14.53
42	LNGPlant	13.60	-10.97	2.18

Table 3.8: Selected Macro Results when the CPI is Shocked Additively in Simulation A3

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
	Model Name	*Economic Name*									
1	a1primgen	Tech Coefficient	0.42	0.36	-0.57	-0.27	-0.23	-0.21	-0.19	-0.18	-0.20
2	aggl	Agg Employment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	cr	Agg Real Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	d_avesub	Change in Ave Subsidy	-0.17	-0.15	0.17	0.10	0.11	0.11	0.12	0.13	0.16
5	d_totsub	Change in Total Subsidy*	-604.13	-673.93	875.28	537.22	550.17	585.76	625.95	671.06	842.16
6	deltab	Change in Real Trade Balance*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	deltabn	Change in Nom Trade Balance*	139.06	127.15	4.82	5.67	5.67	5.67	5.67	5.67	-5.63
8	deltac	Change in Current A/C Balance*	141.49	129.89	4.96	5.84	5.84	5.84	5.84	5.84	-5.80
9	efcreal	Agg Real Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Epsilon1	GDP Deflator	13.34	14.61	16.05	9.45	9.10	9.06	9.02	8.99	8.96
11	Epsilon2	K Goods Price Index	16.32	16.60	12.82	7.52	7.18	7.10	7.05	7.01	6.47
12	Epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
13	f2	Investment Shifter	26.10	22.66	-28.57	-14.35	-12.38	-11.19	-10.21	-9.38	-10.74
14	gdp	Nominal GDP	13.34	14.61	16.05	9.45	9.10	9.06	9.02	8.99	8.96
15	gdpr	Real GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	in	Agg Nominal Investment	16.32	16.60	12.82	7.52	7.18	7.10	7.05	7.01	6.47
17	ir	Agg Real Investment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	lw	Wage-Weighted Emp	0.91	0.74	-1.18	-0.60	-0.53	-0.50	-0.47	-0.44	-0.53
19	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	mn	Money Demand	13.34	14.61	16.05	9.45	9.10	9.06	9.02	8.99	8.96
21	phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	1.00
22	realwage	Real Wage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	-1.00
24	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	twistimp	Import Twist	50.16	36.55	-41.12	-24.70	-23.25	-22.68	-22.17	-21.72	-26.14
26	twistlk	Labour Twist	13.72	13.96	-18.89	-7.88	-6.21	-5.20	-4.42	-3.81	-4.10
27	xi4	Export Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99
28	xig	Other Dd Price Index	9.22	11.20	21.76	12.15	11.45	11.20	10.98	10.78	11.00
29	xim	Import Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99

* In Kina million

impacted on L by less than it did in the previous simulation, and so the deterioration in technology required to maintain constant total output is now less than in the previous simulation. With lesser deterioration in technology now, there is a smaller twist in support of labour in 1998. This is indicated by the 13.7 per cent change in *twistlk* now compared with the 39.3 per cent change in the previous simulation.

As in the previous simulation, in this simulation capital is cheap relative to labour in the first two years. The effect is more pronounced in the current simulation because the nominal labour wage increases by the rate of inflation.

Consider now the impact of cheap labour (relative to simulation A2) on the demand for labour. With the exogenous rise in domestic prices (consumer price index) in this simulation, the weighted-price of *other manufacturing's* domestic and imported goods increased by 22.7 per cent compared to the 18.8 per cent increase in the previous simulation. The fact that the increase is higher now than previously is because domestic prices now rise whereas previously they did not. This induces a fall of 5.0 per cent in household demand for the domestic-import composite of this good, compared to the 10.6 per cent decline in the previous simulation. In the current simulation household demand is relatively strong because the price of *other manufacturing* rises by 9.1 per cent relative to the price increase for domestically produced goods (22.7 - 13.6 = 9.1) whereas in the previous simulation the price of *other manufacturing* rises by 18.8 per cent relative to the increase in the price of domestically-produced goods (18.8 - 0 = 18.8). Underlying the 5.0 per cent fall in household demand for the composite good is a decline of 7.9 per cent and 4.2 per cent in households' demand for the industry's domestic goods and imported goods respectively, compared to the 19.6 per cent and 8.6 per cent declines in the previous simulation. The lesser decline in the households' demand for the industry's domestic goods is the result of a relatively less favourable twist in favour of imports (50.16 per cent in the current simulation compared to 134.86 per cent in the previous simulation) (Tables 3.8 and 3.5, line 25). Consequently, demand for labour by the industry in 1998 fell by 8.83 per cent and activity and the output level fell by 6.2 per cent relative to the 20.37 per cent and 15.5 per cent falls respectively in the previous simulation.

For the years 2000 to 2005, the rental price of capital increases relative to labour and this favours labour-intensive industries and strengthens their demand for labour.

Relative to the previous simulation, in the current simulation the change in domestic price levels resulted in smaller declines in subsidies [taking the change average subsidy (*d_avesub*) as the appropriate indicator here, we see -0.17 per cent in 1998 for simulation *A3* compared to –0.35 in 1998 for simulation *A2*, Tables 3.8 and 3.5 respectively, line 4]. Hence capital's rate of return, *rj*, and rental price, *(ppvj, "capital")* settle to more reasonable percentage changes relative to the previous simulation, declining in the first two years and increasing in the remaining years. Investment growth in the present simulation also followed a relatively less volatile pattern than previously. However, because aggregate real investment is exogenous in the closure and not shocked yet, investment in some industries is required to decline despite the increase in the rate of return to capital. The declines are required to offset increases in the other industries.

Simulation A4: Real Wage Shock

In the PNG economy the real wage rate has declined over the last few years under the floating exchange rate regime. As a "best possible scenario", we forecast that the real wage rate will decline by about one per cent each year over the next five years.

The cut in the real wage rate should entice industries to hire more labour. In this simulation aggregate person-weighted employment, *aggl*, is tied down (exogenous and not shocked yet) and so does not respond to the cut in the real wage rate. Instead, there is a twist against labour and the labour twist variable, *twistlk*, declines by 8.1 per cent, Table 3.9. In the absence of the twist, *aggl* could not have been held constant because the cut in real wage would have stimulated employment.) While *aggl* is constant, wage-weighted employment, *lw*, increases by 1.96 percent.

To explain the 1.96 per cent increase in wage-weighted employment, *lw*, even though aggregate employment, *aggl*, is constant we look at data for individual industries on their composition of the primary factors and their structure of production. We also need to keep in mind the definitions of *aggl* and *lw*.

First, we note that smallholding agricultural export industries such as *smallhcopra* (there are five such industries) and *traditional agriculture* and *informal retail industries* do not have capital as a primary factor. Given this, the twist against labour does not reduce the labour force for these seven industries because they can not resort to maintaining output by employing more capital and reducing labour. On the other hand, the largeholding agricultural export industries such as *plantation copra* and the other non-agricultural industries do have capital and so the twist against labour can affect them. The demand for labour by these industries falls in 1998. In this simulation the demand for labour in the *plantation copra* industry falls by 30.26 per cent whereas in the *smallholding copra* industry it increases by 5.2 per cent (Table 3.11). The changes in the prices of primary factors are shown in Table 3.10.

Table 3.9: Selected Macro Results when Real Wage is Shocked Additively in Simulation A4

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
	Model Name	*Economic Name*				*Percentage Change (unless where indicated)*					
1	a1primgen	Tech Coefficient	0.80	0.67	-0.45	-0.21	-0.18	-0.16	-0.15	-0.13	-0.16
2	aggl	Agg Employment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	cr	Agg Real Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	d_avesub	Change in Ave Subsidy	-0.05	0.00	0.18	0.11	0.11	0.12	0.12	0.13	0.16
5	d_totsub	Change in Total Subsidy*	-175	-19	919	573	581	613	653	699	833
6	deltab	Change in Real Trade Balance*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	deltabn	Change in Nom Trade Balance*	139.06	127.15	4.82	5.67	5.67	5.67	5.67	5.67	-5.63
8	deltac	Change in Current A/C Balance*	141.49	129.89	4.96	5.84	5.84	5.84	5.84	5.84	-5.80
9	efcreal	Agg Real Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Epsilon1	GDP Deflator	14.19	15.41	15.89	9.40	9.06	9.02	8.99	8.96	8.91
11	Epsilon2	K Goods Price Index	19.30	19.37	11.91	7.15	6.85	6.79	6.75	6.72	6.08
12	Epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
13	f2	Investment Shifter	0.11	-0.83	-23.06	-12.43	-11.02	-10.18	-9.46	-8.85	-10.13
14	gdp	Nominal GDP	14.19	15.41	15.89	9.40	9.06	9.02	8.99	8.96	8.91
15	gdpr	Real GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	in	Agg Nominal Investment	19.30	19.37	11.91	7.15	6.85	6.79	6.75	6.72	6.08
17	ir	Agg Real Investment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	lw	Wage-Weighted Emp	1.96	1.85	-1.31	-0.64	-0.58	-0.54	-0.51	-0.48	-0.59
19	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	mn	Money Demand	14.19	15.41	15.89	9.40	9.06	9.02	8.99	8.96	8.91
21	phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	1.00
22	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
23	refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	-1.00
24	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	twistimp	Import Twist	36.20	25.89	-40.47	-24.63	-23.25	-22.71	-22.22	-21.77	-26.11
26	twistlk	Labour Twist	-8.11	-7.28	-13.27	-6.49	-5.44	-4.78	-4.25	-3.82	-4.07
27	xi4	Export Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99
28	xig	Other Dd Price Index	10.97	12.88	21.76	12.19	11.50	11.24	11.02	10.83	11.02
29	xim	Import Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99

* In Kina million

Table 3.10: Percentage Changes in the 1998 Prices for the Primary Factors for Selected Industries: Results from Simulations A2, A3 and A4

	Sim A2 shock: exchange rate			*Sim A3 shock: exchange rate & cpi*			*Sim A4 shock: exchange rate, cpi & real wage*		
	labour	capital	land	labour	capital	land	labour	capital	land
Industry									
SmallHcopra	0.00	-49.90	1.90	13.60	-11.66	14.51	-0.74	29.40	9.79
PlantCoffee	0.00	-46.87	0.81	13.6	-9.3	14.19	-0.74	-6.89	-19.83
PlantCopra	0.00	-70.09	-40.24	13.6	-26.83	-7.38	-0.74	-43.20	-51.50
Forestry	0.00	-48.92	-8.51	13.6	-10.94	9.32	-0.74	21.11	6.89
PorgeraMine	0.00	-36.60	-25.08	13.6	-3.27	2.06	-0.74	33.02	29.22
OkTediMine	0.00	-47.83	-36.21	13.6	-8.98	-3.12	-0.74	36.44	32.00
Machinery	0.00	-52.65	-48.25	13.6	-13.97	-11.7	-0.74	-0.97	-2.37
OthManufact	0.00	-70.58	-49.33	13.6	-27.54	-13.84	-0.74	6.42	-3.68
Education	0.00	-49.22	-12.60	13.6	-11.14	7.28	-0.74	20.49	7.61
Health	0.00	-50.99	-7.62	13.6	-12.35	9.81	-0.74	19.77	4.17
Elect_Garbge	0.00	-41.66	-12.83	13.6	-6.06	7.63	-0.74	23.77	14.37

Table 3.11: Percentage Changes in the 1998 Demand for Primary Factors for Selected Industries: Results from Simulations A2, A3 and A4

	Sim A2 shock: exchange rate			*Sim A3 shock: exchange rate & cpi*			*Sim A4 shock: exchange rate, cpi & real wage*		
	labour	capital	land	labour	capital	land	labour	capital	land
Industry									
SmallHcopra	0.95	0.00	0.00	0.41	0.00	0.00	5.20	0.00	0.00
PlantCoffee	3.70	0.00	0.00	1.72	0.00	0.00	-11.01	0.00	0.00
PlantCopra	-19.79	0.00	0.00	-8.40	0.00	0.00	-30.26	0.00	0.00
Forestry	1.84	0.00	0.00	0.81	0.00	0.00	1.67	0.00	0.00
PorgeraMine	12.46	0.00	0.00	5.00	0.00	0.00	6.67	0.00	0.00
OkTediMine	2.89	0.00	0.00	1.90	0.00	0.00	8.07	0.00	0.00
Machinery	-1.62	0.00	0.00	-0.89	0.00	0.00	-8.20	0.00	0.00
OthManufact	-20.37	0.00	0.00	-8.83	0.00	0.00	-4.79	0.00	0.00
Education	1.58	0.00	0.00	0.70	0.00	0.00	1.41	0.00	0.00
Health	-0.06	0.00	0.00	0.02	0.00	0.00	1.10	0.00	0.00
Elect_Garbge	8.24	0.00	0.00	3.49	0.00	0.00	2.80	0.00	0.00

Second, the seven subsistence-based industries have zero weight in the measure of person-weighted aggregate employment, *aggl*,[19] because in the data base there are no persons of either unskilled or skilled labour in these industries. Intuitively, the labour who are the subsistence farmers/villagers in these industries are not part of formal employment and so are not included in the formal definition of persons employed. Consequently any change in the demand for person-labour in these industries does not affect *aggl*. On the other hand the labour wage (V1LAB) for unskilled labour and the demand for person-labour by skill type, *xpi1qj*, in the seven industries are included in the definition of wage-weighted employment *lw*.[20] Therefore growth in the demand for labour such as the 5.2 per cent increase for the *smallhcopra* industry contributes to changes in *lw*.

The reduction in the real wage rate favours industries with no capital base. These industries cannot hire more capital and so the reduction in the real wage rates induces them to demand more labour. The growth in demand for labour, *xpi1qj*, by these subsistence-based industries together with the movement of labour to high-wage-paying industries explains the 1.96 per cent increase in wage-weighted employment.

With the increase in *lw*, labour, the L in $Y=\frac{1}{A}F(K,L)$ can increase. K, capital stock, remains unchanged as aggregate real investment is tied down. Aggregate output is tied down by the exogenous demand-side components of GDP. If aggregate capital and output are constant, then the increase in L requires that there is deterioration in technology. We see in this simulation that *a1primgen* deteriorates by

19 $aggl = sum(q, ocp, PHI1(q) * lq(q))$.

0.80 per cent in 1998 (Table 3.9, line 1) compared to the 0.42 per cent deterioration in the previous simulation (Table 3.8, line 1). Intuitively, because the increase in *lw* in this simulation, 1.96 per cent, is greater than the 0.91 per cent increase in the previous simulation, it requires a greater deterioration in technology for *Y* to remain constant.

At the industrial level, the constancy of aggregate output is satisfied by increases in output in the smallholding export industries and high-wage-paying industries, such as *beverages and tobacco*, which offset falls in low-wage-paying industries such as *other manufacturing*.

Changes in export subsidies now settle to quite reasonable levels, with reductions in taxes in the first two years 1998 and 1999, (see Table 3.9 line five, compare these with the corresponding figures of Tables 3.5 and 3.8). No longer do capital owners have to pay large taxes out of profits from rentals. Consequently, the rate of return to capital, *rj*, behaves reasonably as well, even increasing for some industries. As a result, investment by industry now behaves more normally, increasing for industries with a positive percentage change in *rj* and declining for industries with a fall in *rj*.

Simulation A5: Aggregate Employment Shock

In simulation A5 we add a shock to aggregate employment. Aggregate employment declined by 2.3 per cent in 1998, increased by 2.55 per cent in 1999 and is forecast to increase in the range of 1 to 2 per cent in each year for the remainder of the forecast period.

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20 $lw = [(1/WAGEBILL) * sum(j, ind, sum(q, ocp, V1LAB(j,q) * (xp1qj(q,j))))]$.

The most noticeable impact of the addition of the aggregate employment shock is on wage-weighted-employment, *lw*, the state of technology, *a1primgen*, and the labour twist variable, *twistlk*. The exogenous economy-wide decline of 2.3 per cent in aggregate person-weighted employment in 1998 is associated with a decline in wage-weighted-employment of 0.29 per cent only in 1998 (see Table 3.12, row 18). The fall in *lw* of 0.29 per cent is small relative to the 2.3 per cent decline in *aggl* and this is so because the smallholding export industries continue to have a positive change in their demand for labour (for example, for smallcopra, an increase of 3.9 per cent). Recall that labour in the five small holding agricultural export and traditional agricultural industries is included in the definition of wage-weighted employment, *lw*, but not in aggregate employment, *aggl*, because labour in these industries is not employed and paid in the formal sense and is not included in the official employment statistics. The continued increase in demand for labour by these smallholding industries partially offsets the decline in other industries (such as the –6.7 per cent change in *other manufacturing*).

For aggregate person-weighted employment to decline by 2.3 per cent in 1998, there has to be a twist against labour. In this simulation there is an -10.88 per cent change in *twistlk* in 1998 (Table 3.12, row 26) compared to the corresponding decline of 8.11 per cent in the previous simulation (Table 3.9, row 26). With real GDP and the demand-side components of GDP fixed, we find that the combination of less labour and the same level of capital in 1998 implies an improvement in technology. This is shown by the –0.17 per cent change in *a1primgen* relative to the 0.80 per cent in the previous simulation. (Compare row 1 in Table 3.12 with row 1 in Table 3.9).

Table 3.12: Selected Macro Results when Aggregate Employment is Shocked Additively in Simulation A5

	Variable Model Name	Economic Name	1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
1	alprimgen	Tech Coefficient	-0.17	1.66	-0.10	0.11	0.12	0.40	0.12	0.12	0.09
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	d_avesub	Change in Ave Subsidy	-0.12	0.07	0.25	0.21	0.24	0.48	0.42	0.52	0.64
5	d_totsub	Change in Total Subsidy*	-415.75	301.29	1254.67	1063.64	1258.53	2531.95	2202.85	2778.53	3429.93
6	deltab	Change in Real Trade Balance*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	deltabn	Change in Nom Trade Balance*	139.06	127.15	4.82	5.67	5.67	5.67	5.67	5.67	-5.63
8	deltac	Change in Current A/C Balance*	141.49	129.89	4.96	5.84	5.84	5.84	5.84	5.84	-5.45
9	efcreal	Agg Real Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	epsilon1	GDP Deflator	14.40	15.21	15.82	9.33	8.98	8.87	8.91	8.88	8.82
11	epsilon2	K Goods Price Index	19.66	19.09	11.87	7.13	6.84	6.78	6.78	6.76	6.12
12	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
13	f2	Investment Shifter	0.30	-1.14	-23.34	-12.77	-11.36	-11.07	-9.83	-9.22	-10.42
14	gdp	Nominal GDP	14.40	15.21	15.82	9.33	8.98	8.87	8.91	8.88	8.82
15	gdpr	Real GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	in	Agg Nominal Investment	19.66	19.09	11.87	7.13	6.84	6.78	6.78	6.76	6.12
17	ir	Agg Real Investment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	lw	Wage-Weighted Emp	-0.29	4.41	-0.32	0.38	0.46	1.58	0.56	0.60	0.50
19	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	mn	Money Demand	14.40	15.21	15.82	9.33	8.98	8.87	8.91	8.88	8.82
21	phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	1.00
22	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
23	refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	1.00
24	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	twistimp	Import Twist	35.11	26.98	-40.30	-24.46	-23.12	-22.43	-22.14	-21.72	-26.10
26	twistlk	Labour Twist	-10.88	-4.09	-12.25	-5.42	-4.37	-2.69	-3.23	-2.80	-3.04
27	xi4	Export Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99
28	xig	Other Dd Price Index	11.76	12.07	21.42	11.86	11.15	10.59	10.66	10.46	10.63
29	xim	Import Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99

* In Kina million

In 2001 to 2006, the forecast increase of one or two per cent in aggregate employment, *aggl*, results in increases in wage-weighted employment of between 0.38 and 1.58 per cent (Table 3.12, row 18). Consequently, deterioration in the technology coefficient is required, as shown by the percentage change in *a1primgen* in the range of 0.09 to 0.40 per cent, to maintain the no-change in real GDP. Intuitively, more of a primary factor producing the same level of output implies deterioration in technology. Consistent with the increases in labour employment, there is a relative twist in support of labour in these years, compared with the immediate past simulation as shown by the resulting percentage changes in *twistlk* (compare row 26 of Table 3.12 with the row 26 of Table 3.9.)

Simulation A6: Aggregate Real Consumption Shock

We now add a shock for aggregate real consumption, *cr*. In 1998 aggregate real consumption declined by 5.20 per cent. For the realized years of 1998 to 1999 actual observed percentage changes in *cr* are used for the shock. For the years 2000 to 2006 (no actual data were reported for 2000 to 2001 at the time of writing) the average 9.3 per cent rise in *cr* for the period 1994 to 1999 is used as the shock.

In 1998 *cr* decreases by 5.20 per cent while the other demand components [*i*+*g*+(*x*-*m*)] remain constant. Consequently real GDP declines by 3.2 per cent, given that consumption comprises about 60 per cent of total GDP[21]. In this simulation, in 1998 wage-weighted employment, *lw*, increased by 0.54 per cent compared to the decline of 0.29 per cent in the previous simulation (see Table 3.13, row 18 and Table 3.12, row 18). The increase in wage-weighted employment in the current simulation is due to growth in demand for labour by the smallholding export industries and by

21 Note that 5.2 * 0.6 = 3.12.

Table 3.13: Selected Macro Results when Aggregate Real Consumption is Shocked Additively in Simulation A6

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
	Model Name	*Economic Name*	*Percentage Change (unless where indicated)*								
1	a1primgen	Tech Coefficient	2.68	-10.12	-6.75	-6.51	-6.64	-6.29	-5.83	-5.81	-5.76
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
4	d_avesub	Change in Ave Subsidy	0.38	-0.83	0.05	0.03	0.03	0.04	0.05	0.05	0.08
5	d_totsub	Change in Total Subsidy*	1388	-3520	267	142	175	204	248	292	435
6	deltab	Change in Real Trade Balance*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	deltabn	Change in Nominal Trade Balance*	139.06	127.15	4.82	5.67	5.67	5.67	5.67	5.67	-5.63
8	deltac	Change in Current Account*	141.49	129.89	4.96	5.84	5.84	5.84	5.84	5.84	-5.80
9	efcreal	Agg Real Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	epsilon1	GDP Deflator	15.99	10.37	13.84	8.06	8.05	8.22	8.30	8.42	8.43
11	epsilon2	K Goods Price Index	22.91	9.13	8.05	4.48	5.00	5.35	5.23	5.42	4.89
12	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
13	f2	Investment Shifter	-9.38	28.73	-25.71	-17.29	-16.79	-14.94	-11.53	-10.79	-12.68
14	gdp	Nominal GDP	12.36	24.37	20.78	14.98	15.23	15.64	15.94	16.26	16.46
15	gdpr	Real GDP	-3.19	12.85	6.20	6.47	6.71	6.92	7.12	7.31	7.48
16	in	Agg Nominal Investment	22.91	9.13	8.05	4.48	5.00	5.35	5.23	5.42	4.89
17	ir	Agg Real Investment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	lw	Wage-Weighted Emp	0.54	2.21	-0.95	-0.44	-0.54	0.37	1.59	1.86	2.21
19	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	mn	Money Demand	12.36	24.37	20.78	14.98	15.23	15.64	15.94	16.26	16.46
21	phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	1.00
22	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
23	refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	-1.00
24	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	twistimp	Import Twist	61.41	-36.67	-54.73	-41.63	-39.60	-33.81	-20.47	-17.85	-20.52
26	twistlk	Labour Twist	-16.75	20.48	-3.83	2.13	2.22	3.15	2.89	2.71	2.35
27	xi4	Export Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99
28	xig	Other Dd Price Index	16.76	-3.25	13.22	6.17	6.41	6.76	6.98	7.28	7.42
29	xim	Import Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99

* In Kina million

some mining industries which more than offset declines in industries such as the plantation exporting industries.

We expected that the contraction in aggregate real consumption would come from contractions in output and in consumption of goods, especially goods such as fruits and vegetables that are consumed locally. However, we find that the expenditure elasticity of fruits and vegetables is close to zero so that this item of consumption does not respond to the reduction in aggregate real consumption. Further, since fruits and vegetables make up a large portion of the production of smallholding agricultural export industries such as *smallhcopra*, there is little contraction in the demand for the products of these industries. Hence the outputs of these industries are not reduced. Given that there is no capital in these industries, the deterioration in technology requires an increase in their demand for labour in order to sustain their output. This explains the increase in wage-weighted employment.

Table 3.13 gives the results for selected macro variables for this simulation. With the increase in *lw*, of 0.54 per cent (row 18) in 1998, a deterioration in technology of 2.68 per cent (row 1) is required [in $Y = \frac{1}{A} F(K, L)$] for the fall in real GDP to be realized.

The results for this simulation, in Table 3.13, also show that in 1998 there is an increase in the twist in favour of imports, 61.41 per cent compared to 35.11 per cent twist in the previous simulation (Tables 3.13 and 3.12, lines 25). The twist is now larger because even though there is a reduction in aggregate real consumption, imports are held fixed. In order to ensure that imports do not decline despite the reduction in consumption, there has to be an even larger twist in favour of imports.

The large twist has a particularly bad impact on import-competing industries such as *other manufacturing*. For example, output of *other manufacturing* declined relative to total output by 11.2 per cent.

In the subsequent years, aggregate real consumption increased by 21.2 per cent in 1999 and is forecast to increase by 9.3 per cent (based on an extrapolation of past data) in each of the remaining forecast years. With other demand components constant, real GDP increased by 12.85 per cent in 1999 and by between 6.20 to 7.48 per cent in the remaining years (Table 3.13, line 15). For Y in $Y = \frac{1}{A} F(K, L)$ to increase, there must be either an improvement in technology or an increase in employment or an increase in both, given that capital stock is held constant. From our results in Table 3.13, line 1, we see that there is an improvement in technology as indicated the by the range of -5.76 to -10.12 per cent change in *a1primgen* in 1999 to 2006. Wage-weighted employment, *lw*, increases in 1999, declines in the period 2000 to 2002 and then rises in the period 2003 to 2006 (Table 3.13, line 18). The movements in *lw* reflect a fall followed by a rise in the demand for labour by the smallholding agricultural export industries.

In this simulation there is no change in the trade and current accounts relative to these accounts in the previous simulation.

Simulation A7: Aggregate Real Investment Shock

In this simulation we shock aggregate real investment, *ir*. The underlying idea behind the exogenous shocks we impose for aggregate real investment is that in the future investment will follow a cycle similar to that in recent history (as shown by data in the National Accounts). We observe that between 1985 and 1995 investment usually increased for two years, then declined for a period of about one to two years and then increased again. In the next four years to 1999 there was a decline in aggregate real investment. Aggregate real investment declined at an average annual rate of one per cent over the period 1985 to 1999. In the absence of any forecast for investment for the economy and with this recent history in mind, we assume that following the decline in real investment in the four years to 1999 and in view of the decline in interest rates between 1999 and 2001, aggregate real investment will increase again. Specifically, we assume a decline of 1.0 per cent in investment in the year 2000 followed by an increase in investment of one to three per cent in 2001 to 2003. This is followed by a decline of one per cent in each of the years 2004 to 2006, given that interest rates rise.

The simulated results in Table 3.14 show that although aggregate real investment changes, aggregate capital stocks do not. This is because as yet there is no shock to the homotopy variable, *del_unity*, whose role is to reconcile the opening values of capital stock in year t with the closing values in year t-1, after allowing for depreciation. This means that investment is allocated between industries depending on the rate of return to capital *rj*, but it does not affect capital stock. The industries with relatively high *rj* attract relatively more investment than those with a relatively low *rj*.

The aggregate real investment shock leads to a percentage change in real GDP of about 18 per cent of the exogenous percentage change in aggregate real investment. This is so because aggregate real investment comprises about 18 per cent of real GDP

Table 3.14: Selected Macro Results when Aggregate Real Investment is Shocked Additively in Simulation A7

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
1	*Model Name*	*Economic Name*									
2	a1primgen	Tech Coefficient	3.58	-6.95	-6.68	-7.04	-6.84	-6.63	-6.90	-6.79	-6.82
3	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
4	cr	Agg Real Consumption	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
5	d_avesub	Change in Ave Subsidy	0.69	-1.06	0.03	0.02	0.03	0.04	0.04	0.05	0.04
6	d_totsub	Change in Total Subsidy *	2538	-4504	171	88	154	204	232	271	236
7	deltab	Real Trade Balance *	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	deltabn	Nominal Trade Balance *	139.06	127.15	4.82	5.67	5.67	5.67	5.67	5.67	-5.63
9	deltac	Current Account *	141.49	129.89	4.96	5.84	5.84	5.84	5.84	5.84	-5.80
10	efcreal	Agg Real Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	epsilon1	GDP Deflator	15.99	9.67	14.14	8.19	8.12	8.28	8.44	8.52	4.67
12	epsilon2	K Goods Price Index	21.66	4.93	8.56	5.25	5.30	5.73	5.88	6.00	2.87
13	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	5.00
14	f2	Investment Shifter	-14.89	16.15	-26.65	-15.41	-16.24	-14.83	-15.66	-14.03	-11.15
15	gdp	Nominal GDP	11.37	20.87	21.22	15.70	15.60	16.08	16.14	16.43	12.51
16	gdpr	Real GDP	-4.05	10.34	6.31	7.01	6.99	7.28	7.18	7.37	7.54
17	in	Agg Nominal Investment	15.48	-11.97	7.49	8.38	6.35	7.83	4.83	4.95	1.85
18	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
19	ksnew	Agg Capital Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	lw	Wage-Weighted Emp	0.89	2.14	-0.83	-0.29	-0.25	0.66	-0.68	-0.15	0.03
21	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	mn	Money Demand	11.37	20.87	21.22	15.70	15.60	16.08	16.14	16.43	12.51
23	phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	[illegible]
24	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
25	refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	-1.00
26	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	twistimp	Import Twist	78.57	-18.20	-55.79	-44.50	-40.68	-40.21	-36.78	-35.38	-31.08
28	twistlk	Labour Twist	-18.09	20.71	-4.43	2.40	2.45	3.97	1.68	2.29	2.90
29	xi4	Export Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99
30	xig	Other Dd Price Index	17.84	-3.55	13.32	5.74	6.08	6.44	7.14	7.26	3.56
	xim	Import Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99

* in Kina million

In 1998 aggregate real investment declines by 5.2 per cent in 1998[22]. The investment decline damps GDP growth by 0.86 percentage points relative to GDP growth in the previous simulations (real GDP declined by 4.05 per cent in this simulation compared to the decline of 3.19 per cent in the previous *(A6)* simulation.) Given that aggregate capital stock is held constant and employment changes very little, for Y to fall in $Y=\frac{1}{A}F(K,L)$, additional technology deterioration is required (3.6 per cent in this simulation compared with 2.68 per cent in the previous simulation). With the decrease in investment, a larger twist in favour of imports than in the previous simulation is required in order to maintain the exogenously given level of imports.

In 2003, when aggregate real investment is forecast to increase by 2.0 per cent, this leads to an increase in real GDP of 0.36 percentage points relative to the previous simulation. In this simulation, real GDP increases by 7.3 per cent compared to the 6.92 per cent in the previous simulation. The demand for labour in each of the three industries, *machineries, quarrying* and *other manufacturing,* increases. These are capital-supplying industries. Wages are relatively high in these industries and so wage-weighted employment, *lw*, increases by 0.66 per cent compared to an increase of 0.37 per cent in the previous simulation. This is not sufficient to generate the 0.36 per cent increase in real GDP. Consequently there is a slight improvement in technology, as shown by the 6.63 per cent decline in *a1primgen*, down from the decline of 6.29 per cent in the previous simulation.

22 This compares with zero change in the previous simulation.

In the last three forecast years, 2004 to 2006, despite the extraneous forecast decline in aggregate real investment, real GDP increases relative to the real GDP growth in the previous simulation. This is so because in this simulation, relative to the previous simulation, the weighted share of investment S_i in real GDP (defined as $gdpr = S_c c + S_i i + S_g g + S_x x - S_m m$) declines while that of consumption S_c increases. Hence, in these years the impact of the exogenous increase in aggregate real consumption outweighs the impact of the exogenous fall in investment and so real GDP increases.

Simulation A8: Other (Government) Demand Shock

The next exogenous variable to be shocked is other demand (real demand by the government), *chie*. Based on an extrapolation of past data, real demand by the government is forecast to increase by 0.36 per cent in each year over the period 2000 to 2006.

Given the shock of 0.36 per cent to *chie* in each of 2000 to 2006 and given that government demand makes up about 20 per cent of GDP, real GDP each year increases in this simulation by between 0.04 and 0.07 percentage points more than it did in the previous simulation. For instance, in 2003 the growth of real GDP increases by an additional 0.04 percentage points, to 7.32 per cent.

For output Y to increase, there has to be an improvement in technology and/or K and/or L should increase in $Y = \frac{1}{A}(K, L)$. With K constant, we see that in this simulation there is a slight improvement in both the wage-weighted employment and in technology, with *lw* increasing from 0.66 per cent in the previous simulation to

0.73 per cent in this simulation and *alprimgen* changing from –6.63 per cent to –6.66 per cent. These results are displayed in Table A8 in appendix D to the chapter.

Let us focus on 1998. When there was a decline of 1.8 per cent in other demand, real GDP declined by 4.42 per cent compared to the decline of 4.05 per cent in the previous simulation. Wage-weighted employment increased by 1.08 per cent compared to the 0.89 per cent increase in the previous simulation, so technology had to deteriorate by 4.02 per cent compared to the 3.6 per cent deterioration previously to account for the decline in *Y*.

Simulation A9: Aggregate Real Exports and Individual Export Demand Shocks

In this simulation we add shocks to aggregate real exports, *efcreal*, and export demand for individual commodities, *x4obs*. The shock values for each traditional export are the projections made by the Balance of Payments division of the Bank of PNG. The shock for *efcreal* is the weighted-sum of the projected commodity export demands using 1997 export values as weights.

As expected, the most significant impact of the additional shocks is on the trade and current accounts, which had not changed in the earlier simulations. The surpluses in the nominal trade and current accounts in 1998 to 2000 and 2002 to 2003 are now larger, and there are deficits in 2001 and 2004 to 2006. The movements in the nominal Kina trade account. (Refer to Table A9 in appendix D for the macro results for this simulation.)

Let us look more closely at 1998. The forecast for total real exports is for an increase of 4.8 per cent. Individual export demands reflect the increase in aggregate exports. Reflecting these export shocks, there is a swing to surplus in the real trade balance from the zero position earlier. The nominal trade and current accounts experience further movement into surplus. The real growth in exports contributes directly to an improvement in real GDP. (GDP in this simulation declines by less, a decline of 1.95 per cent in this simulation compared to the 4.42 per cent decline in the previous simulation.) For the relative growth in real GDP to occur, technology must have improved. Indeed, technology improved as shown by *a1primgen* declining by 0.02 per cent compared to the increase of 4 per cent in the previous simulation.

With the inclusion of the export shocks, there is a decline in the demand for labour by high-wage-paying industries such as *Quarrying, Beverages & Tobacco,* and *Metals & Engineering.* As a result, in this simulation, wage-weighted employment declines by 2.3 per cent in contrast to the 1.08 per cent increase in the previous simulation. Therefore, there has to be a greater twist against labour, and the simulated results indicate that *twistlk* is –20.5 per cent (compared to the –17.9 per cent previously). The larger twist against labour is required to hold person-weighted employment fixed in the presence of improved technology.

Simulation A10: Export Prices Shock

We now add a shock to export prices. The values for the shocks are obtained from the projections of the Balance of Payments Division of the Bank of PNG.

The major impact of the inclusion of the shocks to export prices is on the trade balances, on the terms of trade and on export subsidies (See Table A10 in appendix D). In the years in which export prices rise, the trade account improves relative to the outcome in the previous simulation (either deficits are reduced or surpluses are increased relative to their previous levels). The terms of trade deteriorates in the first two years (1998 and 1999) and then improve in each of the remaining forecast years except 2001. The movements in the terms of trade are consistent with movements in the real trade balance. The percentage change in export subsidies depends on the change in export prices. For each export commodity, the subsidy increases when there is a fall in export price and falls when there is an increase in export price.

The shock to export prices does not affect primary factor inputs to industries and so the state of technology and the labour twist term *twistlk* do not change by much from the results of the previous simulation.

Simulation A11: Shocks to Aggregate Real Imports and to Import Prices

Next, we introduce shocks to real aggregate imports and to import prices. Following an increase of 0.4 per cent in 1998 and 1.4 per cent in 1999, aggregate real imports are forecast to increase by 4.8 per cent in each year from 2000 to 2006 (See Table A11 in Appendix D). The forecast is based on an average of the growth rate in the seven years to 1999. With respect to import prices, following a uniform fall of 12.0 per cent in foreign currency import prices in 1998, in each year from 1999 to 2006 foreign currency import prices are assumed to increase by 2 to 3 per cent a year. This is in line with the forecast inflation rate in the major countries exporting to PNG.

With the forecast increase in aggregate real imports, the real trade balance (change in balance of trade in foreign currency[23]) deteriorates relative to the previous simulation in all years except 1998 and 2000. The improvement in 1998 is attributed to a large fall in import prices. Relative to the previous simulation, in this simulation

23 The change in real trade balance is redefined in foreign currency as

$$100 * deltabotf = \left\{\left[\sum_i PEI1(i) * X4i1\right] * \left[pei1(i) + x4i1(i)\right]\right\} - \left\{\left[\sum_i PMI2(i) * XI2(i)\right] * \left[pmi2(i) + xi2(i)\right]\right\}$$

This is done because the definition in the original model $100 * deltab = (EFOB * efc) - (MCIF * mfc)$ gives, for one of the years, an implausible result of an increase in real trade balance even when an exogenous increase in imports is introduced. This is due to an increase in the weight for export, EFOB, and a decline in the percentage change in the terms of trade for 1998 (0.58) and 1999 (-9.6) settle towards the actual outcome for those years (improvement of 2.9 per cent and deterioration of 12.0 per cent respectively). For the rest of the years, the percentage change in the terms of trade follows the movements in the real trade balance. When the real trade balance improves, the terms of trade improve and vice versa.

Reflecting the increase in aggregate real imports, the import-twist variable *twistimp* changes in favour of imports in all the years except 1998. (In 1998 there was negligible growth in real imports and import prices were lower and so the real trade balance improved in that year.)

The growth in real imports causes real GDP to grow by less for all the years, except 1998, compared to the outcomes in simulation *A10*. The relative growth in 1998 reflects negligible growth in real imports, lower import prices and hence, the improvement in the real trade balance.

Simulation A12: Interest Rate Shock

We now include a shock to the Interest rate.

An exogenous increase in the interest rate increases the economy-wide required rate of return, *lambda*, and discourages investment. An exogenous fall in the interest rate has the opposite effect. However, in this simulation aggregate real investment is tied down and cannot change. Consequently, the results for industries show varying patterns of percentage changes in the rate of return to capital, *rj*, investment, *yj*, and activity, *zy*. Increases in these variables in some industries offset falls in others as investment is re-allocated among industries while aggregate

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the weight for imports, MCIF, in this simulation relative to the previous simulation. So by changing the definition to the above, we avoid the problem of change in weights.

investment is fixed.

The key point portrayed by the simulated results is that the change in the interest rate does not make much difference to real GDP, the technology coefficient, the trade balance and the inflation rate because investment is tied down by the exogenous forecast. Moreover, the rates of return to capital, investment and activity level at the industry level also do not change relative to the previous simulation. Note, however that *lw* declines slightly for all the years relative to the previous outcome for *lw*.

Simulation A13: Del_unity Shock

Finally, the homotopy variable *del_unity*, is shocked. The role of the homotopy variable is to reconcile the opening values of capital stock at the start of year t with the closing stock values at the end of year t-1, after allowing for depreciation.

Selected macro results are shown in Table 3.15. There are small increases of between 0.01 and 0.42 percentage points (Table 3.15, row 26) in real GDP in the forecast years relative to the previous simulation [Table A12, row 17, in appendix D]. This is attributed to a change in the weights of the demand-side components of real GDP in the year-to- year updates of the database. Had it not been for the changes in weights there would have been no change in real GDP as all the demand side components of GDP are constant relative to the previous simulation.

Table 3.15: Selected Macro Results when All Exogenous Shocks (with the inclusion of del_unity) are Introduced under Exogenous Exchange Rate in Simulation A13

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
	Model Name	*Economic Name*									
1	a1primgen	Tech Coefficient	0.90	-10.32	-1.57	3.28	-6.18	-3.83	-0.90	-1.77	-2.56
2	aggl	Aggregate Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cl	Aggregate Nominal Cons	7.78	38.80	26.15	19.35	19.02	19.02	19.02	19.02	19.02
4	chie	Govt Consumption	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36
5	cr	Agg Real Consumption	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
6	d_avesub	Change in Ave Subsidy*	0.78	-0.68	0.63	0.70	-1.58	0.10	-0.15	-0.01	0.10
7	d_totsub	Change in Total Subsidy*	2740	-2779	3470	4115	-7558	504	-828	-57	434
8	del_bt	Change in Trade Balance*	203	96	1414	-750	96	-37	-986	-698	-1099
9	del_btgdp	Change in BT to GDP ratio*	0.03	0.00	0.11	-0.07	0.00	-0.01	-0.06	-0.03	-0.04
10	del_unity	Homotopy Variable	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	deltabotf	Real Trade Account in FC*	88	253	351	-1459	-18	15	-937	-669	-957
12	deltabotd	Nominal Trade Account in DC*	309	641	582	-2371	-25	29	-1577	-1146	-1616
13	deltagb	Govt's Budget Position *	672	-250	786	308	-1056	209	-395	-8	27
14	efcreal	Agg Real Exports	4.80	11.20	0.71	-3.80	6.30	2.80	-8.20	-8.50	-9.10
15	epsilon1	GDP Deflator	14.56	3.88	32.25	6.13	7.80	8.69	8.43	10.47	8.96
16	epsilon2	Capital Goods Price Index	13.11	2.51	12.50	8.13	8.02	7.86	6.70	6.51	5.71
17	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
18	f1	Wage Shifter	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
19	f2	Investment Shifter	-10.34	-11.49	-35.84	-8.63	-2.26	-6.71	0.00	-1.14	-1.26
20	f4	Exports Shifter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	f5	Other Dd Shifter	0.85	-8.50	-4.04	-4.04	-4.04	-4.04	-4.04	-4.04	-4.04
22	f_obs	Shifter for forecast exports	0.33	-1.37	-6.62	-19.21	9.96	-1.12	-2.57	-4.88	-4.73
23	fc	Consumption Shifter	-24.56	75.75	-10.62	-18.72	92.59	13.28	29.41	18.98	17.62
24	gc	Govt Consumption Expenditure	14.58	-6.70	16.29	9.98	9.47	10.09	10.81	10.87	11.20
25	gdp	Nominal GDP	12.04	20.81	37.48	8.47	16.00	15.43	10.23	13.29	12.59
26	gdpr	Real GDP	-2.24	16.38	4.09	2.23	7.68	6.26	1.68	2.58	3.37
27	gex	Total Govt Expd	10.53	-5.38	9.72	7.39	7.46	7.86	8.81	8.97	9.35
28	gi	Govt Capital Expd	6.46	-8.21	-25.05	-1.27	4.86	0.01	5.60	4.16	3.29
29	gireal	Govt Real K Expd	-6.22	-8.35	-34.18	-9.12	-3.23	-7.74	-1.41	-2.53	-2.69
30	go	Other Govt Expenditure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	grev	Total Govt Revenue	58.61	-16.09	53.78	18.94	-23.98	16.38	-4.35	8.94	10.49
32	in	Agg Nominal Investment	7.32	-14.04	11.39	11.35	9.09	10.00	5.65	5.46	4.66
33	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
34	ksnew	Agg Capital Stock	3.63	2.84	1.17	1.03	1.18	1.17	1.23	1.07	0.93
35	lambda	Economy-wide Rate of Return	40.00	-14.60	-27.00	-5.00	0.00	1.00	2.00	2.00	3.00
36	lr	Returns to Land	146.18	-46.83	116.08	52.96	-74.89	17.21	-34.38	-5.69	1.61
38	lw	Wage-Weighted Employment	-2.94	2.11	1.92	8.34	-4.17	1.45	0.30	1.20	1.15
39	mfcreal	Real Imports (fc)	0.40	1.40	4.80	4.80	4.80	4.80	4.80	4.80	4.80
40	mn	Money Demand	8.14	23.21	43.22	9.15	16.00	15.29	9.97	13.02	12.20
41	p0toft	Terms of Trade	0.76	-8.75	30.16	-4.21	-1.42	0.25	-0.78	3.97	-1.24
42	p1lab_io	Nominal Wage	-0.74	1.68	14.46	8.22	7.92	7.92	7.92	7.92	7.92

... continued

Table 3.15 continued

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
	Model Name	*Economic Name*									
43	phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	1.00
44	q1	Households	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
46	refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	-1.00
47	totgexreal	Agg Govt Expd	-4.55	-3.03	-5.22	-1.93	-1.47	-1.53	-1.14	-1.07	-0.96
48	twistimp	Import Twist	26.48	-25.94	-25.46	-1.93	-25.01	-19.46	-6.42	-10.31	-15.42
49	twistlk	Labour Twist	-30.94	19.56	-7.35	5.40	-4.79	-3.07	-0.62	0.06	-0.25
50	xi4	Export Price Index	13.41	16.47	35.04	-0.81	2.57	3.28	2.23	7.10	-0.26
51	xim	Import Price Index	12.57	27.28	3.88	3.53	4.04	3.03	3.03	3.03	0.99

* In Kina million

The crucial effect in this simulation is that aggregate capital stock now increases by between 0.93 to 3.63 per cent (Table 3.15, row 34) during the forecast period compared to the zero growth in all the previous simulations. Factor input of K increases in $Y = \frac{1}{A}F(K,L)$, but total output either changes by very little or increases by proportionately less than the increase in capital stock. More factor (capital) inputs producing the same or a relatively small increase in output implies deterioration in technology and this is shown by the relative increases in *a1primgen* in the forecast years relative to the two preceding simulations. For instance, in 2000, *a1primgen* increases to –1.57 per cent in this simulation from –2.10 per cent in the previous simulation. The additional capital stocks have to be engaged in production and therefore there is a twist against labour in most of the forecast years. For example, in 2000 *twistlk* declined by 7.4 per cent in this simulation compared to the decline of 4.0 per cent in the previous simulation.

3.3.2 *Instability in Few Industry -Level Results and the Adjustments/Rectifications to the Model*

In Set A simulations, we found plausible macro results but there were several problems with regard to volatility in industry level results. Appendix E explains these problems and sets out the way we rectified them. In this subsection we simply sketch out our approach.

First, in all the Set A simulations, there is much volatility in the power of the export subsidy for many commodities and in particular export commodities. For mineral exports, in some years the total export subsidy exceeds the total value of exports. The mineral industries are very capital intensive. In these industries, the constant elasticity of substitution (CES) for primary factors is very low. This means that even if one of the factors (say capital) becomes expensive and the other (say labour) becomes relatively cheap, there would be little substitution between the primary factors. Consequently, we see a lot of volatility in the export subsidy in our results (an increase when the export price is low, and a decrease when the export price is high). The movements in the export subsidy are required to sustain particular levels of output and exports. To get over this problem, we increased the primary-factor substitution for the mineral industries as well as for forestry (the other industry with high volatility in changes in export subsidies).[24] With this change in place, more plausible results for percentage changes in the powers of export subsidy and changes in the total subsidy are obtained in the set A simulations.

Second, capital intensity causes high volatility in labour demand in the mineral industries. This occurs because capital is rigid in the short run and the share of labour in the total factor usage is low, and so demand for labour has to increase/decline by much in order that an increase/decrease in output can be realized in these industries. We address this problem by assuming excess capacity in the initial stock of capital and land so that output can be increased with given stocks of capital and land simply by increasing utilization rates.

Third, in the set A simulations, there is some volatility in labour demand in some of the multi-product agricultural industries and in the output of some of the multi-industry agricultural products. Multi-product agricultural industries such as the smallholding agricultural industries have a low constant elasticity of transformation (CET) for their outputs. This constant low elasticity of transformation in these industries does not allow them enough flexibility to switch between commodities. In other words, they have little room to manoeuvre between the products they produce when there is an exogenous decline in the demand for one of the products. In turn, this leads to the problem of high volatility in demand in multi-industry agricultural products, with big declines observed in the output of the product in the other industry that produces it too. In order to get over this problem, we increase the CET for the agricultural industries and also reduce labour's share of the total factor payments in the smallholding agricultural industries to a number close to that in the original data set. The reduction of labour's share in total factor payments reinforces the impact of the increases in the capital in that the smallholding industries absorb more of the change. For example, consider a decline in the demand for copra. With the lower labour shares and higher CET, we will observe a switch in smallholding agricultural industries towards the production of *fruits and vegetables* and *non-ruminant livestock* and this in turn will save the *plantation copra* industry from collapsing.

24 The CES for primary factors is changed from 0.5 to 2.0 for these commodities.

The three adjustments/rectifications to the model are needed in order to produce plausible industry results. With the adjustments/rectifications in place, we re-run simulation A13 (the simulation in which all the relevant exogenous shocks are introduced under an assumed fixed exchange rate). The results of the new A13 simulation is used for the whole-picture summary presented below.

3.3.3 The Overall Picture and Summary

This section presents a whole picture when all the shocks are introduced simultaneously in the new A13 simulation[25] and summarizes the key findings of the Set A simulations. We focus on macro results, which are presented in Table 3.16. As noted earlier, industry-level analysis will receive more attention after a reasonable set of model-generated macro results has been found.

3.3.3(a) The Overall Story- Comparison of the Results of Revised Simulation A13 and the Initial Solution

Taking the results of the revised simulation A13 relative to the initial solution (the 1997 base), we see that there is a yearly average increase of 3.7 per cent in total output (real GDP) in the forecast period 2002 to 2006 (see Table 3.16). The exogenous aggregate person-weighted employment grows on average by 1.0 per cent a year whereas wage-weighted employment grows at an average annual rate of 0.86 per cent. Aggregate capital stock increases in the early years of the forecast period and declines in the latter years, registering almost no growth over the whole forecast period (a marginal decline of 0.02 per cent.) The flat trend in capital stock reflects

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25 Rerunning each of the simulation in set A with the adjusted/rectified model would produce similar macro results and more plausible industry-level results. So instead of repeating the whole exercise we just rerun simulation A13 for the purpose of giving a whole story. Our summary of what we have learnt would still be the same nonetheless. The usefulness of adjusting and rectifying the model serves its purpose more in set B simulations, particular for the industry-level discussion, and in chapter four.

Table 3.16: Macro Results When All Exogenous Shocks are Introduced Under Exogenous Exchange Rate, Revised Simulation A13

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
	Model Name	*Economic Name*									
1	alprimgen	Tech Coefficient	0.89	-3.69	-3.30	0.85	-7.03	-3.60	-0.28	-0.87	-1.74
2	aggl	Aggregate Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cl	Aggregate Nominal Cons	7.78	25.06	26.15	19.35	19.02	19.02	19.02	19.02	19.02
4	chie	Govt Consumption	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36
5	cr	Agg Real Consumption	-5.20	9.00	9.30	9.30	9.30	9.30	9.30	9.30	9.30
6	d_avesub	Change in Ave Subsidy*	0.05	-0.10	-0.07	-0.06	0.09	0.02	0.06	0.00	0.09
7	d_totsub	Change in Total Subsidy*	152.17	-458.60	-366.12	-384.95	630.48	145.06	447.57	25.19	535.62
8	del_bt	Change in Trade Balance*	157.15	280.39	908.45	-794.85	9.11	46.71	-1150.73	-746.74	-1263.86
9	del_btgdp	Change in BT to GDP ratio*	0.02	0.03	0.07	-0.07	-0.01	0.00	-0.07	-0.04	-0.05
10	del_unity	Homotopy Variable	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	deltabotd	Nominal Trade Account in DC*	296.18	649.57	1143.04	-1356.34	-152.61	241.36	-2226.82	-1525.35	-2228.69
12	deltabotf	Real Trade Account in FC*	77.50	260.02	696.04	-954.21	-88.35	116.84	-1149.93	-776.71	-1135.49
13	deltagb	Govt's Budget Position*	71.54	266.83	120.28	-28.03	145.42	131.02	-37.39	-18.92	-0.72
14	efcreal	Agg Real Exports	4.80	11.20	0.71	-3.80	6.30	2.80	-8.20	-8.50	-9.10
15	epsilon1	GDP Deflator	12.71	7.98	26.68	5.72	7.31	9.46	8.13	11.11	8.85
16	epsilon2	Capital Goods Price Index	10.56	6.22	12.24	12.65	7.82	7.11	6.97	6.49	5.78
17	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
18	f1	Wage Shifter	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
19	f2	Investment Shifter	3.70	-17.86	-34.66	15.09	-9.92	-8.16	-4.06	-3.76	-4.67
20	f4	Exports Shifter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	f5	Other Dd Shifter	0.85	-3.38	-4.04	-4.04	-4.04	-4.04	-4.04	-4.04	-4.04
22	f_obs	Shifter for forecast exports	0.02	-0.52	-0.67	-7.97	7.58	-0.60	-1.45	-3.71	-2.75
23	fc	Consumption Shifter	0.77	20.33	24.31	18.34	16.56	15.05	18.53	18.29	18.19
24	gc	Govt Consumption Expenditure	10.97	0.31	14.38	6.12	8.96	8.40	10.40	10.11	10.68
25	gdp	Nominal GDP	10.22	17.37	31.25	7.48	15.48	15.96	8.73	12.82	11.49
26	gdpr	Real GDP	-2.25	8.78	3.72	1.68	7.68	6.01	0.56	1.55	2.45
27	gex	Total Govt Expd	9.03	-0.61	8.43	6.08	6.59	6.36	8.25	8.15	8.66
28	gi	Govt Capital Expd	19.55	-10.09	-23.47	28.73	-1.64	-1.02	2.77	2.32	0.59
29	gireal	Govt Real K Expd	8.38	-13.69	-32.57	15.06	-9.13	-7.96	-4.34	-4.25	-5.34
30	go	Other Govt Expenditure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	grev	Total Govt Revenue	13.90	15.52	15.70	4.72	13.42	11.87	7.34	7.88	9.01
32	in	Agg Nominal Investment	4.88	-10.87	11.13	15.98	8.89	9.24	5.91	5.44	4.73
33	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
34	ksnew	Agg Capital Stock	3.68	3.74	0.07	0.68	0.38	1.18	-0.44	-0.46	-0.78
35	lambda	Economy-wide Rate of Return	40.00	-14.60	-27.00	-5.00	0.00	1.00	2.00	2.00	3.00
36	lr	Returns to Land	32.27	3.91	2.84	-7.17	10.99	6.02	-0.63	-1.60	-1.38

... continued

Table 3.16 continued

	Variable: Model Name	Economic Name	1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
37	lw	Wage-Weighted Employment	-5.40	4.10	0.68	5.56	-2.03	2.27	0.92	1.60	1.53
38	mfcreal	Real Imports (fc)	0.40	1.40	4.80	4.80	4.80	4.80	4.80	4.80	4.80
39	mn	Money Demand	6.38	19.71	36.76	8.15	15.48	15.83	8.47	12.55	11.10
40	p0toft	Terms of Trade	-0.44	-5.00	19.93	-6.72	-2.06	1.88	-1.44	4.58	-1.95
41	p1lab_io	Nominal Wage	-0.74	1.68	14.46	8.22	7.92	7.92	7.92	7.92	7.92
42	phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-14.35	-1.00	-1.00	-1.00	-1.00	1.00
43	q1	Households	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
45	refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	-1.00
46	totgexreal	Agg Govt Expd	-3.49	-3.49	-5.16	-0.66	-1.89	-1.68	-1.34	-1.22	-1.15
47	twistimp	Import Twist	33.69	7.05	-37.14	27.11	-20.88	-21.72	-4.72	-9.65	-15.55
48	twistlk	Labour Twist	-27.19	5.16	-5.56	16.76	-9.17	-0.84	-1.95	0.36	-0.91
49	xi4	Export Price Index	12.08	21.10	24.47	11.42	1.90	4.96	1.55	7.73	-0.97
50	xim	Import Price Index	12.57	27.28	3.88	19.27	4.04	3.03	3.03	3.03	0.99

poor investment growth in some of the non-mineral industries and the assumed excessive initial capital in the mineral industries (relatively low utilization rate). For real GDP (Y) in $Y = \frac{1}{A} F(K, L)$ to grow at an average annual rate of 3.7 per cent, there has to be an overall improvement in technology at a yearly average rate of 2.7 per cent. The accumulated capital stock in the early forecast years has to be engaged in production and therefore there is on balance a twist against labour in the forecast years (average of 2.5 per cent). There is also on balance a twist against imports in the forecast years. This is due to the poor exogenous investment growth and to a decline in real aggregate government, *totgexreal*, a large part of which is on imports.

The impact of capital expansion on labour allocation and employment outweighs the impact of a change in the wage rate. Predominantly in the forecast years, demand for labour is greater in the capital-supplying industries (when their activity level increases) than in the labour-intensive agricultural-exporting industries.

Moreover, wage-weighted employment declines in 1998 (as opposed to an increase when there was a wage reduction without capital expansion) and increases predominantly in the subsequent years (as opposed to the declines when there was a rise in the wage rate without capital expansion).

This suggest two propositions:

- when there is capital growth, labour will migrate to capital-supplying industries, which are mainly urban based and so encourages urban drift.
- capital growth encourages higher-wage employment and can generate higher real GDP growth if investment is free to move.

Agricultural export industries remain an important source of employment and income for small farmers and to the rural population. The sustenance of these industries does not rely on the export commodity alone but also on subsistence agriculture and local market products such as fruits and vegetables.

A devaluation of the exchange rate does not necessarily lead to a surplus (nor an appreciation to a deficit) in the real and nominal trade accounts. The impact on the trade accounts depends to a large extent on the exogenous export and import shocks. Consequently, a devaluation together with a domestic price increase does not necessarily lead to a deterioration in the terms of trade.

The introduction of 13 sequential shocks in Set A simulations were of important learning exercise, with three different but related ideas either emerging or being reinforced in our endeavour to analyse the simulated forecast results. First, by proceeding in this way, we were able to isolate and identify the key impact of each shock. Second, in understanding how the key impacts of each shock are generated, we learnt about the mechanics of the model that drive the results. Understanding the mechanics that drive the results is a pre-requisite to understanding behavioural aspects of the economy. The third idea is the economy-characteristic-induced results, that is, results being driven by specific characteristics of the PNG economy as modeled. In sum, in this set of simulations we have found out more about the linkages between key variables, the responses of these variables to shocks and thus the endogenous impacts on the economy.

3.3.3(b) Six Key Findings

First, an exogenous devaluation in the nominal exchange rate can generate an underlying surplus in the nominal trade account while an appreciation can cause an underlying deficit even in a situation in which there is no change (shock) to the domestic price level and to the volume and prices of exports and imports (simulation A2: exchange rate shock). A depreciation of the exchange rate causes the total domestic-currency value of exports and of imports to increase by the same percentage as the depreciation, while an appreciation causes the domestic-currency value of exports and of imports to decrease by the same percentage as the appreciation. There is a surplus in the trade balance in the 1997 database. Consequently, an exchange-rate devaluation leads to an improvement in the surplus (a positive change in *deltabn*) while an appreciation leads to a decline in the surplus (a negative change in *deltabn*). For example, in 2000 when there is a 0.85 per cent depreciation of the exchange rate (Table 3.16, row 42), the change in the nominal trade balance is K4.82 million $\left(K4.82=[2044*0.0085]-[2379*0.0085]\right)$[26], which means that the trade surplus increases by K4.82 above its level in 1999. In 2006, when the exchange rate appreciates by 1.0 per cent, the change in the nominal trade balance is a decline of K5.63 million $\left(K5.63=[2944*-0.0099]-[2379*-0.0099]\right)$ from its level in 2005.

26 Based on the tablo definition of nominal trade balance, $100*deltabn = EFOB*ed - mcif*md$, where $ed = sum\left(i,com,EI1(i)*(pei1(i)+x4i1(i)-phi\right)$ and $md = sum\left(i,com,MI2(i)*(pmi2(i)+xi2(i)-phi\right)$.

The real trade balance is not affected by the exchange rate shocks in simulation A2.

Second, in the absence of a change in the domestic price level relative to prices in the rest of the world, the "phantom" export subsidies play a role in bridging the gap between the two prices (*simulation A2: exchange rate shock*). The reconciliatory role of export subsidies between the domestic prices and rest-of-the-world prices is also evident when there are differences in the percentage changes in the domestic price level and the nominal exchange rate (*simulation A3: inflation shock*). A domestic price level which is low relative to rest-of-the world prices leads to an increase in export subsidies, and a domestic price level which is high relative to rest-of-the-world prices leads to a fall in export subsidies (increase in export taxes), in order to equate the domestic and rest-of-the-world prices. The bridging of the gap between the relative prices notionally offsets any positive impact (increases price competitiveness) a devaluation might have had on the supply of exports. Similarly it offsets any negative impact (decrease in price competitiveness) a revaluation of the nominal exchange rate might have on the supply of exports. This suggests two propositions:

- first, any increase in price competitiveness (decrease in competitiveness) gained from a devaluation (revaluation) of the nominal exchange rate is diluted in the model by the imposition of an increase (fall) in export subsidies, given the supplies and prices of exports; and

- second, under a fixed exchange rate system, the purchasing power parity theorem (Cassel. G 1916)[27] does not hold for the domestic economy but the imposition of ("phantom") export subsidies and taxes can help attain the law of one price.

Third, smallholding agricultural export industries play an important role in maintaining employment (broadly defined) in the economy. Given that these industries do not have capital as a factor of production, a fall in the real wage rate greatly increases their demand for labour (*simulation A4: real wage shock*). When there is a contraction in aggregate real consumption, these industries stand apart, not supporting the contraction (*simulation A6: aggregate real consumption shock*). This is so because the industries produce not only the cash crop but also *fruits and vegetables* and *non-ruminant livestock*, products whose expenditure elasticity is very low. Industries such as the low-wage, import-competing *other manufacturing* are the ones adversely affected especially when there is a twist in favour of imports. When investment declines, the smallholding agricultural export industries are not adversely affected since they rely only on labour and land (*simulation A7: aggregate investment shock*). In these simulations (A6 and A7) the mobility of labour between industries and its impact on wage-weighted employment can be traced back to changes in the real wage rates and to the nature of the activity in the industries. Reduction in the real wage rate encourages demand for labour in the smallholding agricultural export industries and that in turn tends to increase wage-weighted employment. An increase in investment activity in the capital-supplying industries, which are mostly high wage-

27 The doctrine of purchasing power parity (ppp) was first set out by Gustav Cassel in 1916 to determine the exchange rate parity between two trading countries. In absolute terms, the rate of the exchange between the currencies of two countries is determined by the quotient between the general price level of prices in the two countries (Frenkel Jacob, 1981, p.145). In relative terms, ppp relates equilibrium domestic to foreign prices. The theory postulates that beginning from a equilibrium position of the spot exchange rate between two countries any change in the differential rate of inflation between them tends to be offset in the long term by an equal but opposite change in the spot rate.

Mathematically, $exchangerate_{[illegible]} = price_{[illegible]} - p_{[illegible]}$.

paying-industries, attracts labour (not necessarily on a skill basis) to these industries and thus increase wage-weighted employment. An increase in export oriented activity favours the agricultural export industries.

Fourth, growth in real GDP in each of the five years 2002 to 2006 arises primarily from the extraneous shocks given to the demand-side components of GDP (see Table 3.16), namely aggregate real consumption, aggregate real investment, aggregate other demand, aggregate real exports and aggregate real imports as in the identity $y = c + i + g + x - m$ (lower-case letters indicate percentage changes in real levels). The simulated results show that given the 9.3 per cent growth in real consumption year, aggregate real consumption contributes 6.2 to 7.2 percentage points of real GDP, as it makes up about 60 per cent of total real GDP. Investment makes up about 18 per cent of GDP and so the marginal contribution of real aggregate investment to real GDP is about 18 per cent of the forecast change in real investment. Real government demand grows by 0.36 per cent per year, and given the weight of the government demand in GDP, it contributes a further 0.07 percentage points to the growth in real GDP. Growth in aggregate real exports and in export prices help improve real GDP while growth in aggregate real imports and in import prices adversely affect real GDP. Growth of real GDP derived in this manner is not model-determined or a causal effect, since all components of expenditure-side GDP are exogenous. The exogenous shocks to these components contribute directly to the growth in real GDP through the aggregate income identity. Growth of GDP will be model-determined only when the expenditure components of GDP are derived endogenously. This will be seen in the next chapter, the chapter on policy analysis, in which the closure is changed and the components of GDP and aggregate GDP are derived endogenously.

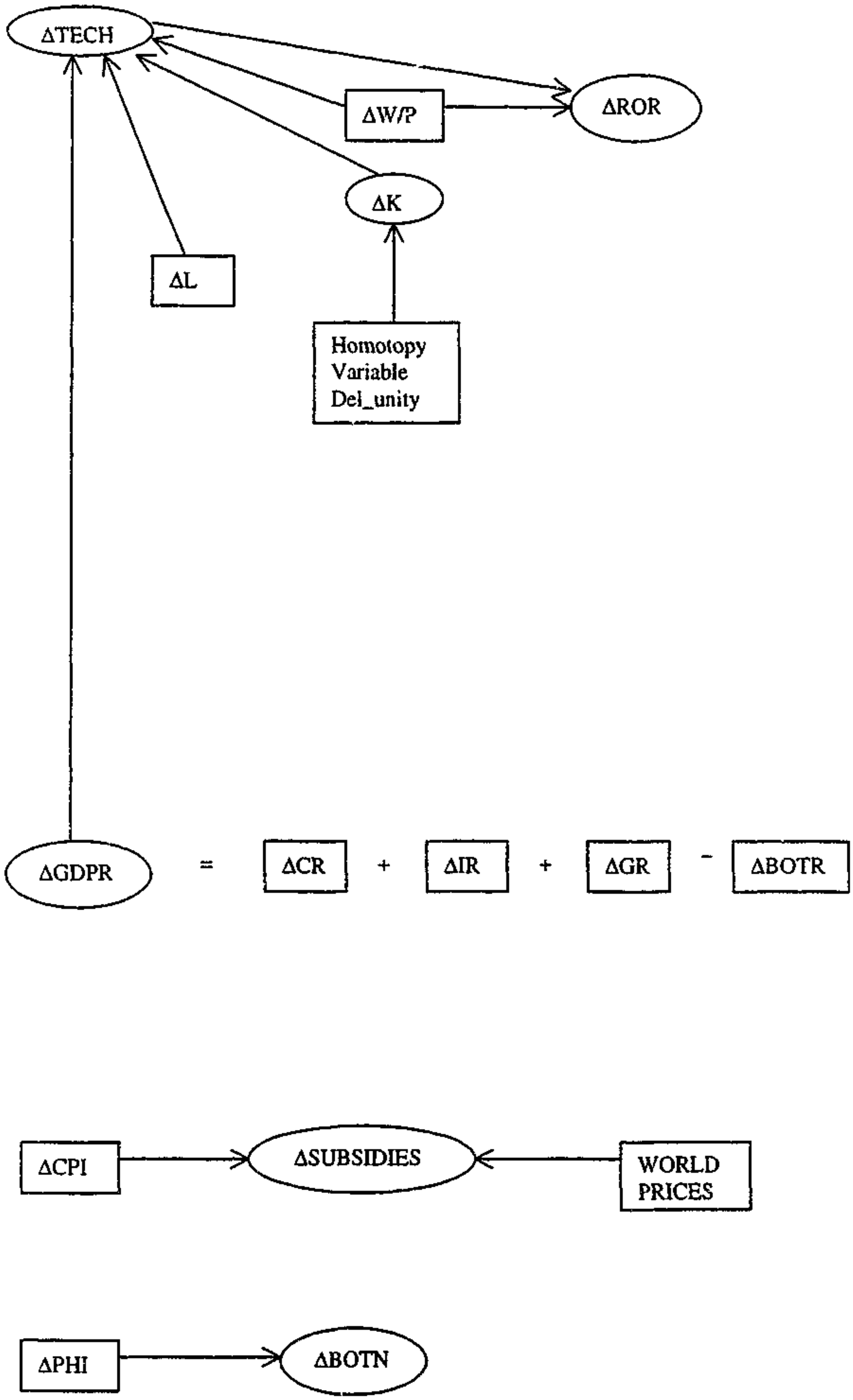
Fifth, in our simulations we saw that exogenous changes in the interest rate do not make much difference to the final outcome for key variables such as real investment, inflation, and real GDP because these variables are tied down by the extraneously forecast values. Changes in the interest rate affect only money demand/supply, which implies that for the rate of growth in nominal GDP to be achieved, the endogenous changes in money demand/supply are required. We expect that the interest rate will have a more active role in the policy deviation simulations, that is, a change in interest rate should cause the economy-wide required rate of return, *lambda*, to change, thus affecting the rate of growth in investment.

Finally, given the closure and our shocks, the *del_unity* shock in equation E_kj, leads to a build-up in capital stock. However, because real investment and other real variables are extraneously tied down, the *del_unity* shock in simulation A13 affects mainly nominal investment and other related nominal variables. The inclusion of the *del_unity* shock causes technology to deteriorate as the increased capital stock has little positive impact on output. With the engagement of the additional capital stock in production there is a twist against labour.

3.3.3(c) Macro Connections of the Set A Forecasts

Figure 3.1 depicts the main macro closure and the macro analysis of cause (exogenous) and effect (endogenous) we deduced from the discussion of the results. Exogenous variables are in rectangles, endogenous variables are in circles and arrows show the direction of causation.

Figure 3.1: Macro connections in the set A forecasting closure



3.3.4 Set B Simulations: Endogenous (Floating) Exchange Rate Changing the Closure to Endogenize the Exchange Rate

The step-by-step simulations in Set A enabled us to amend the model to ensure that reasonable results were generated. In our Set A simulations we saw that under a fixed (exogenous) exchange rate, endogenous changes in export subsidies played a reconciliatory role between price levels in the PNG economy and rest-of-the-world prices. Now we consider an alternative closure in which the "phantom" subsidy/tax does not play a reconciliatory role at the macro level. However, at the industry level the subsidies can change, though the increases and decreases offset each other so that the average rate of export subsidy does not change.

For our Set B simulations we require a closure in which the exchange rate is endogenous. In order to endogenize the exchange rate we exogenize the change-in-average-subsidy, *d_avesub*, with zero shock and swapped with *phi*, thereby enabling the exchange rate to be endogenous. In the Set B simulations, instead of allowing changes in total export subsidies to reconcile incompatibilities between the price level in PNG and the international price level, we allow changes in the exchange rate to play this role. The swap between *f4* and the *consumer price index* is maintained and the consumer price index is now the numeraire.

With this change in the closure the amended model is used for Set B simulations. Under the closure, the endogenous movement of the exchange rate can occur via two mechanims. First, it can move in response to a change in domestic or world prices when either of the prices is shocked. Second, it can move when a shock causes a change in Kina prices brought about by a change in technology. An improvement in technology reduces the Kina cost of production and leads to lower prices for output and hence an appreciation of the exchange rate. Conversely, deterioration in technology increases the Kina cost of production and leads to a depreciation of the exchange rate.

The knowledge of the mechanics behind the results and behavioural aspects of the economy gained from the analysis of the results of the Set A simulations will aid us in working through the results of the simulations under an endogenous exchange rate regime in the Set B simulations. The same step-by-step simulations are carried out and the contributory impacts of each shock on the macro variables are discussed. Following the discussion of the macro results, we present and discuss the industry-level results (Section 3.4).

The values for the shocks in the Set B simulations are the same as those in Set A and the shocks are again introduced one at a time, additively.

Simulation B1: *Inflation Shock*

We used the CPI as our measure of inflation in this simulation. Recall that for the years 1998 to 2001 the actual realized CPI inflation rates are used while for 2002 to 2006 the inflation rate is forecast to be at the underlying rate of 9.0 per cent a year.

The inflation shock causes the other two price indexes, the GDP deflator and the capital goods price index, and all the nominal variables to increase by the rate of inflation each year. With a floating exchange rate, the nominal exchange rate, *phi*, reacts to the changes in prices.

The figure for the rate of depreciation of the Kina is not quite the same as that for the inflation rate. This can be explained as follows.

The exchange rate, *phi*, is defined as

$$phi = \frac{\$Foreign}{Kina}$$

Inflation for the years 2002 to 2006 is forecast at the underlying rate of 9.0 per cent. This requires $\$F / Kina$ to fall by around 9.0 per cent. The initial situation is

$$price_{import\_kina} = price_{import\_foreign\$} / phi$$

$$1 = 1/1$$

With prices up by 9.0 per cent

$$1.09 = 1/phi$$

$$phi = 1/1.09 = 0.917$$

Hence, *phi* moves from 1.0 to 0.917, a fall of 8.34 per cent in the forecast years 2002 to 2006. This explains why the percentage of depreciation (or appreciation) is not exactly the same figure as the percentage change in the price.

Despite the devaluation of the exchange rate, real exports do not vary as they are exogenous and not yet shocked. With the foreign-currency prices and with real exports and imports constant, the depreciation causes the nominal trade and current account surplus to increase.

In contrast to the corresponding simulation in Set A (simulation A3), export subsidies in this simulation do not change. By contrast in A3 we see very large positive and very large negative figures (Table 3.6). The devaluation of the nominal exchange rate offsets the rise in domestic prices so that the foreign buyer faces the same export prices as before. In other words, the devaluation has equated domestic prices with rest-of-the-world prices and so export subsidies need not change.

Total output, *gdpr* does not change. Recall that GDP is tied down on the demand side by the exogenous and yet-to-be-shocked demand components of GDP.

Simulation B2: Real Wage Shock

Next the real wage rate is shocked additively.

A reduction in the real wage rate should encourage more use of labour and hence an increase in employment. However, because person-labour, *aggl*, is tied down on the supply side, it cannot respond. Instead there is a technology twist against labour. For example, in 1998 the employment effect of the exogenous reduction in the real wage rate is offset by a 16.8 per cent twist against labour (see Table 3.17, row 26). On the other hand, wage-weighted labour, *lw*, increases by 0.7 per cent. As in the wage shock simulation in Set A (simulation A4), an increase in the demand for labour by the multi-product smallholding export industries is part of the explanation of the increase in *lw* in this simulation. Further, there is also a movement of labour to some of the high-wage paying industries such as *food processing, metals & engineering* and *other manufacturing*, which accentuates the increase in wage-weighted employment.

A crucial difference between this simulation and the corresponding one in Set A (simulation A4) is that this simulation is run with the revised/rectified model, (the changes are discussed in Appendix E), and consequently capital stock does change in this early stage even without a shock to *del_unity*. This is because the real wage reduction affects the demand for labour by the mineral industries, which in turn affects the demand for capital and land. In this simulation the demand for labour,

Table 3.17: Selected Macro Results when Real wage is Shocked in Simulation B2

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
	Model Name	*Economic Name*									
1	alprimgen	Tech Coefficient	0.34	0.28	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2	aggl	Agg Employment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	cr	Agg Real Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	d_avesub	Change in Ave Subsidy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	d_totsub	Change in Total Subsidy*	0.11	0.18	0.18	0.10	0.09	0.09	0.06	0.09	0.09
6	deltab	Change in Real Trade Balance*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	deltabn	Change in Nom Trade Balance*	69.02	73.37	82.10	49.96	48.38	48.37	48.36	48.35	48.35
8	deltac	Change in Current A/C Balance*	67.62	72.04	83.24	50.77	49.24	49.30	49.37	49.45	49.53
9	efcreal	Agg Real Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	epsilon1	GDP Deflator	14.07	15.34	15.64	9.34	9.04	9.04	9.04	9.04	9.04
11	epsilon2	K Goods Price Index	15.30	16.12	15.69	9.38	9.08	9.08	9.08	9.08	9.07
12	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
13	f2	Investment Shifter	-16.48	-12.89	-1.01	-1.00	-0.99	-0.97	-0.96	-0.95	-0.94
14	gdp	Nominal GDP	14.07	15.34	15.64	9.34	9.04	9.04	9.04	9.04	9.04
15	gdpr	Real GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	in	Agg Nominal Investment	15.30	16.12	15.69	9.38	9.08	9.08	9.08	9.08	9.07
17	ir	Agg Real Investment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	ksnew	Agg Capital Stock	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	lw	Wage-Weighted Emp	0.69	0.65	0.05	0.05	0.05	0.05	0.05	0.05	0.05
20	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	mn	Money Demand	14.07	15.34	15.64	9.34	9.04	9.04	9.04	9.04	9.04
22	phi	Nominal Exchange Rate	-11.58	-12.27	-13.64	-8.51	-8.25	-8.25	-8.25	-8.24	0.00
23	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-8.24
24	refg	Foreign Grant	-12.75	-13.82	13.78	8.60	8.40	8.40	8.40	8.41	8.40
25	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	twistimp	Import Twist	-9.10	-8.56	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72
27	twistlk	Labour Twist	-16.79	-13.43	-1.08	-1.07	-1.07	-1.06	-1.05	-1.04	-1.03
28	xi4	Export Price Index	12.89	13.75	15.49	9.19	8.89	8.89	8.89	8.89	8.88
29	xig	Other Dd Price Index	14.59	16.16	15.72	9.41	9.11	9.12	9.12	9.12	9.12
30	xim	Import Price Index	12.89	13.75	15.49	9.19	8.89	8.89	8.89	8.89	8.88

* In Kina million

capital and land by the industries *other mine* and *oil* increase. Consequently, aggregate capital stock increases (by 0.06 per cent in 1998). For real GDP to remain constant, technology deteriorates by 0.34 per cent in 1998 to counter the increase in *lw* and *ksnew* (capital stock). In the years 2000 to 2006, the reduction in the real wage rate is very small and has a very small impact on the mineral industries' demand for labour, capital and land.

With the given domestic price percentage changes, there is a slight appreciation of the nominal exchange rate. This prompts changes in export subsidies by industry, with some increasing and others declining, while the average and the total export subsidy remain the same. However, the percentage changes in the powers of export subsidies are not as volatile as in the corresponding simulation in Set A. The nominal exchange rate now plays a bigger part of the reconciliatory role between domestic and international prices.

Simulation B3: Aggregate Employment Shock

Except for the exchange rate and capital stock, the results on the direction of change of relevant key variables, namely the state of technology, *a1primgen*; the labour twist variable, *twistlk*; and wage-weighted employment, *lw*, are the same as those in simulation 5 in Set A.

A decline in person-weighted employment, *aggl*, directly imposes a reduction in *lw*, and consistent with this, twistlk changes against labour. With real GDP constant, this implies an improvement in *a1primgen*. The only difference in the $Y = \frac{1}{A}F(K,L)$ relationship between simulation 5 in Set A and this simulation is that in this simulation, a decline in capital (reflecting the adverse effect of a decline in demand for labour by the mineral industries) further supports the improvement in technology. This can be seen in the results for 1998 (Table 3.18 for simulation B3). Conversely, in the period 2000 to 2006 an increase in *aggl* directly imposes an increase in *lw* and *twistlk* changes in support of labour. With real GDP constant, this implies deterioration in *a1primgen*. Demand for capital increases, which supports the case for deterioration in *a1primgen*. (Table 3.18, rows 1, 2, 19 and 27 for 2002 to 2006).

Table 3.18: Selected Macro Results when Aggregate employment is Shocked Additively in Simulation B3

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
	Model Name	*Economic Name*	*Percentage Change (unless where indicated)*								
1	a1primgen	Tech Coefficient	-0.58	1.19	0.36	0.36	0.36	0.69	0.35	0.35	0.35
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	d_avesub	Change in Ave Subsidy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	d_totsub	Change in Total Subsidy*	0.09	0.12	0.13	0.02	0.08	-0.01	0.05	0.11	0.08
6	deltabn	Change in Real Trade Balance*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	deltabn	Change in Nom Trade Balance*	72.17	69.67	80.65	48.51	46.93	45.48	46.92	46.92	46.9
8	deltac	Change in Current A/C Balance*	73.57	71.38	82.59	49.89	48.39	47.05	48.63	48.77	48.92
9	efcreal	Agg Real Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	epsilon1	GDP Deflator	14.34	15.04	15.51	9.22	8.92	8.80	8.91	8.91	8.91
11	epsilon2	K Goods Price Index	15.93	15.43	15.42	9.13	8.83	8.57	8.82	8.82	8.81
12	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
13	f2	Investment Shifter	-16.54	-12.71	-1.03	-1.02	-1.02	-1.02	-1.02	-1.01	-1.01
14	gdp	Nominal GDP	14.34	15.04	15.51	9.22	8.92	8.80	8.91	8.91	8.91
15	gdpr	Real GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	in	Agg Nominal Investment	15.93	15.43	15.42	9.13	8.83	8.57	8.82	8.82	8.81
17	ir	Agg Real Investment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	ksnew	Agg Capital Stock	-0.11	0.22	0.07	0.07	0.07	0.13	0.07	0.07	0.07
19	lw	Wage-Weighted Emp	-1.19	2.79	0.89	0.89	0.89	1.73	0.89	0.89	0.89
20	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	mn	Money Demand	14.34	15.04	15.51	9.22	8.92	8.80	8.91	8.91	8.91
22	phi	Nominal Exchange Rate	-12.08	-11.69	-13.41	-8.27	-8.01	-7.77	-8.01	-8.01	-8.01
23	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
24	refg	Foreign Grant	12.79	13.75	13.74	8.60	8.36	8.32	8.36	8.36	8.36
25	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	twistimp	Import Twist	-7.87	-10.10	-1.45	-1.45	-1.45	-2.15	-1.44	-1.44	-1.44
27	twistlk	Labour Twist	-19.06	-10.62	0.13	0.13	0.14	1.37	0.15	0.16	0.16
28	xi4	Export Price Index	13.51	13.02	15.20	8.92	8.61	8.34	8.61	8.61	8.61
29	xig	Other Dd Price Index	15.37	15.30	15.35	9.06	8.76	8.40	8.75	8.74	8.74
30	xim	Import Price Index	13.51	13.02	15.20	8.92	8.61	8.34	8.61	8.61	8.61

* in Kina million

Simulation B4: *Aggregate Real Consumption Shock*

Results for the main macro variables are presented in Table 3.19. As in the corresponding Set A simulation (simulation A6), there is in this simulation a marginal contribution of around 60 per cent of the percentage change in *cr* to real GDP, other expenditure components of real GDP remaining unchanged.

Table 3.19: Selected Macro Results when Aggregate Real Consumption is Shocked Additively Under Endogenous Exchange Rate in Simulation B4

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
	Model Name	*Economic Name*	*Percentage Change (unless where indicated)*								
1	alprimgen	Tech Coefficient	2.36	-9.66	-5.32	-5.66	-5.35	-1.89	-1.82	-1.95	-2.08
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
4	d_avesub	Change in Ave Subsidy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	d_totsub	Change in Total Subsidy*	0.17	0.04	0.11	0.06	0.06	0.04	0.13	0.10	0.05
6	deltab	Change in Real Trade Balance*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	deltabn	Change in Nom Trade Balance*	83.95	23.54	62.65	32.90	32.30	34.73	36.44	36.11	35.95
8	deltabotd	Nominal Trade Account in DC*	116.0	36.0	102.9	58.9	61.3	69.9	78.0	82.5	87.5
9	deltabotf	Real Trade Account in FC*	0.00	0.00	0.00	0.00	0.00	0.18	0.12	-0.02	-0.22
10	deltac	Change in Current A/C Balance*	85.76	23.26	61.59	33.41	32.90	35.45	37.26	37.04	36.99
11	efcreal	Agg Real Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	epsilon1	GDP Deflator	15.82	9.39	13.83	8.15	8.23	8.41	8.50	8.53	8.57
13	epsilon2	K Goods Price Index	19.13	2.82	10.64	5.85	6.61	6.48	6.48	6.43	6.41
14	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
15	f2	Investment Shifter	-16.00	-18.62	-8.67	-9.30	-9.44	-2.63	-0.95	-1.98	-3.06
16	gdp	Nominal GDP	12.18	23.33	20.85	15.14	15.47	15.88	16.17	16.39	16.61
17	gdpr	Real GDP	-3.19	12.89	6.27	6.53	6.76	6.96	7.14	7.32	7.48
18	in	Agg Nominal Investment	19.13	2.82	10.64	5.85	6.61	6.48	6.48	6.43	6.41
19	ir	Agg Real Investment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	lw	Wage-Weighted Emp	-1.74	4.53	1.16	0.88	1.32	2.64	1.66	1.77	1.87
21	ksnew	Agg capital stock	0.42	-1.77	-0.90	-0.92	-0.83	-0.28	-0.27	-0.28	-0.30
22	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	mn	Money Demand	12.18	23.33	20.85	15.14	15.47	15.88	16.17	16.39	16.61
24	phi	Nominal Exchange Rate	-13.93	-4.09	-10.57	-5.68	-5.58	-5.98	-6.27	-6.22	-6.19
25	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
26	refg	Foreign Grant	16.42	-2.24	-8.48	4.50	5.02	5.70	6.20	6.59	6.89
27	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	totgexreal	Agg Real Govt Expenditure	-1.21	-1.21	-0.46	-0.45	-0.41	-0.10	-0.04	-0.07	-0.11
29	twistimp	Import Twist	16.98	-64.11	-31.44	-29.87	-28.75	-1.73	8.17	7.89	7.75
30	twistlk	Labour Twist	-22.49	5.98	7.47	6.70	6.89	4.03	1.48	1.77	2.00
31	xi4	Export Price Index	15.86	4.24	11.64	5.97	5.86	6.31	6.63	6.57	6.54
32	xig	Other Dd Price Index	19.73	-1.34	9.58	4.93	5.77	6.73	7.06	7.05	7.06
33	xim	Import Price Index	15.86	4.24	11.64	5.97	5.86	6.31	6.63	6.57	6.54

* in Kina million

The key differences between this simulation and the corresponding simulation in Set A relate to the exchange rate and the nominal trade account. We consider these in turn.

With respect to the exchange rate we see that relative to the previous simulation in years in which there is an increase (decrease) in aggregate real consumption, the exchange appreciates (depreciates). (See Table 3.19, rows 3 and 24 and 3.18, rows 3 and 22). This is so because with moderate changes in *K* and *L*, and the quite large changes in aggregate consumption which in turn lead to changes in real GDP, technology is required to change. The improvement (deterioration) in technology leads to the appreciation (depreciaton) of the exchange rate. Consider the year 2002. Aggregate real consumption, *cr* is given a shock of 9.30 per cent, wage-weighted employment, *lw,* increases by 0.43 per cent and aggregate capital stock, *ksnew,* declines by 0.90 per cent relative to the previous simulation, B3 (Compare Tables 3.19, rows 3). There is an increase in real GDP of 6.76 per cent relative to simulation B3, Thus, there is an improvement in technology of 4.99 per cent (reduction in *a1primgen*) relative to simulation B3. The improvement in technology leads to an appreciation of the exchange rate by 2.43 per cent relative to simulation B3.

Regarding the external sector, we see that from simulation A5 to simulation A6 in Set A the trade and current accounts did not change (compare lines 6, 7 and 8 of Table 3.12 with the corresponding lines of Table 3.13) by the inclusion of the aggregate real consumption shock. This was so because the exchange rate, *phi,* was exogenous and was the same in the two simulations. In the present simulation, B4, in the years in which there is an increase in aggregate consumption, the exchange rate appreciates and the trade account deteriorates relative to the previous simulation (B3).

(Compare rows 3, 7 and 24 of Table 3.19 of Simulation B4 with rows 3,7 and 21 of Tables 3.18, rows 3,7 and 22 for Simulation B3). This result can be explained by recalling the definition of the trade balance, namely:

$$BoT = (price_{exports} * exports) - (price_{imports} * imports)$$

$$= \left(\frac{price^{foreign}_{exports}}{phi} * exports \right) - \left(\frac{price^{foreign}_{imports}}{phi} * imports \right) \quad .$$

Taking the year 2002 as an example, the exchange rate devalued from 1 ($1/K1) to 0.9199 in the previous simulation, a depreciation of 8.01 per cent (Table 3.18, row 22). In the current simulation it devalued from 1 to 0.9442, a depreciation of 5.58 per cent (Table 3.19, row 24). There is a relative appreciation of 2.64 per cent (0.9442/0.9199). This induces the original trade balance of K565 million in 2002 (in the database) to worsen by 2.64 per cent or K14.92 million. Hence, we see a worsening of the change in the nominal trade balance from K46.93 million in the previous simulation to K32.30 million in this simulation (row 7 in Table 3.18 and in Table 3.19).

Simulation B5: Aggregate Real Investment Shock

Except for the external sector, the key macro results are similar to those in simulation A7, the corresponding simulation set A. Since aggregate real investment accounts for about 18 per cent of total real GDP, its marginal contribution to the percentage change in real GDP is about 18 per cent of the shock in *ir*. For example, when *ir* is shocked by -5.20 per cent in 1998, there is an additional change in real GDP of -0.86 per cent from simulation B4.

Despite the fall of 5.20 per cent *ir* in 1998, aggregate capital stock increases by 0.18 per cent relative to the previous simulation. This is so because the demand for capital by capital-intensive mineral industries generally increases. In this simulation wage-weighted labour declines by 2.01 per cent compared to the decline of 1.74 per cent in the previous simulation. Given these changes in capital and labour, technology, *a1primgen*, had to deteriorate for the decline in real GDP in 1998 to be realized. Technology deteriorates by 1.0 per cent relative to the last simulation (B4). Consistent with the fall in *lw*, there is a twist against labour of 23.14 per cent compared to 22.49 per cent in the previous simulation. (Refer to Tables 3.19 and 3.20)

In the remaining years, 1999 to 2006, real GDP predominantly increases along with a rise in *lw*, which is explained by a rise in demand for labour by the high-wage paying industries. The movements in the aggregate capital stock, *ksnew*, do not mimic the changes in aggregate real investment, *ir*, because *ksnew* depends importantly on the demand for primary factors in the mineral industries. The changes in *ksnew* do not affect the level of investment as investment is set exogenously.

As was the case in the immediate past simulation, the improvement (deterioration) in technology reduces (increase) the cost of production and causes the exchange rate to appreciate (devalue) relative to the last simulation for most the years. While not formally modelled here, the appreciation of the exchange rate in the years of increased investment is consistent with the observation that most of the investment funds come from abroad. With domestic saving constant, this generates an increase in

Table 3.20: Selected Macro Results when Aggregate Real Investment is Shocked Additively in Simulation B5

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
	Model Name	*Economic Name*									
1	alprimgen	Tech Coefficient	3.36	-7.24	-5.26	-5.23	-3.47	-3.35	-3.31	-2.65	-2.32
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
4	d_avesub	Change in Ave Subsidy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	d_totsub	Change in Total Subsidy*									
6	deltab	Real Trade Balance*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	deltabn	Nominal Trade Balance*	86.18	26.82	60.70	30.31	30.06	31.36	33.91	34.94	35.67
8	deltac	Current Account*	88.08	26.78	61.73	30.91	30.70	32.14	34.84	35.95	36.81
9	efcreal	Agg Real Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	epsilon1	GDP Deflator	15.76	9.13	13.78	8.15	8.15	8.35	8.51	8.60	8.65
11	epsilon2	K Goods Price Index	17.73	-1.30	10.77	6.39	6.24	6.71	6.84	6.90	6.90
12	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
13	f2	Investment Shifter	-17.93	-28.76	-10.83	-7.47	-7.28	-6.22	-7.31	-6.35	-5.75
14	gdp	Nominal GDP	11.16	20.45	20.91	15.70	15.69	16.20	16.27	16.55	16.79
15	gdpr	Real GDP	-4.05	10.49	6.37	7.05	7.04	7.32	7.23	7.40	7.57
16	in	Agg Nominal Investment	11.73	-17.31	9.67	9.55	7.29	8.82	5.78	5.84	5.84
17	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
18	ksnew	Agg Capital Stock	0.60	-1.33	-0.91	-0.87	-0.55	-0.51	-0.50	-0.39	-0.33
19	lw	Wage-Weighted Emp	-2.01	4.12	1.57	2.20	3.79	4.38	3.55	3.76	3.79
20	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	mn	Money Demand	11.16	20.45	20.91	15.70	15.69	16.20	16.27	16.55	16.79
22	phi	Nominal Exchange Rate	-14.27	-4.65	-10.25	-5.24	-5.20	-5.42	-5.85	-6.02	-6.14
23	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
24	refg	Foreign Grant	17.31	-0.30	7.96	4.33	4.42	5.16	5.82	6.01	6.37
25	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	twistimp	Import Twist	30.96	-53.17	-32.76	-31.22	-22.54	-21.57	-15.68	-9.27	-4.45
27	twistlk	Labour Twist	-23.14	4.04	8.08	8.44	9.56	9.94	7.87	7.06	6.26
28	xi4	Export Price Index	16.31	4.85	11.26	5.49	5.45	5.69	6.16	6.35	6.49
29	xig	Other Dd Price Index	20.57	-0.39	8.68	4.25	5.18	5.85	6.54	6.93	7.13
30	xim	Import Price Index	16.31	4.85	11.26	5.49	5.45	5.69	6.16	6.35	6.49

* in Kina million

the demand for the domestic currency and therefore, the nominal exchange rate relatively appreciates for most of the years. In turn, there is an increase in investment goods and this together with the appreciation of the exchange rate lead to a further relative reduction in the nominal trade and current account balances.

Simulation B6: Other (Government) Demand Shock

In the forecast years 2002 to 2006, the forecast percentage growth in real government expenditure is 0.36 per cent. The results shown in Table B6 in appendix D shows that from 2000 onwards the shock to *Other Demand* yields marginal contributions to real GDP of about 0.06 per cent relative to simulation B5, reflecting the fact that the share of government demand in real GDP is about a fifth.

The difference between the forecast results in this simulation and those in simulation 8 in Set A can be explained largely by reference to the production function $Y = \frac{1}{A}F(K,L)$. In simulation 8 in Set A, the increase in GDP was achieved through an improvement in technology. There was very little change in wage-weighted employment, *lw*, and the capital stock remained constant. In this simulation (B6) the increases in real GDP are achieved through increases in *lw* and industry-level capital stock, *kj*, in the mineral industries. Technology plays a small role only. The increase in *kj* directly causes the aggregate capital stock, *ksnew*, to increase. When *ksnew* increases relative to the previous simulation, as it did in 2002 (by 0.11 per cent), labour demands by the mineral industries increase as well. Relatively to the previous simulation (B5), wage-weighted employment increases by 1.05 per cent and technology deteriorates by 0.69 per cent in 2002, implying that the marginal (0.06) per cent increase in real GDP is lower than the growth that K and L could have generated.

For the later forecast years, particularly in 2006, the results exhibit unstable demand for labour and factor payments for labour. The increase in *lw* becomes particularly large and there is a corresponding sharp deterioration in technology. In later Set B simulations the instability in *lw* disappears.

Simulation B7: Aggregate Real Exports and Individual Export Demand Shocks

We next apply the forecasts of aggregate real exports, *efcreal*, and individual export demands, *x4obs*.

There is an immediate impact on the real trade account as well as on the nominal trade and current accounts, just as there was in the corresponding simulation (*simulation 9)* in Set A. In the years of favourable (positive) export growth shocks, the years 1998 to 2000 and 2002 to 2003, there is a surplus in the trade balance. In years in which export growth is subdued, 2001 and 2004 to 2006 there is a deficit in the trade balance. In fact, in simulation B7, the Kina change in the real trade balance for each year is almost identical to its value in the corresponding simulation in the previous set (A9). See Table B7 in appendix D for the results.

In contrast to simulation A9, in this simulation there are changes in capital stock. This is because in Set B simulations we allowed capital in the mineral industries to be taken in and out of production according to activity levels in these industries. Aggregate capital stock falls quiet sharply in 2002 (1.31 per cent) because of declines in the mining industries, particularly *Ok Tedi* (-18.6). Correspondingly, demand for labour falls in these industries and, because they pay high wages, there is a decline in wage-weighted employment, *lw*.

Simulation B8: Export Prices Shocks

The shock to export prices has the effect of reducing the trade balance in foreign currency and deteriorating the terms of trade in the years in which there are negative export price shocks, 1998 for example, while increasing the trade balance and improving the terms of trade in years of positive export price shocks, 2000 for example. There is a positive correlation both between export prices and the trade balance and between export prices and the terms of trade. Export subsidies are also affected. The export subsidy for a commodity increases when there is a fall in its export price and falls when there is an increase in its export price.

The main difference between this simulation and its counterpart (*simulation 10)* in Set A concerns the nominal exchange rate. Compare results in Table B8 with those of Table A10 in appendix D. In this simulation (B8) *phi* is endogenous and reacts to the export price shocks whereas in simulation A10 the exchange rate was exogenous and so was held constant. The endogenous change in the nominal exchange rate in the current simulation reflects the impact of the average change in the foreign-currency price of exports. The shock to foreign-currency export prices has little impact on the domestic-currency export prices. However, to ensure that the domestic-currency export prices remain in line with the imposed changes in foreign-currency export prices, the nominal exchange rate must change. So for the years in which there is a positive shock to export prices, the exchange rate tends to appreciate, as in year 2000. Conversely, the exchange rate must depreciate when foreign-currency export prices fall. So for years in which there is a negative shock to export prices, the exchange rate tends to devalue, as in the year 2004. The nominal exchange rate in turn is positively correlated with the terms of trade. When there is an appreciation of the exchange rate, the terms of trade improve. Conversely, the terms of trade deteriorates when the nominal exchange rate depreciates.

Simulation B9: Aggregate Real Imports and Import Prices Shocks

Relative to the previous simulation (B8), the inclusion of shocks to aggregate import volumes and import prices generates a reduction in both the Kina trade balances, *deltabn*, in all years, except 1998. With the exception of 1998, the introduction of import price shocks causes a deterioration in the terms of trade, *p0toft*, and a corresponding deterioration in the trade balance.

Now consider the year 1998. In 1998 there is terms-of-trade improvement due to a significant fall in import prices and an improvement in the trade balance.

Consistent with the growth in imports, real GDP declines in all the years.

The response of the exchange rate to the shocks to aggregate real imports and to import prices is dependent on two mechanisms. The first is the relationship of the domestic and foreign price levels. The foreign prices of imports are shocks in this simulation while domestic prices are constant. So the exchange rate changes to equate the two prices. When foreign prices increase, the demand for foreign currency should decline and the Kina should appreciate. Falls in foreign prices should cause the reverse. The second mechanism is the change in technology. As explained earlier, an improvement in technology should reduce the cost of production and lead to an appreciation of the Kina. Deterioration in technology should cause the reverse.

Consider 2002 as an example of the effects of these two forces. Foreign currency import prices in 2002 increase by 3.0 per cent. This should discourage PNG's demand for foreign currency and lead to an appreciation of the local currency. However, the net appreciation is very small (0.03 per cent). The expected appreciation is almost entirely offset by the impact of a deterioration in technology (2.44 per cent) which in turn has the effect of forcing the Kina to depreciate. Therefore, as we see in our examination of the year 2002, the net effect of the real import and import price shocks on the exchange rate in each year can either be a depreciation or an appreciation, depending on the strength in any year of the two forces. This explains the mixture of results for the percentage change in *phi* (see Table B9 in appendix D).

In this simulation there is predominantly a twist in favour of imports. The twist is required to hit the target for the growth in imports.

Simulation B10: Interest Rate Shock

Relative to the previous simulation, the results of the B10 simulation are similar to those in the corresponding simulation in Set A (A12) as shown in Table B10.

The interest rate shock does not cause any significant difference to the key outcomes of real GDP, the technology coefficient, the real trade balance and inflation relative to simulation B9. This is so because investment is tied down (to the forecast change). There is reallocation of investment between industries, reflecting changes in the industries' rate of return to capital, but aggregate investment is unchanged.

The demand for money increases when the interest rate falls and declines when the interest rate increases. However, in this simulation (B10) interest changes do not affect investment as one would have expected because investment is tied down to the forecast value. The changes in money supply show the growth in money supply that is required to sustain the rate of growth in nominal GDP.

The technology coefficient, *a1primgen*, and the labour twist variable, *twistlk*, change by little relative to the previous simulation because the total output level and the composition of labour, capital and land change by little relative to previous simulation (B9).

Simulation B11: Del_unity Shock

Finally, we shock the homotopy variable *del_unity*.

In general, we do not expect any changes in real GDP since all the demand-side components of GDP are constant relative to the previous simulation (B10). Relative to the simulation B10, the slight changes in real GDP that we observe for the forecast years, relative to the immediate past simulation, reflect changes in the weights of the demand-side components of real GDP in the updated database for each year.

Recall that in *simulation 13* in Set A a change in capital stock occurs via the shock to *del_unity*. In this simulation (B11) capital stock formation comes both through the shock to *del_unity* and through the activities of the minerals industries as highlighted earlier. Relative to simulation B10, aggregate capital stock in this simulation increases in all years. Despite the exogenous decline in *ir* in some of the years (1999, 2000, 2004-2006) *ksnew* increases in this simulation because, so long as investment is greater than depreciation, capital stock grows. In the forecast years 2002 to 2006 the rate of increase in capital stock is greater than that in simulation 13 in Set A, reflecting the two sources of the increase (noted above).

The additional capital stock has very little effect on output, constituting a deterioration in technology, relative to simulation B10. Reflecting the relative growth of capital stock in the production of output, there is a relative twist against labour for most of the years. (Refer to Table 3.21)

Table 3.21: Macro Results when All Exogenous Shocks are Introduced Under Endogenous Exchange Rate in Simulation B11

	Variable *Model Name*	*Economic Name*	1998	1999	2000	2001	2002	2003	2004	2005	2006	Ave 2002 to 2006
			Percentage Change (unless where indicated)									
1	alprimgen	Tech Coefficient	0.96	-9.89	-3.09	0.32	-6.03	-3.58	-0.66	-1.49	-2.10	-2.77
2	aggl	Aggregate Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00	1.20
3	cl	Aggregate Nominal Cons	7.78	38.80	26.15	19.35	19.02	19.02	19.02	19.02	19.02	
4	chic	Govt Consumption	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
5	cr	Agg Real Consumption	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30	
6	d_avesub	Change in Ave Subsidy*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	d_totsub	Change in Total Subsidy*	0.21	0.32	-0.03	-0.01	-0.08	0.10	0.07	0.04	-0.16	
8	del_bt	Change in Trade Balance*	163.25	252.87	782.04	-710.44	75.38	63.62	-1097.77	-735.26	-1420.31	
9	del_btgdp	Change in BT to GDP ratio*	0.02	0.02	0.05	-0.07	0.00	0.00	-0.06	-0.03	-0.05	
10	del_unity	Homotopy Variable	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
11	deltabotd	Nominal Trade Account in DC*	329.23	522.32	787.03	-1010.62	66.96	260.49	-1963.11	-1468.93	-2338.52	
12	deltabotf	Real Trade Account in FC*	78.10	309.41	590.24	-818.11	-60.05	117.17	-1093.53	-759.18	-1147.32	
13	DeltaC	Nominal Current Account*	204.11	217.23	515.99	-343.55	140.25	89.58	-451.64	-293.16	-548.53	
14	deltagb	Govt's Budget Position*	70.45	339.71	94.18	-13.05	89.28	134.14	-31.62	-22.99	19.52	
15	efcreal	Agg Real Exports	4.80	11.20	0.71	-3.80	6.30	2.80	-8.20	-8.50	-9.10	
16	epsilon1	GDP Deflator	12.65	6.48	24.93	6.46	8.50	9.61	8.31	[illegible]	8.25	
17	epsilon2	Capital Goods Price Index	11.43	0.11	11.94	11.85	11.60	8.04	8.22	6.37	7.66	
18	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00	
19	f1	Wage Shifter	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	
20	f2	Investment Shifter	8.80	-35.97	-38.26	5.81	8.48	-2.96	5.47	-2.95	8.12	
21	f4	Exports Shifter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
22	f5	Other Dd Shifter	0.85	-8.50	-4.04	-4.04	-4.04	-4.04	-4.04	-4.04	-4.04	
23	f_obs	Shifter for forecast exports	0.00	-0.58	-0.89	-8.04	7.67	-0.57	-1.43	-3.67	-2.63	
24	fc	Consumption Shifter	1.12	38.92	23.40	17.44	16.14	14.97	18.31	18.16	17.67	
25	gc	Govt Consumption Expenditure	9.78	-3.02	17.25	9.66	9.53	8.88	9.78	9.97	9.43	
26	gdp	Nominal GDP	10.20	23.82	30.25	9.46	16.79	16.44	9.82	13.30	11.36	
27	gdpr	Real GDP	-2.21	16.41	4.39	2.84	7.72	6.31	1.40	2.19	2.90	4.10
28	gex	Total Govt Expd	8.68	-4.99	10.50	7.93	8.12	7.09	8.32	8.11	8.38	
29	gi	Govt Capital Expd	25.78	-33.11	-28.66	16.51	19.32	4.34	13.17	2.97	15.44	
30	gireal	Govt Real K Expd	13.67	-32.26	-37.35	4.36	7.29	-3.64	4.59	-3.49	7.36	
31	go	Other Govt Expenditure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
32	grev	Total Govt Revenue	13.52	15.40	16.74	7.57	12.21	12.60	7.50	7.74	9.12	
33	in	Agg Nominal Investment	5.71	-16.10	10.84	15.16	12.70	10.18	7.15	5.32	6.59	
34	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00	
35	ksnew	Agg Capital Stock	3.71	2.45	0.47	0.86	0.93	1.32	-0.32	-0.43	-0.69	0.16
36	lambda	Economy-wide Rate of Return	40.00	-14.60	-27.00	-5.00	-1.00	1.00	2.00	2.00	3.00	

... continued

Table 3.21 continued

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006	2002 to 2006
	Model Name	*Economic Name*	*Percentage Change (unless where indicated)*									
37	lr	Returns to Land	30.82	-8.01	5.85	-3.91	11.29	6.36	-1.33	-1.43	-1.63	
38	lw	Wage-Weighted Employment	-5.23	5.24	0.33	4.56	-1.34	2.31	1.48	1.62	2.19	1.25
39	mfcreal	Real Imports (fc)	0.40	1.40	4.80	4.80	4.80	4.80	4.80	4.80	4.80	
40	mn	Money Demand	6.36	26.26	35.73	10.14	16.92	16.31	9.56	13.03	10.97	
41	p0toft	Terms of Trade	-0.48	-4.29	20.05	-6.69	-2.11	1.88	-1.45	4.62	-1.94	
42	p1lab_io	Nominal Wage	-0.74	1.68	14.46	8.22	7.92	7.92	7.92	7.92	7.92	
43	phi	Nominal Exchange Rate	-24.68	-7.63	3.00	-10.37	-11.15	-3.32	-6.10	-0.87	-6.12	
44	q1	Households	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
45	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	
46	refg	Foreign Grant	22.12	20.41	0.85	14.35	-14.14	5.48	-1.32	-3.09	2.26	
47	totgexreal	Agg Govt Expd	-3.10	-5.21	-5.13	-1.33	-1.01	-1.37	-0.88	-1.15	-0.55	
48	twistimp	Import Twist	48.79	-56.43	-38.87	14.44	15.01	-14.18	10.44	-11.01	4.29	0.91
49	twistlk	Labour Twist	-25.00	7.23	-9.39	7.02	-4.55	0.12	2.00	0.91	4.37	0.57
50	xi4	Export Price Index	15.67	5.64	20.05	6.64	13.29	7.45	6.99	7.62	6.49	
51	xim	Import Price Index	16.21	10.32	0.00	14.15	15.68	5.48	8.55	2.89	8.58	

3.3.5 *The Overall Picture and Summary of Set B Simulations*

This section presents an overall picture relative to the initial story captured by simulation B11. It also summarizes the key findings of the Set B simulations. We focus first on the macro results, which are shown in Table 3.21. (Industry results are discussed in section 3.4.)

3.3.5(a) The Overall Story-Comparison of the Results of Simulation B11 and the Initial Solution

We focus on changes over the period 2002 to 2006.

Table 3.21, line 27 shows a forecast yearly average increase of 4.10 per cent in total output (real GDP) in the period 2002 to 2006. While the exogenous aggregate person-weighted employment is forecast to grow by 1.2 per cent a year, wage-weighted employment is forecast to grow on average by 1.25 per cent a year.

Aggregate capital stock will grow by 0.16 per cent a year between 2002 and 2006, which is less than the forecast growth in simulation A13 (1.11 per cent, Table 3.15, line 34, average of last 5 columns). In the set B simulations the growth in K and L is not enough to generate real GDP growth averaging at 4.10 per cent over the period 2002 and 2006. Consequently the forecasts for 2002 to 2006 show overall primary-factor-saving technical change at an average rate of 2.77 per cent a year. Within primary factors, the forecasts show a small twist favouring the use of labour (an average change in *twsitlk* of 0.57 per cent a year). The twist in favour of labour is consistent with the increase in labour – both wage-weighted and person-weighted - relative to capital. There is a net change towards deficit in the real trade balance for three of the five forecast years. Reflecting this, there is an average of 0.91 per cent twist in support of imports.

In Table 3.21 we see that the terms of trade, *p0toft*, fluctuates between -2.11 per cent and 4.62 per cent in the forecast period 2002 to 2006. The terms of trade improves in line with improvements in export prices, changes in import prices and changes in the Kina exchange rate. The terms of trade deteriorate when export prices fall, import prices increase and the Kina depreciates.

Charts 3.1 and 3.2 show some of the key model-driven changes over the years 2002 to 2006.

Chart 3.1: Forecasts of percentage changes in real GDP, nominal exchange rate and the terms of trade

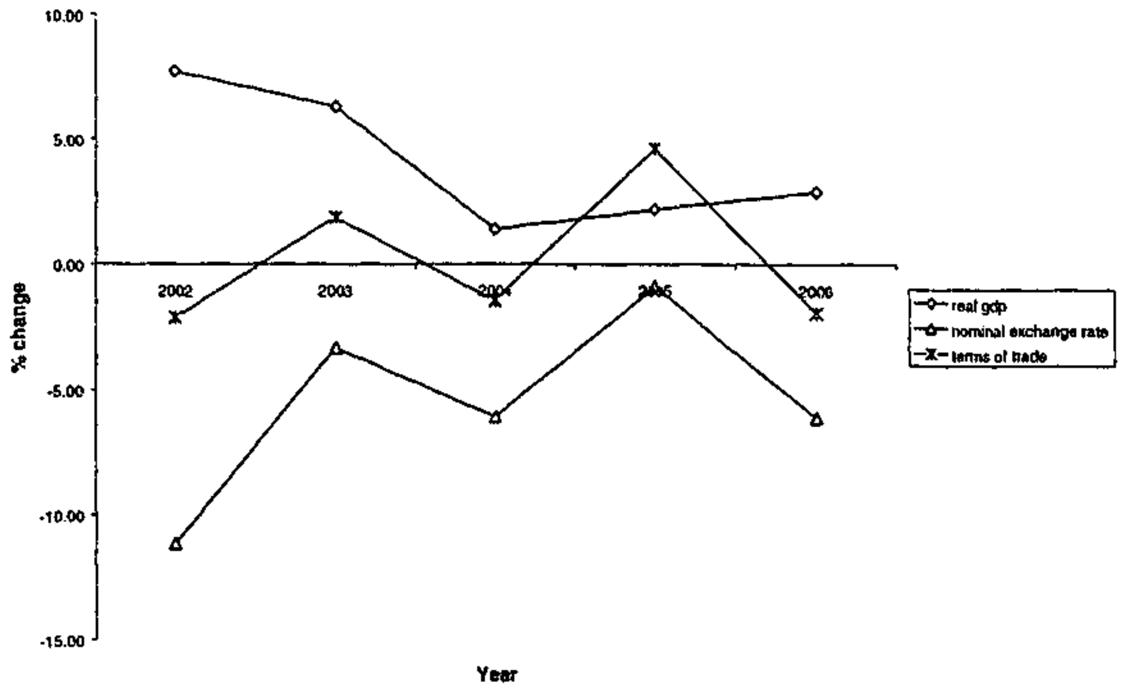
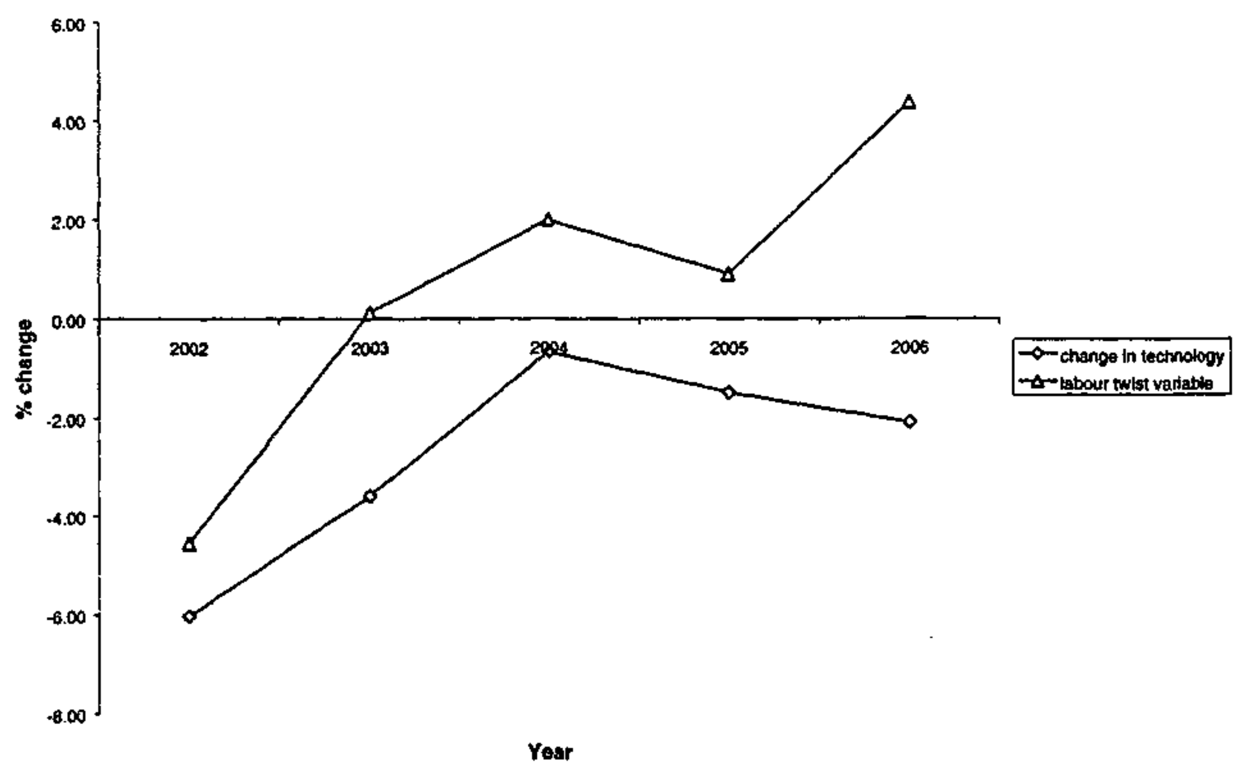


Chart 3.2: Forecasts of percentage changes in primary factor saving technical change and labour twist variable



3.3.5(b) Summary of Key Differences

The mechanisms and behavioural relationships between key variables which underlie the results in Set A simulations also explain the results of the Set B simulations. However, there are differences between the simulations in Set A and B.

The first difference relates to the relationship between relative prices, the state of technology, the nominal exchange rate, export subsidies and the external sector. The second relates to capital accumulation. We discuss these differences in turn.

In Set A simulations, the nominal exchange rate was set exogenously and so did not respond to changes in relative prices. Consequently the nominal external sector balance did not change until export-related and import-related variables were shocked. In Set B simulations, the nominal exchange rate is endogenous and reacts to relative price changes. As we saw in simulation *B1: Price Shock*, when there is an exogenous increase in domestic prices, the higher domestic prices relative to the rest-of-the-world prices force a reduction in foreign demand for the Kina (the domestic currency). The reduced demand for Kina in turn reduces the foreign-currency price of the Kina that is, the nominal exchange rate depreciates. The depreciation of the Kina in turn causes an increase in the value of the initial nominal trade and current account balances and with aggregate real exports and imports held constant, the accounts show an increase in the surplus.

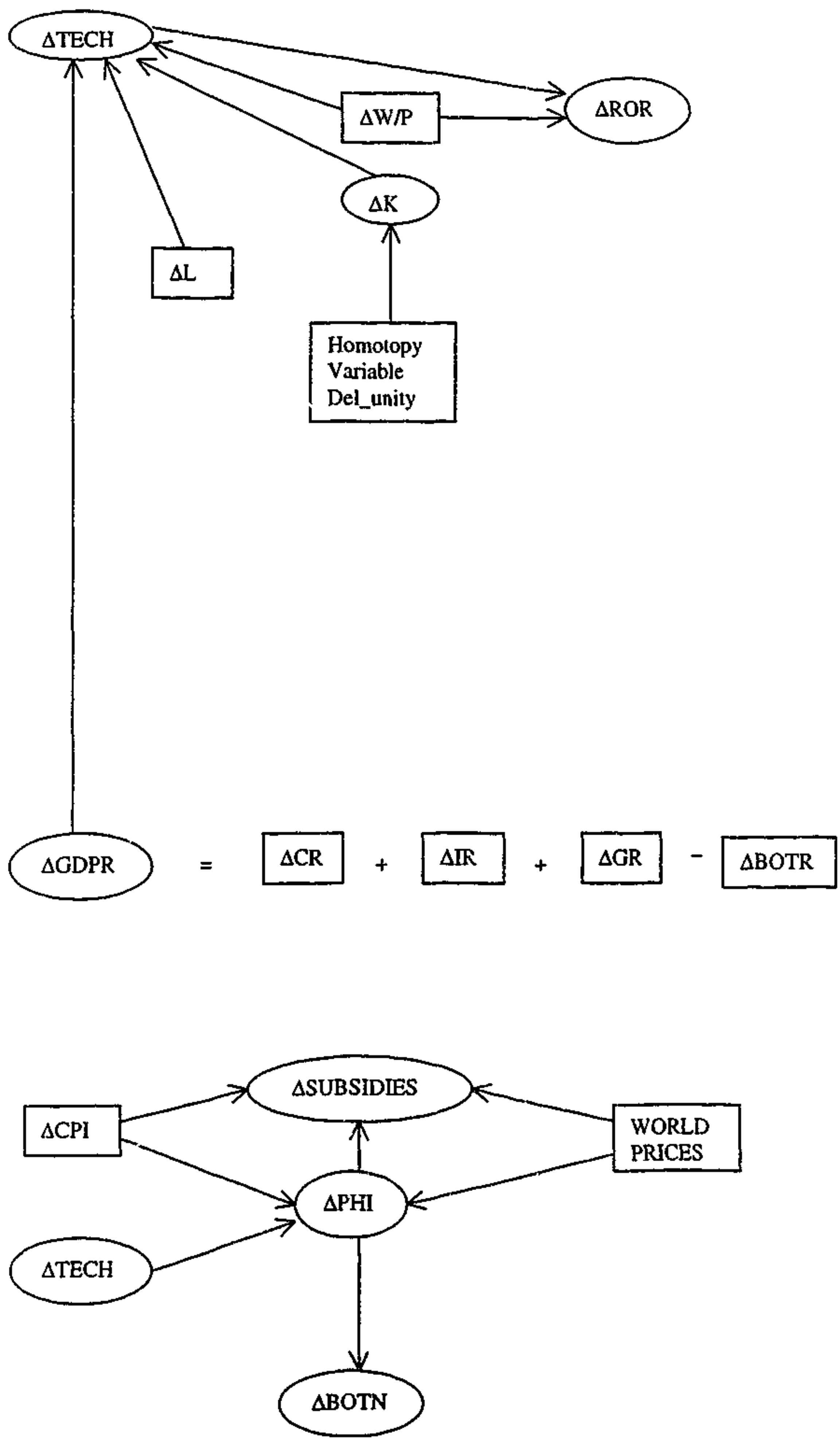
Simulation B4 is an example of a non-trade-sector shock that had a sharp effect on the exchange rate and therefore on the nominal trade and current account balances (see Table 3.19). The forecast increase in aggregate real consumption of 21.20 per cent in 1999 directly contributes to a large increase in real GDP and this implies an improvement in technology. The improvement in technology in 1999 reduces the cost of production and causes an appreciation of the Kina relative to simulation B3. In turn the appreciation of the Kina results in a reduction in the nominal trade and current account balances relative to the results of simulation B3, even though real imports and exports are held constant. (See rows 7 and 9 of Table 3.19 for B4 and Table 3.18 for B3).

In the closure for the set B simulations a change in the nominal exchange rate comes via two mechanisms. The nominal exchange rate will change when there is a change in domestic price levels and when there is a change in the technology coefficient. An example of the first mechanism is found in simulation *B8: Export Price Shock*, where we observe that in a year with exogenous increases in foreign-currency export prices, the exchange rate revalues. Conversely, in a year with exogenous declines in foreign export prices, the exchange rate devalues and domestic prices remain unchanged. An example of the second mechanism was given in the previous paragraph, which described the effect on the exchange rate of an increase in aggregate consumption.

In Set B simulations the endogenous exchange rate plays part of the reconciliatory role between domestic price levels and foreign price levels. This was very evident in simulations B1 and B8, which were concerned with movements in the domestic price level reflected in the CPI and movements in the foreign price level reflected in the prices of exports. In PNG-ORAMON, there are different foreign prices and domestic prices for the 37 commodities. Consequently, the exchange rate (a scalar variable) cannot alone perform all of the reconciliation between domestic and foreign prices. So when there are exogenously imposed changes in either domestic prices or foreign prices, some goods require a subsidy while others require a tax. Hence, so we see that in the Set B simulations industry-level subsidies/taxes still change. However the percentage changes in the power of export subsidies/taxes are not as large as they were in the Set A simulations. This is because as pointed out above, the endogenous adjustment in the exchange rate helps to bridge the gap between the domestic prices and world prices and so takes away some of the reconciliatory burden from the export subsidies/taxes.

The second key difference in the results of Set B simulations compared to Set A simulations relates to capital accumulation. In Set A simulations, there was no capital stock build-up until the homotopy variable, *del_unity*, was shocked. The shock to the homotopy variable facilitated the dynamics of capital accumulation, allowing investment in one year to be carried forward into the capital stock available for use in the next year. In the Set B simulations, we modified the earlier model by introducing variations in capital input to the mineral industries independently of investment. We allowed capital in the mineral industries to be taken in and out of production according to activity levels in these industries. This caused aggregate capital stock to change from year to year in simulations even before we introduced a *del_unity*. For the non-mineral industries, capital accumulation comes via the inter-temporal year-to-year linking of capital stock through the homotopy variable. So in the Set B simulations capital accumulation is generated through two mechanisms: capital growth linked to the activity of the mineral industries and the dynamic year-to-year linking of capital for the non-mineral industries.

Figure 3.2: Macro connections in the Set B forecasting closure



We first consider investment by industry (Table 3.22). In the industry results for B11 we see that labour-intensive industries, mainly the agricultural industries, have very high growth in investment in the first year (1998) before declining sharply in 1999 and 2000. In the period 2001 to 2006 investment in these industries grows and falls in alternate years. Industries in which the factor inputs capital and labour are of similar size, such as *building & construction,* had a fall in investment in the 1998 and a very sharp fall in 1999 followed in the main by growth, and in some years rapid growth (Table 3.22, row 35). The capital-intensive mineral industries fared well in investment growth in 1998, followed by sharp falls in 1999 and 2000 (see Table 3.22, rows 16 to 19).

The changes in investment by industries reflect the rates of return to capital in the various industries. Table 3.23 shows the rate of return to capital by industry. Recall that real aggregate investment declines by 5.20 in 1998, by 16.20 in 1999 and by 1.00 per cent in 2000 (Table 3.21, row 34).

We need to delve deeper in order to explain the very large positive and negative changes in the rate of return to capital, *rj*, and in investment, *yj*, in 1998, 1999 and 2000. We do this in the remainder of this section, where we focus on four categories of industries, namely the agricultural exporting industries, (subsection 3.4.1); formal urban manufacturing (subsection 3.4.2) mineral sector industries (subsection 3.4.3) and public sector industries (subsection 3.4.4).

Table 3.22: Investment by Industry when all Shocks are Introduced Under Endgoenous Exchange Rate in Simulation B11

	Commodity	1998	1999	2000	2001	2002	2003	2004	2005	2006
					(Percentage Change)					
1	TradAgric	na	na	na	na	na	na	na	na	na
2	SmallHCoffee	na	na	na	na	na	na	na	na	na
3	SmallHCocoa	na	na	na	na	na	na	na	na	na
4	SmallHPoil	na	na	na	na	na	na	na	na	na
5	SmallHCopra	na	na	na	na	na	na	na	na	na
6	SmallOther	na	na	na	na	na	na	na	na	na
7	PlantCoffee	55.95	-54.79	-49.42	-54.04	69.89	-17.20	1.06	-12.81	-15.19
8	PlantCocoa	39.42	-57.64	-37.40	-23.61	19.07	-2.99	18.97	-9.76	-3.29
9	PlantPOil	24.67	-34.53	0.44	-6.84	27.09	-1.99	7.83	-5.97	-1.36
10	PlantCopra	43.71	-77.02	-47.95	-80.07	13.67	-8.67	1.68	-11.68	4.16
11	PlantOther	28.53	-55.84	-30.88	6.37	14.30	-2.52	8.38	-1.55	4.31
12	PlantFruit_V	35.90	-35.70	-32.95	-1.50	11.91	-3.37	5.88	-2.77	6.20
13	OthAgric	32.69	-33.97	-24.62	1.74	13.68	-1.80	5.43	0.93	6.74
14	Fishing	8.82	-29.06	-23.15	13.41	12.66	2.11	13.47	4.11	11.47
15	Forestry	11.53	-27.09	-27.53	-3.15	18.69	-3.34	-2.61	-12.17	1.58
16	PorgeraMine	3.63	-37.11	-22.50	-19.39	13.78	-1.48	-5.78	-21.54	-16.88
17	OkTediMine	6.40	-23.73	-25.26	41.46	-9.15	-2.77	-6.83	-7.80	-10.34
18	OtherMine	12.53	-39.91	-18.70	-27.64	17.98	-1.31	-8.14	-25.38	-21.21
19	Oil	11.88	-36.38	-54.02	-22.04	17.03	-12.57	-22.88	-33.87	-22.15
20	Quarrying	7.69	51.62	39.78	25.70	-1.86	2.50	12.22	4.23	3.24
21	TimbProcess	31.12	-50.56	9.70	-10.87	12.84	-5.88	-7.92	-12.16	-13.63
22	FoodProcess	-40.85	150.99	16.31	-7.97	-10.80	7.29	1.16	8.82	0.70
23	Bever_Tobaco	-9.86	68.99	29.40	19.54	-3.43	2.26	20.63	6.70	4.65
24	Metals_Engin	-65.63	135.53	31.06	-33.48	-21.59	13.84	-24.12	2.82	-16.30
25	Machinery	-69.69	216.11	32.19	-3.87	-14.32	15.81	-14.08	5.94	-5.96
26	Chemical_Oil	-40.44	184.46	13.54	-11.87	-11.54	4.55	-35.12	-22.08	-34.34
27	Petroleum_Re	43.67	-63.91	1.39	-10.68	-12.10	-19.45	-4.74	-10.85	-15.19
28	OthManufact	-43.24	236.08	47.48	-13.27	-1.96	14.40	-6.54	10.41	-2.13
29	RoadTrans	-16.98	100.80	29.06	8.50	11.64	4.52	0.25	1.55	4.42
30	WaterTrans	-14.16	-5.17	19.48	-5.08	0.96	-0.71	-2.09	0.81	-2.10
31	AirTrans	-27.98	35.92	15.79	-2.02	-5.98	1.37	3.18	3.25	-1.77
32	Education	16.05	-30.67	-36.37	5.32	8.32	-2.63	5.64	-2.47	8.44
33	Health	14.18	-31.94	-37.17	4.53	7.46	-3.47	4.75	-3.34	7.52
34	Elect_Garbge	7.23	-36.69	-40.12	1.57	4.27	-6.61	1.48	-6.55	4.09
35	Build_Cons	-14.40	-88.49	21.54	28.70	11.99	2.95	12.81	0.77	-4.10
36	Commerce	-16.25	76.70	16.51	7.96	0.46	2.44	-4.34	-0.38	-0.71
37	Finance_Inv	6.59	49.52	28.04	16.72	0.54	0.66	4.81	-0.04	0.57
38	GovtAdm	13.72	-32.26	-37.36	4.33	7.25	-3.68	4.53	-3.55	7.29
39	OthServ	-16.92	68.65	10.15	-2.27	-4.00	4.48	-8.27	-0.22	-5.05
40	Security	30.29	-53.21	13.71	-5.99	6.12	-7.85	0.09	-4.24	-7.17
41	InforRetail	55.02	-53.34	7.16	-13.08	-0.73	-14.58	-5.20	-9.76	-13.14
42	LNGPlant	127.93	-58.27	41.05	45.62	12.02	16.11	65.43	57.82	52.12

na: not applicable because these industries do not have capital

Table 3.23: Rate of Return to Capital when all Shocks are Introduced Under Endogenous Exchange Rate in Simulation B11

		1998	1999	2000	2001	2002	2003	2004	2005	2006
	Commodity				*(Percentage Change)*					
1	TradAgric	na	na	na	na	na	na	na	na	na
2	SmallHCoffee	na	na	na	na	na	na	na	na	na
3	SmallHCocoa	na	na	na	na	na	na	na	na	na
4	SmallHPoil	na	na	na	na	na	na	na	na	na
5	SmallHCopra	na	na	na	na	na	na	na	na	na
6	SmallOther	na	na	na	na	na	na	na	na	na
7	PlantCoffee	343.07	-87.61	-68.60	-98.47	511.02	-39.60	-0.74	-23.64	-56.38
8	PlantCocoa	197.01	-90.14	-21.92	-75.65	62.02	11.69	80.28	-18.04	-28.72
9	PlantPOil	96.17	-29.63	296.32	-48.31	76.51	-6.65	0.77	-20.33	-35.50
10	PlantCopra	231.31	-99.90	-58.76	-216.39	49.11	-0.36	10.53	-12.03	11.22
11	PlantOther	119.91	-87.28	14.79	5.53	31.05	7.59	19.23	11.19	-8.06
12	PlantFruit_V	106.45	-55.50	-22.58	-34.89	4.97	-9.96	-4.23	-6.12	-11.10
13	OthAgric	147.60	-29.68	41.47	-19.94	17.77	1.00	-2.06	13.25	-6.99
14	Fishing	25.27	10.37	63.76	30.51	16.69	21.50	33.56	27.58	9.53
15	Forestry	27.67	12.48	24.21	-33.33	43.86	-3.07	-27.46	-32.48	-18.21
16	PorgeraMine	12.63	-5.02	18.52	-21.89	2.28	0.41	-7.37	-9.36	-15.52
17	OkTediMine	13.77	3.10	15.91	1.51	-7.20	-0.32	-6.96	-1.14	-10.47
18	OtherMine	15.70	-5.86	18.73	-22.17	3.03	0.20	-6.92	-8.34	-14.15
19	Oil	40.17	-9.98	-24.26	-38.79	11.05	-11.37	-31.46	-33.69	-32.55
20	Quarrying	41.89	100.51	62.41	10.36	-14.40	2.77	4.74	4.85	-5.88
21	TimbProcess	60.22	-38.36	27.87	-20.87	2.94	-2.85	-11.35	-7.49	-17.13
22	FoodProcess	-26.82	219.03	23.05	-26.32	-25.31	5.44	-7.81	8.41	-9.46
23	Bever_Tobaco	16.01	118.71	45.21	1.03	-18.60	-0.04	10.24	4.21	-7.31
24	Metals_Engin	-61.19	200.17	39.92	-47.80	-32.29	15.82	-29.08	7.21	-21.12
25	Machinery	-62.36	309.00	45.40	-21.23	-27.56	15.16	-21.66	7.46	-13.83
26	Chemical_Oil	-21.75	270.13	27.30	-25.13	-22.19	6.61	-38.85	-17.36	-36.39
27	Petroleum_Re	83.32	-50.81	18.69	-20.00	-19.98	-16.08	-7.92	-6.25	-19.33
28	OthManufact	-29.02	326.12	51.35	-35.80	-20.96	8.02	-18.71	7.23	-14.24
29	RoadTrans	9.24	163.26	47.57	-6.41	-2.48	3.40	-7.84	2.01	-4.66
30	WaterTrans	6.84	22.13	37.04	-17.55	-10.13	1.02	-7.25	4.14	-8.32
31	AirTrans	-13.26	71.56	27.28	-18.39	-19.55	0.58	-4.56	3.94	-10.35
32	Education	37.48	-58.25	11.79	-13.86	-9.95	-10.05	-2.63	-1.76	-13.67
33	Health	51.98	-39.96	27.22	-9.35	-1.36	-1.33	1.67	4.63	-8.76
34	Elect_Garbge	40.19	79.49	79.32	60.25	39.53	54.78	72.25	73.93	62.44
35	Build_Cons	0.60	-84.83	48.29	20.84	6.05	10.67	12.52	8.67	-6.38
36	Commerce	8.09	129.39	31.32	-7.62	-12.99	1.83	-11.53	1.07	-8.44
37	Finance_Inv	39.06	95.86	46.99	1.35	-12.53	0.45	-2.49	0.99	-7.61
38	GovtAdm	41.10	-55.78	18.38	-4.91	-7.00	-4.40	5.84	5.97	-7.26
39	OthServ	6.05	117.55	23.21	-16.74	-16.25	5.02	-14.50	2.27	-11.67
40	Security	59.23	-41.61	32.93	-16.34	-3.45	-4.67	-3.30	0.57	-11.49
41	InforRetail	97.36	-37.00	25.31	-22.17	-9.50	-11.04	-8.36	-5.12	-17.36
42	LNGPlant	202.83	-39.60	73.85	39.33	8.72	28.20	69.83	75.20	53.98

na: not applicable because these industries do not have capital

3.4.1 *Agricultural Exporting Industries*

Industries such as the agricultural export industries have no capital stock or very little initial capital stock. For these industries the rate of return to capital can be very volatile, swinging sharply from big pluses to big minuses, reflecting the volatility in their export prices and activity levels. Growth in investment in these industries can also fluctuate greatly. *Plantation-coffee* and *plantation-copra*, for instance, have very high positive and negative changes in the rate of return to capital because of large variability in export prices[28] and low starting capital bases. With a low capital base in these industries, volatility in the rate of return to capital causes large changes in investment. For *plantation-copra,* the substantial increase in the rate of return to capital in 1998 (231.31 per cent, Table 3.23, row 10) led to a large increase in investment (43.71 per cent, Table 3.22, row 10). In 1999 it turned around. In 1999 the rate of return to capital for *copra plantation* declined by 99.90 per cent (Table 3.23, row 10) and investment fell by 77.02 per cent (Table 3.22, row 10). The pattern is the same in the *coffee plantation* industry (Table 3.22 and 3.23, lines 7). In both industries the very large increase in the rate of return to capital in 1998 led to a big increase in investment in 1998. The process was reversed in 1999. For the two industries, investment declined in the next two years, 2000 and 2001, then increased and decreased in alternate years in the forecast years 2002 to 2006. The decline in investment in the years 1999 to 2001 was so great as to cause the end-of-year capital stock in each of these industries to below the end-of-1998 value through the forecast period.

28 We found that the sensitivity of investment to rates of return by industry was quite high given the volatility in export prices. Consequently investment growth in our model of PNG is very volatile. Under normal circumstances, industries/exporters are not highly sensitive to price fluctuations in the short term because they have in mind some kind of average price change in the medium to long term. However, it would require considerable time to build a mechanism that reflects this idea into our model. Therefore, to reduce investment sensitivity to unstable export prices, in our amended/rectified model we reduce an elasticity

A further dissection of the results for *plantation copra* for the year 1998 is helpful in explaining the volatility of the rate of return to capital in the industry. The world price of copra (foreign-currency price) declined by 11.0 per cent in 1998 and the exchange rate devalued by 24.7 per cent. In these circumstances we might expect the model to generate an additional export tax of about 13.7 per cent. However, the inflation rate was 13.6 per cent. If there had been an additional tax of 13.7 per cent (making the change in the Kina price of copra close to zero) then copra would have become very cheap in PNG relative to most other goods. In these circumstances, supply of copra from *smallholding copra* (which has the option of producing vegetables and livestock as well as copra) would have collapsed, leaving overall copra supply short of the exogenously-imposed export demand.[29] Thus, the movement in the export subsidy/tax is very small (0.7 per cent) leaving the Kina copra price broadly in line with the rate of inflation. Nominal wages in 1998 moved little (real wages fell by about 13 per cent). With the Kina price of copra increasing in line with inflation and with almost no change in nominal wages, at the 1997 level of output, the *plantation copra* industry would have achieved an increase in its returns to fixed factors, capital and land, equal to about 13 per cent of output. The actual increase in 1998 is even greater than this because the industry's output rose between 1997 and 1998. Given that returns to capital and land are a relatively small share of the value of output in

parameter (investment indexing parameter) BJ for the major exporting industries. Nevertheless, considerable volatility remains even in the Set B simulations.

29 Another possible cause of the high volatility in the capital-investment changes in the plantation copra industry is the mismatch between output, exports, demand for capital and the price of capital which, can lead to wide fluctuations in the rate of return to capital and hence large swings in investment growth. The inconsistency between the observed forecasts of export volumes and the forecast of aggregate real exports is very apparent in 1999. In that year, the export volume of many of the traditional exports increased but aggregate real exports in the national accounts declined by 4.5 per cent (both published in the quarterly economic bulletin of the Bank of Papua New Guinea). This stems from an inconsistency between the outdated weights used for the expenditure-side GDP account, (constant 1983 prices) and the make-up of export values and volumes in more recent years. For instance, the major agricultural exports of coffee and cocoa made up a higher percentage of total export values in 1983 than in a more recent year, such as 1997, because other exports (such as gold) increased their share in the total export value for the economy. We therefore revise our forecast for aggregate real exports based on 1997 export volumes and a weighting scheme using the 1997 export values. Nonetheless considerable volatility remains.

plantation copra, an increase in these returns worth more than 13 per cent of the value of output translates into a very large percentage increase in rental rates on capital (231.31 per cent, Table 3.23, line 10) and therefore on rates of return. Consequently, investment in the industry in 1998 increased by 43.71 per cent (Table 3.22, line 10).

The same transmission mechanisms can be used to explain the volatility in investment for *plantation-copra* in the other years as well to explain the volatility in investment for the other agricultural industries.

In 1999, 2000 and 2001 the decline in investment for *plantation copra* was so rapid (declines of 77.02, 47.95 and 80.07 per cent respectively, Table 3.22, line 10) that by 2002 the industry's level of investment is negligible. Even though the percentage growth in investment in 2002, 2004 and 2006 is large, the level of investment, which was at a negligible level at 2002, stays close to zero. Consequently, the capital stock in the industry declined at a rate close to the rate of depreciation (6 per cent) in the years 2002 to 2006.

The demand for labour by industries such as *plantation copra* and *smallholding copra* follows the trend in export demand for copra. For example 2001, when export demand for copra declined by 33.8 per cent, demand for labour in plantation copra and the *smallholding copra* industries declined. The labour decline is shared between the two industries because the *smallholding copra* industry can switch between the production of *copra* and the production of *fruits & vegetables* and *non-ruminant livestock*. In this instance, the *smallholding copra* industry cuts its production of copra and produces more of fruits & vegetables and non-ruminant livestock. Therefore in 2001, *smallholding copra* demands 4.5 per cent less labour for copra production and this saves the *plantation copra* industry from collapsing. In other words, the declines in labour demand and output of copra in the *plantation copra* industry are not as great as they would otherwise been in order to hit the exogenous declines in copra exports.

When the demand for fruit and vegetables and for non-ruminant livestock increases while the demand for copra is down, the *smallholding copra industry* finds that the expansion in vegetables and livestock is partly offset by a reduction in copra. This is possible through the provision of factor payment (rental) for land, land being one of the three factors of production in the model. In turn this reduces volatility in the demand for labour and output of copra below what would otherwise be the case. This saves the plantation copra industry from a total collapse.

3.4.2 Formal Urban Manufacturing Industries

In the formal urban manufacturing industries, namely, *Food Processing, Beverages and Tobacco, Metal Engineering* and *Machinery*, the results for the key variables are not as volatile as those in the agricultural exporting industries. This is because the mechanism between the demand for primary factors, the rate of return to capital, investment, capital stock, the activity level and output work out more or less as expected. Table 3.24 gives the relevant results for the four urban manufacturing industries. Of the industries in the manufacturing category we focus our discussion on *food processing*.

Analysis of the results for food processing for the year 1998 explains why the results for the key variables are not as volatile as for the agricultural exporting industries. The output of the industry is import-competing rather than for export. In 1998 the exchange rate devalued by 24.68 per cent (Table 3.21, row 43). If nothing

Table 3.24: Key Results for Selected Manufacturing Industries

	1998	1999	2000	2001	2002	2003	2004	2005	2006
				(Percentage change)					
Rate of Return to Capital									
FoodProcess	-26.82	219.03	23.05	-26.32	-25.31	5.44	-7.81	8.41	-9.46
Bever_Tobaco	16.01	118.71	45.21	1.03	-18.60	-0.04	10.24	4.21	-7.31
Metals_Engin	-61.19	200.17	39.92	-47.80	-32.29	15.82	-29.08	7.21	-21.12
Machinery	-62.36	309.00	45.40	-21.23	-27.56	15.16	-21.66	7.46	-13.83
Investment									
FoodProcess	-40.85	150.99	16.31	-7.97	-10.80	7.29	1.16	8.82	0.70
Bever_Tobaco	-9.86	68.99	29.40	19.54	-3.43	2.26	20.63	6.70	4.65
Metals_Engin	-65.63	135.53	31.06	-33.48	-21.59	13.84	-24.12	2.82	-16.30
Machinery	-69.69	216.11	32.19	-3.87	-14.32	15.81	-14.08	5.94	-5.96
Current Capital Stock									
FoodProcess	5.83	0.66	10.64	11.45	8.42	5.89	6.03	5.48	5.84
Bever_Tobaco	0.59	-0.09	4.01	6.41	7.91	6.45	5.96	7.59	7.47
Metals_Engin	16.22	0.69	9.50	12.52	5.02	2.26	3.18	0.77	0.91
Machinery	7.21	-2.19	6.17	9.12	7.33	4.67	5.79	3.59	3.80
End-of-year Capital Stock									
FoodProcess	0.60	10.62	11.49	8.41	5.87	6.04	5.48	5.84	5.26
Bever_Tobaco	-0.10	4.00	6.45	7.94	6.44	5.96	7.61	7.48	7.12
Metals_Engin	0.49	9.60	12.55	4.93	2.22	3.19	0.75	0.91	-0.27
Machinery	-2.32	6.26	9.15	7.32	4.64	5.80	3.57	3.81	2.88
Activity/Output Level									
FoodProcess	-10.32	34.51	12.78	10.5	10.09	10.59	6.51	8.28	8.44
Bever_Tobaco	-8.13	25.39	8.13	9.05	11.14	10.44	8.52	9.79	10.33
Metals_Engin	-12.61	41.96	11.63	6.53	4.12	8.32	-0.71	3.11	1.26
Machinery	1.52	13.26	9.45	8.82	13.31	8.77	6.13	5.26	5.98
Factor Demand									
FoodProcess									
labour	-24.20	59.26	6.93	9.74	-4.40	8.05	5.45	-2.38	6.73
capital	5.83	0.66	10.60	11.45	8.42	5.89	6.03	-0.14	5.84
land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bever_Tobaco									
labour	-15.90	38.07	6.40	16.02	-2.17	6.72	11.78	8.68	9.21
capital	0.59	-0.09	4.01	6.41	7.91	6.45	5.96	5.48	7.47
land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metals_Engin									
labour	-31.02	64.07	6.48	-0.09	-9.49	6.95	-5.94	9.40	-2.47
capital	16.22	0.69	9.50	12.52	5.02	2.26	3.18	7.59	0.91
land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery									
labour	-37.41	77.75	5.04	10.15	-5.53	9.34	-0.36	2.36	3.23
capital	7.21	-2.19	6.17	9.12	7.33	4.67	5.79	0.77	3.80
land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

else had changed, we would expect the Kina price of the commodity to increase by about 25 per cent. However, in 1998 the cif foreign-currency price of the commodity declined by 12 per cent. In view of this we would expect the increase in the price of *food processing* to be about 13 per cent (25 minus 12), which is close to the national rate of inflation (13.6 per cent, Table 3.21, line 18). However, in simulation B11, both the domestic basic price and domestic purchase price of the commodity rose by 3.7 per cent while the import counterparts increased by 16.21 per cent. The overall household purchase price rose by 8.9 per cent.

We see in Table 3.24 that in 1998 the food processing industry's rate of growth of capital, *kj*, was 5.83 per cent whereas its output declined sharply, by 10.32 per cent, reflecting the decline in aggregate consumption of 5.2 per cent (Table 3.21, row 5). Consequently, in 1998 much of capital in the industry was not being fully utilized; some of the capital was not producing output. This underutilization causes a collapse in the rental rate of capital for the industry. Given that the change in the nominal wage rate in 1998 was close to zero (Table 3.21, row 42) and the prices of intermediate inputs, both domestic and imported, rose at a weighted average rate of 13.6 per cent, the rental rate of capital fell by 9.6 per cent.[30] This limited the rise in food processing prices to a much lower level than the rate of inflation.

Because returns to capital comprises a 25 per cent (share) of the value of output in *food processing*, the 9.6 per cent decline in rental rates on capital had a large adverse impact on the rate of return to capital, *rj*, (-26.82 per cent) and so investment

30 The cost of intermediate inputs make up about 50 per cent of the total cost of the food processing industry, wages about 25 per cent and rental on capital about 25 per cent. So if the prices of intermediate inputs increase by around the national rate of inflation (13.6 per cent) and wages barely move, then the rental on capital has to decline by around 10 per cent for the 3.7 per cent increase in the domestic purchase price to be realized. ($p_d = \frac{1}{2}(13.6) + \frac{1}{4}(0) + \frac{1}{4}(x) = 3.7$).

in the industry declined by 40.85 per cent in 1998. Despite the decline in investment, the end-of-year capital stock, *kjplus1*, increased slightly, by 0.6 per cent. Even though investment in 1998 fell sharply, the level of investment remained greater than the level of depreciation, leading to an increase in the capital stock. In other words, the percentage decline in investment adds less to the level of capital stock and still yields an increase in capital stock in percentage terms.

3.4.3 Mineral Sector Industries

Both capital and land have large shares in total factor inputs in the mineral sector industries. This makes possible the existence of excess capacity in these industries and this capacity can be utilized when necessary. The extraneous forecasts of exports dictate the level of activity and output in the mineral sector industries. The required increase in the level of activity dictates the percentage changes in the use of land and capital, which in turn causes a (positively correlated) change in the use of labour. Table 3.25 gives the key results for the four mineral sector industries.

In our discussion we focus on the *Porgera mine* and the *Ok Tedi mine*. Porgera produces gold only whereas Ok Tedi produces mainly copper but also some gold. As Table 3.25 shows, in 1998 there was an increase in gold export demand of 2.00 per cent.[31] Output of gold therefore had to increase. All the increase in gold output occurred at the *Ok Tedi* mine (2.31 per cent) while gold output at *Porgera* declined by 0.23 per cent. This caused factor demand for labour, capital and land to increase more rapidly in *Ok Tedi* than in *Porgera* (see lower sections of Table 3.25). The percentage increase in factor usage in the mines are large relative to the percentage increases in output, constituting a deterioration in technology (0.96 per cent) in the year. The greater usage of capital in *Ok Tedi* relative to *Porgera* led to a greater increase in the end-of-year capital stock in *Ok Tedi* relative to *Porgera*. Underlying this was a greater percentage change in investment in *Ok Tedi* compared to *Porgera* (6.40 per cent compared to 3.63 per cent).

In 2002, export demand for gold increases by 6.71 per cent.[32] Output of gold therefore had to increase. In 2002 *Porgera mine* accounted for all the increase (10.90 per cent). Total output of *Ok Tedi* declined by 10.28 per cent, but recall that copper (not gold) is the main product of the *Ok Tedi* mine. The increase in activity in *Porgera* requires an increase in the use of primary factors, so demand for the composite factor input capital & land increased by 4.09 per cent and for labour increased by 6.52 per cent. In 2002 activity declined in *Ok Tedi* because of a decline in copper export demand and so its demand for primary factors fell, labour by 21.21 per cent and the capital and land composite by 15.02 per cent. In Table 3.25 we see that in the *Porgera* mine, the current capital stock, *kj*, increases by 4.09 per cent and the end-of-year capital stock, *ksnew*, increases by 4.45 per cent whereas for the *Ok Tedi* mine they declined by 15.02 and 14.72 per cent respectively. There is a net improvement in primary-factor-saving technical change. For the increase in *ksnew* to have occurred, investment by *Porgera* must have increased, as it did, by 13.8 per cent. (Recall that investment growth in the mineral industries does not necessarily reflect the extraneous forecast of aggregate real investment.)

3.4.4 Public Sector Industries

In both set A and B simulations, the standard theory of investment in our model (which allocates investment between industries depending on their rates of return to capital) does not apply to the public sector industries of *health*, *education*,

31 Note that in 1998 the export demand for copper, the main product of Ok Tedi increased by 2.00 per cent the same rate as export demand for gold, the other product of the Ok Tedi mine.

32 Note that in 2002 the export demand for copper, the main product of Ok Tedi, decreased by 11.66 per cent.

Table 3.25: Key Industry Results for the Mineral Sector Industries

	1998	1999	2000	2001	2002	2003	2004	2005	2006
				(Percentage change)					
FOB Foreign Currency Price									
Copper	-26.92	-24.55	77.00	1.00	0.00	6.40	-9.60	18.70	0.00
Gold	-11.14	-23.61	50.00	-2.70	2.00	-3.40	0.20	7.40	-10.50
OthMinerals	10.00	10.00	5.00	5.00	1.00	2.00	2.10	3.20	3.20
CrudeOil	6.00	25.61	25.00	-5.10	-13.57	15.70	0.00	-3.60	10.40
Export Demand									
Copper	2.00	30.66	9.13	40.28	-11.66	4.11	-9.33	-1.64	-12.10
Gold	2.00	6.59	15.68	-15.29	6.71	5.40	-9.43	-14.90	-19.04
OthMinerals	2.00	4.99	1.10	-3.39	8.73	2.42	-0.45	-1.64	-5.56
CrudeOil	2.00	8.67	-23.61	-19.09	11.83	-3.75	-19.70	-23.79	-19.33
Rate of Return to Capital									
PorgeraMine	12.63	-5.02	18.52	-21.89	2.28	0.41	-7.37	-9.36	-15.52
OkTediMine	13.77	3.10	15.91	1.51	-7.20	-0.32	-6.96	-1.14	-10.47
OtherMine	15.70	-5.86	18.73	-22.17	3.03	0.20	-6.92	-8.34	-14.15
Oil	40.17	-9.98	-24.26	-38.79	11.05	-11.37	-31.46	-33.69	-32.55
Industry Capital Stock									
PorgeraMine	0.69	-4.22	10.13	-20.11	4.09	1.67	-8.54	-16.62	-19.34
OkTediMine	3.13	12.76	6.98	31.84	-15.02	0.52	-9.66	-4.23	-14.23
OtherMine	8.64	-8.07	15.24	-28.22	7.78	1.90	-10.95	-20.89	-23.87
Oil	2.83	-1.87	-24.90	-17.96	4.91	-6.86	-19.32	-23.87	-20.12
End-of-Year Capital Stock									
PorgeraMine	0.91	-6.72	8.46	-20.08	4.45	1.55	-8.43	-16.81	-19.25
OkTediMine	3.43	9.27	4.82	32.30	-14.72	0.34	-9.51	-4.42	-14.02
OtherMine	8.98	-10.92	13.19	-28.20	8.23	1.74	-10.81	-21.10	-23.75
Oil	3.55	-4.85	-26.59	-18.11	5.34	-7.08	-19.45	-24.22	-20.18
Invesment Growth									
PorgeraMine	3.63	-37.11	-22.50	-19.39	13.78	-1.48	-5.78	-21.54	-16.88
OkTediMine	6.40	-23.73	-25.26	41.46	-9.15	-2.77	-6.83	-7.80	-10.34
OtherMine	12.53	-39.91	-18.70	-27.64	17.98	-1.31	-8.14	-25.38	-21.21
Oil	11.88	-36.38	-54.02	-22.04	17.03	-12.57	-22.88	-33.87	-22.15
Activity/Output Growth									
PorgeraMine	-0.23	5.97	14.16	-21.32	10.90	5.51	-8.36	-16.14	-18.51
OkTediMine	2.31	25.55	10.73	33.32	-10.28	4.26	-9.54	-2.99	-13.06
OtherMine	8.08	1.55	19.71	-29.73	15.02	5.75	-10.90	-20.66	-23.31
Oil	2.00	8.67	-23.61	-19.09	11.83	-3.75	-19.70	-23.79	-19.33
Porgera Factor Demand									
labour	1.05	-6.53	16.21	-29.97	6.52	2.66	-13.22	-25.28	-29.40
capital	0.69	-4.22	10.13	-20.11	4.09	1.67	-8.54	-16.62	-19.34
land	0.69	-4.22	10.13	-20.11	4.09	1.67	-8.54	-16.62	-19.34
Ok Tedi Factor Demand									
labour	4.56	19.32	10.40	49.51	-21.21	0.77	-13.91	-6.16	-20.29
capital	3.13	12.76	6.98	31.84	-15.02	0.52	-9.66	-4.23	-14.23
land	3.13	12.76	6.98	31.84	-15.02	0.52	-9.66	-4.23	-14.23
Other Mine Factor Demand									
labour	12.01	-11.09	21.79	-37.42	11.08	2.68	-15.10	-28.34	-32.32
capital	8.64	-8.07	15.24	-28.22	7.78	1.90	-10.95	-20.89	-23.87
land	8.64	-8.07	15.24	-28.22	7.78	1.90	-10.95	-20.89	-23.87
Oil Factor Demand									
labour	5.33	-3.66	-43.71	-32.55	9.71	-13.06	-34.40	-40.96	-34.48
capital	2.83	-1.87	-24.90	-17.96	4.91	-6.86	-19.32	-23.87	-20.12
land	2.83	-1.87	-24.90	-17.96	4.91	-6.86	-19.32	-23.87	-20.12

government administration and *electricity & garbage*. In these public sector industries investment growth depends on social objectives, for example, an equitable distribution of goods and services. We model this by assigning a value of zero to the coefficient *I2J* in these industries investment function.

Consequently, we see that the standard behavioural relationship between the rate of return to capital, investment growth and the change in capital stock is not evident in the public sector industries. Investment growth in these industries is dictated by the scalar shifter for investment rather than by the industry's rate of return to capital. Table 3.26 shows results for relevant variables for the public sector industries.

Activity levels in the government industries reflect government spending (other demand) and aggregate consumption, rather than investment. There are positive changes in activity levels for all years except 1998. These reflect increases in government spending and aggregate consumption. When activity levels in the electricity/garbage industry increase (fall) demand for labour increases (decreases). Even though activity levels in the other three public sector industries (education, health and government administration) increase in each of the years 1999 to 2006, the results for changes in the demand for labour are sometimes positive and sometimes negative; we have not tried to trace the explanation for this result. Despite the increase in activity level in the government industries, capital stock for most of the industries declines during most of the period.

Table 3.26: Key Results for Public Sector Industries

	1998	1999	2000	2001	2002	2003	2004	2005	2006
					(Percentage change)				
Rate of Return to Capital									
Education	37.48	-58.25	11.79	-13.86	-9.95	-10.05	-2.63	-1.76	-13.67
Health	51.98	-39.96	27.22	-9.35	-1.36	-1.33	1.67	4.63	-8.76
Elect_Garbge	40.19	79.49	79.32	60.25	39.53	54.78	72.25	73.93	62.44
GovtAdm	41.10	-55.78	18.38	-4.91	-7.00	-4.40	5.84	5.97	-7.26
Investment									
Education	16.05	-30.67	-36.37	5.32	8.32	-2.63	5.64	-2.47	8.44
Health	14.18	-31.94	-37.17	4.53	7.46	-3.47	4.75	-3.34	7.52
Elect_Garbge	7.23	-36.69	-40.12	1.57	4.27	-6.61	1.48	-6.55	4.09
GovtAdm	13.72	-32.26	-37.36	4.33	7.25	-3.68	4.53	-3.55	7.29
Current Capital Stock									
Education	6.74	7.82	2.89	-0.46	-0.15	0.34	0.16	0.49	0.3
Health	5.01	5.95	1.67	-1.22	-0.95	-0.53	-0.69	-0.4	-0.56
Elect_Garbge	-1.46	-1.06	-2.84	-4.04	-3.92	-3.75	-3.81	-3.69	-3.76
GovtAdm	4.57	5.48	1.37	-1.41	-1.15	-0.74	-0.9	-0.62	-0.78
End-of-year Capital Stock									
Education	7.85	2.89	-0.51	-0.14	0.35	0.16	0.49	0.3	0.81
Health	5.97	1.68	-1.27	-0.95	-0.52	-0.69	-0.39	-0.56	-0.12
Elect_Garbge	-1.06	-2.84	-4.06	-3.92	-3.75	-3.81	-3.69	-3.76	-3.58
GovtAdm	5.5	1.37	-1.45	-1.15	-0.74	-0.9	-0.62	-0.78	-0.35
Activity/Output Level									
Education	-2.21	3.92	1.48	1.56	1.61	1.79	1.68	1.81	1.94
Health	-2.93	7.66	2.98	2.62	2.42	3.01	2.15	2.6	2.48
Elect_Garbge	-7.21	20.68	3.57	2.77	4.47	3.45	1.13	1.29	1.67
GovtAdm	-2.42	5.25	1.87	1.93	2.05	2.25	1.98	2.13	2.27
Primary Factor Demand									
Education									
labour	-5.22	-13.56	-3.78	3.06	-6.50	-2.86	1.41	0.20	-0.42
capital	6.74	7.82	2.89	-4.60	-0.15	0.34	0.16	0.49	0.30
land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Health									
labour	-3.44	-4.99	-0.62	4.00	-4.40	-0.70	2.02	1.43	0.54
capital	5.01	5.95	1.67	-1.22	-0.95	-0.53	-0.69	-0.43	-0.56
land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elect_Garbge									
labour	-12.00	27.63	7.10	22.43	4.35	12.01	18.34	16.77	18.30
capital	-1.46	-1.06	-2.84	-4.04	-3.92	-3.75	-3.81	-3.69	-3.76
land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GovtAdm									
labour	-6.32	-13.99	-3.34	5.45	-6.45	-1.95	3.18	1.64	0.86
capital	4.57	5.48	1.37	-1.41	-1.15	0.74	-0.90	-0.62	-0.78
land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3.5 *Conclusion*

The aim of this chapter was to achieve a reasonable set of model-generated forecasts for the PNG economy. We started by developing a forecasting closure for the PNG-ORAMON dynamic general equilibrium model of the Papua New Guinea economy. We ran two sets of simulations, the first with an exogenous exchange rate (Set A) and the second with an endogenous exchange rate (Set B). In the first set of simulations changes in export subsidies/taxes are crucial in attaining parity between domestic prices and the rest-of-the-world prices. In contrast, in the second set of simulations, there are two new adjustment mechanisms. First, the exchange rate adjusts in response to changes in domestic prices relative to changes in the rest-of-the-world prices, and second, primary-factor-saving technical change plays part of the reconciliatory role. Whenever the extraneous change in the *CPI* is less than the change in the exchange rate, industry-level export subsidies/taxes adjust to reconcile the difference. The increases and decreases in the subsidies/taxes offset each other so that the average and the total export subsidy/taxes remain unchanged. The model-generated nominal exchange rate depreciations for 1989 to 2001 are close to the actual outcomes for the years.

From the analysis of the Set A simulations, we made improvements to our initial model. The improved model is used in the Set B simulations. The modifications to the model relate in particular to primary-factor intensity and usage, and to capital accumulation. We adopted different approaches in our analysis of primary factor demand, capital-investment linkage and output for the four broad categories of industries in the economy. Adopting different approaches in the analysis for the four sectors seems appropriate given the dual nature of the economy and the different developmental stages of the various industries. Important features are the modelling of multi-product industries (such as smallholding industries) and of the multi-industry products of copra, cocoa, coffee and palm oil.

In generating our forecasts for the PNG economy we allowed all the determinants of the expenditure-side of GDP to be exogenous. In allowing aggregate real investment to be exogenous, the linkage between the interest rate and investment does not come into play. The dynamics of interest, investment and capital stock will have a role in the next chapter, which discusses policy-induced deviations in the forecast results from the basecase forecasts generated in this chapter.

We use the forecast results of simulation B11 (in which all relevant exogenous variables are shocked) for our policy analysis in the next chapter. The choice of set B simulations over set A is based on three reasons. First, authorities in PNG know what the underlying inflation rate is and make forecasts of inflation whereas it is not a usual practice in PNG to make predictions about changes in the exchange rate. Second, Set B gives reasonable results in the context of the current floating exchange rate regime. Although it could be argued that changes in the Kina exchange rate are important in explaining inflation changes, it makes sense to let the nominal exchange rate be endogenous in the model. Third, the modifications to the model, following the set A simulations, have enabled the model to better capture the four different broad groupings of the 42 industries in the model.

Chapter 4

The Effects of Changes in Fiscal and Monetary Policies

4.1 Introduction

Having established the baseline path (pre-policy-shock forecasts) of the economy in chapter three, in this chapter we now want to examine the "disturbances" to that path as a results of policy shocks. In particular, we examine the impact on the economy of changes in fiscal and monetary polices for the forecast period 2002 to 2006. We do this by looking at policy-induced deviations in variables away from the basecase forecasts. In analysing the deviations, we explore the transmission pathways of the introduced shocks as they work through the economy. The pathways reflect three factors. The first is the modelling of the behaviour of different agents which is underpinned by economic theory. The second is the inter-dependencies of industries which are underpinned by the input-output matrices in the database of the PNG model. The third is the closure for policy simulations which we explain in section 4.2. Where appropriate we employ a back-of-the-envelope model technique (a model of a model) to help us abstract from the intricacies of the actual model and explain the results.

In the mid-1980s to 2000, the fiscal policy of successive governments of PNG was expansionary. Monetary policy reacted to this and bore the brunt of fiscal policy, being either accommodating or counter-active to the impact of the expansionary fiscal policy. Our primary concern in this chapter is to analyse the economic impacts of "reactionary" monetary policy change, under a floating exchange rate regime, the aim of which is the pursuit of macroeconomic stability.

We examine three policy-change scenarios. Each scenario involves the national government's fiscal policy and the central bank's monetary policy. In each, the fiscal policy involves an increase in government spending. The increase in government spending is not always accompanied by an increase in government revenue (an increase in tax rates for example). There are two options for monetary policy. The first option is that the central bank opts for an accommodating monetary policy by leaving interest rates unchanged, directly or indirectly.[33] With an accommodating monetary policy, central bank allows the money supply to increase, and tolerates the inflationary consequences with a view to maintain investment growth. The second option is one of tight monetary policy through money supply (exogenous) targeting and a flexible interest rate (endogenous). With tight monetary policy, the bank is prepared to sacrifice investment growth in order to achieve low inflation.

Our first policy change scenario (policy scenario A) will involve interest rate targeting by the central bank under an expansionary fiscal policy but with no increase in tax rates. The second policy scenario (policy scenario B) will involve money supply targeting by the central bank under an expansionary fiscal policy but still with no increase in tax rates. The third policy scenario (policy scenario C) will involve money supply targeting under an expansionary fiscal policy backed by an increase in tax rates.

33 The issue of direct control of interest rates or indirect control (via open market operations), is not within the scope of this thesis. In a closure where the interest rate is endogenous, the change in the interest rate required for money supply not to change or to change by a given amount can be viewed as an indirect control of the interest rate.

The basecase forecasts from which we compute policy-induced deviations is simulation B11, in which all the relevant exogenous variables were shocked under the closure depicting a floating exchange rate regime (that is, endogenous nominal exchange rate).

In this chapter our time horizon is the five-year period 2002 to 2006 as these are the genuine future years (at the time of writing).

4.2 The Policy Closure

In the policy closure, many of the variables which were exogenous in the forecasting closure are now endogenous. Rather than getting forecasts of these variables from responsible agents or making estimates for them, as was the case for the forecasting closure, we now want to see the impact of a policy change on them. We develop our policy closure from the basic closure as shown in column 2 of Table 3.1 (for the BOTE model) and column 2 of Table 3.2 (for the actual model). In our policy closure we want key variables such as the demand components of GDP to be endogenous, so that when a shock representing a policy change is applied, the model determines by how much the endogenous variables change.

As explained in Chapter 3, the basic closure is quite similar to the starting closure, the exceptions being the exogenization of F_I, investment shifter, and W_R, the real wage rate, in place of I, aggregate real investment, and L, aggregate employment, respectively. To remind ourselves of the basic macro closure and thereby help us to establish the macroeconomic connections in terms of a flow chart for each of the policy scenarios, we use the back-of-the-envelope (BOTE) model presented in Chapter 3. The BOTE model is a useful tool to understand and explain the policy-induced results of the actual model. The relevant equations of the BOTE model are reproduced here with some simplifications.

Production function:

$$Y = \frac{1}{A} F(K, L) \tag{4.1}$$

GDP identity:

$$Y = C + I + G + (X - M) \tag{4.2}$$

Real wage rate equals marginal product of labour. Marginal product of labour depends on technology and K/L ratio:

$$\left(\frac{W}{P_d}\right) = \frac{1}{A} F_l \left(\frac{K}{L}\right) \tag{4.3}$$

Real rental rate equals marginal product of capital. Marginal product of capital depends on technology and K/L ratio:

$$\left(\frac{Q}{P_d}\right) = \frac{1}{A} F_k \left(\frac{K}{L}\right) \tag{4.4}$$

Public consumption depends on GDP:

$$G = APCG * Y \tag{4.5}$$

Private consumption depends on GDP:

$$C = APC * Y \tag{4.6}$$

Investment depends on the rate of return (ROR) compared with the interest rate (R). Investment can also move independently of ROR and R via the shift variable (F_I):

$$I = I(ROR, R, F_I) \tag{4.7}$$

Demand for money depends on nominal GDP and the rate of interest:

$$M^d = M^d(P*Y, R) \tag{4.8}$$

These variables were defined in section 3.2 of chapter three.

4.2.1 Macro connections in flow-chart

The closure showing the macro connections is fundamentally similar in the three policy scenarios. The key differences reflect the monetary policy stance of the central bank, with the interest rate or the money supply being the target variable. Policy scenario A has the interest rate as the exogenous variable (accommodating monetary policy) while money supply is the exogenous variable (tight monetary policy) in policy scenario B. In policy scenario A, the exogenous interest rate (together with nominal income) can be thought of as determining the money supply via equation (4.8) whereas in policy scenario B the exogenous money supply (together with nominal income) can be thought of as determining the interest rate via equation (4.8). The closure in policy scenario C is the same as that for policy scenario B with the exception being the increase tax rates.

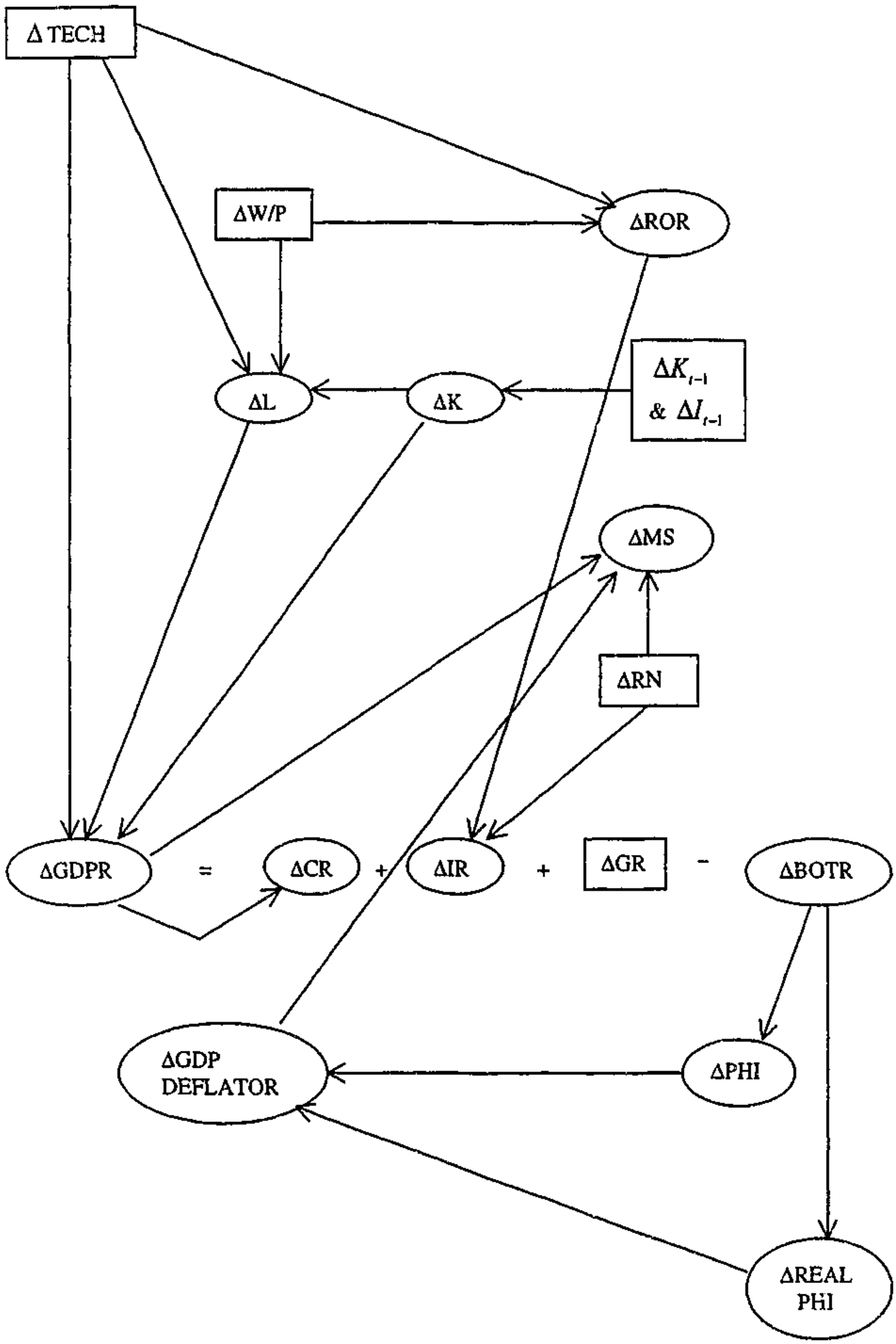
Figure 4.1 shows diagrammatically the macro connections in the closure for policy scenario A. In this Figure (and the other two as well), a variable in a square or rectangle is exogenous while that in an oval is endogenous. An arrow shows the causation path. The production function (4.1) tells us that technology, labour and capital influence real GDP. Thus, we have arrows linking factor inputs ΔTECH, ΔL and ΔK to ΔGDPR. Real wage rate, $\frac{W}{P_d}$, is normally exogenous or at least sticky by assumption in our policy simulations.

From equation (4.3) the real wage equals the marginal product of labour which in turn depends on the capital-labour ratio and technology. Equation (4.3) can be rearranged so that labour growth, ΔL is a function of the real wage rate, technology and capital, $L = \psi\left(K, \frac{W}{P}, \frac{1}{A}\right)$. This relationship is represented by arrows pointing from $\Delta\frac{W}{P}$, ΔTECH and ΔK to ΔL.

Capital stock, ΔK, is shown as an endogenous variable in Figure 4.1. This is because in the actual model the level of capital stock at the start of a year is dependent on the capital stock and investment flow in the previous year, $K_t = f\left(K_{t-1}, I_{t-1}\right)$[34]. Implementation of this lagged relationship is facilitated by the homotopy variable del_unity.

34 However, logically the capital stock at the start of a year can be viewed as a given because the investment flow in the previous year increases the capital stock by the end of that year, which, after allowing for depreciation, becomes the capital stock level at the start of the next year.

Figure 4.1: Macro Connections in the Closure for Policy Scenario A



From equation (4.4) the rate of return to capital can be expressed as a function of the marginal product of capital, which in turn depends on the capital-labour ratio and technology. The rate of return to capital is also equal to the real rental on capital; $MPK\left(\frac{K}{L}, A\right) = \frac{Q}{P_d} = ROR$. From this equation and equation (4.3), we can deduce that $ROR = \gamma\left(A, \frac{W}{P}\right)$. Hence, there are arrows from ΔTECH and $\Delta\frac{W}{P}$ to ΔROR.

Through equation (4.8), GDP, the price level and the interest rate affect the demand for money, which is equal to the money supply. Thus, there are arrows from ΔGDPR, ΔGDPDEFLATOR and ΔRN to ΔMS. The interest rate affects investment growth through the investment function (4.7). Investment growth is also dependent on the rate of return to capital. These justify the arrows linking ΔRN and ΔROR to ΔIR.

Within the GDP identity aggregate consumption is endogenized via equation (4.5). This is indicated in Figure 4.1 by an arrow linking ΔGDPR to ΔCR. Other demand (government) ΔGR is exogenous. The balance of trade is endogenized as a residual.

The realization of the residual change in the balance of trade (ΔBOTR) requires the real exchange rate to move. The direction and extent of the required movement in the real exchange rate (ΔREALPHI) partly depends on the elasticities of the supply and demand for exports and imports. The higher these elasticities the smaller is the movement in the real exchange rate change that is required to facilitate any residual movement in the trade balance. Furthermore, the higher the elasticities, the smaller is the terms-of-trade movement associated with any given change in the trade balance. In the figure we encapsulate all this with an arrow from ΔBOTR to ΔREALPHI.

In the actual PNG model we have included a causation from the trade balance to the nominal exchange rate to reflect the floating exchange rate regime: $phi = f(BOT)$, represented by an arrow from ΔBOTR to ΔPHI. In effect, the nominal exchange rate is the numeraire although it is endogenous.

Given the definition of the real exchange rate: $realexch = phi + gdpdeflator - price_{foreign}$, and assuming that $price_{foreign}$ is fixed, the nominal exchange rate and the real exchange rate determine the domestic price level (the GDP deflator).

In policy scenario B, the central bank opts for a tight monetary policy stance by targeting money supply. Money supply, ΔMS, is therefore exogenized through the enodogenization of the interest rate, ΔRN (that is, ΔMS is swapped with ΔRN). The macro closure for the policy scenario B is depicted in Figure 4.2, in which there is an arrow from ΔMS to ΔRN. Through the money demand function (4.7), GDP and the domestic price level impact on the interest rate. These are the only changes moving from Figure 4.1 to Figure 4.2.

Figure 4.2: Macro Connections in the Closure for Policy Scenario B

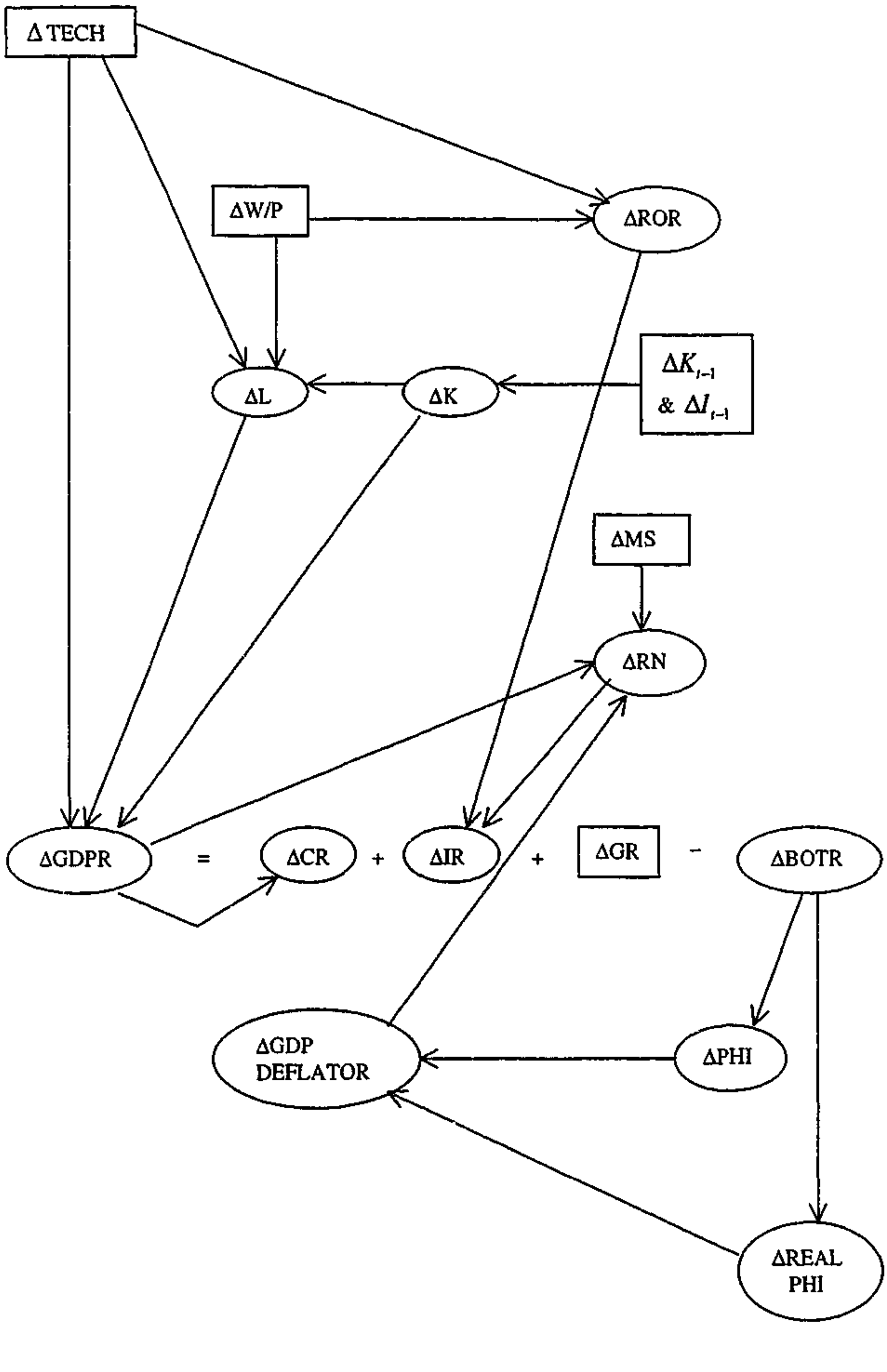
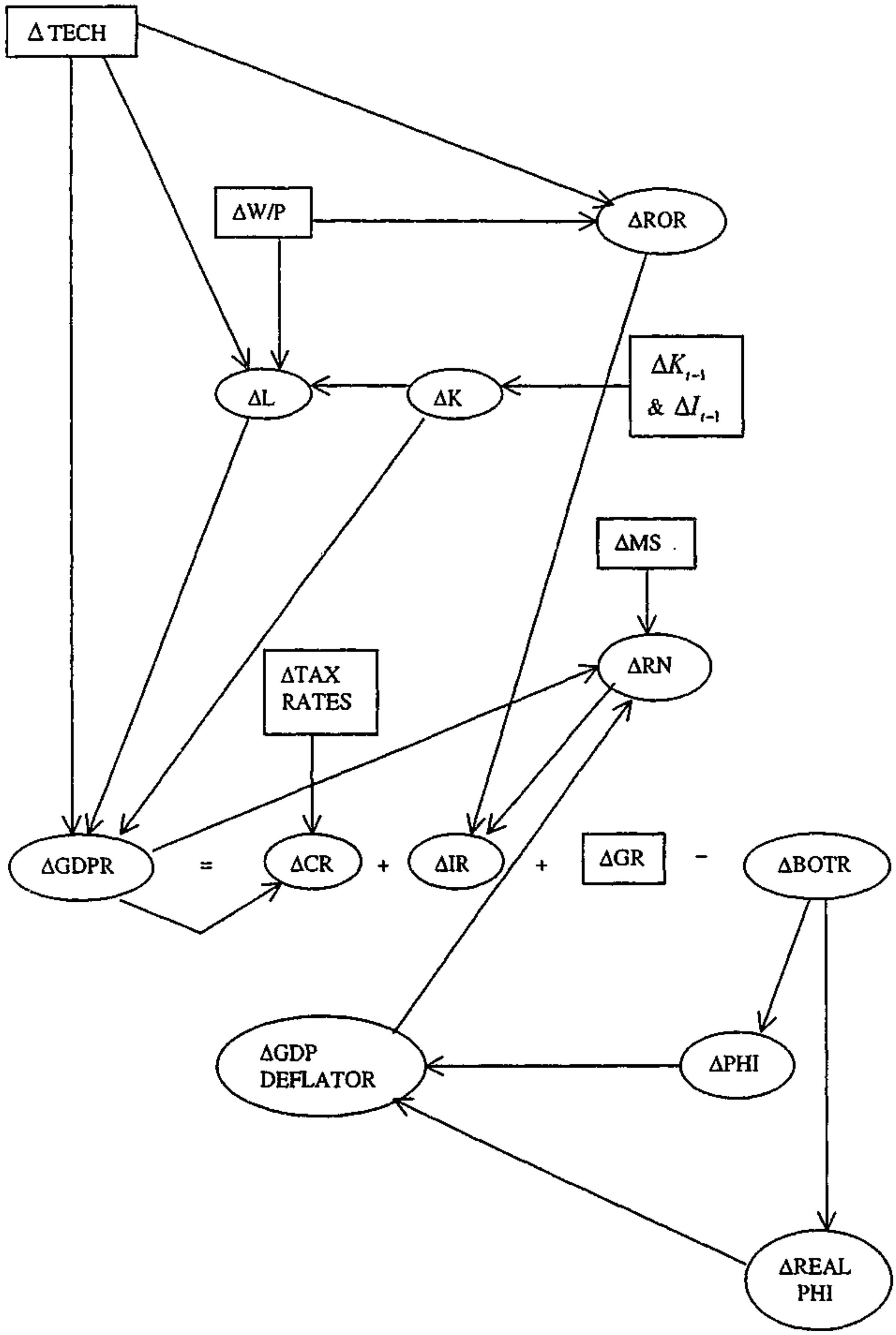


Figure 4.3: Macro Connections in the Closure for Policy Scenario C



In policy scenario C, the central bank continues to pursue a tight monetary policy but this time the increase in government spending is backed by an increase in revenue obtained through an increase in excise and tariff rates, which are exogenous in all the three policy closures. The macro closure depicted in Figure 4.3 is therefore the same as for policy scenario B. The only addition is the tax rates. This impacts on aggregate consumption. Hence, the arrow linking ΔTAXRATES to ΔCR.

The tax changes introduced in policy scenario C include increases in tariffs. Because tariff increases have a direct damping effect on imports we could include another arrow in Figure 4.3, connecting ΔTAXRATES to ΔREALPHI. The damping effect of tariffs on imports means that any given increase in the balance of trade can be achieved with less real devaluation than if there had been no increase in tariffs. Thus, tariff movements affect the real exchange rate.

4.3 Technique Adopted for Policy Analyses

The technique adopted for policy analyses, is to report percentage deviations away from a control solution. This technique was developed and is used in the application of the MONASH model (Dixon and Rimmer, 2002). The basecase forecasts we use here were generated using the forecasting closure described in the previous chapter. The deviations are generated by comparing the results from the policy closure with those from the forecasting closure.

To compute deviations attributable to policy changes, the basic closure, which in effect becomes the policy closure, is used to reproduce the control or basecase forecasts by:

- applying to the variables which are exogenous in both closures the shocks which were applied under the forecasting closure; and
- applying to the variables which are exogenous in the basic closure but endogenous in the forecasting closure shocks identical to the solution values for the variables in the results from the forecasting simulation (the results for simulation B11 of chapter three in this case).

In essence, the results produced using the basic closure should be the same as the basecase forecasts produced using the forecasting closure.

The next step is to run the policy deviation simulations. For this we add shocks to the relevant variable or variables to represent the policy change of interest. The projections of the effects of the policy change are the differences between the results for the variables which are endogenous in both the policy simulations and the control forecasting simulations.

4.4 The Background Setting

In its 2002 budget, the National Government plans to increase its nominal spending by 3.5 per cent relative to 2001. Given that 2002 is an election year, we assume that nominal expenditure will in fact exceed the 3.5 per cent. Specifically, we assume that real recurrent government expenditure will increase by 2.5 per cent in 2002. Graphically, the demand curve for the government would shift to the right. In the simulations, variable *f5* is shocked by 2.5 per cent.

An increase in government expenditure in the PNG economy can cause liquidity in the banking system to increase, especially if the increase is financed domestically, and can lead to inflationary pressures and so exert downward pressure on the foreign-currency value of the domestic currency. The central bank has two options as mentioned earlier. Its first option is to accommodate the expansionary fiscal policy by adopting an easy monetary policy stance (for investment growth consideration). Its second option is to tighten monetary policy via an increase in interest rates (in order to absorb excess liquidity and reduce the volatility in both inflation and the exchange rate).

4.5 The Three Simulations

4.5.1 Policy Scenario A: Accommodating Monetary Policy (Interest Rate Targeting) in response to Increased Government Spending

First, we examine the case in which the central bank is concerned primarily about investment growth. To encourage business activity in the private sector and the economy at large, the central bank decides that monetary policy should be accommodative of the expansionary fiscal policy. Thus it responds to an increase in government spending by allowing the money supply to increase to such an extent that there is either no increase or an increase of a desirable small amount in the interest rate. In this scenario, the interest rate is exogenous. It can be held constant by not shocking it or can be allowed to change by shocking it with a targeted small percentage change. We will look at the scenario where the interest rate is held constant relative to the baseline forecasts.

In the context of the PNG model, the motivation for the central bank to avoid an interest rate increase is that such an increase has a bearing on the economy-wide required rate of return, *lambda*. An increase in the interest rate leads to an increase in *lambda* (because the cost of borrowing affects net returns to capital) . Unless the rate of return to capital also increases by the same amount or by more than *lambda*, an industry's investment growth would decline. So a higher *lambda* requires an increase in the rate of return to capital for an industry to sustain its current investment growth rate or better still increase its investment growth rate under its current resources and capacity. If investment growth is sustained, it will in turn sustain a particular output level. Consequently, changes in the interest rate affect *lambda*, which in turn affects investment. Real investment is therefore inversely related to *lambda*, as shown in the industry investment function[35] in the model.

Macro Results for Policy Scenario A

We apply the BOTE model to establish our *a priori* expectations of the results before examining the actual results.

Predictions Based On the BOTE Model

From the equations of the BOTE model in section 4.2 (equations 4.1 to 4.8) we can deduce what to expect. In the first year (the short run), technology and capital do not change relative to the basecase forecast. By assumption, the real wage rate does not change relative to the basecase forecast. Therefore, with the twist in the capital-labour choice exogenous, the marginal product of labour in equation (4.3) does not change. If K and W/P are constant then L has to be constant as well relative to the basecase forecast in order for equation (4.3) to hold. Hence, we can expect little or no change in labour, L. Thus, from equation (4.1) there can be little change in output Y.

---

35 $yj_{(i)} = f1J_{(i)} * kj_{(i)} + BJ_{(i)} * f2J_{(i)} * \left(rj_{(i)} - lambda\right) + f2j_{(i)} + f2$

With little change in Y, aggregate consumption C, which is proportional to Y, can also change by little (equation 4.5).

Aggregate investment depends on the rental rate to capital, the interest rate and the industry's investment shifter. As noted above, K is constant and L changes little. So the marginal product of capital also changes little. For the marginal product of capital to hardly change, the real rental price of capital in equation (4.7) has little room to move. Therefore, aggregate investment also changes little.

Total *Other Demand* (Government), G, is given a positive exogenous shock. To allow this to happen, the average propensity of the government to consume out of the total expenditure is endogenous (see equation 4.5).

With little changes in C and I, and given the exogenous increase in G, there has to be a decline in the trade balance relative to the base forecast in order for the small change in Y to be realized. This implies either a reduction in exports or an increase in imports or a combination of both.

Deterioration in the trade balance is facilitated in the model by real appreciation, that is, an increase in the real exchange rate where the percentage change in the real exchange rate is defined by

$$realexch = phi + epsilon1 - pm \quad . \tag{4.9}$$

In this equation phi is the percentage change in the nominal exchange rate, $epsilon1$ is the percentage change in the GDP price deflator, and pm is the percentage change in an index of cif foreign-currency import prices. We measure inflation in the rest of the world by pm and inflation in PNG by $epsilon1$. Thus, real appreciation occurs when the excess of inflation in PNG over that in the rest of the world is not offset by nominal devaluation.

Real appreciation leads to a deterioration in the trade balance in two ways. First, it harms export industries. Kina costs in export industries tend to move with $epsilon1$ (domestic inflation) whereas Kina selling prices for export industries tend to move with $pm - phi$. When there is real appreciation

$$pm - phi \prec epsilon1 \quad . \tag{4.10}$$

Consequently, export industries suffer because of a decrease in their selling prices relative to their costs. The second way in which real appreciation leads to a deterioration in the trade balance is by harming import competing industries. For these industries, the movement in the Kina price of competing imports is $pm - phi$ and the movement in costs is $epsilon1$. Consequently, import-competing industries suffer an erosion of their competitive position in the PNG market.

Actual Simulation Results for the Short Term: Year 2002

In this simulation, there is no change in the interest rate in the policy forecasts relative to the control forecasts. The macro results are expressed as cumulative percentage deviations in the policy simulation from the basecase forecasts. They are presented in Table 4.1.

Table 4.1: Cumulative Deviated Macro Results Under Fiscal Expansion and Interest Rate Targeting (with investment theory turned off for public sector industries)

	Variable Model Name	Economic Name	2002	2003	2004	2005	2006
			percentage change (unless where indicated)				
1	a1primgen	Tech Coefficient	0.00	0.00	0.00	0.00	0.00
2	aggl	Aggregate Employment	0.52	0.44	0.41	0.38	0.34
3	c1	Aggregate Nominal Cons	0.54	0.46	0.42	0.39	0.36
4	chie	Govt Consumption	2.39	2.38	2.38	2.38	2.38
5	cr	Agg Real Consumption	-0.19	-0.21	-0.21	-0.20	-0.20
6	d_avesub	Change in Ave Subsidy*	0.00	0.00	0.00	0.00	0.00
7	d_totsub	Change in Total Subsidy*	-0.49	-0.74	-0.49	-0.30	0.02
8	del_bt	Change in Trade Balance*	-12.75	-13.00	-21.54	-26.59	-34.86
9	del_btgdp	Change in BT to GDP ratio*	0.00	0.00	0.00	0.00	0.00
10	del_unity	Homotopy Variable	0.00	0.00	0.00	0.00	0.00
11	deltab	Real Trade Account*	-7.79	-7.67	-8.47	-9.38	-10.38
12	deltabn	Nominal Trade Account*	-2.71	-3.67	-5.41	-6.59	-8.14
13	deltabotd	Trade balance in Dom Currency*	-11.00	-9.08	-33.93	-50.87	-73.77
14	deltabotf	Trade balance in For Currency*	-11.90	-10.71	-17.53	-22.51	-28.78
15	deltac	Current Account*	-2.71	-3.67	-5.41	-6.59	-8.14
16	deltagb	Govt's Budget Position*	-54.56	-52.62	-53.22	-53.50	-52.51
17	efcreal	Agg Real Exports	-0.09	-0.10	-0.12	-0.15	-0.18
18	epsilon1	GDP Deflator	0.90	0.81	0.77	0.73	0.69
19	epsilon2	Capital Goods Price Index	0.85	0.73	0.67	0.60	0.53
20	epsilon3	Consumer Price Index	0.74	0.67	0.64	0.60	0.56
21	f1	Wage Shifter	0.00	0.00	0.00	0.00	0.00
22	f2	Investment Shifter	0.00	0.00	0.00	0.00	0.00
23	f4	Exports Shifter	0.00	0.00	0.00	0.00	0.00
24	f5	Other Dd Shifter	2.50	2.50	2.50	2.50	2.50
25	f_obs	Shifter for forecast exports	0.00	0.00	0.00	0.00	0.00
26	f_phi	Shifter for forecast exchange rate	0.64	0.55	0.49	0.43	0.37
27	fc	Consumption Shifter	0.00	0.00	0.00	0.00	0.00
28	gc	Govt Consumption Expenditure	4.21	4.03	3.98	3.92	3.82
29	gdp	Nominal GDP	0.96	0.84	0.79	0.73	0.68
30	gdpr	Real GDP	0.07	0.04	0.02	0.01	0.00
31	gex	Total Govt Expd	3.31	3.21	3.21	3.22	3.17
32	gi	Govt Capital Expd	0.86	0.74	0.68	0.61	0.54
33	gireal	Govt Real K Expd	0.00	0.00	0.00	0.00	0.00
34	go	Other Govt Expenditure	0.00	0.00	0.00	0.00	0.00
35	grev	Total Govt Revenue	0.80	0.70	0.65	0.61	0.56
36	in	Agg Nominal Investment	0.86	0.71	0.63	0.55	0.46
37	ir	Agg Real Investment	0.02	-0.02	-0.03	-0.05	-0.07
38	ksnew	Agg Capital Stock	0.00	0.00	0.00	0.00	-0.01
39	Lambda	Economy-wide Rate of Return	0.00	0.00	0.00	0.00	0.00
40	lr	Returns to Land	0.54	0.45	0.37	0.30	0.24
41	lw	Wage-Weighted Employment	0.57	0.50	0.48	0.45	0.42
42	mfcreal	Real Imports	0.18	0.14	0.13	0.13	0.13
43	mn	Money Demand	0.96	0.84	0.79	0.73	0.68
44	p0toft	Terms of Trade	0.00	0.00	0.00	0.00	0.00
45	p1lab_io	Nominal Wage	0.74	0.67	0.64	0.60	0.56
46	phi	Nominal Exchange Rate	-0.65	-0.56	-0.49	-0.43	-0.37
47	q1	Households	0.00	0.00	0.00	0.00	0.00

... Continued

Table 4.1 continued

Variable *Model Name*	*Economic Name*	2002	2003	2004	2005	2006
48 realwage	Real Wage	0.00	0.00	0.00	0.00	0.00
49 refg	Foreign Grant	0.00	0.00	0.00	0.00	0.00
50 rn	Interest Rate	0.00	0.00	0.00	0.00	0.00
51 totgexreal	Agg Govt Expd	1.73	1.79	1.83	1.89	1.93
52 twistimp	Import Twist	0.00	0.00	0.00	0.00	0.00
53 twistlk	Labour Twist	0.00	0.00	0.00	0.00	0.00
54 xi4	Export Price Index	0.63	0.54	0.48	0.42	0.36
55 xig	Other Demand Price Index	1.81	1.65	1.60	1.54	1.44
56 xim	Import Price Index	0.63	0.54	0.48	0.42	0.36
57 realphi	Real Exchange Rate	0.27	0.27	0.29	0.31	0.37

* change in Kina million

The increase in government spending accompanied by an easy monetary policy causes real appreciation (the rate of domestic inflation is higher than the rate of devaluation) See table 4.1, rows 18 and 46. As we spell out in more detail when discussing the industry results for this simulation, we find that exporting and import-competing industries fared badly. With the real appreciation, real imports (defined in foreign-currency) increase as a result of the policy change by 0.18 per cent while real exports (defined in foreign-currency) decline by 0.09 per cent in 2002 (Table 4.1, rows 42 and 17). This yields a decline of K7.79 million in the real trade balance. In nominal terms, the trade balance deteriorates by K11.0 million in 2002 relative to the control forecast (Table 4.1, row 13).

In all the policy simulations the nominal exchange rate is endogenous. It depends on the gap between the result for the balance of trade to GDP ratio in the policy simulation compared to the result for the same ratio in the basecase forecast. For this, equation (2.94) defined in sub-section 2.2.11 of chapter two, now comes into play:

$$\left(\frac{EXCH}{EXCH\_F}\right)*(phi-phi\_f)= \\ 100*ALPHA*(del\_btgdp-del\_btgdp\_f)+del\_f\_btgdp \quad . \tag{4.11}$$

In the basecase forecasts this equation was redundant as *phi* was equal to *phi_f*. In policy forecasts *phi* is model-determined (and different from its value in the forecast simulation). With the policy-induced deterioration in the nominal trade balance[36], the Kina depreciates by 0.65 per cent in 2002 relative to the basecase forecast (Table 4.1, row 46). Intuitively, the increase in imports and the decline in exports under the policy change exert downward pressure on the Kina exchange rate.

While exports are being squeezed by the real appreciation of the exchange rate, the increase in government spending impacts positively on the public sector industries. The rise in government spending directly induces an increase in activity and in the demand for labour by these labour-intensive industries. Moreover, the increase in activity in the public sector industries (see Table 4.3(c)) has a spin-off effect on intermediate-input-supplying industries to the government.

In the discussion of the expected BOTE results earlier it was deduced that employment would not be affected by the shocks under consideration. In fact the increase in activity in the public sector and the associated industries prompts an increase in their demand for labour. This leads to an increase in

36 In the model the nominal exchange, *phi*, is linked to the nominal trade account *deltabn* (defined in the original model), which deteriorates by less than the deteriorations in *deltabotd* and *deltabotf* (the new definitions). For the discussion on the trade account throughout the chapter we use figures for *deltabotd* for nominal and *deltab* for real as they appear to be more reasonable than the figures for *deltabn*. Although *phi* is linked to *deltabn* the direction of the changes are the same so our discussion on the impact of the trade account on the exchange rate holds.

aggregate person-weighted employment, *aggl*, of 0.52 per cent and wage-weighted employment of 0.57 per cent in 2002 relative to the basecase forecast (Table 4.1, rows 2 and 41).

Because L increases, Y in equation (4.1) increases as well in 2002, but by a negligible 0.07 per cent relative to the basecase forecast for 2002 (Table 4.1, row 30).

In the money market, money supply is required to increase to match the increase in money demand, which arises from the increase in the nominal income, so that the price of money, the interest rate, does not increase (held fixed in this simulation). Thus, through equation (4.8) money supply increases by 0.96 per cent more than it otherwise would have in 2002 (Table 4.1, row 43). The increase in nominal income arises mainly from increases in prices (deviating by 0.74 per cent in 2002 relative to the base forecast), and the price increase is caused mainly by the nominal devaluation associated with deterioration in the trade account (Table 4.1, row 15).

Despite the slight increase in real GDP, aggregate real private (household) consumption in equation (4.6) declines by 0.19 per cent in 2002 relative to the basecase forecast (Table 4.1, row 5). The decline in real consumption reflects a real decline of 0.20 (0.54 minus 0.74) per cent in land rental (Table 4.1, rows 40 and 20) with real wages being constant.

Increases in investment in a few of the capital-supplying industries largely offset the decreases in the exporting industries, resulting in a negligible rise in real aggregate investment of 0.02 per cent in 2002 relative to the base forecast (Table 4.1, row 37). With no change in the interest rate, it is not surprising that the model shows little change in investment (see equation 4.7).

Consi·tent with equation (4.5), in 2002 total real government expenditure itself increases by 1.73 per cent more than it did in the basecase forecasts (Table 4.1, row 51). This is a direct result of the expansionary fiscal policy.

Actual Simulation Results for the Medium Term: Forecast Years 2003 to 2006

In the remaining four forecast years, 2003 to 2006, the main effects of the shock that we observed in 2002 persist. Employment growth (as a direct impact of spending in the public sector industries) and crowding-out of exports (as a result of real appreciation) continue, but at declining rates. In the medium term, person-weighted employment grows by 0.44 per cent (2003) and by 0.34 per cent (2006) more than it did in the basecase forecasts and wage-weighted employment grows by 0.50 per cent (2003) and by 0.42 per cent (2006) relative to the basecase forecasts. (Table 4.1, rows 2 and 41). The rate of increase slows down towards the end of the forecast period.

There is hardly any deviation in aggregate real investment in the period 2003 to 2006. The dismal investment performances of the mineral and agricultural exporting industries which reflect the real appreciation, are offset by increases in a few capital-supplying industries. The results we observe are consistent with what we would expect, given equation (4.7).

Growth in investment adds to the capital stock of an industry and the economy through the tablo equations E_kjplus1[37] for end-of-year capital stock and E_kj[38] for start-of-year capital stock.

Aggregate real investment changes very little in the policy change simulation relative to the basecase forecasts in 2003 to 2006, and so aggregate capital stock also does not change. This shows that interest rate targeting tends to mitigate any adverse impact on investment that the expansionary fiscal policy might have had. Charts 4.1 and 4.2 show that aggregate investment and capital stock are largely unaffected under interest rate targeting and fiscal expansion relative to the pre-policy paths (basecase forecasts).

With the changes in employment and capital, real GDP grows very slightly, ranging from a high of 0.04 per cent in 2003 and to a low of 0.00 per cent in 2006 (Table 4.1, row 30). Aggregate real consumption declines between 0.21 per cent in 2003 and by 0.20 per cent in 2006 relative to the base forecasts (Table 4.1, row 5) as real land rental continues to decline (Table 4.1, rows 40 and 20).

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37 Equation
E_kjplus1 # *Capital accumulation through the forecast year(t) related to investment in the year* #
(All,j,IND)[KPLUS1(j) + TINY]*kjplus1(j) = [1- DEP(j)]*KAP(j)*kj(j) + ICAP(j)*yj(j);

38 Equation E_kj#*Gives shock in yr-to-yr forecasting to capital at begining of year* #
(All,j,IND) [KAP(j) + TINY]*(kj(j)+ff_kj(j)) = 100*{ICAP_B(j) - DEP(j)*KAP_B(j)}*del_unity + 100*d_f_kj(j);

Chart 4.1: Cumulative Investment growth in Policy Forecasts and Base Forecasts Under Interest Rate Targeting

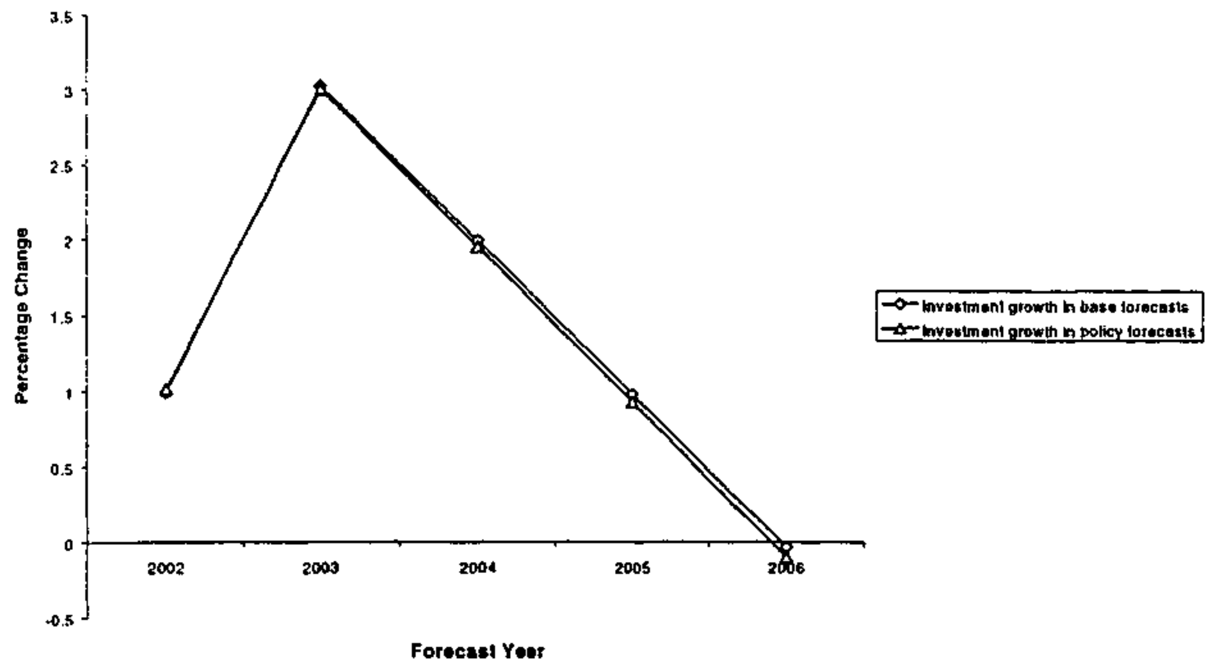
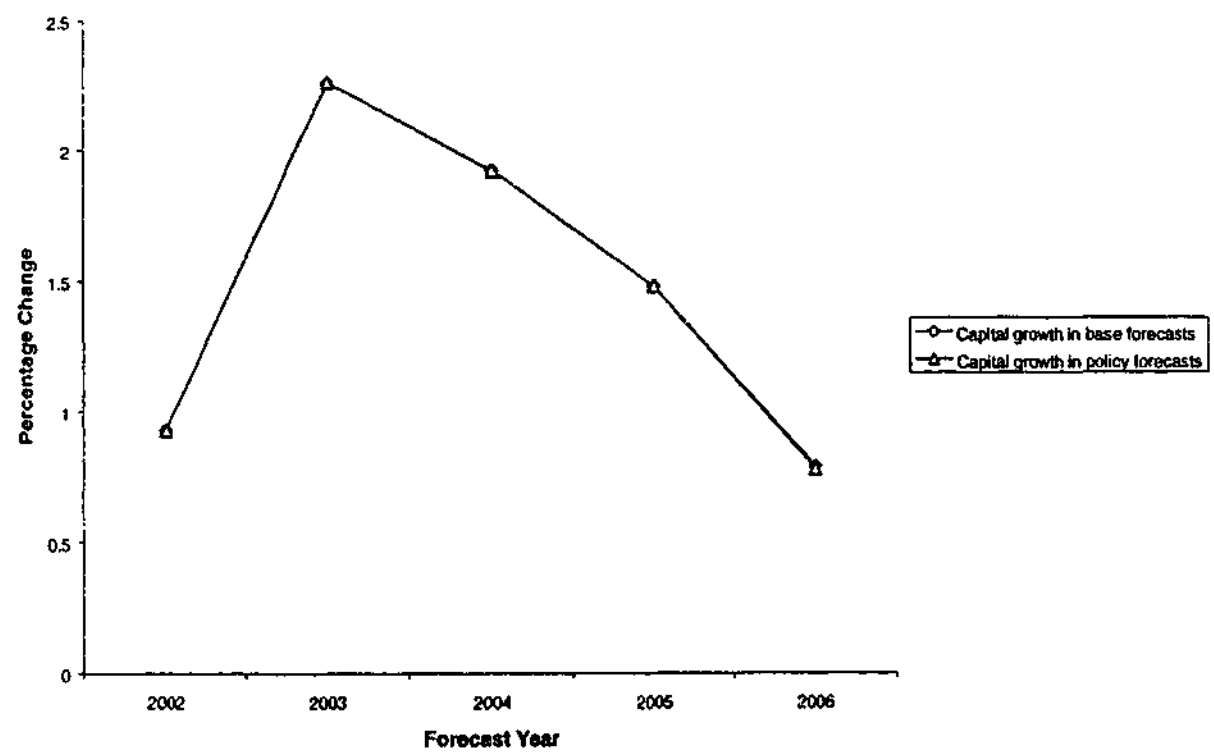


Chart 4.2: Cumulative Aggregate Capital Stock Growth in Policy Forecasts and Base Forecasts Under Interest Rate Targeting



In the external sector, total real imports increase by 0.14 per cent in 2003 and settle at 0.13 per cent in 2004 to 2006, while total real exports decline by 0.10 per cent in 2003 to 0.18 per cent in 2006 relative to the control forecasts (Table 4.1, lines 42 and 17). The net result is a deviated deterioration in the real trade balance of K7.67 million in 2003. This trend continues, with the deviated deterioration reaching K10.38 million in 2006 in the policy forecast relative to the control forecasts. The nominal trade account deteriorated by K9.08 million in 2003 to K73.77 million in 2006 (Table 4.1, rows 11 and 13).

The deterioration in the trade account leads to a depreciation of the nominal exchange rate by between 0.56 per cent in 2003 and 0.37 per cent in 2006 (Table 4.1, row 46).

Industry Level Results for Policy Scenario A

Industry-level results for this simulation are shown in Table 4.2(a) to 4.2(c). Some of the features of these results have already been touched on in our discussion of the macro results. In the macro results, we saw that what underlies the poor performance of the exporting industries under the accommodating monetary policy of interest rate targeting is the appreciation of the real exchange rate. Specifically, we find that the exporting industries, including the mineral and agricultural industries, fared poorly. Their investments and exports decline in the first year relative to the base forecast. This is because costs of production are higher relative to export prices. The rental price of capital declines for a few agricultural exporting industries while increasing for other agricultural exporting industries and the mineral industries.

Table 4.2(a): Key Results for Selected Industries under Accommodative Monetary Policy (Policy Scenario A)

	2002	2003	2004	2005	2006
		Deviated Percentage Change			
Asset price (cost) of capital					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	0.86	0.75	0.69	0.62	0.55
Plantation cofee	0.86	0.75	0.68	0.62	0.55
Ok Tedi	0.86	0.75	0.69	0.62	0.55
Porgera mine	0.86	0.75	0.69	0.62	0.55
Other mine	0.86	0.75	0.68	0.62	0.55
Oil	0.86	0.75	0.69	0.62	0.55
Food processing	0.87	0.75	0.69	0.62	0.55
Building &construction	0.73	0.63	0.57	0.51	0.44
Metals &Engineering	0.70	0.60	0.54	0.48	0.41
Machinery	0.72	0.60	0.54	0.49	0.43
Rental price of capital					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	0.49	0.40	0.31	0.22	0.14
Plantation coffee	-0.24	-0.59	-0.93	-1.46	-2.64
Ok Tedi	0.50	0.42	0.34	0.26	0.18
Porgera mine	0.55	0.46	0.38	0.31	0.23
Other mine	0.54	0.45	0.37	0.30	0.22
Oil	0.52	0.43	0.32	0.19	0.05
Food processing	0.40	0.48	0.54	0.55	0.54
Building &construction	2.33	1.91	1.64	1.36	1.11
Metals &Engineering	1.23	0.87	0.62	0.46	0.34
Machinery	0.83	0.64	0.50	0.38	0.28
Rate of return to Capital					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	-0.51	-0.48	-0.51	-0.55	-0.57
Plantation coffee	-1.38	-1.73	-2.13	-2.84	-4.55
Ok Tedi	-0.55	-0.51	-0.53	-0.55	-0.56
Porgera mine	-0.48	-0.44	-0.45	-0.47	-0.48
Other mine	-0.49	-0.45	-0.47	-0.48	-0.49
Food processing	-0.75	-0.46	-0.26	-0.14	-0.06
Building &construction	2.42	1.94	1.63	1.31	1.02
Metals &Engineering	0.78	0.39	0.10	-0.04	-0.13
Machinery	0.14	0.01	-0.11	-0.19	-0.26

Table 4.2(b): Key Results for Selected Industries under Accommodative Monetary Policy (Policy Scenario A)

	2002	2003	2004	2005	2006
			Deviated Percentage Change		
Investment					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	-0.13	-0.13	-0.13	-0.14	-0.15
Plantation coffee	-0.41	-0.51	-0.62	-0.82	-1.24
Ok Tedi	-0.14	-0.13	-0.15	-0.16	-0.17
Porgera mine	-0.12	-0.11	-0.12	-0.13	-0.15
Other mine	-0.12	-0.12	-0.13	-0.14	-0.16
Food processing	-0.73	-0.52	-0.37	-0.28	-0.21
Building &construction	2.40	1.99	1.74	1.47	1.22
Metals &Engineering	0.76	0.44	0.18	0.05	-0.04
Machinery	0.14	0.02	-0.10	-0.18	-0.27
Current Capital Stock					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	0.00	0.00	0.00	0.00	0.00
Plantation coffee	0.00	-0.01	-0.03	-0.04	-0.06
Ok Tedi	0.00	-0.01	-0.01	-0.02	-0.04
Porgera mine	0.00	-0.01	-0.01	-0.02	-0.03
Other mine	0.00	-0.01	-0.01	-0.02	-0.04
Food processing	0.00	-0.08	-0.13	-0.15	-0.16
Building &construction	0.00	0.07	0.12	0.18	0.22
Metals &Engineering	0.00	0.06	0.10	0.10	0.10
Machinery	0.00	0.02	0.02	0.01	-0.01
End-of-year Capital Stock					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	0.00	0.00	0.00	0.00	0.00
Plantation coffee	-0.01	-0.03	-0.04	-0.06	-0.09
Ok Tedi	-0.01	-0.01	-0.02	-0.03	-0.04
Porgera mine	0.00	-0.01	-0.01	-0.02	-0.03
Other mine	-0.01	-0.01	-0.02	-0.03	-0.05
Food processing	-0.08	-0.13	-0.15	-0.17	-0.17
Building & construction	0.07	0.13	0.18	0.23	0.26
Metals &Engineering	0.06	0.10	0.10	0.10	0.09
Machinery	0.01	0.02	0.01	-0.01	-0.03
Activity/Output Level					
Smallholding copra	-0.02	-0.02	-0.03	-0.03	-0.03
Smallholding coffee	-0.01	-0.02	-0.02	-0.02	-0.02
Plantation copra	-0.05	-0.05	-0.06	-0.08	-0.09
Plantation coffee	-0.42	-0.56	-0.71	-0.95	-1.50
Ok Tedi	-0.04	-0.05	-0.06	-0.07	-0.08
Porgera mine	-0.03	-0.03	-0.04	-0.05	-0.06
Other mine	-0.04	-0.05	-0.06	-0.07	-0.08
Food processing	-0.07	-0.12	-0.15	-0.16	-0.17
Building &construction	0.41	0.39	0.38	0.37	0.36
Metals &Engineering	0.11	0.10	0.09	0.06	0.04
Machinery	0.00	0.01	0.01	0.00	-0.02

Table 4.2(c): Key Results for the Public Scetor Industries under Accommodative Monetary Policy (Policy Scenario A)

	2002	2003	2004	2005	2006
			Deviated Percentage Change		
Asset price of capital					
Education	0.86	0.75	0.69	0.62	0.55
Health	0.86	0.75	0.69	0.62	0.55
Government Administration	0.86	0.75	0.69	0.62	0.55
Electricity & Garbage	0.86	0.75	0.68	0.62	0.55
Rental price of capital					
Education	6.72	6.43	6.30	6.14	5.97
Health	4.91	4.67	4.56	4.41	4.28
Government Administration	7.53	7.19	7.08	6.92	6.76
Electricity & Garbage	1.54	1.37	1.33	1.29	1.25
Rate of return to Capital					
Education	8.99	8.72	8.62	8.48	8.34
Health	6.16	5.98	5.90	5.79	5.70
Government Administration	10.24	9.89	9.83	9.70	9.55
Electricity & Garbage	1.05	0.96	0.98	1.02	1.06
Investment					
Education	0.00	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00	0.00
Government Administration	0.00	0.00	0.00	0.00	0.00
Electricity & Garbage	0.00	0.00	0.00	0.00	0.00
Current Capital Stock					
Education	0.00	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00	0.00
Government Administration	0.00	0.00	0.00	0.00	0.00
Electricity & Garbage	0.00	0.00	0.00	0.00	0.00
End-of-year Capital Stock					
Education	0.00	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00	0.00
Government Administration	0.00	0.00	0.00	0.00	0.00
Electricity & Garbage	0.00	0.00	0.00	0.00	0.00
Activity/Output Level					
Education	2.00	1.95	1.91	1.87	1.83
Health	1.67	1.61	1.57	1.52	1.48
Government Administration	1.83	1.77	1.72	1.67	1.63
Electricity & Garbage	0.11	0.09	0.07	0.06	0.05

However, the percentage growth in the rental price of capital is lower than the percentage growth in the cost of capital. The rate of return to capital for these industries is lower than in the pre-policy change scenario because percentage growth in the cost of capital, *piej*, now exceeds the percentage growth in the rental price of capital, *ppvj*. For the agricultural industries in particular this mechanism of linking cost and rate of return to capital to investment leads to a decline in investment.

For the mineral industries, we recall from chapter three that the mechanism of investment-capital linking with the required rate of return to capital does not apply to them. The decline in investment for these industries is tied down to the decline in export demand and the fall in activity level.

The results also show that import-competing industries such as *food processing* are adversely affected by the real appreciation. The industry's cost of production, as indicated by the GDP deflator, increases by more (0.90 per cent) than the increase (0.63 per cent) in the price of the imports that compete with its output. In order to compete with imports, the industry faces a profit squeeze, namely, a reduction in the rental on its capital relative to the domestic price level (a reduction in real rental rate). This is brought about by a contraction in the industry's output. The reduction in the output allows substitution of *food processing* imports for domestic *food processing*. Reduction in the real rental rate of the industry's capital reduces the industry's rate of return to capital and investment. As we have just argued, for the exporters and import-competing industries, real appreciation causes the rate of return to capital, *rj*, to decline (as a result of lower rental price of capital relative to cost of capital) and consequently investment-by-industry, *yj*, decreases marginally for these industries relative to the base forecasts. For example, export industries such as *Plantation Coffee* and *Plantation Copra* and import-competing industries such as *Food processing* have persistent declines in *yj* investment throughout the forecast period (Table 4.2(b), lines 3, 4 and 8).

In the public sector industries, the increase in government spending has a direct positive impact on activity level and the demand for labour, while investment and capital are constant by assumption. Furthermore, as we have already noted, the increase in spending in public-sector industries induces a rise in activity in industries which supply the government-sector industries with intermediate inputs. In the MAKE matrix the government industries buy as intermediate inputs, as opposed to investment goods, outputs from industries such as *building & construction*. Government-section industries also buy intermediate inputs from *transportation industries*. Tables 4.2(a) and 4.2(b) show results for the building and construction industry. Given these interdependencies, these intermediate input-supplying industries benefit from the increase in spending in *health*, *education*, *electricity & garbage* and *government administration*. Activity grows more than otherwise would have been the case in these industries in the present policy scenario. The rental rate on capital exceeds the percentage change in the cost of capital in these. This yields an increase in the rate of return to capital under the policy relative to the base forecasts, and leads to growth in investment and activity in these industries.

Chart 4.3 shows deviated investment growth (results for the policy simulation compared with the results of the basecase forecast) in an exporting industry, *plantation coffee*, and a non-exporting industry that supplies the government-sector industries with intermediate inputs, *building and construction*. This illustrates the point that the policy favours industries supplying the government at the expense of exporting industries.

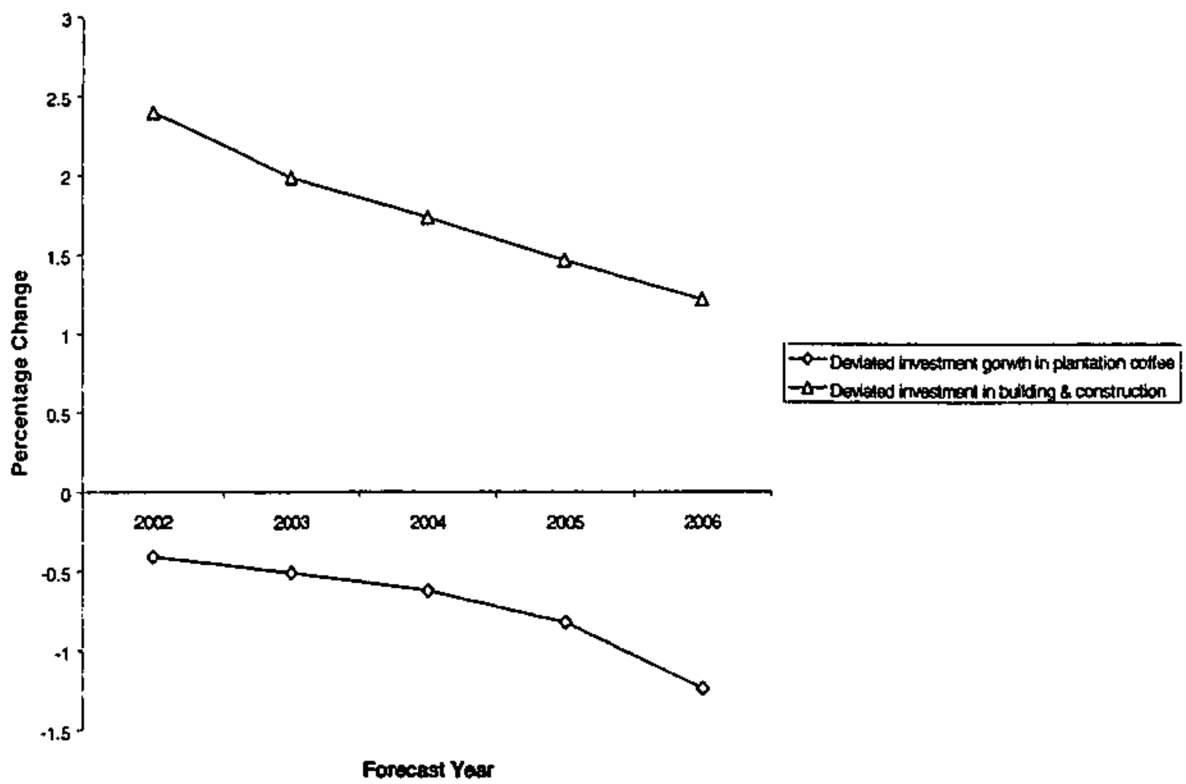
In line with the trend for industry investment growth in the forecast period, there are slight declines in the current capital stock and the end-of-year capital stock relative to the control forecasts for the exporting industries and import-competing industries, while there are marginal increases in *building and construction*, an industry that supplies intermediate inputs to the government.

The positive performances in industries that supply the government and the negative performance of the exporting and import-competing industries offset each other, netting the average percentage changes in aggregate investment and capital stock discussed earlier.

Two digressions: (a) violation of BOTE equation (4.3) and (b) investment in public-sector industries

When analyzing the simulated results for Policy Scenario A, we noted that the results from the actual model violated BOTE equation (4.3). We also noticed the key role played by the public sector industries in explaining our results, and conducted an experiment in which we allowed the rate-of-return theory of investment to apply to public sector as it does for the private sector industries. We these two issues before proceeding to policy scenario B.

Chart 4.3: Deviated investment growth in an exporting industry (plantation coffee) versus a non- exporting industry (building & construction) under the interest rate targeting policy



Violation of the BOTE Equation for the Real Wage Rate

It can be seen from Table 4.1 that whereas the aggregate capital stock and the real wage rate are virtually unaffected by the policy, there are sizeable changes in labour (rows 2, 38, 41 and 48). With virtually no change in capital stock and no change in the real wage rate, we would have expected virtually no change in aggregate employment. Consider the year 2002. Neither the capital stock nor the real wage rate change relative to the base forecasts, but person-weighted employment increases by 0.52 per cent (row 2) and wage-weighted employment rises by 0.57 per cent (row 41) relative to the control forecasts. With technology (row 1) and *twistlk* (line 53) held constant, this violates BOTE equation (4.3).

The explanation of the "*mysterious*" increase in employment in the actual model has to do with the increase in spending by the public-sector industries. As noted earlier, these industries are labour-intensive relative to many exporting industries, particularly those in the mineral sub-sector. The rise in government spending in this simulation thus has a positive direct impact on person-weighted labour and wage-weighted labour. While the dependency of real wage on the capital to labour ratio $W_R = \frac{1}{A}\frac{\partial F}{\partial L}\left(\frac{K}{L}\right)$ and thus the maintenance of the fixed $\frac{K}{L}$ ratio when W_R is fixed holds in a one-sector model, it need not hold in a multi-sectoral model, in which there are different $\frac{K}{L}$ ratios in different industries.

Investment in Public Sector Industries

The results that we have discussed so far in policy scenario A (and for the simulations in chapter 3 and will cover for policy scenarios A and B) are for the case in which the theory of investment allocation, (in which investment growth is a function of the rate of return to capital) does not apply to the public sector industries. We take the line that investment growth in the public sector industries does not necessarily depend on rates of return to capital but rather on social objectives such as achieving a more equitable distribution of goods and services. Therefore, we turn off the part of the investment equation that captures the rate-of-return theory by assigning zero to the coefficient *I2J* in the investment equation for these industries.

We now consider what would happen if the rate-of-return theory of investment *does* apply to the government sector industries. In this experiment, the closure and all the shocks are the same. The only difference is that the coefficient *I2J* for the government industries is set at 1.0 as it is for the rest of the industries, rather than at zero. The simulation for policy scenario A is run again (with the new setting for the coefficient *I2J* for public sector industries). When the investment theory is turned on for the public-sector industries of *health*, *education*, *government administration* and *electricity & garbage*, the increase in government spending accompanied by an accommodating monetary policy now leads to positive investment growth and further increase in employment in the public sector industries. The government industries are major employers in the economy. So capital expansion (now relative to the no-change previously) in the industries stimulates investment and employment growth relative to the basecase forecasts. This is in contrast to the no-deviated growth in investment for these industries under the policy when the investment theory did not apply to the government sector industries. Consequently, growth in aggregate real investment for the whole economy is now greater under the policy change relative to the pre-policy base forecasts. The growth in investment in turn leads to a positive change in capital stock accumulation. These effects can be clearly distinguished by comparing Charts 4.4 and 4.5 and Table 4.3 (under the scenario of activating the investment theory for the government industries) with Charts 4.1 and 4.2 and Table 4.1 (under the scenario of non-applicability of the investment theory to government industries).

Table 4.3: Cumulative Deviated Macro Results under Fiscal Expansion and Interest Targeting (with investment theory on for public sector industries)

	Variable		2002	2003	2004	2005	2006
					percentage change		
	Model Name	*Economic Name*					
1	a1primgen	Tech Coefficient	0.00	0.00	0.00	0.00	0.00
2	aggl	Aggregate Employment	0.58	0.45	0.40	0.36	0.33
3	c1	Aggregate Nominal Cons	0.64	0.48	0.43	0.38	0.35
4	chie	Govt Consumption	2.36	2.36	2.36	2.37	2.38
5	cr	Agg Real Consumption	-0.23	-0.25	-0.24	-0.22	-0.20
6	d_avesub	Change in Ave Subsidy*	0.00	0.00	0.00	0.00	0.00
7	d_totsub	Change in Total Subsidy*	-0.42	-0.58	-0.21	0.09	0.47
8	del_bt	Change in Trade Balance*	-16.16	-15.47	-24.69	-29.65	-38.55
9	del_btgdp	Change in BT to GDP ratio*	0.00	0.00	0.00	0.00	0.00
10	del_unity	Homotopy Variable	0.00	0.00	0.00	0.00	0.00
11	deltab	Real Trade Account*	-9.56	-8.79	-9.24	-9.69	-10.05
12	deltabn	Nominal Trade Account*	-3.28	-4.32	-5.95	-6.83	-7.92
13	deltabotd	Trade balance in Dom Currency*	-14.51	-10.96	-39.69	-58.75	-85.52
14	deltabotf	Trade balance in For Currency*	-15.19	-12.65	-19.98	-24.90	-31.17
15	deltac	Current Account*	-3.28	-4.32	-5.95	-6.83	-7.92
16	deltagb	Govt's Budget Position*	-64.79	-54.14	-49.79	-44.39	-38.92
17	efcreal	Agg Real Exports	-0.08	-0.09	-0.10	-0.12	-0.13
18	epsilon1	GDP Deflator	1.08	0.88	0.79	0.70	0.62
19	epsilon2	Capital Goods Price Index	1.17	0.92	0.83	0.71	0.62
20	epsilon3	Consumer Price Index	0.88	0.74	0.68	0.61	0.55
21	f1	Wage Shifter	0.00	0.00	0.00	0.00	0.00
22	f2	Investment Shifter	0.00	0.00	0.00	0.00	0.00
23	f4	Exports Shifter	0.00	0.00	0.00	0.00	0.00
24	f5	Other Dd Shifter	2.50	2.50	2.50	2.50	2.50
25	f_obs	Shifter for forecast exports	0.00	0.00	0.00	0.00	0.00
26	f_phi	Shifter for forecast exchange rate	0.80	0.64	0.56	0.49	0.44
27	fc	Consumption Shifter	0.00	0.00	0.00	0.00	0.00
28	gc	Govt Consumption Expenditure	4.51	3.96	3.71	3.46	3.26
29	gdp	Nominal GDP	1.15	0.90	0.81	0.72	0.64
30	gdpr	Real GDP	0.07	0.04	0.03	0.02	0.03
31	gex	Total Govt Expd	3.91	3.41	3.22	3.01	2.84
32	gi	Govt Capital Expd	7.64	5.61	4.51	3.61	2.90
33	gireal	Govt Real K Expd	6.46	4.70	3.70	2.91	2.30
34	go	Other Govt Expenditure	0.00	0.00	0.00	0.00	0.00
35	grev	Total Govt Revenue	0.97	0.78	0.71	0.64	0.59
36	in	Agg Nominal Investment	1.86	1.40	1.28	1.12	0.98
38	ir	Agg Real Investment	0.69	0.49	0.46	0.41	0.37
39	ksnew	Agg Capital Stock	0.00	0.05	0.08	0.11	0.13
40	Lambda	Economy-wide Rate of Return	0.00	0.00	0.00	0.00	0.00
41	lr	Returns to Land	0.69	0.52	0.44	0.36	0.32

...continued

Table 4.2 continued

	Variable		2002	2003	2004	2005	2006
					percentage change		
	Model Name	*Economic Name*					
42	lw	Wage-Weighted Employment	0.64	0.50	0.46	0.42	0.39
43	mfcreal	Real Imports (fc)	0.25	0.19	0.18	0.17	0.16
44	mn	Money Demand	1.15	0.90	0.81	0.72	0.64
45	p0toft	Terms of Trade	0.00	0.00	0.00	0.00	0.00
46	p1lab_io	Nominal Wage	0.88	0.74	0.68	0.61	0.55
47	phi	Nominal Exchange Rate	-0.80	-0.64	-0.57	-0.50	-0.45
48	q1	Households	0.00	0.00	0.00	0.00	0.00
49	realwage	Real Wage	0.00	0.00	0.00	0.00	0.00
50	refg	Foreign Grant	0.00	0.00	0.00	0.00	0.00
51	totgexreal	Agg Govt Expd	2.04	2.01	2.02	2.03	2.04
51	twistimp	Import Twist	0.00	0.00	0.00	0.00	0.00
52	twistlk	Labour Twist	0.00	0.00	0.00	0.00	0.00
53	xi4	Export Price Index	0.79	0.63	0.55	0.48	0.42
54	xig	Other Demand Price Index	2.13	1.59	1.35	1.10	0.89
55	xim	Import Price Index	0.78	0.62	0.55	0.48	0.43

* change in Kina million

Chart 4.4: Cumulative Growth of Aggregate Investment in Policy Forecasts versus Base Forecasts when Public Sector Industries Invest in Policy Scenario A

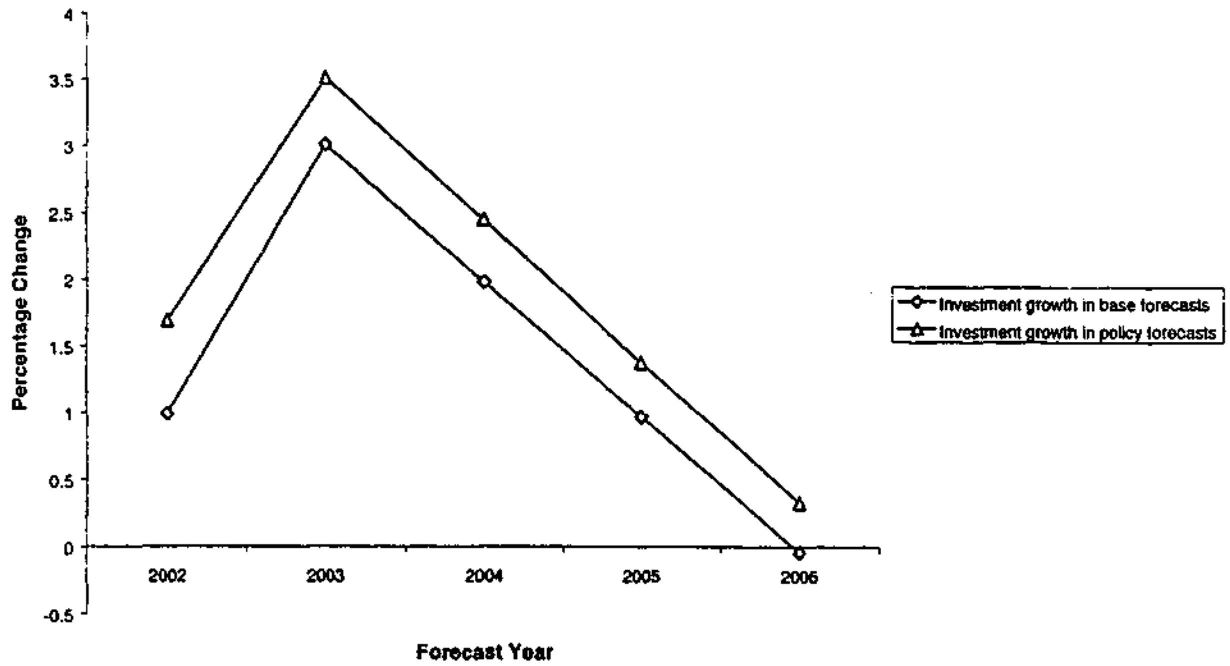
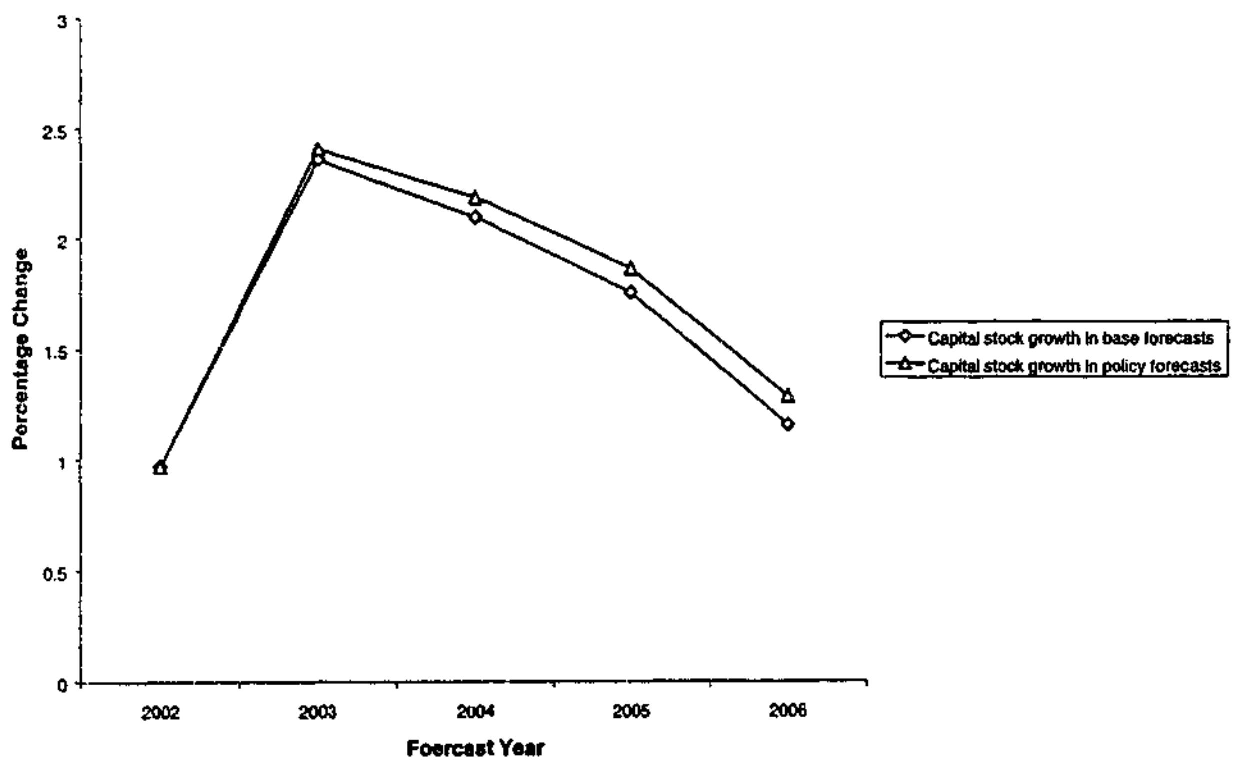


Chart 4.5: Cumulative Growth of Aggregate Capital Stock in Policy Forecasts versus Base Forecasts when Public Sector Industries Invest in Policy Scenario A



This experiment demonstrates that the policy of interest rate targeting by the central bank is conducive to investment, more so when the investment theory is turned on for the public sector industries. Nonetheless, the policy (with the rate-of-return theory turned on for the public sector industries) still has an adverse effect on exporting industries.

4.5.2 Policy Scenario B: Tight Monetary Policy (Money Supply Targeting) in response to Increased Government Spending

In this policy scenario, the monetary authority (central bank) targets money supply and lets the interest rate move in response to the government's expansionary fiscal policy. The bank may adopt such a policy with a view to reducing the effect on inflation of an expansionary fiscal policy. That is, a low rate of inflation is the primary objective, attainable through control of the money supply.

The targeting of the money supply means that the central bank wants either no change or a desirable (target) small percentage change in it (money supply). In the simulation, we assume that the central bank takes the stance of no further growth in money supply from the rate prior to the policy change (that is, money supply to grow at the same rate before and after the policy change).

The only change to the closure is a swap between the interest rate and money supply, with the exogenization of the money supply via the endogenization of the interest rate.

Macro Results for Policy Scenario B

Again, we first look at the predictions of the BOTE model.

Predictions Based On the BOTE Model

The difference between this simulation and the last simulation for policy A is that the rate of interest, R, is now endogenous and free to move. In equation (4.7) of the BOTE model investment, I will therefore change. To determine the directions in which we expect R and I to move we work with the BOTE model, which allows us to establish our *a priori* expectations of the results.

As in policy scenario A, on the basis of the BOTE model, we expect in policy scenario B to see no effect on K in the first year of the policy shock. Technology, A, is fixed. As W/P is constant by assumption, we expect to see little change in L. With K and A fixed and little change in L, Y should not change significantly. With little change in Y, there will be little change in C. As A, K and L are approximately constant, the marginal product of capital will also be approximately constant. For this to hold, the real rental price of capital has to be approximately constant too.

Let us now consider the direction in which R moves. Let us guess initially that R falls. With a fall in R and an approximately constant rental price of capital, equation (4.7) implies an increase in I. From equation (4.2), with little changes in C and Y, and increases in I and in G, we see that the trade balance must decline, i.e., $(X-M)$ falls. This requires real appreciation. Because the nominal exchange rate is linked to the trade balance (see equation 4.11), the nominal exchange rate devalues. Thus, for real appreciation to occur, we need an increase in the domestic price level, P. With Y approximately constant, we now know that nominal income, $P*Y$, must increase. With constant money supply, a decline in interest rate, R, and an increase in nominal income there is a violation of the money demand equation (4.8), Thus we conclude that our initial guess for R must be wrong.

Hence, R must rise.

With the rental rate on capital approximately constant and an increase in R, I must fall. With Y and C approximately constant, G increasing and I falling, the effect of the policy on $(X - M)$ is unclear from the BOTE model. The actual model will shed light on this, and we now we turn to discussing the results for the year 2002.

Actual Simulation Results for the Short Run: Year 2002

Because it is targeted, money supply, *mn*, does not change from the levels in the control forecasts in this simulation. The actual macro results expressed again as cumulative percentage deviations under the policy change relative to the control forecasts presented in Table 4. 4.

The results show very little effect on the trade balance in 2002. We examine why this is the case.

Consistent with the BOTE model, the simulated results show that, with the money supply held constant and the increase in government spending there is a fall in aggregate real investment of 2.72 per cent from the level in the base forecast (Table 4.4, row 37). Investment falls because an increase of 3.96 in the interest rate (Table 4.4, row 51) forced the economy-wide required rate of return to capital, *lambda* to rise also by 3.96 per cent (Table 4.4, row 39) from

Table 4.4: Cumulative Deviated Macro Results under Fiscal Expansion and Money Supply Targeting (with investment theory turned off for public sector industries)

	Variable		2002	2003	2004	2005	2006
			percentage change (unless where indicated)				
	Model Name	*Economic Name*					
1	a1primgen	Tech Coefficient	0.00	0.00	0.00	0.00	0.00
2	aggl	Aggregate Employment	0.41	0.16	0.01	-0.07	-0.11
3	c1	Aggregate Nominal Cons	0.29	0.12	0.03	-0.02	-0.04
4	chie	Govt Consumption	2.49	2.35	2.26	2.21	2.19
5	cr	Agg Real Consumption	0.01	-0.26	-0.43	-0.52	-0.57
6	d_avesub	Change in Ave Subsidy*	0.00	0.00	0.00	0.00	0.00
7	d_totsub	Change in Total Subsidy*	-0.74	-1.18	-0.70	-0.10	0.60
8	del_bt	Change in Trade Balance*	-0.17	-3.01	-8.33	-11.87	-17.41
9	del_btgdp	Change in BT to GDP ratio*	0.00	0.00	0.00	0.00	0.00
10	del_unity	Homotopy Variable	0.00	0.00	0.00	0.00	0.00
11	deltab	Real Trade Account*	-1.12	-2.94	-4.56	-5.59	-6.19
12	deltabn	Nominal Trade Account*	-0.25	-1.66	-3.30	-4.31	-5.32
13	deltabotd	Trade balance in Dom Currency*	1.66	-0.91	-12.05	-20.82	-34.18
14	deltabotf	Trade balance in For Currency*	0.07	-2.01	-6.21	-9.22	-12.97
15	deltac	Current Account*	-0.25	-1.66	-3.30	-4.31	-5.32
16	deltagb	Govt's Budget Position*	-58.57	-57.14	-57.22	-56.39	-54.05
17	efcreal	Agg Real Exports	-0.13	-0.20	-0.27	-0.32	-0.38
18	epsilon1	GDP Deflator	0.37	0.47	0.55	0.59	0.62
19	epsilon2	Capital Goods Price Index	-0.21	0.07	0.25	0.38	0.50
20	epsilon3	Consumer Price Index	0.28	0.39	0.46	0.50	0.53
21	f1	Wage Shifter	0.00	0.00	0.00	0.00	0.00
22	f2	Investment Shifter	0.00	0.00	0.00	0.00	0.00
23	f4	Exports Shifter	0.00	0.00	0.00	0.00	0.00
24	f5	Other Dd Shifter	2.50	2.50	2.50	2.50	2.50
25	f_obs	Shifter for forecast exports	0.00	0.00	0.00	0.00	0.00
26	f_phi	Shifter for forecast exchange rate	0.11	0.16	0.19	0.21	0.24
27	fc	Consumption Shifter	0.00	0.00	0.00	0.00	0.00
28	gc	Govt Consumption Expenditure	3.78	3.60	3.53	3.46	3.38
29	gdp	Nominal GDP	0.46	0.35	0.30	0.26	0.23
30	gdpr	Real GDP	0.09	-0.12	-0.25	-0.33	-0.38
31	gex	Total Govt Expd	2.92	2.84	2.84	2.84	2.80
32	gi	Govt Capital Expd	-0.24	0.06	0.25	0.40	0.51
33	gireal	Govt Real K Expd	0.00	0.00	0.00	0.00	0.00
34	go	Other Govt Expenditure	0.00	0.00	0.00	0.00	0.00
35	grev	Total Govt Revenue	0.24	0.18	0.16	0.16	0.16
36	in	Agg Nominal Investment	-2.90	-2.08	-1.59	-1.21	-0.86
37	ir	Agg Real Investment	-2.72	-2.18	-1.86	-1.62	-1.37
38	ksnew	Agg Capital Stock	0.00	-0.19	-0.34	-0.45	-0.55
39	Lambda	Economy-wide Rate of Return	3.96	3.02	2.56	2.23	2.02
40	lr	Returns to Land	0.02	-0.05	-0.11	-0.14	-0.15
41	lw	Wage-Weighted Employment	0.44	0.22	0.12	0.05	0.02
42	mfcreal	Real Imports	-0.12	-0.15	-0.16	-0.17	-0.16
43	mn	Money Demand	0.00	0.00	0.00	0.00	0.00

...Continued

Table 4.4 continued

	Variable *Model Name*	*Economic Name*	2002	2003	2004	2005	2006
44	p0toft	Terms of Trade	0.00	0.01	0.00	0.00	0.00
45	p1lab_io	Nominal Wage	0.28	0.39	0.46	0.51	0.53
46	phi	Nominal Exchange Rate	-0.11	-0.16	-0.19	-0.21	-0.24
47	q1	Households	0.00	0.00	0.00	0.00	0.00
48	realexch	Real Exchange Rate	0.27	0.32	0.37	0.39	0.39
49	realwage	Real Wage	0.00	0.00	0.00	0.00	0.00
50	refg	Foreign Grant	0.00	0.00	0.00	0.00	0.00
51	rn	Interest Rate	3.96	3.02	2.56	2.23	2.02
52	totgexreal	Agg Govt Expd	1.89	1.81	1.77	1.76	1.76
53	twistimp	Import Twist	0.00	0.00	0.00	0.00	0.00
54	twistlk	Labour Twist	0.00	0.00	0.00	0.00	0.00
55	xi4	Export Price Index	0.11	0.16	0.19	0.21	0.23
56	xig	Other Demand Price Index	1.29	1.25	1.27	1.25	1.19
57	xim	Import Price Index	0.11	0.16	0.19	0.20	0.23
58	ximf	Import Price Index in Foreign Curr	0.00	0.00	0.00	0.00	0.00

* change in Kina million

its rate in the base forecast. Demand pressures on the restricted money supply causes the rise in the interest rate. Unless the rate of return to capital, *rj*, also increases by the same amount or by more than *lambda*, an industry's investment growth would decline. The results show that for a lot of the industries *rj* falls or is low compared to *lambda*. This prevents many industries from maintaining the growth in investment experienced in the base forecast and so aggregate investment falls.

Investment flows impact on capital stock. With the decline in investment, capital stock, *ksnew*, declines negligibly relative to the basecase forecast. (The decline is so small that it does not appear in Table 4.4, row 38, which shows the results to two decimal points.)

In the labour market, the increase in spending in the labour-intensive public sector industries has a positive impact on employment, with person-weighted employment increasing by 0.41 per cent and wage-weighted employment increasing by 0.44 per cent relative to the basecase forecasts (Table 4.4, rows 2 and 41).

With the negligible change in capital and the small increase in labour, real GDP increases slightly by 0.09 per cent in 2002 from the basecase level (Table 4.4, row 30). Consumption increases by 0.01 per cent (Table 4.4, row 5). The increase in consumption is lower than the increase in GDP because the real land rental (an important component of disposable income) declines by 0.26 per cent (Table 4.4, 0.02 in row 40 minus 0.28 in row 20). Overall, the magnitudes of the changes in capital, labour and consumption are small as were predicted by our BOTE analysis.

Total real government expenditure, *totgexreal*, increases by 1.89 per cent in 2002 relative to the base forecast (Table 4.4, row 52), as a direct result of the expansionary fiscal policy.

Given the relative shares of government expenditure (20 per cent) and investment (18 per cent) in total GDP, the increase (1.89 per cent) in G more or less offsets the decrease (2.72 per cent) in I. Consumption, which has the dominant share, increases very little. The small increase in real GDP requires the trade balance to move by little relative to the basecase forecast. The results show that all the trade balance figures (rows 11 to 14 of table 4.4) move by very little. The real trade balance decreases by K1.12 million and the nominal (Kina terms) trade balance increases by K1.66 million, relative to the levels in the base forecast.

Because the trade balance changes only slightly, we know that exports and imports must move by similar percentages. We see from Table 4.4 that real imports fall by 0.12 per cent and real exports fall by 0.13 per cent (rows 42 and 17). We now examine why both imports and exports fall. We start with imports. With little change in real income, the decline in investment means that there is little demand for imported investment goods. Thus imports decline and consequently exports must decline also. The decline in exports is facilitated by an appreciation in 2002 of the real exchange rate (0.27 per cent relative to the base forecast, Table 4.4, row 48).

The more-or-less offsetting changes in exports and imports give rise to hardly any change on the overall trade balance, (captured by all four measures in rows 11-14 of Table 4.4). As the nominal exchange rate is linked to *deltabn*, which shows a deviated deterioration of K0.25 million (row 12 of Table 4.4) there is a small impact on the nominal exchange rate, (-0.11 per cent). With real appreciation of 0.27 per cent and nominal devaluation of 0.11 per cent, the GDP deflator must rise by about 0.38 per cent, and we see in Table 4.5, row 18, that the increase is 0.37 per cent.

To understand the movements in the expenditure deflators, we define the percentage change in the GDP price deflator as

$$P_{gdp} = S_c P_c + S_i P_i + S_g P_g + \left(S_x P_x - S_m P_m\right) \tag{4.12}$$

where

P_c is the percentage change in the consumer price index,

P_i is the percentage change in the capital goods price index,

P_g is the percentage change in the price deflator for government expenditure,

P_x is the percentage change in the export price index,

P_m is the percentage change in the import price index, and

S_c, S_i, S_g, S_x and S_m are the shares of consumption, investment, government, exports and imports in GDP.

If we assume that $S_x = S_m$ (which is approximately the case for PNG), then;

$$P_{gdp} = S_c P_c + S_i P_i + S_g P_g + S_x \left(P_x - P_m\right) \qquad (4.13)$$

where

$\left(P_x - P_m\right)$ is the percentage in the terms of trade.

In the simulated results for 2002 in Table 4.4, row 44, the percentage change in the terms of trade, *p0toft*, is zero. So

$$P_{gdp} = S_c P_c + S_i P_i + S_g P_g \quad . \qquad (4.14)$$

The summation on the RHS makes up the price deflator for gross national expenditure. So when the percentage change in the terms of trade is zero $P_{gdp} = P_{gne}$.

We have already established above what the percentage change in the GDP price deflator is. Thus, we have now explained the percentage change in the GNE deflator. It must be about 0.38 per cent.

Within the GNE deflator (the RHS of equation (4.14)) there is a large increase (1.29 per cent) in the price deflator for government expenditure (Table 4.4, row 56). This is due to an increase in the rental price of capital in government sector industries, which reflects a strong increase in the demand for their products. In the short run, their capital-labour ratios fall. Partially offsetting the increase in the price deflator for government expenditure is a decrease (0.21 per cent) in the capital goods price index. This reflects weakened demand for investment goods. With P_i and P_g moving in opposite directions P_c is approximately the same as P_{gdp}. In our simulation the increase in the consumer price index (0.28 per cent) is very close to the increase in the GDP deflator (0.38 per cent).

The increase in domestic inflation causes the total nominal income (GDP) to increase by 0.46 per cent relative to the base forecast (row 29). With the increases in nominal income and interest rate, the money demand/supply equation (4.8) is satisfied.

Simulation Results for the Medium Term: 2003 to 2006

On average, total real government spending is 1.78 per cent above its forecast level in each of the years from 2003 to 2006 (Table 4.4, row 52). This is directly as a result of the fiscal expansionary shock.

Under the tight monetary policy stance whereby the money supply is held constant, the nominal interest rate is forced to be on average 2.46 per cent higher than it was in the base forecasts (Table 4.4, row 51). Over the period, the required economy-wide rate of return increases on average by about 2.46

per cent (Table 4.4, row 39) while the rate of return to capital for many industries is either relatively lower or declining. This causes aggregate investment to deviate below the basecase forecast on average by 1.76 per cent (Table 4.4, row 37). As a result industries cannot maintain the pre-policy-change activity level.

Subsequently, the level of aggregate capital stock falls on average by 0.38 per cent over the period (Table 4.4, row 38).

The depressed investment climate has an adverse impact on demand for imports, with aggregate real imports falling by 0.16 per cent on average from the base forecasts. At the same time, aggregate real exports fall on average by 0.29 per cent because of real exchange rate appreciation (an average of 0.36 per cent) relative to the base forecasts. These yield a deviated average real trade account deficit of K4.8 million and a nominal trade balance deficit of K16.99 million Kina (on average) from the base forecasts over the period Table 4.4, rows 11 and 13). As a consequence there is downward pressure on the nominal exchange rate. It depreciates by an average of 0.20 per cent over the four-year period (Table 4.4, row 46).

The rise in government spending in 2002 initially has a positive effect on employment (increases of 0.16 per cent in 2003, and 0.01 per cent in 2004). With rigid real wages, the employment deviation eventually turns negative (-0.07 per cent in 2005 and -0.11 per cent in 2006), reflecting the negative deviation in capital stock. On average, over the years 2003 to 2006, person-weighted labour is 0.003 per cent below its base forecast level while wage-weighted employment is 0.10 per cent above its base forecast level (Table 4.4, rows 2 and 41). The divergence between person-weighted and wage-weighted employment reflects the above-average wage rates of public servants.

The negative deviations in capital and person-weighted labour give rise to negative deviations in real GDP under the policy. These average 0.27 per cent over the four years (Table 4.4, row 31). From this, aggregate real consumption shows an average negative deviation of 0.45 per cent (Table 4.4, row 5).

Overall, the expansionary fiscal policy together with the policy of money-supply targeting crowd out investment and growth in capital stock suffers relative to the basecase forecasts. Charts 4.6a and 4.6b illustrate this story. The increase in government spending takes away funds from investment activities. This in turn impacts negatively on imports. Exports on the other hand are hurt by the real exchange rate appreciation. The fall in imports more or less offsets the decline in exports, leading to little changes in the trade balance.

Industry Results for Policy Scenario B

As Table 4.5(c) shows, the increase in government spending has a direct positive impact on the public sector industries of *health*, *education*, *government administration* and *electricity & garbage*. In these industries there are increases in activity level and the demand for labour. Investment and capital are constant under the non-application of the investment allocation theory.

Chart 4.6a: Cumulative Aggregate Investment Growth in Policy Forecasts versus Base Forecasts under Money Supply Targeting

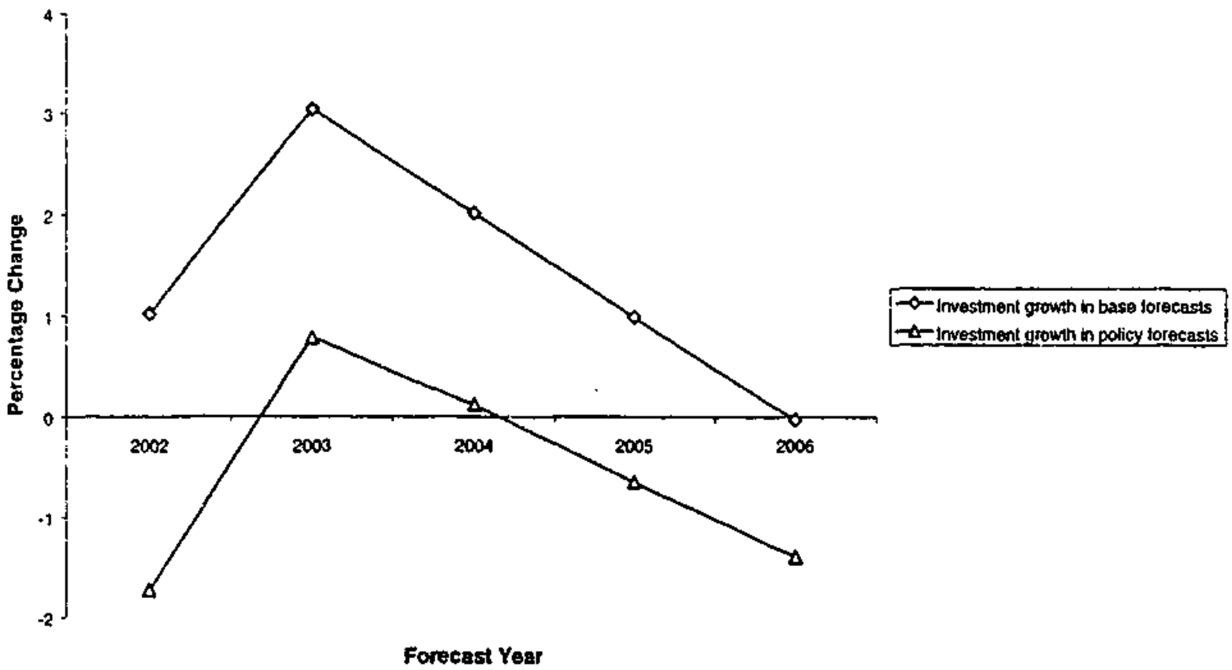
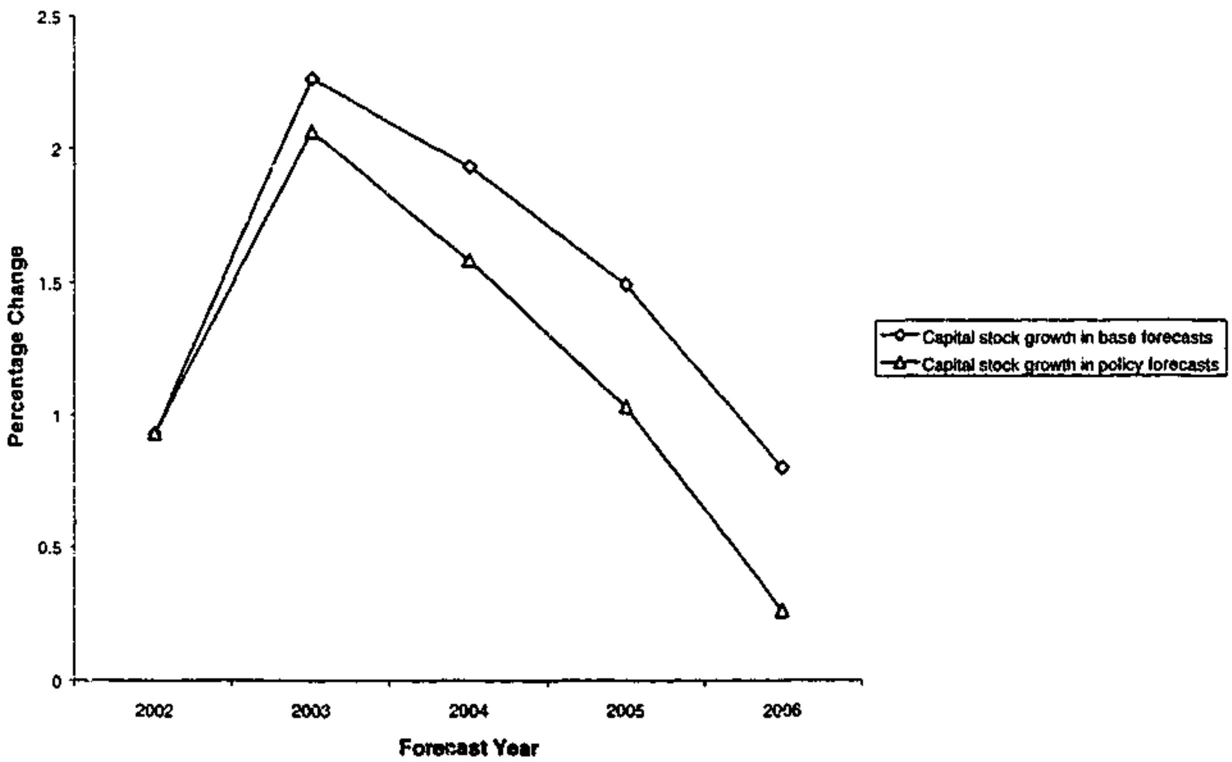


Chart 4.6b: Cumulative Growth of Aggregate Capital Stock in Policy Forecasts versus Base Forecasts under Monetary Policy Tightening

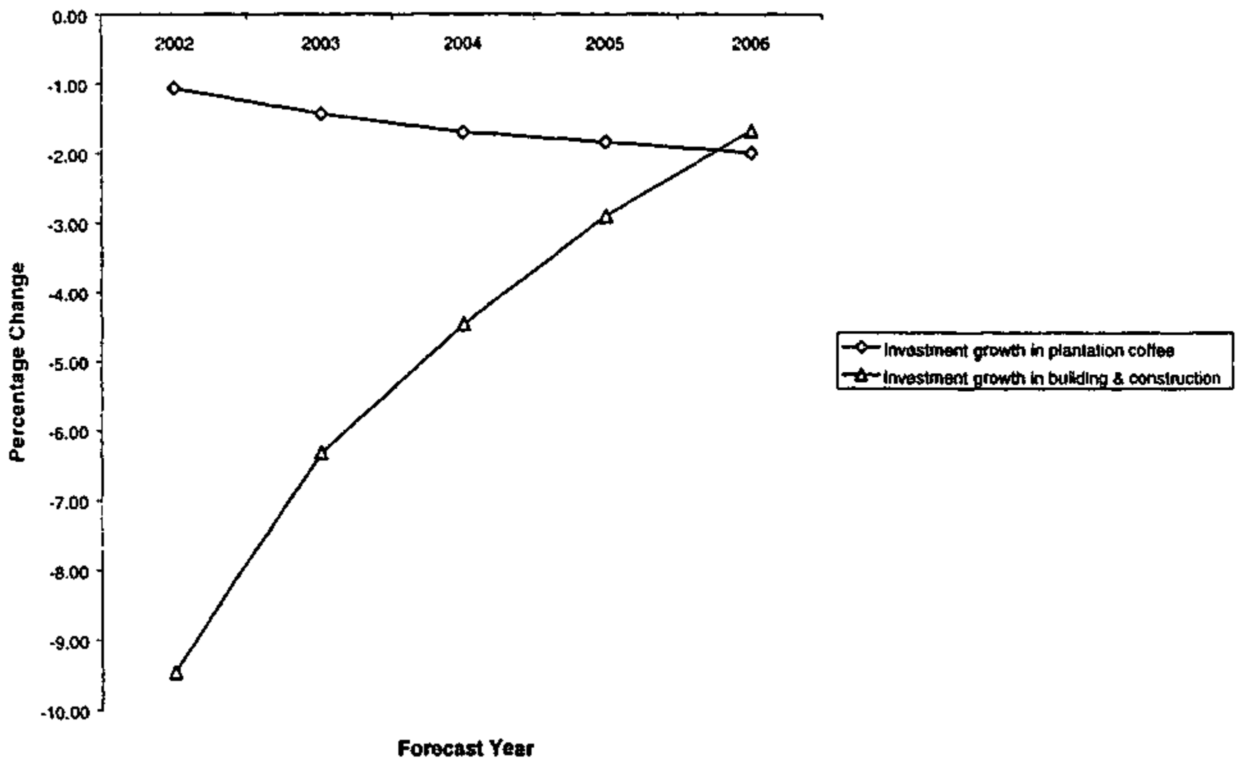


In contrast to policy scenario A, the industries that are associated with the government as suppliers of intermediate inputs such as *building & construction* do not increase their investment and activity in the policy scenario B (compare Tables 4.5(b) and 4.2(b)). This is because under the tight monetary policy, the economy-wide required rate of return, which is linked to the interest rate, has increased in many industries relative to their actual rate of return to capital. The rate of return to capital in *building & construction* falls relative to the basecase forecasts because the rental price of capital declines for a lot of the investment-driven industries. In turn, industries such as *machinery* and *building & construction,* that have some dependency on *building & construction,* are affected. Thus, investment and activity levels fall in these industries relative to the basecase forecasts.

For exporting industries, we again see that the real appreciation of the exchange rate leads to a situation in which the cost of production exceeds returns. This has an adverse impact on activity and subsequently investment and activity levels in exporting industries fall for most of the forecast period relative to the basecase forecasts (Table 4.5(b)). Real appreciation also has an adverse effect on importing-competing industries such as *food processing*.

Chart 4.7 shows that under the central bank's money-supply-targeting policy in response to the government's expansionary fiscal policy, there is an adverse impact on investment in exporting industries such as *plantation coffee*, and in the government intermediate-input supplying industries such as *building & construction.* This is in contrast to the policy scenario A, in which *building & construction* had positive investment growth relative to their investment in the basecase. (Compare Chart 4.7 with Chart 4.3.)

Chart 4.7: Deviated Investment Growth in an Exporting Industry and a Non-exporting Industry Under the Money Supply Targeting Policy



End-of-year capital stock and current-year capital which are linked to investment, experience a decline for most industries, apart from the government industries, as a result of the declines in investment. As noted earlier, the investment theory in our model does not apply to the public-sector industries. This is captured by the zero per cent changes for investment and capital stock in the results shown in table 4.5(c).

The simulated results in support of the above industry-level discussion are shown in Tables 4.5(a) to 4.5(c).

Table 4.5(a): Key Results for Selected Industries under a Tight Monetary Policy (Policy Scenario B)

	2002	2003	2004	2005	2006
			Deviated Percentage Change		
Asset price of capital					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	-0.24	0.06	0.25	0.39	0.51
Plantation coffee	-0.24	0.06	0.25	0.39	0.51
Ok Tedi	-0.24	0.06	0.25	0.39	0.51
Porgera mine	-0.24	0.06	0.25	0.39	0.51
Other mine	-0.24	0.06	0.25	0.39	0.51
Oil	-0.24	0.06	0.25	0.39	0.51
Food processing	-0.24	0.06	0.25	0.39	0.51
Building &construction	-0.04	0.12	0.23	0.30	0.37
Metals &Engineering	0.02	0.15	0.24	0.29	0.35
Machinery	-0.01	0.14	0.24	0.30	0.37
Rental price of capital	n/a	n/a	n/a	n/a	n/a
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	-0.09	-0.07	-0.07	-0.08	-0.04
Plantation copra	-0.57	-1.8	-2.54	-2.86	-3.19
Plantation coffee	-0.05	-0.12	-0.18	-0.20	-0.20
Ok Tedi	0.00	-0.02	-0.05	-0.07	-0.07
Porgera mine	-0.01	-0.04	-0.07	-0.08	-0.06
Other mine	-0.02	-0.07	-0.19	-0.34	-0.05
Oil	0.37	0.64	0.92	1.15	1.40
Food processing	-3.97	-2.05	-0.84	0.17	1.00
Building &construction	-2.37	-0.52	0.61	1.12	1.56
Metals &Engineering	0.17	0.54	0.94	1.11	1.41
Machinery					
Rate of return to Capital					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	0.22	-0.21	-0.50	-0.73	-0.84
Plantation coffee	-0.51	-2.89	-4.27	-4.96	-5.66
Ok Tedi	0.29	-0.26	-0.64	-0.90	-1.07
Porgera mine	0.37	-0.12	-0.46	-0.70	-0.88
Other mine	0.35	-0.15	-0.48	-0.72	-0.87
Food processing	0.96	0.91	1.04	1.17	1.37
Building &construction	-5.92	-3.32	-1.65	-0.25	0.90
Metals &Engineering	-3.68	-1.12	0.47	1.16	1.75
Machinery	0.27	0.61	1.06	1.23	1.59

Table 4.5(b): Key Results for Selected Industries under a Tight Monetary Policy (Policy Scenario B)

	2002	2003	2004	2005	2006
			Deviated Percentage Change		
Investment					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	-0.90	-0.78	-0.74	-0.72	-0.71
Plantation coffee	-1.06	-1.43	-1.70	-1.84	-2.00
Ok Tedi	-0.91	-0.87	-0.90	-0.93	-0.99
Porgera mine	-0.86	-0.79	-0.79	-0.82	-0.87
Other mine	-0.86	-0.80	-0.81	-0.85	-0.92
Food processing	-2.98	-2.46	-2.14	-1.87	-1.60
Building &construction	-9.46	-6.33	-4.47	-2.91	-1.68
Metals &Engineering	-7.43	-4.67	-3.05	-2.21	-1.51
Machinery	-3.64	-2.80	-2.19	-1.85	-1.41
Current Capital Stock					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	0.00	0.00	-0.01	-0.01	-0.01
Plantation coffee	0.00	-0.03	-0.06	-0.11	-0.15
Ok Tedi	0.00	-0.05	-0.10	-0.15	-0.22
Porgera mine	0.00	-0.03	-0.07	-0.11	-0.17
Other mine	0.00	-0.04	-0.08	-0.14	-0.23
Food processing	0.00	-0.33	-0.57	-0.74	-0.86
Building &construction	0.00	-0.27	-0.45	-0.58	-0.66
Metals &Engineering	0.00	-0.59	-0.50	-1.08	-1.15
Machinery	0.00	-0.37	-0.63	-0.77	-0.87
End-of-year Capital Stock					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	0.00	-0.01	-0.01	-0.01	-0.02
Plantation coffee	-0.03	-0.07	-0.11	-0.15	-0.19
Ok Tedi	-0.05	-0.09	-0.14	-0.19	-0.26
Porgera mine	-0.03	-0.06	-0.10	-0.14	-0.19
Other mine	-0.04	-0.07	-0.12	-0.18	-0.26
Food processing	-0.33	-0.57	-0.74	-0.86	-0.94
Building &construction	-0.27	-0.45	-0.59	-0.67	-0.70
Metals &Engineering	-0.60	-0.95	-1.09	-1.16	-1.18
Machinery	-0.37	-0.64	-0.78	-0.87	-0.92
Activity/Output Level					
Smallholding copra	-0.02	-0.04	-0.06	-0.07	-0.07
Smallholding coffee	-0.02	-0.03	-0.05	-0.06	-0.06
Plantation copra	-0.08	-0.10	-0.11	-0.13	-0.13
Plantation coffee	-0.39	-1.00	-1.40	-1.62	-1.86
Ok Tedi	-0.06	-0.11	-0.16	-0.20	-0.24
Porgera mine	-0.04	-0.07	-0.11	-0.14	-0.17
Other mine	-0.06	-0.10	-0.14	-0.18	-0.22
Food processing	0.02	-0.28	-0.48	-0.62	-0.70
Building &construction	-1.14	-0.91	-0.78	-0.68	-0.56
Metals &Engineering	-0.65	0.79	-0.90	-0.92	-0.89
Machinery	0.00	-0.36	-0.62	-0.75	-0.84

Table 4.5(c): Key Results for the Public Sector Industries under a Tight Monetary Policy (Policy Scenario B)

	2002	2003	2004	2005	2006
			Deviated Percentage Change		
Asset price (cost) of capital					
Education	-0.24	0.06	0.25	0.39	0.51
Health	-0.24	0.06	0.25	0.39	0.51
Government Administration	-0.24	0.06	0.25	0.39	0.51
Electricity & Garbage	-0.24	0.06	0.25	0.39	0.51
Rental price of capital					
Education	6.59	6.02	5.71	5.45	5.27
Health	4.56	4.10	3.84	3.65	3.54
Government Administration	7.51	6.74	6.37	6.07	5.85
Electricity & Garbage	1.48	0.58	0.02	-0.38	-0.69
Rate of return to Capital					
Education	10.61	9.20	8.41	7.79	7.31
Health	7.40	6.19	5.49	4.97	4.61
Government Administration	12.05	10.33	9.44	8.73	8.21
Electricity & Garbage	2.58	0.80	-0.30	-1.10	-1.71
Investment					
Education	0.00	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00	0.00
Government Administration	0.00	0.00	0.00	0.00	0.00
Electricity & Garbage	0.00	0.00	0.00	0.00	0.00
Current Capital Stock					
Education	0.00	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00	0.00
Government Administration	0.00	0.00	0.00	0.00	0.00
Electricity & Garbage	0.00	0.00	0.00	0.00	0.00
End-of-year Capital Stock					
Education	0.00	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00	0.00
Government Administration	0.00	0.00	0.00	0.00	0.00
Electricity & Garbage	0.00	0.00	0.00	0.00	0.00
Activity/Output Level					
Education	2.11	1.91	1.78	1.68	1.62
Health	1.72	1.50	1.36	1.26	1.20
Government Administration	1.95	1.74	1.59	1.48	1.41
Electricity & Garbage	0.16	0.03	-0.04	-0.07	-0.09

4.5.3 Policy Scenario C: Fiscal Expansion with an increase in Import Duty and Excise Rates and Money Supply Targeting

This policy scenario entails the same monetary policy stance of the central bank as in policy scenario B. The difference between the two scenarios is that the expansionary fiscal policy of the national government is supported in by increases in the import duty and excise rates in scenario C. Tax rates are increased in order to raise the revenue necessary to meet all or part of the increase in government expenditure. The objective of the central bank remains the achievement of a low rate of inflation.

In the simulation, we assume that the import duty and excise tax are both increased by 2.5 per cent uniformly across all the applicable goods in 2002.[39]

Macro Results for policy Scenario C

To analyze the macro results we once more utilize a BOTE model to establish our *a priori* expectations.

Predictions Based on the BOTE-M Model

To aid in the task of providing explanations to the results of for policy scenario C, we adopt a back-of-the-envelope (BOTE-M) model developed and used in MONASH (see Dixon & Rimmer, 2002, section 7.2) to explain the macro results of a MONASH simulation involving a tariff reduction on imported cars.

39 The figure of 2.5 per cent is taken from the PNG 2002 national budget document. But whereas the Government wanted a half yearly increase of 2.5 per cent in the excise tax in May and November, we assume the 2.5 per cent once for the whole year and is applicable to both the excise and tariff rates.

In our application of the BOTE-M model it is assumed that the PNG economy produces one good only (an agricultural food, denoted f) and imports one good (vehicles, denoted v). Food is produced via a constant-returns-to-scale production function of capital and labour inputs. Food and vehicles are both consumption and capital goods. Units of consumption and investment are derived from Cobb-Douglas functions for food and vehicles. Henceforth, the unit cost functions are of Cobb-Douglas form. Finally, it is assumed that the costs of employing units of capital and labour equal their marginal products. Under these assumptions, the BOTE-M model is specified as:

$$P_c = \left(P_f T_{fc}\right)^{\alpha_{fc}} \left(P_v T_{vc}\right)^{\alpha_{vc}}, \tag{4.15}$$

$$P_i = \left(P_f T_{fi}\right)^{\alpha_{fi}} \left(P_v T_{vi}\right)^{\alpha_{vi}}, \tag{4.16}$$

$$W = P_f M_l, \tag{4.17}$$

$$Q = P_f M_k, \tag{4.18}$$

$$W_{real} = W/P_c, \tag{4.19}$$

and

$$R = Q/P_i \tag{4.20}$$

where:

P_f and P_v are the basic price of agricultural food and the c.i.f price of vehicles;

P_c and P_i are the purchasers' prices of a unit of consumption and a unit of investment;

T_{fc}, T_{vc}, T_{fi} and T_{vi} are the powers (one plus rates) of the taxes (including tariffs) applying to consumption and investment purchases;

Q and W are factor payments, the rental rate and the wage rate;

W_{real} is the real wage rate;

R is the rate of return on capital calculated as the rental or user price of capital divided by the cost or asset price of a unit of capital; and

the α's are positive parameters reflecting the shares of food and vehicles in consumption and investment, such that $\alpha_{fc} + \alpha_{vc} = 1$ and $\alpha_{fi} + \alpha_{vi} = 1$.

The average powers of the taxes on consumption and investment are defined respectively as:

$$T_c = T_{fc}^{\alpha_{fc}} * T_{vc}^{\alpha_{vc}} \text{ and } T_i = T_{fi}^{\alpha_{fi}} * T_{vi}^{\alpha_{vi}} \quad . \tag{4.21}$$

Substituting average power of taxes on consumption in (4.21) into (4.15) we get

$$P_c = P_f^{\alpha_{fc}}.P_v^{\alpha_{vc}}.T_c$$

From (4.17) we get

$$M_l = \frac{W}{P_f} = \frac{W_{real}.P_c}{P_f} = \frac{W_{real}.P_f^{\alpha_{fc}}.P_v^{\alpha_{vc}}.T_c}{P_f}$$

Using the property $\alpha_{fc} + \alpha_{vc} = 1$ and so $\alpha_{fc} - 1 = -\alpha_{vc}$ the above equation can be simplified to:

$$M_l(\frac{K}{L}) = W_{real} * \left(\frac{P_v}{P_f}\right)^{\alpha_{vc}} * T_c \quad (4.22)$$

where $\left(\frac{P_v}{P_f}\right)^{\alpha_{vc}}$ can be interpreted as an inverse function of the terms of trade.

Equation (4.22) states that marginal product of labour is a positive function of the real wage, a negative function of the terms of trade and a positive function of the average power of consumption taxes.

Similarly, the marginal product of capital can be derived as:

$$M_k(\frac{K}{L}) = R * \left(\frac{P_v}{P_f}\right)^{\alpha_{vi}} * T_i \quad . \quad (4.23)$$

Equation (4.23) states that the marginal product of capital is a positive function of the rate of return on capital, a negative function of the terms of trade and a positive function of the average power of investment taxes.

As outlined earlier both the import duty and excise tax are raised. In terms of the BOTE-M model, this has the effect of increasing both the average power of the tax on consumer goods (T_c) and average power of the tax on investment goods (T_i) in the short run. Because we adopt high export demand elasticities in PNG-ORAMON, we would not expect the shocks under consideration here to cause noticeable changes in the terms of trade. In terms of BOTE-M we would expect $\frac{P_v}{P_f}$ to be close to constant. Thus, with W_{real} fixed, equation (4.22) indicates that the imposition of excise taxes and tariffs will increase the marginal product of labour (M_l), implying an increase in $\frac{K}{L}$. In the short run K is fixed. Thus we would expect the imposition of excise taxes and tariffs to have a short-run negative effect on employment. As we will see, this expectation is borne out by the results.

Because M_l increases in the short run, the marginal product of capital (M_k) must fall. With little change in the terms of trade and with an increase in T_i, via equation (4.23) we see that R must fall. This sets up an expectation that PNG-ORAMON will show a decrease in investment and capital stocks resulting from the imposition of indirect taxes. As we will see, relative to the base forecasts this expectation is borne out by the results. However, relative to policy scenario B, this expectation is not borne out by the results.

Actual Simulation Results for the Short Run: Year 2002

The main macro results are shown in Table 4.6. The key results are noted briefly to highlight the points that we will need to explain. Relative to the basecase forecasts,

- the increase in the two tax rates dampens demand for imports. This leads to an increase in the trade balance.
- the increase in the trade balance causes an appreciation of the nominal exchange rate.
- there are negative deviations in aggregate real consumption and in investment from the base forecasts. However, relative to the results in policy scenario B, there is an increase in aggregate real investment.
- the decline in investment occurs in spite of a reduction in the interest rate relative to the base forecast.
- aggregate capital stock is slow to move in the short run and declines in the medium term.
- there is a negative deviation in employment from the base forecasts.

- the real wage rate hardly changes (there is a very small decline, but it is not apparent in the table of results, which reports figures to two decimal points).

We have a two-tier explanation of the results from the actual model. The first looks at the deviations from the basecase forecasts and the second examines the results of policy scenario C relative to the results of policy scenario B.

We start with the supply-side story for which the fundamental relationship is $Y = \frac{1}{A} F(K, L)$. This is used together with the preceding BOTE-M presentation to guide the analysis of the results.

In the labour market, the real wage rate is more or less constant (the declines are too small to be noticeable in Table 4.6, which reports the figures to two decimal points.) The exogenous increase in the consumption tax is a uniform 2.5 per cent increase in the power of the excise while the endogenous improvement in the terms of trade is 0.02 (Table 4.6, row 44). So, from equation (4.2), the marginal product of labour, M_l, has to increase. For that to be realized, employment has to fall given that capital stock, $ksnew$, is constant. Aggregate person-weighted employment, *aggl*, falls by 0.77 per cent and wage-weighted employment falls by 0.64 per cent in 2002 relative to the basecase forecasts (Table 4.6, rows 2 and 41). Relative to the results of policy simulation B, the declines in aggregate person-weighted and wage-weighted employment in 2002 are 1.18 and 1.08 per cent respectively (compare rows 2 and 41 in Tables 4.6 and 4.4).

Table 4.6: Cumulative Deviated Macro Results under Fiscal Expansion, Increase in Duty and Excise Rates, and Money Supply Targeting (with investment theory turned off for public sector industries)

	Variable Model Name	Economic Name	2002	2003	2004	2005	2006
			percentage change				
1	a1primgen	Tech Coefficient	0.00	0.00	0.00	0.00	0.00
2	aggl	Aggregate Employment	-0.77	-0.90	-0.93	-0.89	-0.87
3	c1	Aggregate Nominal Cons	-0.88	-1.01	-1.07	-1.05	-1.05
4	chie	Govt Consumption	1.97	1.87	1.87	1.89	1.93
5	cr	Agg Real Consumption	-0.99	-1.18	-1.19	-1.16	-1.07
6	d_avesub	Change in Ave Subsidy*	0.00	0.00	0.00	0.00	0.00
7	d_totsub	Change in Total Subsidy*	-6.27	-7.91	-6.81	-5.91	-4.52
8	del_bt	Change in Trade Balance*	23.06	27.41	39.74	50.33	67.66
9	del_btgdp	Change in BT to GDP ratio*	0.00	0.00	0.00	0.00	0.00
10	del_unity	Homotopy Variable	0.00	0.00	0.00	0.00	0.00
11	deltab	Real Trade Account*	8.56	9.66	9.55	10.18	8.77
12	deltabn	Nominal Trade Account*	1.88	2.98	2.34	2.84	2.13
13	deltabotd	Trade balance in Dom Currency*	27.83	30.92	69.96	104.32	154.92
14	deltabotf	Trade balance in For Currency*	23.56	26.35	37.51	47.33	57.90
15	deltac	Current Account*	1.88	2.98	2.34	2.84	2.13
16	deltagb	Govt's Budget Position*	77.68	88.23	98.19	105.38	120.88
17	efcreal	Agg Real Exports	-0.66	-0.72	-0.83	-0.91	-1.05
18	epsilon1	GDP Deflator	0.16	0.18	0.13	0.07	-0.02
19	epsilon2	Capital Goods Price Index	0.00	0.14	0.12	0.08	0.00
20	epsilon3	Consumer Price Index	0.10	0.17	0.11	0.10	0.01
21	f1	Wage Shifter	0.00	0.00	0.00	0.00	0.00
22	f2	Investment Shifter	0.00	0.00	0.00	0.00	0.00
23	f4	Exports Shifter	0.00	0.00	0.00	0.00	0.00
24	f5	Other Dd Shifter	2.50	2.50	2.50	2.50	2.50
25	f_obs	Shifter for forecast exports	0.00	0.00	0.00	0.00	0.00
26	f_phi	Shifter for forecast exchange rate	-0.82	-0.85	-1.01	-1.07	-1.20
27	fc	Consumption Shifter	0.00	0.00	0.00	0.00	0.00
28	gc	Govt Consumption Expenditure	2.68	2.48	2.37	2.31	2.21
29	gdp	Nominal GDP	-0.22	-0.31	-0.36	-0.37	-0.39
30	gdpr	Real GDP	-0.38	-0.50	-0.49	-0.44	-0.37
31	gex	Total Govt Expd	2.07	1.96	1.89	1.88	1.81
32	gi	Govt Capital Expd	-0.16	0.01	0.01	-0.02	-0.09
33	gireal	Govt Real K Expd	0.00	0.00	0.00	0.00	0.00
34	go	Other Govt Expenditure	0.00	0.00	0.00	0.00	0.00
35	grev	Total Govt Revenue	4.83	4.89	5.18	5.42	5.72
36	in	Agg Nominal Investment	-1.06	-0.33	-0.02	0.12	0.24
37	ir	Agg Real Investment	-1.07	-0.48	-0.15	0.03	0.23
38	ksnew	Agg Capital Stock	0.00	-0.08	-0.11	-0.11	-0.11
39	lambda	Economy-wide Rate of Return	-1.85	-2.58	-3.02	-3.08	-3.26
40	lr	Returns to Land	-1.40	-1.51	-1.72	-1.77	-1.88
41	lw	Wage-Weighted Employment	-0.64	-0.77	-0.78	-0.74	-0.71
42	mfcreal	Real Imports	-1.16	-1.26	-1.26	-1.26	-1.20
43	mn	Money Demand	0.00	0.00	0.00	0.00	0.00
44	p0toft	Terms of Trade	0.02	0.02	0.00	0.00	-0.02

... continued

Table 4.6 continued

	Variable Model Name	Economic Name	2002	2003	2004	2005	2006
					percentage change		
45	p1lab_io	Nominal Wage	0.10	0.17	0.11	0.10	0.01
46	phi	Nominal Exchange Rate	0.84	0.87	1.03	1.09	1.23
47	q1	Households	0.00	0.00	0.00	0.00	0.00
48	realexch	Real Exchange Rate	1.00	1.06	1.15	1.16	1.20
49	realwage	Real Wage	0.00	0.00	0.00	0.00	0.00
50	refg	Foreign Grant	0.00	0.00	0.00	0.00	0.00
51	rn	Interest Rate	-1.85	-2.58	-3.02	-3.08	-3.26
52	totgexreal	Agg Real Govt Expd	1.52	1.46	1.49	1.54	1.60
53	twistimp	Import Twist	0.00	0.00	0.00	0.00	0.00
54	twistlk	Labour Twist	0.00	0.00	0.00	0.00	0.00
55	xi4	Export Price Index	-0.79	-0.82	-1.00	-1.05	-1.20
56	xig	Other Demand Price Index	0.72	0.62	0.51	0.44	0.30
57	xim	Import Price Index	-0.81	-0.84	-0.99	-1.05	-1.18
58	ximf	Import Price Index in Foreign Curr	0.00	0.00	0.00	0.00	0.00

* change in Kina million

With an increase in the capital-labour, K/L, ratio, the marginal product of capital, M_k, falls. Given the increase in investment tax and the very small increase in the terms of trade, the rate of return to capital has to fall for the decline in the marginal product of capital to be realized (see equation (4.23)). The actual results show that the rate of return to capital, rj (in the actual model), increases for some industries and declines for others. In aggregate terms, capital stock hardly changes (there is a negligible decline of 0.0009 per cent) and real investment falls by 1.07 per cent relative to the base forecasts (Table 4.6, rows 37 and 38). These results are consistent with the predictions of the BOTE-M model.

Aggregate investment increases relatively by 1.65 per cent. [Real investment declines in policy scenario C by 1.07 per cent (Table 4.6, row 37) and in policy scenario B by 2.72 per cent (Table 4.4, line 37)]. This is so because investment depends not only on the rate of return to capital but also on the economy-wide required rate of return to capital, *lambda*, which is linked to the interest rate. *Lambda* falls as a result of the decline in the interest rate, and so investment increases in policy scenario C relative to investment in policy scenario B. Intuitively, the interest rate and thus *lambda* fall because the central bank does not worry about financing the increase in G. The interest rate is also damped by the reduction in Y, which reduces the demand for money. (We return to this point later and provide a more rigorous justification for the fall in the interest rate).

Relative to the basecase forecast, in 2002 the fall in labour and the constant capital stock give rise to a deviated fall in real GDP of 0.38 per cent (Table 4.6, row 30).

We turn now to the demand-side story for which the fundamental equation is the all too common $Y = C + I + G + (X - M)$. The result that stands out in this simulation is the positive change (improvement) in the trade balance, $(X - M)$, in 2002, relative to both the basecase forecast and the results for policy simulation B (compare the result for *deltab*, *deltabn*, *deltabotd* and *deltabbotf* in rows 11 to 14 of Tables 4.6 and Table 4.4).

The increase in government revenue generated by increased tax rates aimed at meeting all or part of the increase in government expenditure, G, comes at a cost. The cost is a reduction in aggregate real consumption, C, of 0.99 per cent in 2002 relative to the base forecast (Table 4.6, row 5). The increases in the tax rates make the purchasers' prices for the affected goods rise and therefore reduces effective demand.

With aggregate consumption, government expenditure and investment making up 60 per cent, 20 per cent and 18 per cent of GDP respectively, the movements in these variables shown in Table 4.6 imply a reduction in real national expenditure of 0.48 per cent ((-0.99*0.60)+(1.52*0.20)+(-1.07*0.18)). GDP falls by 0.38 per cent only, and so we would expect an improvement in the balance of trade.

In line with our expectation, the results show a small, K27.83 million, increase in the nominal trade balance from the base forecast level (Table 4.6, line 13). We would usually expect an increase in $(X-M)$ to be accompanied by a real devaluation. However, in this simulation there is a real exchange rate appreciation of 1.00 per cent (Table 4.6, row 48). This reflects the increase of 0.16 per cent in the GDP price deflator (row 18) and 0.84 per cent appreciation of the nominal exchange rate (row 46). We have to look further to explain the increase in $(X-M)$. The tariff increases act directly to reduce imports and imports are further reduced by the tax-induced reduction in consumption and investment. Thus, aggregate real imports, *mfcreal*, declines by 1.16 per cent relative to the basecase forecast despite the real appreciation. There is also a decline in aggregate real exports, *efcreal*, a negative deviation of 0.66 per cent from the base case forecast in 2002, reflecting the real appreciation of the exchange rate. The fall in imports is greater than the fall in exports, and so the trade account improves relative to the basecase forecast.

Relative to the results in policy scenario B, *mfcreal* falls 1.04 per cent and *efcreal* falls by 0.53 per cent (Tables 4.6 and 4.4, rows 42 and 17). Thus the effect of the increased indirect taxes, especially the increased tariff, is to reduce trade, particularly imports. Thus, we see a positive deviation of K26.17 million in the nominal trade account when comparing the results of policy simulation C with those of policy simulation B (compare 2002 figures in row 13 in Tables 4.6 and 4.4).

The positive change in $(X-M)$ in the simulation exerts upward pressure on the nominal exchange rate, with *phi* appreciating by 0.84 per cent relative to the base forecast (Table 4.6, row 46). With the appreciation of the nominal exchange rate we would expect, the domestic price level to fall. The actual result is a small rise (0.16 per cent) in the GDP deflator relative to the basecase forecast (Table 4.6, row 18). However, relative to policy scenario B, there is a fall of 0.21 per cent in the GDP deflator (compare row 18 Tables 4.6 and 4.4), indicating that the tighter fiscal policy allows the increase in government consumption to be implemented with less inflation than occurred when we relied only on tight monetary policy. With the fall in prices in policy scenario C relative to policy scenario B we would have expected interest rate to be lower in policy scenario C. In fact, the interest rate is 5.81 per cent lower in policy scenario C than in policy scenario B (Tables 4.6 and 4.4, row 51). The declines in real GDP, prices and the interest rate relative to the basecase forecasts and relative to policy scenario B satisfy the money demand equation (4.8).

Actual Simulation Results for the Medium Term: 2003 to 2006

The positive impact of the policy change on the trade balance continued into the medium-term forecast period, 2003 to 2006. Relative to the base forecasts real exports decline by an annual average of 0.87 per cent while real imports decline by an annual average of 1.24 per cent, netting an average of K90.03 million improvement in the nominal trade balance (Table 4.6, rows 17, 42 and 13).

The positive deviation in the trade balance from the base-case forecasts causes the nominal exchange rate to appreciate by an average of 1.05 per cent from the base-forecast rates (Table 4.6, row 46).

Employment contunues to decline but at a declining rate. Person-weighted employment declines on average by 0.90 per cent a year and wage-weighted employment declines on average by 0.75 per cent a year relative to the basecase forecasts (Table 4.6, rows 2 and 41).

In policy scenario C the capital stock increases relative to capital stock in policy scenario B. This reflects the increase in investment in this policy scenario relative to that in policy scenario B. As we see in Table 4.6, row 38, relative to the basecase forecasts, there is on average a 0.10 per cent a year contraction in capital. This is so because real investment falls as the rate of return to capital declines for some industries. However, in the last two forecast years (2005 and 2006), real investment increases relative to the base forecasts by 0.03 and 0.23 per cent (Table 4.6, row 37.). In 2005 and 2006, for some industries the interest rate and therefore the economy-wide required rate of return declines by more than the decline in their rate of return to capital, making it conducive for them to invest. Charts 4.8 and 4.9 show the cumulative growth in aggregate investment and aggregate capital stock in the forecast period, under the policy scenario C relative to the basecase forecasts.

Chart 4.8: Cumulative Growth of Aggregate Investment Growth in Policy Forecasts and Base Forecasts in Policy Scenario C

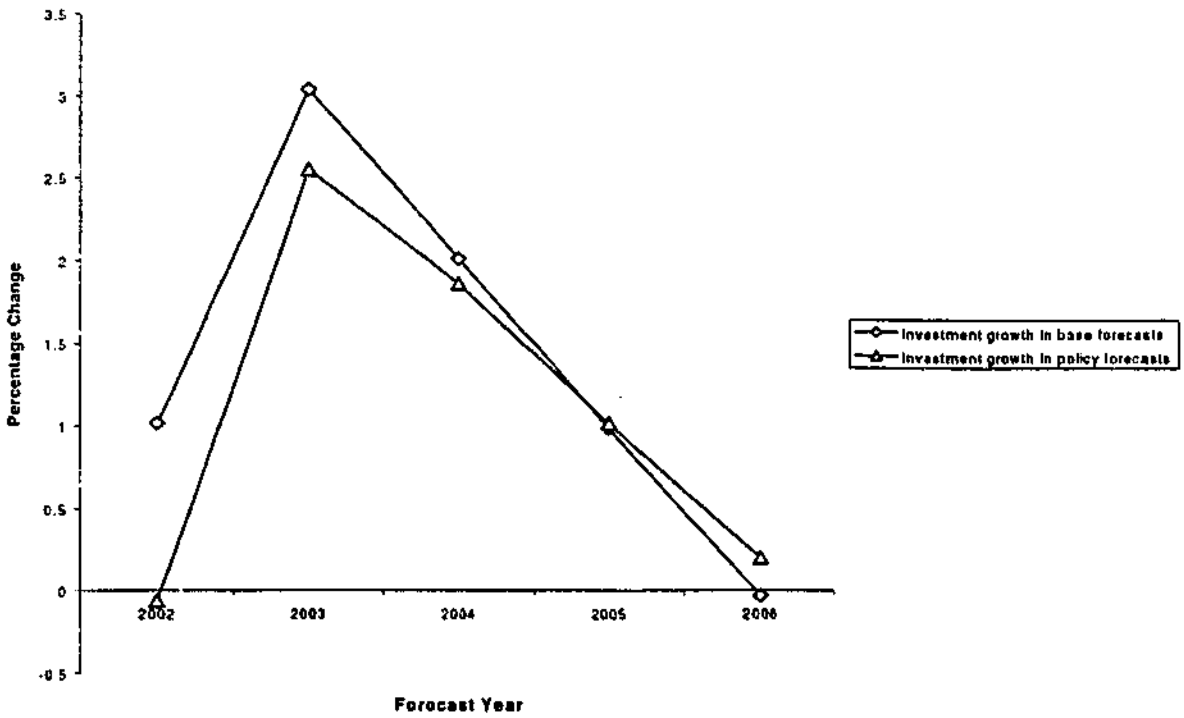
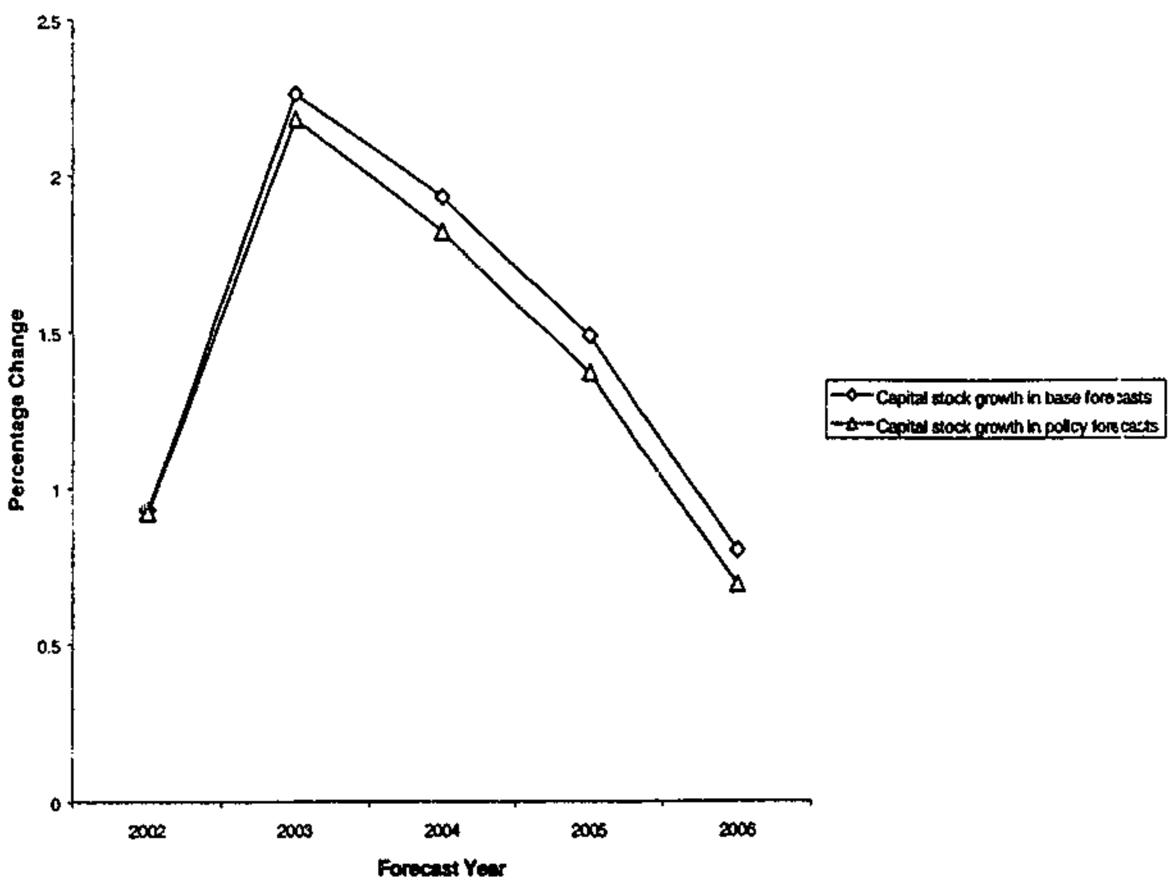


Chart 4.9: Cumulative Growth of Aggregate Capital Stock in Policy Forecasts and Base Forecasts in Policy Scenario C



The fall in employment and in capital stocks has a negative impact on output, with real GDP declining at an average rate of 0.45 per cent from the basecase forecasts (Table 4.6, row 30). This in turn has a negative impact on aggregate real consumption, which falls at an average annual rate of 1.15 per cent (Table 4.6, row 5).

In sum, the imposition of increased taxes in support of the increase in government spending crowds out consumption relative to both the basecase forecasts and the forecasts in policy scenario B. Investment also declines relative to the basecase forecasts but increases relative to the forecasts in policy scenario B. With the increase in tariffs, there is a sharp decline in imports, and a consequent negative movement in exports. The decline in imports is greater than the decline in exports, resulting in a positive movement in the trade balance.

Industry Level Results for Policy Scenario C

The increase in government spending, accompanied by an increase in the powers of the import duty and the excise tax, has a positive impact on the public sector industries of *health*, *education* and *government administration*, though not on *electricity & garbage*. Activity level and demand for labour increase in *health*, *education* and *government administration* relative to the baseline forecasts (Table 4.7(c)).

Table 4.7(a): Key Results for Selected Industries under Fiscal Expansion, Rise in Duty & Excise Rates a Tight Monetary Policy

	2002	2003	2004	2005	2006
		Cumulated Deviated Percentage Change			
Asset price of capital					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	-0.16	0.01	0.01	-0.02	-0.09
Plantation coffee	-0.16	0.00	0.00	-0.02	-0.10
Ok Tedi	-0.16	0.01	0.01	-0.02	-0.10
Porgera mine	-0.16	0.01	0.01	-0.02	-0.10
Other mine	-0.16	0.01	0.01	-0.02	-0.10
Oil	-0.16	0.01	0.01	-0.02	-0.10
Food processing	-0.16	0.01	0.01	-0.02	-0.09
Building &construction	0.83	0.86	0.77	0.71	0.60
Metals &Engineering	1.09	1.07	0.93	0.86	0.74
Machinery	0.96	0.96	0.82	0.76	0.65
Rental price of capital					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	-0.15	-0.22	-0.4	-0.51	-0.69
Plantation coffee	-8.56	-9.08	-8.41	-8.12	-9.05
Ok Tedi	-2.09	-2.14	-2.40	-2.47	-2.73
Porgera mine	-1.58	-1.63	-1.85	-1.97	-2.22
Other mine	-1.66	-1.71	-1.94	-2.05	-2.29
Oil	-1.75	-1.87	-2.36	-2.82	-3.54
Food processing	0.20	-1.07	-1.48	-1.69	-1.81
Building &construction	-2.01	-0.43	0.37	0.51	0.63
Metals &Engineering	3.13	2.24	1.15	0.57	0.08
Machinery	1.49	0.37	-0.49	-0.80	-1.10
Rate of return to Capital					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	0.00	-0.35	-0.63	-0.75	-0.90
Plantation coffee	-11.72	-12.74	-11.76	-11.29	-12.59
Ok Tedi	-2.93	-3.26	-3.64	-3.71	-3.99
Porgera mine	-2.15	-2.47	-2.81	-2.94	-3.21
Other mine	-2.27	-2.60	-2.94	-3.06	-3.31
Oil	-2.40	-2.83	-3.57	-4.24	-5.21
Food processing	0.56	-1.61	-2.24	-2.50	-2.58
Building & construction	-4.26	-1.97	-0.64	-0.33	0.01
Metals &Engineering	3.08	1.78	0.35	-0.43	-0.98
Machinery	0.78	-0.90	-1.99	-2.36	-2.64

Table 4.7(b): Key Results for Selected Industries under Fiscal Expansion, Rise in Duty & Excise Rates a Tight Monetary Policy (Policy Scenario C)

	2002	2003	2004	2005	2006
Investment		*Cumulated Deviated Percentage Change*			
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	0.46	0.56	0.61	0.60	0.61
Plantation coffee	-3.17	-3.34	-3.04	-2.97	-3.31
Ok Tedi	-0.27	-0.18	-0.18	-0.19	-0.23
Porgera mine	-0.08	0.02	0.05	0.04	0.02
Other mine	-0.11	-0.01	0.02	0.00	-0.02
Oil	-0.14	-0.07	-0.15	-0.31	-0.53
Food processing	2.46	1.28	1.21	1.09	1.26
Building &construction	-2.45	0.58	2.42	2.90	3.55
Metals &Engineering	5.01	4.87	4.32	3.81	3.63
Machinery	2.69	2.01	1.55	1.34	1.31
Current Capital Stock					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	0.00	0.00	0.00	0.01	0.01
Plantation coffee	0.00	-0.09	-0.17	-0.25	-0.31
Ok Tedi	0.00	-0.01	-0.03	-0.04	-0.05
Porgera mine	0.00	0.00	0.00	0.00	0.00
Other mine	0.00	0.00	-0.01	-0.01	-0.01
Oil	0.00	-0.01	-0.01	-0.02	-0.03
Food processing	0.00	0.27	0.38	0.47	0.54
Building &construction	0.00	-0.07	-0.05	0.04	0.14
Metals &Engineering	0.00	0.40	0.79	1.03	1.21
Machinery	0.00	0.27	0.46	0.56	0.63
End-of-year Capital Stock					
Smallholding copra	n/a	n/a	n/a	n/a	n/a
Smallholding coffee	n/a	n/a	n/a	n/a	n/a
Plantation copra	0.00	0.00	0.01	0.01	0.01
Plantation coffee	-0.09	-0.17	-0.25	-0.31	-0.38
Ok Tedi	-0.01	-0.02	-0.03	-0.04	-0.06
Porgera mine	0.00	0.00	0.00	0.00	0.00
Other mine	-0.01	0.00	0.00	0.00	-0.01
Oil	-0.01	-0.01	-0.01	-0.03	-0.05
Food processing	0.28	0.39	0.47	0.54	0.62
Building & construction	-0.07	-0.05	0.04	0.14	0.26
Metals & Engineering	0.40	0.80	1.03	1.22	1.35
Machinery	0.27	0.46	0.56	0.64	0.69
Activity/Output Level					
Smallholding copra	-0.13	-0.16	-0.19	-0.20	-0.20
Smallholding coffee	-0.10	-0.13	-0.16	-0.17	-0.17
Plantation copra	-0.05	-0.08	-0.10	-0.12	-0.14
Plantation coffee	-4.24	-4.67	-4.41	-4.38	-4.91
Ok Tedi	-0.38	-0.41	-0.45	-0.46	-0.49
Porgera mine	-0.23	-0.25	-0.27	-0.27	-0.28
Other mine	-0.34	-0.37	-0.40	-0.41	-0.42
Food processing	0.02	0.04	0.08	0.14	0.20
Building &construction	-0.56	-0.23	0.00	0.13	0.28
Metals & Engineering	0.72	0.88	1.05	1.14	1.22
Machinery	0.04	0.28	0.44	0.53	0.60

Table 4.7(c):Key Results for Public Sector Industries under Fiscal Expansion, Rise in Duty & Excise Rates a Tight Monetary Policy (Policy Scenario C)

	2002	2003	2004	2005	2006
	Cumulated Deviated Percentage Change				
Asset price (cost) of capital					
Education	-0.16	0.01	0.01	-0.02	-0.10
Health	-0.16	0.01	0.01	-0.02	-0.10
Government Administration	-0.16	0.01	0.01	-0.02	-0.10
Electricity & Garbage	-0.16	0.01	0.01	-0.02	-0.10
Rental price of capital					
Education	4.68	4.25	4.08	4.01	3.95
Health	3.24	2.95	2.83	2.80	2.77
Government Administration	5.14	4.57	4.40	4.35	4.33
Electricity & Garbage	-1.43	-1.92	-2.10	-2.13	-2.13
Rate of return to Capital					
Education	7.50	6.54	6.27	6.21	6.24
Health	5.22	4.50	4.32	4.32	4.40
Government Administration	8.20	7.03	6.76	6.73	6.82
Electricity & Garbage	-1.90	-2.86	-3.13	-3.14	-3.03
Investment					
Education	0.00	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00	0.00
Government Administration	0.00	0.00	0.00	0.00	0.00
Electricity & Garbage	0.00	0.00	0.00	0.00	0.00
Current Capital Stock					
Education	0.00	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00	0.00
Government Administration	0.00	0.00	0.00	0.00	0.00
Electricity & Garbage	0.00	0.00	0.00	0.00	0.00
End-of-year Capital Stock					
Education	0.00	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00	0.00
Government Administration	0.00	0.00	0.00	0.00	0.00
Electricity & Garbage	0.00	0.00	0.00	0.00	0.00
Activity/Output Level					
Education	1.55	1.40	1.35	1.34	1.35
Health	1.27	1.13	1.10	1.09	1.11
Government Administration	1.37	1.21	1.16	1.14	1.15
Electricity & Garbage	-0.21	-0.25	-0.23	-0.20	-0.16

Relative to policy scenario B, activity level falls in all four government-sector industries in all the forecast years [compare results in Table 4.7(c) and Table 4.5(c)]. The government-sector industries sell not only to government but also to households. The weaker performance in policy scenario C relative to that in policy scenario B is attributed to the general decline in households purchases of goods and services.

In policy scenario C, capital supplying industries in the private sector benefited. Output increases in *metals & engineering* and *machinery* relative to the basecase forecasts (Table 4.7(b)) and increases for *building and construction, metals and engineering* and *machinery* relative to policy scenario B. Relative to the basecase forecast, there is also an increase in investment in *metals & engineering* and *machinery*. Relative to policy scenario B, there is an increase in investment in all these three industries [Table 4.7(b) and 4.5(b)]. The improved performance in investment and output is driven by an increase in the rate of return to capital for *metals & engineering* and *machinery* industries relative to the base forecasts and for all the three industries relative to policy scenario B [compare results in Tables 4.7(a) and 4.5(a)]. Intuitively, the self-financing increase in government spending has freed up funds to be used by these industries.

Mineral and agricultural exporting industries fare poorly in policy scenario C because, as we saw in line 48 of Table 4.6, there is still a real appreciation of the exchange rate. Relative to both the baseline forecasts and to the results for policy scenario B, the demand for most exports fall and subsequently activity level in these exporting industries falls. (See Table 4.7(b)).

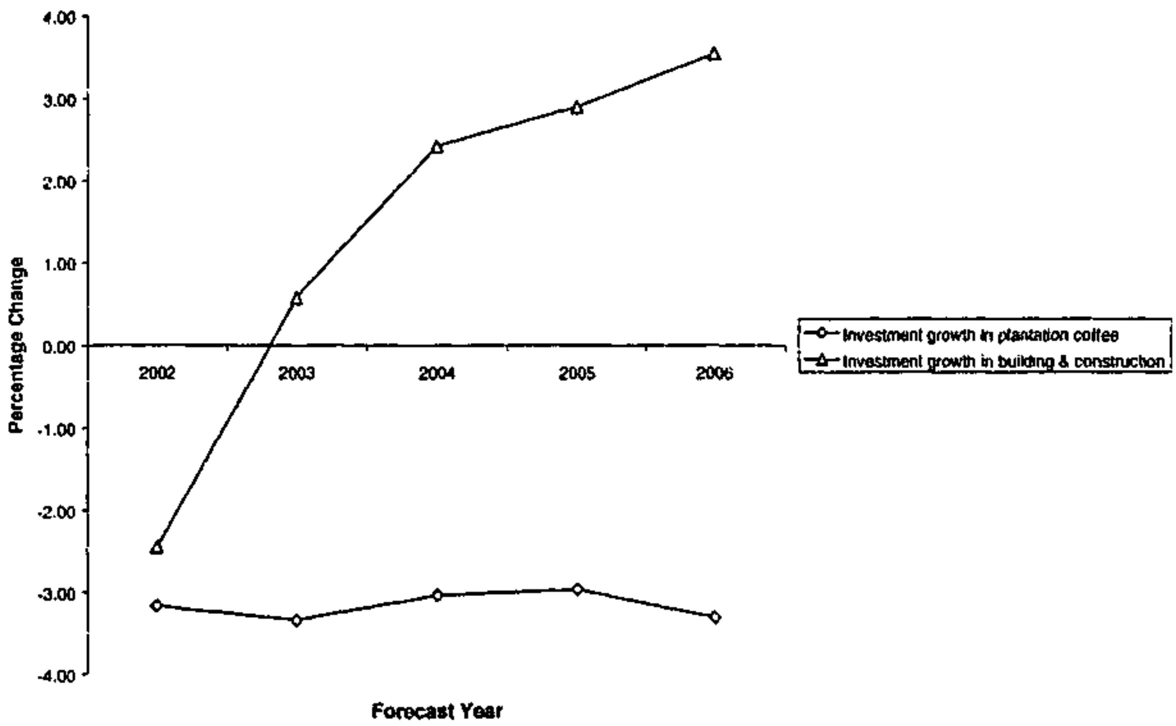
Chart 4.10 shows that under policy scenario C, *building & construction* fares better in terms of investment growth than *plantation coffee*, which suffers under policy scenario C relative to policy scenario B. By comparing Chart 4.10 and Chart 4.7, we see that investment in *building and construction* (an industry that provides intermediate inputs to the government sector) is strong in policy scenario C relative to policy scenario B and that investment in *plantation coffee* (an exporting industry) is weak in scenario C compared to scenario B.

The industries that gain most in policy scenario C are import-competing industries such as *food processing*. Relative to both the base forecasts and policy scenario B, investment and activity increase in *food processing* in all forecast years [Table 4.7(b) and Table 4.5(b)]. This is explained by the increase in the purchasers prices of imports, directly caused by the imposition of tariffs, relative to the purchasers prices of domestic substitutes.

4.6 Conclusion

In this chapter we examined the feed-through effect of a change in monetary policy in response to an increase in government spending (recurrent expenditure). We examined three scenarios. The first involved the combination of an expansionary fiscal policy (an increase in government expenditure without a compensating increase in government revenue) and an accommodating monetary policy (fixed interest rate). The second involved the combination of an expansionary fiscal policy with a tight monetary policy (fixed money supply). In the third, we assumed a balanced fiscal policy stance (an increase in government expenditure with a compensating increase in government revenue) and tight monetary policy (fixed money supply).

Chart 4.10: Deviated Cumulative Investment Growth in an Exporting Industry and a Non-exporting Industry in Policy Scenario C



The transmission of the shocks from one variable to another depends on the pathways that we have modelled, based on economic theory. We summarize the crucial pathways here, which we then use to draw conclusions on the impacts of the three policy scenarios.

We first consider the pathways on the supply side. On the supply side, capital stock does not change in the short run. After the first year, in the medium term, capital stock can change. A change in capital stock away from its basecase forecast level can be caused by a change in the investment flow. There are two factors that can cause a change in investment. First, a change (rise or fall) in the interest rate would cause a change (rise or fall) in the economy-wide required rate of return to capital which causes a change (decline or increase) in investment. Second, the rate of return to capital, also depends on the change in the cost of capital and the rental price of capital. An increase (a fall) in the rate of return to capital causes investment to increase (to fall). Investment growth is thus an inverse function of the economy-wide required rate of return and a positive function of the expected rate of return to capital. Relative to the basecase forecast levels, growth in investment adds to the capital stock while a decline in investment reduces capital stock at the end of a year. The capital stock at the end of a year is linked to the following year's opening capital stock by the dynamic inter-temporal link between investment and capital in the capital-accumulation equation, and in particular, by the homotopy variable, *del_unity*.

Labour employment is a function of the real wage rate. A fall in the real wage rates encourages employment growth while an increase damps it. In addition, we saw that a direct positive shock on labour-intensive industries has a positive impact on employment growth at any given real wage rate.

Changes in labour and capital (and technology, which was held constant in our simulations) in turn affect real output, that is real GDP. Real GDP is an increasing function of both labour and capital.

Next we consider the pathways on the demand side. On the demand side, aggregate real consumption is an increasing function of real GDP via the marginal propensity to consume. In addition, we saw that real consumption depends also on real land rental. Real land rental was an important factor affecting real consumption in rural smallholding industries.

The pathway for investment was covered in our discussion of accumulation of capital.

Government demand is exogenous in our simulations.

The trade sector is a residual. Once we have explained GDP, C, I and G, we can deduce $(X-M)$. Whatever the change in $(X-M)$ required by the GDP identity can be facilitated by adjustment in the real exchange rate. In our modelling, we assumed that the trade balance impacts on the nominal exchange rate. A positive deviation in $(X-M)$ relative to the basecase forecasts causes nominal appreciation and is usually associated with real devaluation while a negative deviation in $(X-M)$ relative to the basecase forecasts causes nominal depreciation (devaluation) and is usually associated with real appreciation. Thus, a positive deviation in $(X-M)$ is normally associated with a reduction in inflation, and a negative deviation in $(X-M)$ is normally associated with an increase in inflation.

Having had the pathways outlined, a summary of the key results for three policy simulations is presented. Reference is made to Charts 4.11 to 4.14, which show for the three policy scenarios the percentage deviation from the basecase forecasts in GDP, the consumer price index, the GDP deflator and real investment.

Chart 4.11: Real GDP in the Three Policy Scenarios
(% Deviation from Basecase Forecasts)

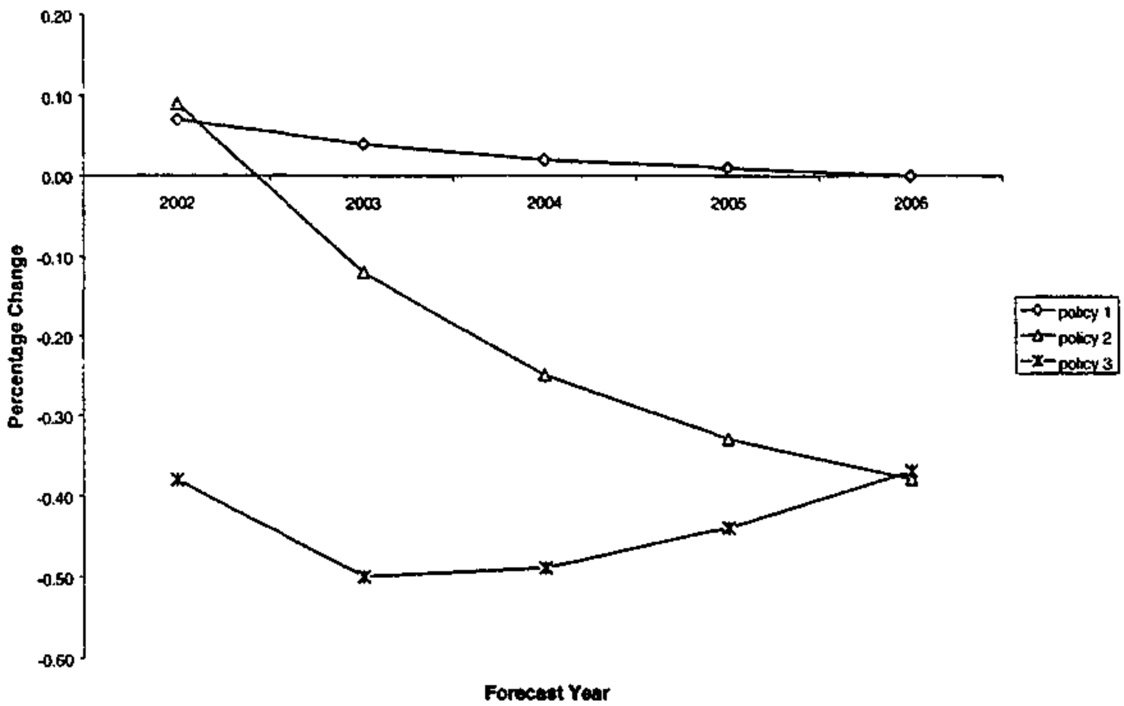


Chart 4.12: Consumer Price Index in the Three Policy Scenarios
(% Deviation from Basecase Forecasts)

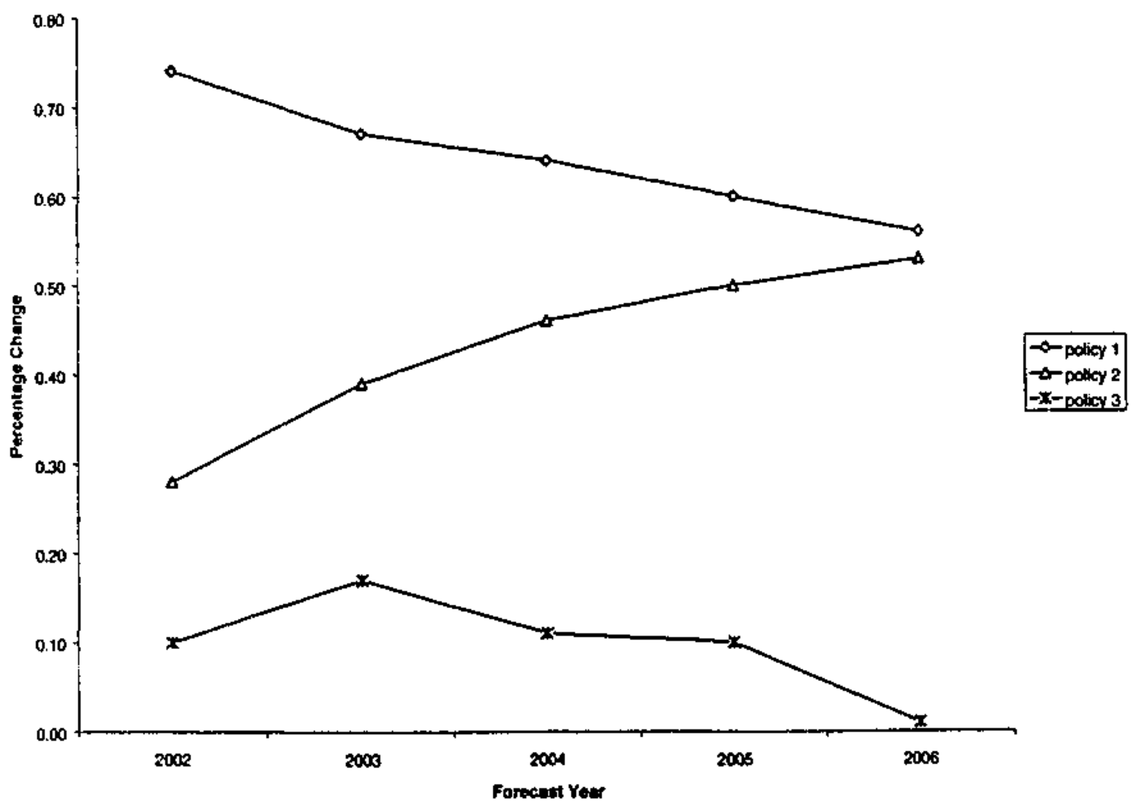


Chart 4.13: GDP Deflator in the Three Policy Scenarios (% Deviation from Basecase Forecasts)

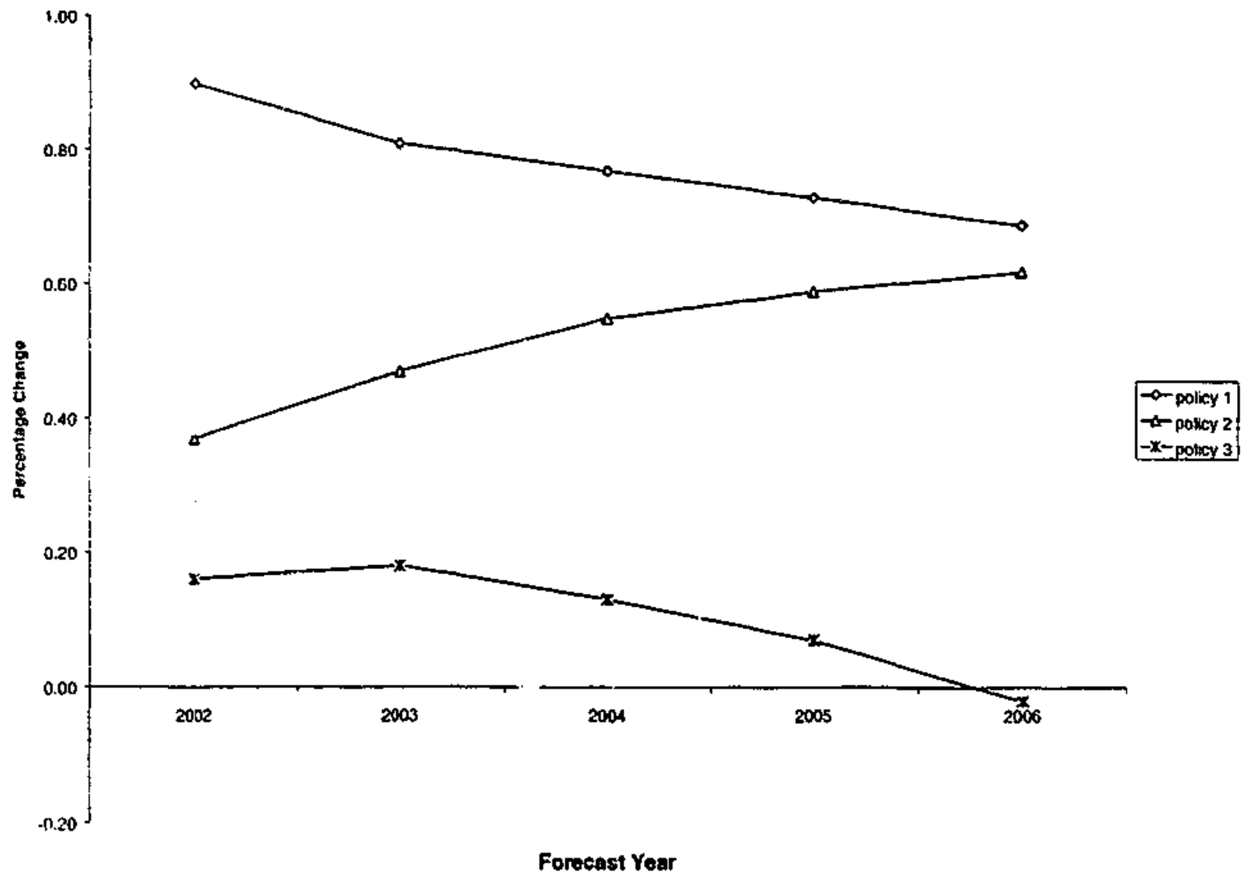
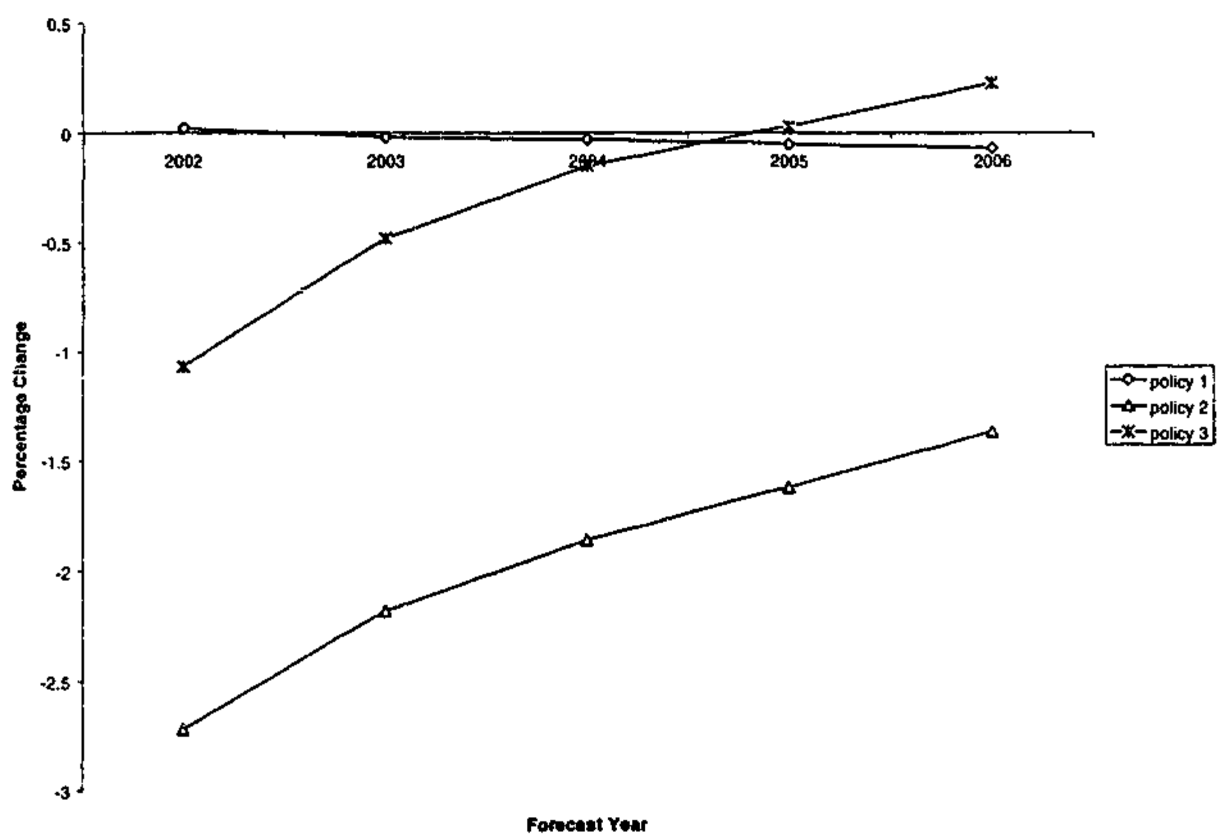


Chart 4.14: Aggregate Real Investment in the Three Policy Scenarios (% Deviation from Basecase Forecasts)



In the first policy scenario (case A) of interest rate targeting and increased government spending, the central bank was primarily concerned about investment growth. By forcing the interest rate to remain unchanged relative to the basecase forecasts, the economy-wide required rate of return also did not change. With zero percentage change in the economy-wide required rate of return our first guess would be that real investment would not be affected. While this holds true for aggregate real investment, it does not for industry level investment. The policy stance proved inflationary and led to a real exchange rate appreciation. Exporting and import-substituting industries were adversely affected. Costs of production exceeded returns and subsequently, investment and capital stock declined in these industries. On the other hand, because of the increase in government spending, there was an increase in demand for capital and thus an increase in the rate of return to capital for industries, *such as building and construction*, that supply goods as intermediate inputs to the public-sector industries. This led to an increase in investment and capital stock in these government-oriented industries. The investment declines in some industries more or less offset the investment increases in other industries. In aggregate terms therefore, investment and capital stock deviated little from their growth paths in the basecase forecasts.

The negative impact on exports and positive impact on imports of the real appreciation resulted in a negative deviation in the trade balance from the basecase forecast. In macro terms, the central bank was successful in its policy aim of sustaining investment growth. However, there was a trade-off. Exports were squeezed and imports increased. In other words, the expansionary fiscal policy combined with an accommodating monetary policy crowded out the trade balance. Furthermore, by causing real appreciation and nominal devaluation, the combination of expansionary fiscal policy with an accommodating monetary policy led in the short run to an increase in inflation.

If growth in investment and capital stock are important aims of economic policy, then it is tempting to propose interest-reducing policies. What would happen if the central bank went further than just accommodating the expansionary fiscal policy, namely a situation in which the central bank allowed the interest rate to fall. While not reported in this thesis, we ran such a simulation. It shows that investment is encouraged but the problems highlighted in policy scenario A are accentuated. With a loose monetary policy (reduction in the interest rate), exporters were squeezed even more and imports were encouraged even further, leading to a bigger negative deviation in the trade balance. This generated a bigger nominal devaluation and required a bigger real appreciation. Consequently, the loose monetary policy simulation generated more inflation than was apparent in policy simulation A.

In the second policy scenario (case B), the tight control on money supply led to a rise in the interest rate, which caused the economy-wide required rate of return to increase. The rate of return to capital declined for many industries, even in the industries that supply to the government, as demand for industry capital falls. Investment is crowded out. Intuitively, funds are channeled to the government away from productive investment. There is a small real appreciation relative to the basecase forecasts and a real depreciation relative to policy scenario A. Consequently, exports decline relative the base forecasts and increase relative to the outcome in policy scenario A. The decline in investment caused a decline in imports. In aggregate terms, real exports and imports decline slightly by around the same percentage rate, resulting in a negligible change in the trade balance. Consequently, the depreciation of the nominal exchange rate in policy scenario B is less than it was in policy scenario A. The depreciation of the nominal exchange rate transmits a small increase in the basic prices for exports and imports, and ultimately a lower rate of increase in domestic prices than in policy scenario A. In summary, in policy scenario B the central bank is successful in attaining its objective of low inflation rate but at the cost of investment growth in the economy. That is, the expansionary fiscal policy combined with tight monetary policy crowds out investment.

In the third policy scenario (case C), the imposition of the increased tariff and excise tax rates to support the increase in government spending renders a relative fiscal tightness on the part of the government. The increase in tax rates leads to an increase in purchasers' prices. Thus, aggregate real consumption is reduced relative to real consumption in the basecase forecasts as well relative to real consumption in policy scenario B. The increase in the tariff rate has a direct negative effect on imports. This led to an increase in the trade balance relative to the basecase forecasts and the trade balance in policy scenario B, despite the real appreciation. The positive deviation in the trade balance leads to appreciation of the nominal exchange rate. In turn the domestic price level in the forecast period increases by a lower rate than in policy scenario B. With the relatively lower inflation rate and low demand for money from the subdued nominal GDP, the interest rate falls relative to the interest rate in both the basecase forecasts and in policy scenario B.

Consequently, investment is encouraged relative to case B but is lower than in policy scenario A and the basecase forecasts. Thus, with help from the fiscal branch of the government via increased tax rates, the central bank can achieve a low rate of inflation in the forecast period with only minor reductions in investment and no deterioration in the trade balance. In this policy scenario, C, the increase in government spending mainly crowds out private consumption.

We find that an increase in government spending has costs in all the three policy scenarios. Real exchange rate appreciation occurs in all three. In policy scenario A, exports are squeezed by the real appreciation of the exchange rate. Import-substitution industries are also hurt by the real appreciation. In a nutshell, investment was financed by foreigners and this drove down the trade balance. In policy scenario B, increased government spending took away funds that could otherwise go for investment and consequently investment was crowded out. In policy scenario C, the imposition of taxes has the negative impact of crowding out consumption. On the other hand, the increased tariff rates damp imports as does the reduced level of consumption, and the trade balance improves.

Chapter 5

Overview, Policy Implications and Directions for Future Research

5.1 Overview

The focus of this thesis has been the transmission or feed-through effect of a change in monetary policy together with an increase in government spending in the Papua New Guinea economy.

We adopted and adapted a computable general equilibrium model of the PNG economy. We made three extensions or developments to the adopted model. The first two developments are related and reflect the particular focus of our thesis; the third development introduces dynamics into the model. The first development was the introduction of an equation showing money demand as an increasing function of nominal GDP and an inverse function of the interest rate. This equation links the monetary sector to the rest of the economy via the relationship between the interest rate and the economy-wide required rate of return for capital. The second development is the linking of the nominal exchange rate to the trade balance to capture the idea that export and import demand impinge on the exchange rate under a floating exchange rate regime. With this mechanism, we find that under a expansionary fiscal policy the model generates exchange rate depreciation and inflationary pressure when there is a deterioration in the trade balance. The third development that we made to the adopted model was the introduction of inter-temporal dynamics of investment and capital. This enabled the implementation of the year-on-year simulations. Together the three developments provide the pathways for fiscal and monetary policies to impact on industry-level investment, the balance of trade and inflation, and capital stocks and GDP growth.

In Chapter 3, the adapted model was used to derive basecase forecasts (path without policy shocks) for the PNG economy for the period 1998 to 2006. For the period 1998 to 2001, the exogenous shocks were actual data for macro economic and trade variables. Thus, the early part of our forecast simulation played the role of updating the database from 1997 to 2001. In deriving the basecase forecasts, we added shocks for the exogenous variables one vector at a time. By proceeding in this way, we were able to learn about the model's behaviour and to detect and correct several weaknesses in its initial theoretical structure and database.

Having derived the base forecast path (without policy shocks), we switched from the forecasting closure to a policy closure. This involved endogenizing various macro and trade variables and exogenizing various macro-propensity and export-demand-shift variables. In the forecast simulations, the macro and trade variables were exogenous so that they could be were shocked with actual data for the period 1998 to 2001 and with forecasts from relevant authorities or, in some cases, by simple extrapolations for the period 2002 to 2006. To accommodate the macro and trade shocks we needed to allow endogenous shifts in macro propensities and export demands. For the policy simulations in Chapter 4, we wanted to investigate the effects of policy shocks on macro and trade variables. Thus, it was necessary to make the macro and trade variables model-determined (endogenous) while the macro propensities and export demand shifts were set exogenously.

Once we had established the policy closure, we conducted in chapter 4 simulations in which the macro-propensities and export demand shifts were given their basecase forecast values. In addition, we shocked the policy variable of interest, government spending, to simulate expansionary fiscal policy. In the absence of the policy shock, our policy simulations would have reproduced the basecase forecasts. With the inclusion of the positive shock to government spending, the policy simulations produced deviations from the basecase forecasts that represented the effects of the policy shock.

In the policy simulations in Chapter 4, we considered the impact of an increase in government spending under two options for monetary policy. Under one option, monetary policy was tight, targeting the money supply. Under the second option, monetary policy was accommodative, targeting the interest rate. The results from Chapter 4 can be summarized in three propositions.

Proposition One: *In the presence of an expansion in government spending, there is a trade-off, determined largely by monetary policy, between investment and output growth on one hand and macroeconomic stability in terms of inflation on the other hand.*

Our simulations in Chapter 4 indicated that in an environment of ambitious government spending, particularly on consumption, monetary policy has a crucial part to play. As illustrated in the simulations, monetary policy determines the balance between the effects of government spending on macro stability (inflation, the trade balance and the exchange rate) and growth (increases in investment and real GDP). Where growth is sustained through an accommodative monetary policy, there is a sacrifice of economic stability. Where economic stability is sustained through tight monetary policy, there is a sacrifice of growth.

Given an increase in government spending, we saw that:

- an accommodative monetary policy could allow maintenance of investment growth, but lead to a significant increase in inflation and crowd out the trade scetor (specifically exports);
- a tight monetary policy could allow maintenance of low inflation but crowd out investment; and
- a tight monetary policy accompanied by increases in taxes on imports could allow maintenance of investment and low inflation but crowd out consumption.

A common results in all three policy simulations in Chapter 4 is appreciation of the real exchange rate. Under an accommodative monetary policy, real appreciation crowded out exports while investment was sustained through the constant interest rate. Under a tight monetary policy, the increased cost of borrowed-funds crowded out investment (an import-intensive component of demand). The resulting reduction in demand for imports led to real appreciation of the exchange rate. Under a tight monetary policy accompanied by increases in import taxes, there is a double-strength reduction in imports and a double-strength real appreciation.

These results suggest that under the different monetary policy options, an increase in government spending will increase the cost or price per unit of output in the PNG economy relative to that in the rest of the world. Why is there real appreciation in all the three cases, even under nominal exchange rate appreciation, which might be expected to lower domestic prices? One way of answering this question is to view the change in the balance of trade as an endogenized residual after

Y, C, I and G are determined. The residual change in $(X-M)$ requires the real exchange rate to change in the necessary direction, which, in the event, was an appreciation in all the three policy scenarios. This leads to our second proposition.

Proposition Two: To a large extent, the balance of trade (X - M) should be thought of as a residual after the determination of Y, C, I and G. The residual (X - M) then determines movements in the nominal and real exchange rates, and, ultimately, in inflation.

In explaining this proposition, we focus on the short run, that is, on the effects in 2002 of the assumed increase in government spending.

In policy scenario A (accommodating monetary policy), we saw that through the equation $Y = \frac{1}{A} F(K,L)$ there was a slight increase in Y. With K being fixed in the short run, the slight increase in Y comes from a small increase in L. Employment increases (despite the real wage rate being constant by assumption) because public sector industries are highly labour-intensive. There was a small decline in C despite the slight increase in Y as real land rentals declined. Investment was not affected because the economy-wide required rate of return to capital did not change (as the interest rate did not change). The increase in government spending was an exogenous shock. Given the small changes in Y, C and I and the significant increase in G, we find in accordance with proposition two that there is a negative deviation in $(X-M)$. The negative deviation in $(X-M)$ is facilitated by the appreciation of the real exchange rate, which drives down exports and increases imports. The determination of the trade account leads to a depreciation of the nominal exchange rate. The appreciation of the real exchange rate and depreciation of the nominal exchange rate subsequently cause the domestic price level to increase.

In policy scenario B (tight monetary policy), we saw that again there was only a small increase in Y induced by a small increase in L. The increase in L is again attributed to the increased spending in the labour-intensive public sector industries. With the small increase in Y comes a small increase in C. A rise in the economy-wide required rate of return to capital (resulting from an increase in the interest rate) caused a significant fall in I. This is the crucial impact under the tight monetary policy. In our simulation, the fall in I approximately offsets the given increase in G. With small movements in Y and C, and the offsetting movements in I and G, the residual change in $(X-M)$ was small, and happened to be negative. Expectations might be that the little effect on the trade balance should cause little change in the real exchange rate. Instead, we saw that there was a sizeable real appreciation of the exchange rate. The reason for this is that with the decline in investment there could have been a big fall in imports, given the import-intensive nature of investment goods. But the negligible movement in the trade balance requires that import volumes decline only slightly. To facilitate a negligible movement in the trade balance, export volumes also fell, influenced by the real appreciation. The small negative deviation in the trade balance causes a slight devaluation of the nominal exchange, which together with the real appreciation leads to a restricted increase in the domestic price level.

In policy scenario C (monetary policy tightening and fiscal expansion backed by an increase in excise and tariff rates), Y again changed by only a small amount, this time a decline caused by a fall in L. C declined by a lot more than Y. This is the crucial impact in policy scenario C and it is attributed to the increase in the purchasers' prices faced by households faced, due directly to the imposition of increased taxes. Investment declined (despite a fall in interest rate attributed to the fall in Y) as the rate of return to capital fell. Together, the falls in C and I more than offset the increase in G, and so the trade balance had to improve. The improvement in the trade balance should lead to a real devaluation of the exchange rate. Instead, there was a real appreciation. The imposition of increased tariffs has a strong negative impact on imports, requiring real appreciation to restrict the improvement in the trade balance to the level which is compatible with the movements in Y, C, I and G. The real appreciation acts on the trade balance by not only increasing M but also by reducing X. With the improvement in the trade balance, there is nominal exchange rate appreciation. In combination the real and nominal appreciations have little impact on the domestic price level. The aim of achieving a low inflation rate is best attained in an environment of a tight monetary policy combined with some fiscal discipline.

Throughout the analysis in this thesis, we have abstracted from many complications and applied two fundamental equations, $Y = \frac{1}{A} F(K, L)$ and $Y = C + I + G + (X - M)$, in explaining our simulated results. Within the two equations the determination of each variable is tied down and explained, with $(X - M)$ being the endogenized residual change. This strategy of providing explanations for the simulated results of PNG-ORAMON is sound in that: (i) it explains the main features of a wide array of results; and (ii) it is an interesting way to understand and talk about the economy.

Proposition Three: Money neutrality is a good approximation under interest rate targeting.

Where the money supply and the price level increase while the interest rate is held constant, we observe that aggregate real investment and total output (real GDP) hardly deviate from the basecase forecasts in the five-year forecast period. This is illustrated by the deviated growth path of aggregate real investment under policy scenario A in chart 4.14 and also by the deviated growth path of real GDP under policy scenario A in chart 4.11. This lends support to the Monetarists' proposition of money neutrality and the Classical (Economics) dichotomy that a change in money supply does not matter to real output, it only affects the price level proportionately.

Further Comments arising from the policy simulations

We further offer a brief note on the movements in domestic inflation and the nominal exchange rate as these are key target variables of monetary policy.

Inflation

Inflation, in the model, is largely caused by movements in the nominal exchange rate. Where there is relatively a large depreciation of the nominal exchange rate, the inflation rate is relatively high, as in policy scenario A. In addition, in policy scenario A we find that a high inflation rate is associated with growth in the money supply. Conversely, where there is relatively a small depreciation or even an appreciation of the nominal exchange rate, the inflation rate is relatively low, as in policy scenarios B and C. The money supply does not change in either policy scenario B or C (monetary policy is tight). Inflation rate is the lowest when the government displays fiscal discipline to accompany monetary tightness.

Nominal Exchange Rate

Changes in the nominal exchange rate are caused by movements in the trade account. Improvement in the trade account causes an appreciation of the nominal exchange rate as in policy scenario C. Of the three policy scenarios, the nominal exchange rate depreciates most in policy scenario A in which the trade balance suffered most in terms of a negative deviation from its base forecast path. Associated with this is the observation that the money supply increased relative to the basecase forecasts. This is consistent with the popular theoretical contention that a growth in the domestic money supply exerts downward pressure on the nominal exchange rate. Thus, we find that, consistent with theory, an increase in money supply is associated with an increase in the domestic price level and a downward pressure on the nominal exchange rate.

5.2 Implications for Policy and Directions for Future Research

The emphasis of the analysis in this thesis has been on macro impacts of policy shocks. The considerations for policy that arise from our work are not new. However, we have tried to make a contribution by providing sound quantitative analysis.

Our work suggests that the PNG government needs to be more disciplined in its spending. The discipline on the part of the government involves: (i) more emphasis productive spending than on consumption spending, so that even if there is an adverse impact on the exchange rate and thus inflation, infrastructure and essential services are enhanced; (ii) increased spending has to be accompanied by increased revenue; and (iii) the government should restrict its domestic borrowing as it tends to crowd out investment.

To aid the course for fiscal and monetary policies, micro policies and initiatives need to be geared towards balance-of-trade improvement. Such policies, may include assistance for downstream processing of export products and for import-replacement activities. Such policies may help to increase exports and cut down imports, thereby lessening the downward pressure on the exchange rate and thus helping to attain a low inflation rate.

If PNG is to have strong growth in public expenditure, direct micro level policies may be needed to generate export growth. In all three of our policy scenarios involving increased public expenditure, there was real exchange rate appreciation. This is detrimental to export growth, raising the question of how PNG could reduce its unit cost of output so that it could attract demand for its commodities, including the traditional exports.

For protection and growth of import-substitution industries such as *food processing*, increased duty rates in support of an expansionary fiscal policy appear to be helpful. This line of government fiscal discipline is also helpful to monetary policy in its aim of achieving a low inflation rate.

There were two factors that limited our analysis of micro and industry level policy considerations.

The first factor is the lack of quality micro data. While the input-output data were sufficiently good for basic analysis such as the impact of on output of an export price shock, the data were not sufficiently detailed for analysis on issues such as the effect on distribution of income and wealth of a shock. There was lack of data on certain parameters such as the industry's substitution elasticity between two outputs. The implication of lack of sound data was evident in chapter three, particularly in some of the set A simulations for which implausible results were obtained.

In view of problems revealed in the Set A simulations in Chapter 3, we made a number of rectifications and improvements to PNG-ORAMON. Out of this comes the second factor. Better modelling of the different types of industries is required.

We learnt a good lesson. The dynamics of investment-capital and interest rate does not work for the mineral industries in PNG. This makes a lot of sense because apart from the logical assumption of excess capacity in the industries already, the capital-supplying multi-national firms involved in the mineral projects have direct in- and-out access to outside funds and do not resort to the domestic finance system for funds. So our adjustment and rectification was an improvement to the model. This highlights the the need for better modelling of industries and households so as to better capture the characteristics of different categories/classes of these economic agents in the economy.

The first area for future research emerges from the need for adequate data and better modelling of different types of industries and households. If we are equipped with improved data and modelling, the impact of the monetary and fiscal shocks that we have covered in this thesis can be taken further to cover income distribution and employment by occupation and region. Micro and regional developmental questions in general can also be looked at as separate issues.

Second, there is the need to cover the external sector more fully in future research. Our current model has only the trade account. An obvious limitation of the model is the lack of depth on the movement of various components in the balance of payments account. A natural progression for future research then is to model the balance of payments account in more detail. This would include specifications for the capital account. Within the capital account, an item of great significance is PNG's foreign debt. The accumulation of net foreign assets or liabilities needs a close attention in its modelling. It is important not only for the balance of payments position but also it has a significant influence on the Kina exchange rate movements.

Modelling of the whole balance of payments will yield a complete macro story compared to what we currently have.

A third area for future research is the application of PNG-ORAMON to explaining past developments in the economy. That is, use can be made of the MONASH technique of historical and decomposition closures to analyse the contribution of certain polices and events to outcomes that were realized. This can would be a useful validation of the model.

While there were limitations imposed by the quality of data, this research has made a few advances. These include:

(i) the correcting of some poorly or inappropriately defined equations in the adopted PNG model;

(ii) the superimposing of monetary phenomena (specifically money demand and nominal exchange rate equations) onto the real sector, enabling better analysis of the impacts of macro shocks than was previously possible; and

(iii) the finding that there is a need to treat different types of industries differently in the model, as we did for the mineral sector industries, for which the neo-classical postulations do not to work.

Appendix A: Commodities and Industries in the Papua New Guinea CGE Model

Table A1: Listing of commodities and industries in the Papua New Guinea CGE model

Commodity	Industry
1 Fruits and vegetables	1 Traditional agriculture
2 Non-ruminimant livestock	2 Smallholder coffee
3 Coffee	3 Smallholder cocoa
4 Cocoa	4 Smallholder palm oil
5 Palm oil	5 Smallholder copra
6 Copra	6 Smallholder other
7 Other tree crps	7 Plantation coffee
8 Other agriculture	8 Plantation cocoa
9 Fishing	9 Plantation palm oil
10 Forestry	10 Plantation copra
11 Copper	11 Plantation other
12 Gold	12 Plantation fruit and vegetables
13 Other minerals	13 Other agriculture
14 Crude oil	14 Fishing
15 Quarrying	15 Forestry
16 Timber processing	16 Porgera mining
17 Food processing	17 Ok Tedi mining
18 Beverages and tobacco	18 Other mining
19 Metals and engineering	19 Oil
20 Machinery	20 Quarrying
21 Chemicals and oils	21 Timber processing
22 Petroleum refining	22 Food processing
23 Other manufacturing	23 Beverages and tobacco
24 Road transport	24 Metals and engineering
25 Water transport	25 Machinery
26 Air transport	26 Chemicals and oils
27 Education	27 Petroleum refining
28 Health	28 Other manufacturing
29 Electricity and garbage	29 Road transport
30 Building and construction	30 Water transport
31 Commerce	31 Air transport
32 Finance and investment	32 Education
33 Government administarion	33 Health
34 Other services	34 Electricity and garbage
35 Secruity	35 Building and construction
36 Informal retail	36 Commerce
37 LNG Plant	37 Finance and investment
	38 Government administarion
	39 Other services
	40 Secruity
	41 Informal retail
	42 LNG Plant

Appendix B: A Schematic Representation of the Input-Output Database

Input-output Structure of the Papua New Guinea Economy[*]

Links between producing and consuming sectors within Papua New Guinea (PNG) and between PNG and the rest of the world are captured through an input-output database. From this data base various structural coefficients - mainly in the form of cost and sale shares- are computed.

The structural detail incorporated in the PNG model's input-output data base can be represented by a schematic diagram as in Figure B1. The Figure contains g commodities (g = 37) produced in h industries (h = 42). The first commodity (subsistence crops) is mainly for household on-farm consumption and hence does not enter the market.

The other domestic commodities compete with imported commodities for sales in the domestic market.

The entries in Figure B1 are value flows. The figure in each cell can be considered as representing the product of a base period price and a base period quantity.

[*] Taken from the Vincent *et al.* 1990.

Figure B1: Schematic representation of the input-output data base for the Papua New Guinea Model

	Industries (current goods) h	Industries (capital goods) h	Household consump-tion	Exports	Other Dd (mainly govern-ment)	Duty	
Domestic Commodities g	A	B	C	D	E		Row sums = total usage of domestic commodities
Imports g	F	G	H		I	-Z	Row sums = total imports cif
Labour Occupations q	K						
Capital 1 Land 1 Other costs 1	L M N						
	Column sums = outputs of domestic industries	Column sums = investment expenditure by industry	Column sums = total household expenditure	Column sums = total exports	Column sums = total other final demand	Column sums = total duty	

	h	
Domestic commodities g	O	Row sums = output by commodity
	Column sums = output by industry	

Industries are shown as producing current goods (which are used up in one production period) and capital goods.

Matrix A contains domestically produced goods as inputs into the production of domestic industries. For example, the entry in row 20 column 17 (in reference to Table A1 in Appendix A) shows expenditure by Ok Tedi mining on domestically produced machinery related repairs (Matrix B shows the domestic commodities as inputs into industries producing investment goods. Only in industries such as building and construction, and metals and engineering will there be significant non-zero entries in B. Vector C contains domestically produced goods that goes to households for consumption.

Vectors D and E show the flows of domestically produced commodities that goes for exports (of the trade balance) and to "other" demand (mainly government) respectively.

Matrix F contains inputs of imported commodities into industries for current production. For example, row 22, column 7 shows the plantation coffee industry's use of imported petroleum products. Imported commodities as inputs into industries producing capital goods are in Matrix G. Vectors H and I respectively contain household and government consumption of imported goods. Matrix Z contains the negative of the duty paid on imported goods.

The remaining matrices specify the components of industry value added. Matrix K shows the occupational composition of labour used by each industry. For example, row 1 column 7 shows the plantation coffee industry's use of unskilled labour. The rental value (returns to fixed capital) of each industry's fixed capital are shown in Matrix L while Matrix M gives the rental value of land used by each industry. M has non-zero entries only for agricultural and mining activities. For mineral industries, the entries represent the return to the ore body. Other things equal, the larger the share of the value of production accruing to the mine the lower the output supply elasticity of that mine. N is a vector of industry's 'other costs'. It consists mainly of returns to working capital and taxes on primary factors.

Lastly, Matrix O shows the commodity composition of each industry's output. Multi-product outputs are confined to agricultural and mining industries. For all other industries the normal input-output convention of a 1:1 mapping of row commodities with column industries is followed. That is, for these industries the only non-zero entries are along the commodity-industry diagonals.

In addition to the input-output data shown in Figure, which capture the production and sale accounts of the PNG economy, the model's database also contains a number of additional data. In particular, there is data on the central governments fiscal operations (revenues and expenditures).

Adding-up properties of Figure B1

The database of Figure B1 contains a number of important summation properties which are of use in the model's theoretical structure. For example, the sum of all entries in A+F+K+L+M+N equals the output of each sector. This can also be obtained from the column sums of Matrix O. Similarly, the rows sums of A+B+C+D+E represent the outputs of each commodity. This can also be obtained from the column sums of O. The row sums of F+G+H+I+(-Z) equal the cif value of imports. Similarly, the fob value of exports is given by the column sums of Matrix D.

Construction of database depicted in Figure B1

The database depicted in Figure B1 is constructed from input-output accounts of Papua New Guinea and information from other sources. The national input-output accounts used in Vincent *et al.* (1990) was for 1982-83, constructed by Guest (1989). Guest re-sectored industries/sectors using the (earlier) 1972-73 input-output tables for PNG constructed by Baxter (1976). Levantis (1998) updated the database to 1994 and increased the number of industries to 42 producing 37 commodities. For this thesis we adopted the database for the year 1997 of the Centre for International Economics-Levantis PNG CGE model, itself being an update of the Levantis' 1994 database.

Appendix C: The Tablo Code of PNG-ORAMON

!TABLO input for the PNG General Equilibrium Model!
!PNG-ORAMON!

!CENTRE OF POLICY STUDIES, MONASH UNIVERSITY!
!January 2003!

! Adapted from !

! CENTRE FOR INTERNATIONAL ECONOMICS!
!and the !
! NATIONAL CENTRE FOR DEVELPOMENT STUDIES!

*!*** DEFINING DATA FILE ***!*

File Data *# The input-output data for the Model #* ;

!Section 1: Definition of Sets !

Set

! Name ! ! Description ! ! Elements ! ! Subscript !

Com *# Commodities #*
(Fruit_Vegs, NonRLivestk, Coffee, Cocoa, PalmOil, Copra,
OthTCrops, OthAgric, Fishing, Forestry, Copper, Gold,
OthMinerals, CrudeOil, Quarrying, TimbProcess, FoodProcess,
Bever_Tobaco, Metals_Engin, Machinery, Chemical_Oil, Petroleum_Re,
OthManufact, RoadTrans, WaterTrans, AirTrans, Education, Health,
Elect_Garbge, Build_Cons, Commerce, Finance_Inv, GovtAdm,
OthServ, Security, InforRetail, LNGPlant); *!(i1-i37)!*

Ind *# Industries #*
(TradAgric, SmallHCoffee, SmallHCocoa, SmallHPoil, SmallHCopra,
SmallOther, PlantCoffee, PlantCocoa, PlantPOil, PlantCopra,
PlantOther, PlantFruit_V, OthAgric, Fishing, Forestry, PorgeraMine,
OkTediMine, OtherMine, Oil, Quarrying, TimbProcess, FoodProcess,
Bever_Tobaco, Metals_Engin, Machinery, Chemical_Oil, Petroleum_Re,
OthManufact, RoadTrans, WaterTrans, AirTrans, Education, Health,
Elect_Garbge, Build_Cons, Commerce, Finance_Inv, GovtAdm, OthServ,
Security, InforRetail, LNGPlant); *!(j1-j42)!*

Source *# Sources for Inputs #* (domestic,import) ;

```
   Fact  # Primary Factors # (labour,capital,land) ;

   Ocp   # Occupations # (o1,o2);

   Mine  # mining sub-sector # (PorgeraMine, OkTediMine,
                    OtherMine, Oil) ;

Subset
   mine is subset of ind;

Set Nonmine = Ind - Mine ;


!Section 2: List of Model Variables !

variable

            (all,i,com)(all,s,source)(all,j,ind)
x1isj(i,s,j) # demand for input of current production #;

          (all,j, ind)
zj(j)       # industry activity levels #;

            (all,i,com) (all,s,source)
pis(i,s)    # domestic price of domestic and imported commodties #;

             (all,v,fact)(all,j,ind)
xpvj(v,j)    # industry demand for labour, capital and land #;

             (all,v,fact)(all,j,ind)
ppvj(v,j)    # price of labour (wage),capital (rental) and land (rental)#;

             (all,q,ocp)(all,j,ind)
xp1qj(q,j)   # industry demand for labour by occupation #;

             (all,q,ocp)(all,j,ind)
pp1qj(q,j)   # price of labour by occupation by industry #;

           (all,j,ind)
x0j(j)      # demands for other costs #;

              (all,i,com)(all,s,source)(all,j,ind)
x2isj(i,s,j)  # demand for inputs to capital creation #;

          (all,j,ind)
yj(j)       # investment by industry #;

            (all,i,com) (all,s,source)
x3is(i,s)   # household demand by source #;
```

(**all**,i,com) (**all**,s,source)
a3(i,s) *# household demand by source #*;

(**all**,i,com)
x3i(i) *# household demand undifferentiated by source #*;

(**all**,i,com) (**all**,s,source)
pstaris(i,s) *# purchase price of goods to households by source #*;

q1 *# number of households #*;

c1 *# aggregate nominal household consumption #*;

(**all**,k,com)
pstark(k) *# price of goods to houdeholds #*;

(**all**,i,com)
x4i1(i) *# export demands #*;

(**all**,i,com)
pei1(i) *# FOB foreign currency export prices #*;

(**all**,i,com)
f4i1(i) *# shift term for exports #*;

(**all**,i,com)(**all**,s,source)
x5is(i,s) *# other demands #*;

(**all**,i,com)(**all**,s,source)
f5is(i,s) *# other demands shift term #*;

(**all**,i,com)(**all**,j,ind)
xi1j(i,j) *# commodity output by industry #*;

(**all**,i,com)
xi1(i) *# commodity output levels #*;

(**all**,j,ind)
poj(j) *# prices of other costs #*;

(**all**,j,ind)
picj(j) *# cost of capital by industry (asset price of capital)#*;

(**all**,i,com)
vi(i) *# one plus the rate of export subsidy #*;

(**change**)(**all**,i,com)
d_expsub(i) *# change in export subsidy #*;

(change)
d_totsub *# change in total export subsidy/tax #*;

(change)
d_avesub *# Average export subsidy #*;

(**all**,i,com)
pmi2(i) *# CIF foreign currency import price #*;

(**all**,i,com)
ti(i) *# one plus the ad valorem tariff or tariff equivalent #*;

phi *# exchange rate #*;

realexch *# real exchange rate #*;

(**all**,q,ocp)
lq(q) *# occupational employment #*;

(**all**,j,ind)
kj(j) *# industry capital stocks #*;

(**all**,j,ind)
nj(j) *# agricultural land and mining sector rebates #*;

rt1 *# government revenue from personal tax #*;

rt23 *# government revenue from company taxes #*;

rtt *# government revenue from import duties #*;

rtc *# government revenue from excise duties #*;

(**all**,i,com)(**all**,s,source)
tci(i,s) *# power of the tax rate on excisable goods #*;

rto *# government revenue from other taxes #*;

gdp *# nominal gdp #*;

rtm *# government revenue from mining, royalties #*;

rnto *# government revenue from other non-tax revenue ex aid #*;

refg *# government revenue from foreign grants #*;

gc *# nominal government consumption expenditure #*;

cr *# aggregate real household consumption #*;

gi # *nominal government capital spending* #;

grev # *aggregate government revenue* #;

gex # *total government expenditure* #;

go # *other government expenditure* #;

(change)
deltagb # *governments budget position* #;

(**all**,j,ind)
rj(j) # *industry rate of return to capital* #;

rk # *absolute rate of return* #;

(**all**,j,ind)
frj(j) # *relative rate of return* #;

lambda # *economy-wide expected rate of return* #;

(**all**,j,ind)
f2j(j) # *industry investment shift* #;

ir # *aggregate real investment* #;

in # *aggregate nominal investment* #;

epsilon2 # *capital goods price index* #;

ks # *aggregate capital stock* #;

epsilon1 # *GDP deflator* #;

epsilon3 # *consumer price index* #;

(**all**,j,ind)
pj1(j) # *industry output price* #;

(**all**,i,com)
xi2(i) # *import volume* #;

mfc # *aggregate foreign currency imports* #;

efc # *aggergate foreign currency exports* #;

md # *aggregate domestic currency imports* #;

ed # *aggergate domestic currency exports* #;

(change)
deltab *# real balance of trade #*;

(change)
deltabotf *# balance of trade in foreign currency #*;

(change)
deltabotd *# balance of trade in domestic currency#*;

(change)
deltac *# current account deficit #*;

(change)
deltabn *# nominal balance of trade #*;

fc *# consumption function shift term #*;

(**all**,q,ocp)(**all**,j,ind)
f1qj(q,j) *# industry wage shift variable #*;

(**all**,q,ocp)
f1q(q) *# occupation wage shift variable #*;

f1 *# economy wide wage shift variable #*;

(**all**,j,ind)
foj(j) *# industry other cost shift variable #*;

gdpr *# real GDP #*;

chie *# aggregate other demand #*;

aggl *# aggregate employment based on persons weights #*;

lw *# aggregate employment based on wage bill #*;

lr *# returns to land #*;

xig *# price index for other demands #*;

xi4 *# price (domestic currency) index for exports #*;

xim *# price index for imports #*;

ximf *# index of cif import prices, foreign currency #*;

rn *# interest rate #*;

mn *# money demand #*;

p0toft *# terms of trade #*;

twistimp *# component of comm-use tech coeff relating to imp/dom mix #*;

goreal *# real other Government expenditure #*;

mfcreal *# real aggregate foreign currency imports #*;

f5 *# scalar shifter for other demands #*;

gsum *# sum of gcreal and goreal #*;

gireal *# real gov't investment expenditure #*;

totgexreal *# total real gov't expenditure #*;

f4 *# scalar shifter for exports #*;

f2 *# scalar shifter for agg real investment #*;

efcreal *# aggregate real foreign currency exports #*;

(change)
del_btgdp *# change in ratio of balance of trade to gdp #*;

phi_f *# exchange rate in forecast #*;

(change)
del_bt *# change in balance of trade #*;

(change)
del_btgdp_f *# change in ratio of BOT to GDP, forecast #*;

(change)
del_f_btgdp *# shifter for exchange rate equation #*;

(change)
del_ff_btgdp *# shifter for del_btgdp_f equation #*;

f_phi *# shifter for phi_f equation #*;

(All,i,Com)
x4obs(i) *# observation of forecast exports #*;

f_obs *# shifter for forecast exports #*;

a1primgen *# Overall primary-factor saving/using technical change#*;

twistlk *# labour-capital twist #*;

```
                (All,j,Ind)
kjplus1(j)      # Capital stock, end of year #;

ksnew           # Aggregate k stock with value of capital weights # ;

                (Change) (All,j,Ind)
d_f_kj(j)       # shift in opening capital stock equation #;

                (Change)
del_unity       # Homotopy variable, shocked from zero to one #;

                (All,j,Ind)
fmine(j)        #shifter in land supply#;

                (All,j,Ind)
f2mine(j)       #shifter in capital supply#;


! *** DEFINING COEFFICIENTS AND CONSTRUCTION *** !

Coefficient (All,i,Com) SIGMA1(i)
        # CES Import Elasicity used in Industry j #;
Read SIGMA1 from file data header "SIG1";

Coefficient (all,i,com) (all,j,ind) V1BASDOM(i,j)
        # Current Inputs of Dom. produced com i to industry j #;
Read V1BASDOM from file data header "BAS1";

Coefficient (All,i,Com) (All,j,Ind) V1BASIMP(i,j)
        # Current inputs of imported comm i to industry j #;
Read V1BASIMP from file data header "BAS2";

Coefficient (All,i,Com) (All,s,Source) (All,j,Ind) ICU1(i,s,j)
        # Total current inputs of commodity i to industry j #;
Formula (All,i,Com) (All,j,Ind)
        ICU1(i,"domestic",j) = V1BASDOM(i,j);
Formula (All,i,Com) (All,j,Ind)
        ICU1(i,"import",j)  = V1BASIMP(i,j);

zerodivide (zero_by_zero) default 0.5;
Coefficient (All,i,Com) (All,s,Source) (All,j,Ind) S1ISJ(i,s,j)
        # Share of good i from source s in industry j for cur prod #;
Formula (All,i,Com) (All,s,Source) (All,j,Ind)
        S1ISJ(i,s,j) = ICU1(i,s,j) / SUM (q,source,ICU1(i,q,j));

Coefficient (all,j,ind) SIGMA1PRIM(j)
        # CES Substitution Elasticity between Primary Factors in Ind j #;
Read SIGMA1PRIM from file data header "SIGP";
```

```
Coefficient (all,j,ind)(all,v,fact) IFACT(j,v)
        # Input of primary factors to industry j #;
Read IFACT from file data header "FACT";

zerodivide (zero_by_zero) default 0.3333;
Coefficient (all,v,fact) (all,j,ind) SVJ(v,j)
        # Cost Share of Primary Factora in Industry j #;
Formula (All,v,Fact) (All,j,Ind)
        SVJ(v,j) = IFACT(j,v) / SUM (w,fact,IFACT(j,w));

Coefficient (All,j,Ind) SIGMA1LAB(j)
        # Ces elasticity betwn different occupations in industry j #;
Read SIGMA1LAB from file data header "SLAB";

Coefficient (All,j,Ind) (All,q,Ocp) V1LAB(j,q)
        # Input of Occupation q to Ind j #;
Read V1LAB from file data header "1LAB";

zerodivide (zero_by_zero) default 0.5;
Coefficient (All,q,Ocp) (All,j,Ind) S1QJ(q,j)
        # share of labour of occ q in total lab cost of industry j #;
Formula (All,q,Ocp) (All,j,Ind)
         S1QJ(q,j) = V1LAB(j,q) / SUM(p,ocp,V1LAB(j,q));

Coefficient (All,i,com) (All,j,ind) V2BASDOM(i,j)
        # Capital inputs of dom. produced comm i to industry j #;
Read V2BASDOM from file data header "2BAS";

Coefficient (All,i,com) (All,j,ind) V2BASIMP(i,j)
        # Capital inputs of imported comm i to industry j #;
Read V2BASIMP from file data header "MBAS";

Coefficient (All,i,com) (All,s,source) (All,j,ind) ICA1(i,s,j)
        # Total capital inputs of commodity i to industry j #;
Formula (All,i,com) (All,j,ind)
        ICA1(i,"domestic",j) = V2BASDOM(i,j);
Formula (All,i,com) (All,j,ind)
        ICA1(i,"import",j)  = V2BASIMP(i,j);

zerodivide (zero_by_zero) default 0.5;
Coefficient (All,i,Com) (All,s,Source) (All,j,Ind) S2ISJ(i,s,j)
        # Share of good i from Source s in Ind j to capital creation #;
Formula (All,i,Com) (All,s,Source) (All,j,Ind)
         S2ISJ(i,s,j) = ICA1(i,s,j) / SUM(q,source,ICA1(i,q,j));

Coefficient (All,i,Com) (All,s,Source) V3BAS(i,s)
        # Household's consumption of good i from all Sources #;
Read V3BAS from file data header "3BAS";
```

```
Coefficient (All,i,Com) (All,s,Source) EXCTAX(i,s)
        # excise taxes on consumption #;
Read EXCTAX from file data header "EXCT";

Coefficient (All,i,Com) (All,s,Source) HHCONPP(i,s)
        # HH consumption of good i from all sources #;
Formula (All,i,Com) (All,s,Source)
     HHCONPP(i,s)=V3BAS(i,s)+EXCTAX(i,s);

zerodivide (zero_by_zero) default 0.5;
Coefficient (All,i,Com) (All,s,Source) S3IS(i,s)
        # Shr of Value of gd i from source s in tot purch of i by HH #;
Formula (all,i,com) (all,s,source)
     S3IS(i,s) = HHCONPP(i,s) / SUM(q,source,HHCONPP(i,q));

Coefficient (All,i,Com) S3I(i)
        # Share of value of good i in total HH consumption #;
Formula (all,i,com)S3I(i) = 0.00;
Formula (all,i,com)
     S3I(i) = SUM(s,source,HHCONPP(i,s)) /
                    SUM(k,com,SUM(s,source,HHCONPP(k,s)));

Coefficient (All,i,Com) MHHBS(i) # marginal budget shares #;
read MHHBS from file data header "MBS";

Coefficient (all,i,com) EPSILONI (i)
        # Household Expenditure Elasticity for good i) #;
Formula (All,i,Com) EPSILONI(i) = MHHBS(i)/S3I(i);

! Frisch parameter = 6.0 !

Coefficient (All,i,Com) (All,k,Com) ETAIK(i,k)
        # Household Own and Cross Price Elasticities for Good i #;
Formula (All,i,Com) (All,k,Com) ETAIK(i,k) = 0.0;
Formula (All,i,com) (All,k,Com)
         ETAIK(i,k) = -EPSILONI(i)*S3I(k)*(1-(EPSILONI(k)/2.5));
Formula (all,i,com)
         ETAIK(i,i) = -EPSILONI(i)*S3I(i)*(1-(EPSILONI(i)/2.5)) -
                         EPSILONI(i)/2.5;

Coefficient (All,i,Com) EXP_ELAST(i)
        # Reciprocal of the foreign demand elast for PNG export of i #;
Read EXP_ELAST from file data header "GAMA";

Coefficient (All,i,Com) (All,s,Source) H5IS(i,s)
        # Indexes government demands to aggergate real consumption #;
Read H5IS from file data header "H5IS";
```

```
Coefficient  (All,j,Ind) SIGMACET(j)
        # Transformation ELA between products produced by ind j #;
Read SIGMACET from file data header "SCET";

Coefficient (All,i,Com)(All,j,Ind)MAKE(i,j)
        # Flows of com i to ind j (O matrix) #;
Read MAKE from file data header "MAKE";

Coefficient (All,i,Com) (All,j,ind) CI1J(i,j)
        # Revenue share of product i in the total revenue of ind j #;
Formula (All,i,Com) (All,j,Ind)
     CI1J(i,j)= MAKE(i,j) / SUM(m,com,MAKE(m,j));

Coefficient (All,i,Com) (All,j,Ind) DI1J(i,j)
        # Share of the value of output of good i produced in j #;
Formula (All,i,Com) (All,j,Ind)
     DI1J(i,j) = MAKE(i,j) / SUM(m,ind,MAKE(i,m));

Coefficient (All,j,Ind) V1OCT(j)
        # Other costs in ind j #;
Read V1OCT from file data header "1OCT";

zerodivide (zero_by_zero) default 0.0;

Coefficient (All,j,Ind) TOTCOST(j)
        # Total costs of industry j #;
Formula (All,j,Ind)
     TOTCOST(j) = SUM(i,Com,V1BASDOM(i,j)) +
                  SUM(i,Com,V1BASIMP(i,j)) +
                        SUM(v,Fact,IFACT(j,v)) + V1OCT(j);
Display TOTCOST ;

Coefficient (All,i,Com) (All,s,Source) (All,j,Ind) H1ISJ(i,s,j)
        # Cost share of good i fm source s in the tot cost of ind j #;
Formula (All,i,Com) (All,s,Source) (All,j,Ind)
     H1ISJ(i,s,j) = ICU1(i,s,j) / TOTCOST(j);

Coefficient (All,v,Fact) (All,j,Ind) HPVJ(v,j)
        # Cost share of primary factor v in the total cost of ind j #;
Formula (All,v,Fact) (All,j,Ind)
     HPVJ(v,j) = IFACT(j,v) / TOTCOST(j);

Coefficient (All,j,Ind) HOJ(j)
        # Cost shr of other costs in the total cost of ind j #;
Formula (All,j,Ind)HOJ(j) = V1OCT(j) / TOTCOST(j);

Coefficient (All,j,Ind) OCIND(j)
        # index price of other costs  #;
Read OCIND from file data header "HCOJ";
```

```
Coefficient (All,i,Com) (All,s,Source) (All,j,Ind) H2ISJ(i,s,j)
            # Cost shr of good i from source s in tot cost of cap cr. #;
Formula (All,i,Com)(All,s,Source) (All,j,Ind)
      H2ISJ(i,s,j) = ICA1(i,s,j) /(SUM(n,Com,V2BASDOM(n,j)) +
                                  SUM(n,com,V2BASIMP(n,j)));

Coefficient (All,i,Com) V4BAS(i)
        # Exports of commodity i #;
Read V4BAS from file data header "4BAS";

Coefficient (All,i,Com)(All,s,Source)V5BAS(i,s)
        # Govt use of commodity i from source s #;
Read V5BAS from file data header "5BAS";

Coefficient (All,i,Com) TDODA(i)
        # Total domestic demand of good i #;
Formula (All,i,Com)
      TDODA(i) = SUM(j,ind,ICU1(i,"domestic",j)) +
                 SUM(j,ind,ICA1(i,"domestic",j)) +
             V3BAS(i,"domestic") + V4BAS(i) +
                    V5BAS(i,"domestic");
Display TDODA ;

Coefficient (All,i,Com) TIMDA(i)
        # Total import demand of good i  - duty paid #;
Formula (All,i,Com)
      TIMDA(i) = SUM(j,ind,ICU1(i,"import",j)) +
                 SUM(j,ind,ICA1(i,"import",j)) +
                    V3BAS(i,"import") + V5BAS(i,"import");

Coefficient (All,i,Com) (All,j,Ind) B1I1J(i,j)
        # share of tot sales of dom good i absorbed by ind j cur pr #;
Formula (All,i,Com) (All,j,Ind)
      B1I1J(i,j) = ICU1(i,"domestic",j) / TDODA(i);

Coefficient (All,i,Com) (All,j,Ind) B2I1J(i,j)
        # share of tot sales of dom good i absorbed by ind j cap cr #;
Formula (All,i,Com) (All,j,Ind)
      B2I1J(i,j) = ICA1(i,"domestic",j) / TDODA(i);

Coefficient (All,i,Com) B3I1(i)
        # Share of total sales of domestic good i absorved by ind j #;
Formula (All,i,Com)B3I1(i) = V3BAS(i,"domestic") / TDODA(i);

Coefficient (All,i,Com)  B4I1(i)
        # Share of total sales of domestic good i exported #;
Formula  (All,i,Com)B4I1(i) = V4BAS(i) / TDODA(i);
```

```
Coefficient (All,i,Com) B511(i)
        # Share of tot sales of domestic good i absorbed by other DD #;
Formula (All,i,Com)B511(i) = V5BAS(i,"domestic") / TDODA(i);

Coefficient WAGEBILL
   # Wage bill share of occupation q in economy wide wage bill #;
Formula WAGEBILL = SUM(p,ocp,SUM(m,Ind,V1LAB(m,p)));

Coefficient RLAND # Total Land Rental #;
Formula RLAND = SUM(j,Ind,IFACT(j,"land"));

Coefficient RCAPITAL # Total Capital Payment #;
Formula RCAPITAL = SUM(j,ind,IFACT(j,"capital"));

Coefficient (All,j,Ind)(All,m,Ocp) PTAX(j,m)
     # Share of tot govt revenue from personal taxes from  ind j #;
Read PTAX from file data header "PTAX";

Coefficient (all,i,com) V0DUT(i) # Duty on imported good i #;
Read V0DUT from file data header "DUTY";

Coefficient (all,j,ind) CTAX(j) # Company taxes #;
Read CTAX from file data header "CTAX";

Coefficient (All,i,Com) (All,s,Source) S5IS(i,s)
        # Shr of tot DD acct for by other DD for good i in source s #;
Formula (All,i,Com) (All,s,Source)
      S5IS(i,s) = V5BAS(i,s) / SUM(n,Com,SUM(q,Source,V5BAS(n,q)));

Coefficient (All,j,Ind) INVG(j)
        # Investment by government #;
Read INVG from file data header "INVG";

Coefficient VTAX1 # Share of total govt rev obtained from personal taxes #;
Read VTAX1 from file data header "TAX1";

Coefficient VTAX2  # Share of total govt rev obtained from company taxes #;
Read VTAX2 from file data header "TAX2";

Coefficient VTAX3 # Share of total govt rev obtained from import duties #;
Read VTAX3 From File data header "TAX3";

Coefficient VTAX4 # Share of total govt rev obtained from excise duties #;
Read VTAX4 from file data header "TAX4";

Coefficient VTAX5 # Share of total govt rev obtained from other taxes  #;
Read VTAX5 from file data header "TAX5";

Coefficient VTAX6 # Share of total govt rev obtained from mining royalties #;
Read VTAX6 from file data header "TAX6";
```

Coefficient NONTAX
 # Share of total govt rev obtained from other non-tax reven #;
Read NONTAX **from file** data **header** *"NTAX"*;

Coefficient GRANT *# Share of total govt rev obtained from foreign grants #*;
Read GRANT **from file** data **header** *"GRNT"*;

Coefficient VEXP1
 # Consumption Spending in Government Expenditure #;
Read VEXP1 **from file** data **header** *"EXP1"*;

Coefficient VEXP2 *# Capital Spending in Government Expenditure #*;
Read VEXP2 **from file** data **header** *"EXP2"*;

Coefficient VEXP3
 # Other Spending in Government Expenditure #;
Read VEXP3 **from file** data **header** *"EXP3"*;

Coefficient VGREV
 # Total govt rev in govt fiscal oper summary base period #;
Read VGREV **from file** data **header** *"GREV"*;

Coefficient VGEXP
 # Total govt expend in govt fiscal oper summary base period #;
Read VGEXP **from file** data **header** *"GEXP"*;

Coefficient (**All**,j,Ind) QJ(j)
 # Ratio of gross (before depn.) to net (after depn.) ROR for ind j #;
Read QJ **from file** data **header** *"Qj"*;

Coefficient (**All**,j,Ind) I1J(j)
 # Indexing parameter #;
Read I1J **from file** data **header** *"I1J"*;

Coefficient (**All**,j,Ind) I2j(j)
 # Indexing parameter #;
Read I2J **from file** data **header** *"I2J"*;

Coefficient (**All**,j,Ind) BJ(j)
 # indexing investment parameter #;
Read BJ **from file** data **header** *"BJ"*;

Coefficient (**All**,j,Ind) ICAP(j) *# Total real investment in ind j #*;
Coefficient (**All**,j,Ind) ICAP_B(j)*# Total real invest in ind j, in base period #*;
(**All**,j,Ind) LEVPIEJ(j) *# Level of the Price Index for Investment in j #*;
Read LEVPIEJ **from file** data **header** *"LEVP"*;
Update (**All**,j,Ind) LEVPIEJ(j) = piej(j);

Formula (all,j,ind)
ICAP(j) = {**SUM**(i,com,ICA1(i,*"domestic"*,j)) +
SUM(i,com,ICA1(i,*"import"*,j))}/LEVPIEJ(j);

Formula (Initial) (**All**,j,Ind)
ICAP_B(j)=ICAP(j);

Coefficient (**All**,j,Ind) TJ(j)
 # Share of total investment accounted for by ind j #;
Formula (**All**,j,Ind)
TJ(j) = ICAP(j)*LEVPIEJ(j) / **SUM**(m,Ind,ICAP(m)*LEVPIEJ(m));

Coefficient (**All**,j,ind) PhI2J(j)
 # Share of economy-wide cap stock rep by cap stock of j #;
Formula (**All**,j,Ind)
PHI2J(j) = **SUM**(i,Com,**SUM**(s,Source,ICA1(i,s,j))) /
SUM(i,Com,**SUM**(s,Source,**SUM**(m,Ind,ICA1(i,s,m))));

Coefficient (**All**,i,Com) (**All**,s,Source) W3IS(i,s)
 # Weight of good i from source s in the CPI #;
Formula (**All**,i,Com) (**All**,s,Source)
W3IS(i,s) = HHCONPP(i,s)/**SUM**(n,com,**SUM**(q,source,HHCONPP(n,q)));

Coefficient (**All**,i,Com) (**All**,j,Ind) B1I2J(i,j)
 # Shr of the total shr of M good i absorbed by sales to ind j for CP #;
Formula (**All**,i,Com) (**All**,j,Ind)
B1I2J(i,j) = ICU1(i,*"import"*,j) / TIMDA(i);

Coefficient (**All**,i,Com) (**All**,j,Ind) B2I2J(i,j)
 # Shr of the total shr of M good i absorbed by sales to ind j for CR #;
Formula (**All**,i,Com) (**All**,j,Ind)
B2I2J(i,j) = ICA1(i,*"import"*,j) / TIMDA(i);

Coefficient (**All**,i,Com) B3I2(i)
 # Share of the total shr of M good i absorbed by sales to hseholds #;
Formula (**All**,i,Com)
B3I2(i) = V3BAS(i,*"import"*) / TIMDA(i);

Coefficient (**All**,i,Com) B5I2(i)
 # Share of the total shr of M good i absorbed by sales to other dds #;
Formula (**All**,i,Com)
B5I2(i) = V5BAS(i,*"import"*) / TIMDA(i);

Coefficient (**All**,i,Com) MI2(i)
 # Share of the total CIF cost accounted for by Ms of good i #;
Formula (**All**,i,Com)
MI2(i) = (TIMDA(i)-V0DUT(i)) / **SUM**(n,com,TIMDA(n)-V0DUT(n));

```
Coefficient (All,i,Com) EI1(i)
        # Share of total export earnings accounted for by good i #;
Formula (All,i,Com)EI1(i) = V4BAS(i) / SUM(n,Com,V4BAS(n));

Coefficient EFOB # aggregate value of exports FOB #;
Read EFOB from file data header "EFOB";

Coefficient MCIF # aggregate value of imports CIF #;
Read MCIF from file data header "MCIF";

Coefficient RFG # base period foreign grants #;
Read RFG from file data header "RFG";

Coefficient (All,q,Ocp) H1Q(q)
        # Occupation wage indexation parameter #;
Read H1Q from file data header "H1Q";

Coefficient SC # Aggregate consumption in GDP_B #;
Read SC from file data header "SC";

Coefficient SI # Aggregate investment in GDP_B #;
Read SI from file data header "SI";

Coefficient SG # Aggregate govt spending in GDP_B #;
Read SG from file data header "SG";

Coefficient SE # Aggregate exports in GDP_B #;
Read SE from file data header "SE";

Coefficient SM # aggregate imports in GDP_B #;
Read SM from file data header "SM";

Coefficient BT # Balance of Trade in Dom Currency #;
Formula BT = SE - SM;

Coefficient  GDP_B # base GDP #;
Formula GDP_B = (SC + SI + SG + (SE - SM)) ;
Display GDP_B ;

Coefficient BTGDP # Ratio of BOT to GDP #;
Formula BTGDP = BT/GDP_B;

Coefficient (All,j,Ind)(All,q,Ocp)PERS(j,q)
        # No. persons of ocp q in ind j #;
Read PERS from file data header "PERS";

Coefficient (All,q,Ocp)       PHI1Q(q)
        # Share of occup q in tot demand for labour #;
```

```
Formula (All,q,Ocp)
      PHI1Q(q) = SUM(j,Ind,PERS(j,q)) /
             SUM(j,Ind,SUM(r,Ocp,PERS(j,r)));

Coefficient (All,q,Ocp) (all,j,ind) B1QJ(q,j)
        # Share of economic-wide empl in occupation q in ind j #;
Formula (All,q,Ocp) (All,j,ind)
      B1QJ(q,j) = PERS(j,q) / SUM(m,ind,PERS(m,q));

Coefficient (All,i,Com)(All,j,Ind) KD(i,j);
Formula (All,i,Com)(All,j,Ind) KD(i,j)=1.0;
Formula (All,i,Com)KD(i,"LNGPlant")=1.0;

Coefficient RATE;
Formula (initial) RATE = 5;
Update RATE = rn;

Coefficient MDEM;
Formula (initial) MDEM = EXP(1.0*LOGE(GDP_B) - 0.019-0.6*RATE);
Update MDEM = mn;

Coefficient (All,s,Source) SOURCEDOM(s)
        # Equals 1 if s="domestic", equals zero if s="import" # ;
Formula SOURCEDOM("domestic")=1;
     SOURCEDOM("import")=0;

Coefficient EXCH # Level of Exchange Rate #;
Read EXCH from file Data Header "EXCH";

Coefficient EXCH_F # Level of exchange rate in forecast #;
Read EXCH_F from file Data Header "XCHF";

Coefficient (All,i,Com) SUB4(i)# Export Subsidy/Tax #;
Read SUB4 from File Data Header "SUB4";

Coefficient
  (All,j,IND)
KAP(j) # Capital, start of year #;
  (All,j,IND)
KAP_B(j) # Capital, start of year, base #;
  (All,j,IND)
KPLUS1(j) # Capital, end of year #;
  (All,j,IND)
KPLUS1_B(j) # Capital, end of year, base #;
  (All,j,IND)
DEP(j) # Depreciation rates #;

TINY # Tiny number used to avoid zero divide problems #;
Formula
 (Initial)
```

```
TINY = 0.000000000001;
 (Initial)(All,j,IND)
ICAP_B(j) = ICAP(j);

Read
DEP from file DATA Header "DEP " ;
KAP from file DATA Header "KAP " ;

Formula
    (Initial)(All,j,IND)
KAP_B(j)  = KAP(j) ;
(All,j,IND)
KPLUS1(j)  = KAP(j)*(1 - DEP(j)) + ICAP(j);
    (Initial)(All,j,IND)
KPLUS1_B(j)  = KPLUS1(j) ;

Coefficient (All,v,Fact) (All,j,Ind)
SOURCE_SHRLK(v,j) #Labour and capital shares in labour-capital inputs#;
Formula (All,j,Ind)SOURCE_SHRLK("labour",j)= IFACT(j,"labour")/
            {IFACT(j,"labour")+IFACT(j,"capital")};

(All,j,Ind)SOURCE_SHRLK("capital",j)= IFACT(j,"capital")/{IFACT(j,"labour")
                              +IFACT(j,"capital")};
(All,j,Ind)SOURCE_SHRLK("land",j)= 0;

Coefficient (all,v,fact) (all,j,ind)COEFF_TWIST(v,j)
#Coefficient of twistlk in factor demand equation#;
Formula (All,j,Ind)COEFF_TWIST("labour",j)= SOURCE_SHRLK("capital",j);
Formula (All,j,Ind)COEFF_TWIST("capital",j)= -SOURCE_SHRLK("labour",j);
Formula (All,j,Ind)COEFF_TWIST("land",j)= 0;

Coefficient  AGGREVM
# Aggregate duty revenue #;
Formula  AGGREVM = Sum(i,com,V0DUT(i));

Coefficient AGGPERTax;
Formula AGGPERTax = Sum(m,ocp,Sum(j,ind,PTAX(j,m)));

Coefficient AGGCTAX;
Formula AGGCTAX = sum(j,nonmine,CTAX(j));

Coefficient AGGREV3
# Aggregate revenue from households #;
Formula AGGREV3 = sum(i,com,sum(s,source,EXCTAX(i,s)));

Coefficient AGGREVO
# Aggregate revenue from other costs #;
Formula AGGREVO = sum(j,ind,V1OCT(j));
```

Coefficient AGGMTAX;
Formula AGGMTAX = **sum**(j,mine,CTAX(j));

Coefficient TINVG;
formula TINVG=**sum**(j,ind,INVG(j));

Coefficient (**All**,i,Com) (**All**,j,Ind)
DUMZ(i,j) *#Zero if MAKE (i,j) is zero, otherwise 1 #*;

Formula
(**all**,i,com) (**all**,j,ind)
DUMZ(i,j)= 0 + **if**(MAKE(i,j)>0,1);

Coefficient BOTF *# Balance of Trade in Foreign Currency #*;
Formula BOTF = **SUM**{i,Com,[V4BAS(i)-SUB4(i)]- [TIMDA(i)-V0DUT(i)]}*EXCH;

Coefficient (**All**,j,Ind)
VKAP(j) *#Value of capital in each industry#*;

Read VKAP **From File** DATA **Header** *"VKAP"*;

*! *** DEFINING MODEL EQUATIONS *** !*

*! *** INDUSTRY INPUTS *** !*

Equation

DDIMIPUTS *# Demand for Intermediate Inputs#*
(**All**,i,Com) (**All**,j,Ind) (**All**,s,Source)
x1isj(i,s,j) = zj(j) - KD(i,j) * [SIGMA1(i)* (pis(i,s) -
Sum(t,source,S1ISJ(i,t,j)*pis(i,t)))]-
(SOURCEDOM(s)-S1ISJ(i,*"domestic"*,j))*twistimp;

Equation E_xpvj *# demand for land, labour and capital#*
(**All**,v,Fact) (**All**,j,Ind)
xpvj(v,j) = zj(j) - SIGMA1PRIM(j) * (ppvj(v,j) -
sum(w,fact,SVJ(w,j)*ppvj(w,j))) + COEFF_TWIST(v,j)*twistlk
+a1primgen;

DDLABOCP *# demand for labour of each occupation #*
(**all**,q,ocp) (**all**,j,ind)
xp1qj(q,j) = xpvj(*"labour"*,j) - SIGMA1LAB(j) * (pp1qj(q,j)-
sum(r,ocp,S1QJ(r,j)*pp1qj(r,j))) ;

DDCOST *#demand for other cost#*
(**all**,j,ind)
x0j(j) = zj(j) ;

*! *** FINAL DEMANDS *** !*

```
DDINPKCR # demand for inputs to capital creation #
(All,i,Com) (All,s,Source) (All,j,Ind)
x2isj(i,s,j) = yj(j) - SIGMA1(i)*(pis(i,s)-
          sum(u,source,S2ISJ(i,u,j)*pis(i,u)))-
          (SOURCEDOM(s)-S2ISJ(i,"domestic",j))*twistimp;

HHDDCOMS # household demand for commodity by source #
(All,i,Com) (all,s,source)
x3is(i,s) = x3i(i)-SIGMA1(i) * (pstaris(i,s) -
        SUM(u,source,S3is(i,u)*pstaris(i,u)))
        + a3(i,s)-(SOURCEDOM(s)-S3IS(i,"domestic"))*twistimp;

HHDDCOMUS # Household demand for com undifferentiated by s #
(All,i,Com)
x3i(i) - q1 = epsiloni(i)*(c1-q1) +
         SUM(k,com,ETAIK(i,k)*pstark(k)) ;

PCOMMOHH # price of commodties to household #
(All,i,Com)
pstark(i) = SUM(s,Source,S3IS(i,s)*pstaris(i,s));

TAXCONS # allows tax on consumption #
(All,i,Com) (All,s,Source)
pstaris(i,s) = pis(i,s) + tci(i,s) ;

EXPTDDS # Export Demands #
(All,i,Com)
pei1(i) = -EXP_ELAST(i)*x4i1(i)+f4i1(i)+f4;

E_x4obs # Observed Forecast of Exports #
(All,i,Com)
x4i1(i)= x4obs(i)+f_obs;

E_efcreal # real aggregate Foreign Currency exports #
efcreal = SUM(i,com,EI1(i)* x4i1(i)) ;

OTHRDDS # Other Demands #
(All,i,Com)(All,s,Source)
x5is(i,s) = H5IS(i,s)*cr+f5is(i,s)+f5;

! *** COMMODITY SUPPLIES *** !

Equation
MKTCOMSUP # Market Commodity Supplies by industry #
(All,i,Com) (All,j,Ind)
xi1j(i,j) = DUMZ(i,j)*zj(j) + DUMZ(i,j)*SIGMACET(j)*(pis(i,"domestic")-
        SUM(n,com,CI1J(n,j)*pis(n,"domestic")));
```

```
TOTOPT #Total Output of Good i #
(All,i,Com)
xi1(i) = SUM(j,ind,DI1J(i,j)*xi1j(i,j));

! *** ZERO PURE PROFITS *** !

ZEROPFINPRODN # Zero Pure profits in production #
(All,j,Ind)
pj1(j) = SUM(i,Com,SUM(s,Source,H1ISJ(i,s,j)*pis(i,s))) +
      SUM(v,fact,HPVJ(v,j)*ppvj(v,j)) +
      HOJ(j)*poj(j);

ZEROPFINCAP # Zero pure profits in capital creation #
(All,j,Ind)
piej(j) = SUM(i,Com,SUM(s,Source,H2ISJ(i,s,j)*pis(i,s)));

ZPFINIMPT # Zero Pure Profits in importing #
(All,i,Com)
pis(i,"import") = pmi2(i) + ti(i) - phi;

ZPFINEXPT # Zero pure profits in exporting #
(All,i,Com)
pis(i,"domestic") = pei1(i) + vi(i) - phi;


! *** MARKET CLEARING *** !

SDIDFRDPC # Supply DD equality for domestically produced mkt com #
(all,i,com)
xi1(i) = SUM(j,ind,B1I1J(i,j)*x1isj(i,"domestic",j)) +
      SUM(j,ind,B2I1J(i,j)*x2isj(i,"domestic",j)) +
            B3I1(i)*x3is(i,"domestic") +
            B4I1(i)*x4i1(i) + B5I1(i)*x5is(i,"domestic");

LABOFOCP # Labour of each Occupation #
(all,q,ocp)
lq(q) = SUM(j,ind,B1QJ(q,j)*xp1qj(q,j));

INDCAP # Industry capital #
(all, j,ind)
kj(j)  = xpvj("capital",j);

INDLAND # Industry land #
(all,j,ind)
nj(j) = xpvj("land",j);

set fixed (capital, land);
subset fixed is subset of fact;
Coefficient (all,j,ind) INDGOS(j);
Formula (all,j,ind)
```

```
INDGOS(j)=sum(k,fixed, IFACT(j,k));

Variable (all,j,ind) gos(j);
equation GOSBYIND (all,j,ind)

gos(j) = (1/INDGOS(j)) * sum(k,fixed,IFACT(j,k)* [ppvj(k,j)+xpvj(k,j)] );


! *** GOVERNMENT SECTOR *** !

equation GRFMPTAX # Govt. revenue from personal Tax #
rt1 = (1/AGGPERTax)*Sum(q,ocp,SUM(j,ind,PTAX(j,q)*[Pp1qj(q,j)
    +xp1qj(q,j)]));

GRFMCOMTAX # Govt. revenue from Company Tax #
rt23 = (1/AGGCTAX) * SUM(j,nonmine,CTAX(j)*gos(j)) ;

GRFMIMDUS # Govt. Revenue from Import duties #
rtt = (1.0/AGGREVM)* (SUM(i,com,V0DUT(i)*(pmi2(i) - phi + xi2(i))
         + TIMDA(i)*ti(i)));

GRFMEXDUS # Govt.Rev from Excise Duties #
rtc  = (1.0/AGGREV3)*( SUM(i,com, EXCTAX(i,"domestic")

    *[pis(i,"domestic")+  x3is(i,"domestic")]

    + [EXCTAX(i,"domestic")+ V3BAS(i,"domestic")]*tci(i,"domestic")

    + EXCTAX(i,"import")*[pis(i,"import")+  x3is(i,"import")]

    + [EXCTAX(i,"import")+ V3BAS(i,"import")]*tci(i,"import")));

GRFMOTXS # Govt rev from other taxes #
rto = (1/AGGREVO) * sum(j,ind,V1OCT(j)*[poj(j)+x0j(j)]);

GRFMMINGRTS # Govt. revenue from Mining Tax #
rtm = (1/AGGMTAX) * SUM(j,mine,CTAX(j)*gos(j));

GRFMONTXS # Govt rev from other non-tax sources #
rnto = gdp;

NOMGCEXP # Nominal Govt Consumption Expenditure #
gc  = SUM{i,com,SUM(s,source,S5is(i,s)*(x5is(i,s)+pis(i,s)))};

NOMGCAEXP # Nominal govt capital expenditure#
gi = (1/TINVG) * SUM(j,ind,INVG(j)*[yj(j)+piej(j)]);

E_gireal # Real Gov't capital expenditure #
gireal = (1/TINVG) * SUM(j,ind,INVG(j)*yj(j));
```

TOTGR # *Total govt, revenue #*
grev = (1/VGREV) * (VTAX1*rt1+VTAX2*rt23+VTAX3*rtt+ VTAX4*rtc + VTAX5*rto
+ VTAX6*rtm + NONTAX*rnto+GRANT*refg);

TOTGE # *Total govt. expenditure #*
gex = (1/VGEXP)*(VEXP1*gc + VEXP2*gi + VEXP3*go) ;

E_goreal # *real other gov't expenditure #*
goreal = go - epsilon3;

E_gsum # *Sum of goreal and gcreal #*
gsum = (1/VGEXP)*(VEXP1*chie+VEXP3*goreal) ;

E_totgexreal # *Total real Gov't expenditure #*
totgexreal = (1/VGEXP)*(VEXP1*chie + VEXP2*gireal + VEXP3*goreal);

GOVEBUG # *Govt's Budget position #*
100*deltagb = VGREV*[grev-xig] - VGEXP*[gex-xig];

*! *** MISCELLANEOUS *** !*

RORCAP # *Rate of Return to Capital#*
(**all**,j,ind)
rj(j) = QJ(j)*(ppvj(*"capital"*,j)-piej(j));

RELROR # *Relative rates of returns #*
(**all**,j,ind)
rj(j) = rk + frj(j);

INVESTBYIND # *Investment by industry #*
(**all**,j,ind)
yj(j) = I1J(j)*kj(j) + BJ(j)*I2J(j)*(rj(j)-lambda) + f2j(j)+ f2;

AGGRENTINV # *aggregate real investment #*
ir = **SUM**(j,ind,TJ(j)*yj(j)) ;

AGGNOMINV #*Aggregate nominal investment #*
in = ir + epsilon2;

AGGCAPSTK #*aggregate capital stock #*
ks = **SUM**(j,ind,PHI2j(j)* kj(j)) ;

*! *** PRICE INDICES *** !*

PRIOFINDOUT # *price of industry output #*
(**all**,j,ind)
pj1(j) = **SUM**(i,Com,CI1J(i,j)*pis(i,*"domestic"*));

```
CAPGDSPI #Capital goods price index #
epsilon2 = SUM(j,ind,TJ(j)*piej(j));

CPI # Consumer Price Index #
epsilon3 = SUM(i,com,SUM(s,source,W3IS(i,s)*pstaris(i,s)));

! *** TRADE BALANCE *** !

IMVOL # import volumes #
(All,i,Com)
xi2(i) = SUM(j,ind,B1I2J(i,j)*x1isj(i,"import",j))+
          SUM(j,ind,B2I2J(i,j)*x2isj(i,"import",j))+
          B3I2(i)*x3is(i,"import")+B5I2(i)*x5is(i,"import");

AGGFCMPTS # aggregate Foreign currency imports #
mfc = SUM(i,com,MI2(i)*(pmi2(i)+ xi2(i)));

E_mfcreal # real aggregate imports #
mfcreal = SUM(i,Com,MI2(i)* Xi2(i));

AGGFCMPTSIND # aggregate Foreign currency imports #
xim + phi = SUM(i,Com,MI2(i)* (pmi2(i)));

E_ximf # Index of cif import prices, foreign currency #
ximf = SUM(i,Com,MI2(i)* (pmi2(i)));

AGGFCEXPTS # Aggregate Foreign Currency exports #
efc = SUM(i,Com,EI1(i)*(pei1(i)+x4i1(i)));

AGGFCEXPTSIND # Aggregate Foreign Currency exports #
xi4 + phi = SUM(i,Com,EI1(i)*(pei1(i)));

BOT # balance of trade #
100*deltab = efob*efc -mcif*mfc;

E_BOTF # Balance of Trade in Foreign Currency #
100*deltabotf = SUM{i,Com,[V4BAS(i)-SUB4(i)]*[pei1(i)+x4i1(i)]}-
          SUM{i,Com,[TIMDA(i)-V0DUT(i)]*[pmi2(i)+xi2(i)]};

Equation
E_BOTK # Balance of Trade in Kina #
100*deltabotd = (1/EXCH)*[-BOTF*phi+100*deltabotf];

AGGDOMIMPTS # Aggregate Dom Cur Imports #
md = Sum(i,Com,Mi2(i)*(pmi2(i)+xi2(i)-phi));

AGGDOMEXPTS # Aggregate dom cur exports#
ed = SUM(i,Com,EI1(i)*(pei1(i)+X4i1(i)-phi));
```

```
BOTNOM # Nominal balance of Trade #
100*deltabn = EFOB*ed- MCIF*md;

CURACTS # Current Accounts #
 DeltaC = deltaBn +(Rfg/100)* refg;

E_p0toft # Terms of Trade #
p0toft = xi4 - xim;

E_realphi # Real Exchange Rate #
realexch = phi + epsilon1 - ximf;

Equation E_d_expsub # change in export subsidy #
(All,i,Com)
d_expsub(i)= 1/100*[{V4BAS(i)*vi(i)}+SUB4(i)*{pei1(i)+x4i1(i)-phi}];

E_d_totsub # change in total export subsidy #
d_totsub = SUM{i,Com,d_expsub(i)};

E_d_avesub # change in average subsidy #
d_avesub = {1/SUM[i,Com,V4BAS(i)-SUB4(i)]}*{d_totsub -
        [1/{100*SUM(j,Com,V4BAS(j)-SUB4(j))}]*
        SUM[i,Com,(V4BAS(i)-SUB4(i))*(pei1(i)+x4i1(i)-phi)]};

! *** CONSUMPTION - INCOME LINK *** !

CONFUNC # Consumption function #
c1 = [1/(RLAND+WAGEBILL)] * ( WAGEBILL*lw + RLAND*lr)+ fc;

! *** OTHER  EQUATIONS *** !

Equation E_ppvj # Price to each industry of labour #
(All,j,Ind)
ppvj("labour",j) = SUM(q,Ocp,S1QJ(q,j)*pp1qj(q,j));

Equation E_pp1qj # Flexible handling of OCP. wages #
(All,q,Ocp) (All,j,Ind)
pp1qj(q,j) = H1Q(q)*epsilon3 + f1qj(q,j) + f1q(q) + f1;

Coefficient V1LAB_IO # Total payments to labour #;
Formula V1LAB_IO = SUM{j,Ind,IFACT(j,"labour")};

Variable p1lab_io # Average nominal wage #;
Equation E_p1lab_io # Average nominal wage #
V1LAB_IO*p1lab_io = SUM{j,ind,IFACT(j,"labour")*ppvj("labour",j)};

Variable realwage # Average real wage #;
Equation E_realwage # Average real wage #
realwage = p1lab_io - epsilon3;
```

Equation E_poj *# Price of other costs #*
(**all**,j,ind)
poj(j) = OCIND(j) * epsilon3 + foj(j);

Equation E_gdpr *# Defining real GDP - Expenditure Side #*
gdpr = (1/GDP_B) * (SC*cr + SI*ir + SG*chie + SE*efcreal - SM*mfcreal);

Equation E_epsilon1 *# GDP deflator #*
epsilon1 = (1/GDP_B) * (Sc * epsilon3 + Si*epsilon2
+Sg*xig + Se*xi4 -Sm*xim);

Equation E_chie *# Aggregate other demands #*
chie = **SUM**(i,Com,**SUM**(s,source,S5IS(i,s)*x5is(i,s)));

Equation E_xig *# Aggregate other demands price index #*
xig = **SUM**(i,Com,**SUM**(s,source,S5IS(i,s)*pis(i,s)));

Equation E_aggl *# define aggregate employment formal sector only #*
aggl = **SUM**(q,ocp,PHI1Q(q)*lq(q));

Equation TOTRETLAND *# total return ot land #*
lr = (1/RLAND)***sum**(j,ind,IFACT(j,*"land"*)*[nj(j)+ppvj(*"land"*,j)]);

Equation E_lw *# alt. defn. for agg. employment #*
lw = (1/WAGEBILL)*
sum(j,ind,**SUM**(q,ocp,V1LAB(j,q)*[xp1qj(q,j)]));

Equation E_gdp *# Nominal GDP #*
gdp = gdpr + Epsilon1;

Equation E_c1 *# Aggregate Nominal Consumption #*
c1 = cr + epsilon3 ;

! Linking Exchange Rate to the Trade Account !

Coefficient ALPHA *# Exchange Rate Sensitivity Parameter #*;
Formula (initial) ALPHA = 5.0;

Equation E_del_bt *# Change in BOT #*
del_bt = (Se/100) *(efcreal+xi4) - (Sm/100) * (mfcreal + xim);

Equation E_phi *# exchange rate #*
(EXCH/EXCH_F)*(phi-phi_f) = 100*ALPHA*(del_btgdp - del_btgdp_f)
+del_f_btgdp;

Equation E_del_btgdp *# Change in the Ratio of Balance of Trade to GDP#*
del_btgdp = (1/GDP_B)*del_bt - 0.01*BTGDP*gdp;

```
Equation E_del_btgdp_f # Change in the Ratio of BOT to GDP, forecast#
del_btgdp_f = del_btgdp + del_ff_btgdp;

Equation E_phi_f # Exchange Rate, Forecast#
phi_f = phi + f_phi;

! *** MONEY DEMAND *** !
E_rn # Interest_rate #
rn = ((1/0.6)*RATE)*((1.0*gdp)-mn);

E_lambda # Linking ROR to interest rate #
lambda = rn;

!*** INVESTMENT-CAPITAL INTERTEMPORAL LINKS*** !

Equation E_ksnew #Aggregate k stock with value of capital weights#
Sum(r,ind,VKAP(r))*ksnew=sum(j,ind,VKAP(j)*kj(j));

Equation E_kjplus1
# Capital accum thru the fcst year (t) related to investment in the year #
(All,j,IND)
[KPLUS1(j) + TINY]*kjplus1(j) = [1-DEP(j)]*KAP(j)*kj(j) + ICAP(j)*yj(j);

Equation E_kj
# Gives shock in yr-to-yr forecasting to capital at begining of year t #
(All,j,IND)
[KAP(j) + TINY]*kj(j)
    = 100*{ICAP_B(j) - DEP(j)*KAP_B(j)}*del_unity+100*d_f_kj(j);

! *** EXCESS CAPACITY IN MINERAL INDUSTRIES *** !

Equation E_nj
#Supply of Land used for mining#
(All,j,Ind)
nj(j) = 0.95*(zj(j)+a1primgen)+fmine(j);

Equation E_f_kj
#Supply of Capital used for mining#
(All,j,Ind)
kj(j) = 0.95*(zj(j)+a1primgen)+f2mine(j);

!____________________________________________________________________!

UPDATE (change)
(all,i,com)(all,j,ind:V1BASDOM(i,j) ne 0)
V1BASDOM(i,j) = V1BASDOM(i,j)*(pis(i,"domestic")+x1isj(i,"domestic",j))/100 ;

UPDATE (change)
(all,i,com)(all,j,ind:V1BASIMP(i,j) ne 0)
V1BASIMP(i,j) = V1BASIMP(i,j)*(pis(i,"import")+x1isj(i,"import",j))/100 ;
```

UPDATE (change)
(**all**,i,com)(**all**,j,ind:V2BASDOM(i,j) **ne** 0)
V2BASDOM(i,j) = V2BASDOM(i,j)*(pis(i,*"domestic"*)+x2isj(i,*"domestic"*,j))/100 ;

UPDATE (change)
(**all**,i,com)(**all**,j,ind:V2BASIMP(i,j) **ne** 0)
V2BASIMP(i,j) = V2BASIMP(i,j)*(pis(i,*"import"*)+x2isj(i,*"import"*,j))/100 ;

Update (change)
(**all**,j,ind)(**all**,q,ocp:V1LAB(j,q) **ne** 0)
V1LAB(j,q)= V1LAB(j,q)*[pp1qj(q,j)+xp1qj(q,j)]/100;

Update (change)
(**all**,j,ind)(**all**,q,ocp:V1LAB(j,q) **ne** 0)
PERS(j,q)= PERS(j,q)*xp1qj(q,j)/100;

update (change)
(**all**,v,fact)(**all**,j,ind)
IFACT(j,v) = IFACT(j,v)*(ppvj(v,j)+xpvj(v,j))/100;

update (change)
(**all**,i,com)(**all**,s,source)
V3BAS(i,s) = V3BAS(i,s)*(pis(i,s)+x3is(i,s))/100;

update (change)
(**all**,j,ind)
V1OCT(j) = V1OCT(j)*(Poj(j)+x0j(j))/100;

update (change)
(**all**,i,com)
V4BAS(i) = V4BAS(i)*(pis(i,*"domestic"*)+x4i1(i))/100;

update (change)
(**all**,i,com)(**all**,s,source)
V5BAS(i,s) = V5BAS(i,s)*(pis(i,*"domestic"*)+x5is(i,s))/100;

update (change)
(**all**,i,com)(**all**,j,ind)
MAKE(i,j) = MAKE(i,j)*(pis(i,*"domestic"*)+Xi1j(i,j)) / 100;

UPDATE (CHANGE) (all,i,com)
V0DUT(i)= TIMDA(i)*(pis(i,*"import"*)+xi2(i))/100
    -[TIMDA(i)-V0DUT(i)]*(pis(i,*"import"*)+xi2(i)-ti(i))/100;

UPDATE (CHANGE)
(**all**,i,com)(**all**,s,source)
EXCTAX(i,s)= (EXCTAX(i,s)+V3BAS(i,s))* (pis(i,s)+x3is(i,s)+tci(i,s))/100
    -V3BAS(i,s)*(pis(i,s)+x3is(i,s))/100;

```
update (change)
(all,j,ind)(all,m,ocp)
PTAX(j,m) = PTAX(j,m)*[Pp1qj(m,j) + xp1qj(m,j)]/100;

update (change)
(all,j,ind)
CTAX(j) = CTAX(j) * gos(j) / 100;

update (change)
(all,j,ind)
INVG(j) = INVG(j) * [Yj(j)+Piej(j)]/100;

update (change) Sc = Sc * c1/100;
update (change) Si = Si * in/100;
update (change) Sg = Sg * gc/100;
update (change) Se = Se * (efcreal+xi4)/100;
update (change) Sm = Sm * (mfcreal +xim)/100;

update (change) Efob=Efob*efc/100;
update (change) Mcif=Mcif*mfc/100;
update (change) Rfg=Rfg*refg/100;

update (change) VTAX1 = VTAX1 * rt1 /100;
update (change) VTAX2 = VTAX2 * rt23 /100;
update (change) VTAX3 = VTAX3 * rtt /100;
update (change) VTAX4 = VTAX4 * rtc /100;
update (change) VTAX5 = VTAX5 * rto /100;
update (change) VTAX6 = VTAX6 * rtm /100;
update (change) NONTAX = NONTAX * rnto /100;
update (change) GRANT = GRANT * refg /100;

update (change) VEXP1 = VEXP1 * gc /100;
update (change) VEXP2 = VEXP2 * gi /100;
update (change) VEXP3 = VEXP3 * go /100;

update (change) VGREV = VGREV * grev /100;
update (change) VGEXP = VGEXP* gex /100;

update EXCH = phi;
update EXCH_F = phi_f;

update (change)(All,i,Com)SUB4(i) = d_expsub(i);

Update (All,j,IND)
KAP(j) = kj(j);

Update (All,j,Ind)
VKAP(j)= kj(j)*piej(j);
```

Appendix D: Tables for Simulations in Sets A and B Not Included in the Text of Chapter 3

Table A8: Selected Macro Results when Other Demand (Government) Shocked Additively in Simulation A8

Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
		Percentage Change (unless where indicated)								
Model Name	*Economic Name*									
a1primgen	Tech Coefficient	4.02	-7.16	-6.79	-7.13	-6.91	-6.66	-6.78	-6.85	-6.86
aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
cr	Agg Real Consumption	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36
chie	Other Demand (Gov't)	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
d_avesub	Change in Ave Subsidy	0.87	-1.22	0.03	0.02	0.03	0.04	0.04	0.05	0.04
d_totsub	Change in Total Subsi *	3189	-5144	167	86	154	205	238	271	236
deltab	Real Trade Balance*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
deltabn	Nominal Trade Balance*	139.06	127.15	4.82	5.67	5.67	5.67	5.67	5.67	-5.63
deltac	Current Account*	141.49	129.89	4.96	5.84	5.84	5.84	5.84	5.84	-5.80
efcreal	Agg Real Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
epsilon1	GDP Deflator	15.73	9.84	14.18	8.22	8.14	8.29	8.42	8.52	4.67
epsilon2	K Goods Price Index	21.67	4.82	8.60	5.27	5.32	5.73	5.81	6.02	2.88
epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	5.00
f2	Investment Shifter	-15.98	17.42	-26.54	-15.33	-16.18	-14.74	-15.30	-14.08	-11.17
gdp	Nominal GDP	10.70	21.31	21.35	15.80	15.68	16.14	16.17	16.47	12.54
gdpr	Real GDP	-4.42	10.57	6.39	7.07	7.05	7.32	7.22	7.40	7.56
in	Agg Nominal Investment	15.49	-12.06	7.53	8.41	6.36	7.83	4.76	4.97	1.86
ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
ksnew	Agg Capital Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
lw	Wage-Weighted Emp	1.08	1.98	-0.83	-0.30	-0.25	0.73	-0.20	-0.19	-0.01
mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mn	Money Demand	10.70	21.31	21.35	15.80	15.68	16.14	16.17	16.47	12.54
p0toft	Terms of Trade	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	1.00
realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	-1.00
rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
twistimp	Import Twist	82.00	-19.32	-55.98	-44.65	-40.80	-40.27	-36.64	-35.48	-31.13
twistlk	Labour Twist	-17.94	20.82	-4.57	2.29	2.37	3.97	2.17	2.17	2.78
xi4	Export Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99
xig	Other Dd Price Index	16.61	-2.95	13.52	5.90	6.19	6.49	7.06	7.32	3.59
xim	Import Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99

* in Kina million

Table A9: Selected Macro Results when Aggregate Exports and Individual Export Demand are Shocked Additively in Simulation A9

Variable *Model Name*	*Economic Name*	1998	1999	2000	2001	2002	2003	2004	2005	2006
					Percentage Change (unless where indicated)					
a1primgen	Tech Coefficient	-0.02	-11.66	-5.05	-2.00	-9.52	-7.65	-5.16	-5.48	-6.15
aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
cr	Agg Real Consumption	-5.2	21.2	9.3	9.3	9.3	9.3	9.3	9.3	9.3
chie	Other Demand (Gov't)	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36
d_avesub	Change in Ave Subsidy	0.37	-0.40	0.34	1.30	-1.97	0.03	0.04	0.13	0.27
d_totsub	Change in Total Subsidy*	1370	-1894	1926	6713	-9692	148	231	653	1186
deltab	Real Trade Balance*	137.06	345.96	26.54	-129.09	206.83	98.36	-297.10	-283.12	-277.54
deltabn	Nominal Trade Balance*	291.54	539.44	35.58	-118.87	217.24	110.37	-285.85	-274.79	-283.01
deltac	Current Account*	293.98	542.19	35.72	-118.70	217.41	110.53	-285.68	-274.62	-283.18
efcreal	Agg Real Exports	4.80	11.20	0.71	-3.80	6.30	2.80	-8.20	-8.50	-9.10
epsilon1	GDP Deflator	15.05	11.04	13.21	7.95	7.61	7.85	8.00	8.31	8.54
epsilon2	K Goods Price Index	19.89	6.25	9.12	5.54	5.35	6.19	5.53	5.79	5.48
epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
f2	Investment Shifter	-10.21	-4.32	-26.03	-14.03	-11.12	-15.64	-12.86	-12.61	-13.49
gdp	Nominal GDP	12.85	29.93	20.22	12.86	17.73	16.36	12.04	13.26	14.25
gdpr	Real GDP	-1.95	17.25	6.30	4.60	9.50	7.97	3.78	4.61	5.32
in	Agg Nominal Investment	13.79	-10.84	8.04	8.69	6.40	8.30	4.48	4.74	4.44
ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
ksnew	Agg Capital Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
lw	Wage-Weighted Emp	-2.30	2.69	0.47	3.09	-4.46	-0.09	-0.56	-0.28	-1.02
mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mn	Money Demand	12.85	29.93	20.22	12.86	17.73	16.36	12.04	13.26	14.25
p0toft	Terms of Trade	-0.14	0.03	0.06	0.06	-0.07	-0.01	0.02	0.01	0.00
phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	1.00
realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	-1.00
rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
twistimp	Import Twist	76.39	-37.37	-51.40	-33.30	-46.11	-42.63	-31.02	-33.00	-38.40
twistlk	Labour Twist	-20.54	15.11	-3.57	5.55	1.52	3.28	2.06	3.71	4.04
xi4	Export Price Index	27.26	24.88	0.92	1.07	0.93	0.99	1.03	1.01	-0.99
xig	Other Dd Price Index	14.44	-2.17	14.02	6.89	5.71	6.81	7.09	7.15	7.37
xim	Import Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99

* in Kina million

Table A10: Selected Macro Results when Exports Prices are Shocked Additively in Simulation A10

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
	Model Name	*Economic Name*									
1	a1primgen	Tech Coefficient	-0.02	-11.66	-5.05	-1.99	-9.52	-7.65	-5.17	-5.48	-3.72
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36
4	chic	Other Demand (Gov't)	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
5	d_avesub	Change in Ave Subsidy	0.84	-0.43	0.29	1.68	-2.53	0.00	0.02	0.08	-0.12
6	d_totsub	Change in Total Subsidy*	2601	-1393	1263	6771	-9539	21	99	332	-482
7	deltab	Real Trade Balance*	-858.32	102.70	728.66	-178.93	210.71	238.73	-233.69	-72.85	-160.38
8	deltabn	Nominal Trade Balance*	-811.13	52.99	729.80	-174.38	215.21	245.50	-226.59	-67.37	-164.63
9	deltac	Current Account*	-808.70	55.73	729.94	-174.22	215.37	245.67	-226.42	-67.20	-164.80
10	efcreal	Agg Real Exports	4.80	11.20	0.71	-3.80	6.30	2.80	-8.20	-8.50	-9.10
11	epsilon1	GDP Deflator	-5.66	4.70	33.09	7.30	8.71	10.23	8.59	10.30	9.37
12	epsilon2	K Goods Price Index	19.89	6.25	9.12	5.54	5.35	6.19	5.53	5.79	4.25
13	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
14	f2	Investment Shifter	-10.21	-4.32	-26.03	-14.03	-11.12	-15.62	-12.87	-12.61	-13.27
15	gdp	Nominal GDP	-8.02	24.23	42.52	12.97	19.19	19.23	13.15	15.66	15.23
16	gdpr	Real GDP	-2.48	18.77	7.35	5.32	9.74	8.27	4.25	4.92	5.42
17	in	Agg Nominal Investment	13.79	-10.84	8.04	8.68	6.40	8.30	4.48	4.74	3.21
18	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
19	ksnew	Agg Capital Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	lw	Wage-Weighted Emp	-2.30	2.69	0.47	3.09	-4.46	-0.07	-0.56	-0.29	2.64
21	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	mn	Money Demand	-8.02	24.23	42.52	12.97	19.19	19.23	13.15	15.66	15.23
23	p0toft	Terms of Trade	-32.56	-5.72	32.39	-2.41	1.32	5.17	0.94	6.52	3.84
24	phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	1.00
25	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
26	refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	-1.00
27	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-21.33
28	twistimp	Import Twist	76.39	-37.37	-51.40	-33.30	-46.11	-42.59	-31.04	-33.02	-3.06
29	twistlk	Labour Twist	-20.54	15.11	-3.57	5.55	1.52	3.28	2.06	3.72	2.82
30	xi4	Export Price Index	-13.01	17.91	33.48	-1.43	2.34	6.22	1.95	7.59	6.99
31	xig	Other Dd Price Index	14.44	-2.17	14.02	6.89	5.71	6.81	7.10	7.15	-0.99
32	xim	Import Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99

* in Kina million

Table A11: Selected Macro Results when Aggregate Imports and Import Prices are Shocked Additively in Simulation A11

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
					Percentage Change (unless where indicated)						
	Model Name	*Economic Name*									
1	alprimgen	Tech Coefficient	-0.19	-10.64	-2.07	2.09	-7.41	-4.83	-1.38	-2.00	-3.30
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36
4	chie	Other Demand (Gov't)	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
5	d_avesub	Change in Ave Subsidy	0.74	-0.22	1.35	1.12	-2.90	0.00	-0.17	-0.02	0.00
6	d_totsub	Change in Total Subsidy*	2,612	-871	7,360	6,198	-13,629	20	-908	-112	7
7	deltab	Real Trade Balance*	66	1	1027	-376	73	119	-638	-231	-568
8	deltabn	Nominal Trade Balance*	213	153	1036	-361	86	133	-626	-224	-572
9	deltac	Current Account*	216	156	1036	-361	86	133	-625	-223	-572
10	efcreal	Agg Real Exports	4.80	11.20	0.71	-3.80	6.30	2.80	-8.20	-8.50	-9.10
11	epsilon1	GDP Deflator	15.93	4.15	35.99	5.65	6.46	9.03	6.35	10.86	8.25
12	epsilon2	K Goods Price Index	17.15	4.49	10.75	5.93	5.24	5.70	5.19	5.26	5.01
13	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
14	f2	Investment Shifter	-28.81	-5.61	-20.60	-4.37	1.31	-8.38	-6.10	-9.33	-12.78
15	gdp	Nominal GDP	13.37	20.71	41.22	7.81	14.51	15.72	7.92	13.52	11.69
16	gdpr	Real GDP	-2.25	15.98	4.00	2.06	7.63	6.21	1.48	2.43	3.21
17	in	Agg Nominal Investment	11.18	-12.35	9.66	9.09	6.29	7.80	4.14	4.22	3.97
18	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
19	ksnew	Agg Capital Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	lw	Wage-Weighted Emp	-2.85	3.01	2.71	7.41	-5.01	2.05	1.09	2.69	1.33
21	mfcreal	Agg Real Imports	0.40	1.40	4.80	4.80	4.80	4.80	4.80	4.80	4.80
22	mn	Money Demand	13.37	20.71	41.22	7.81	14.51	15.72	7.92	13.52	11.69
23	p0toft	Terms of Trade	0.58	-9.60	37.80	-3.70	-2.13	2.56	-3.86	6.60	-1.48
24	phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	1.00
25	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
26	refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	-1.00
27	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	twistimp	Import Twist	17.53	-22.23	-24.05	-2.76	-26.21	-21.91	-6.08	-10.71	-17.51
29	twistlk	Labour Twist	-29.94	14.94	-4.09	10.44	2.55	4.35	3.53	5.13	1.62
30	xi4	Export Price Index	13.21	15.42	42.93	-0.29	1.83	5.65	-0.93	9.80	-0.50
31	xig	Other Dd Price Index	20.66	-4.68	15.53	6.46	4.58	5.84	6.76	6.50	7.06
32	xim	Import Price Index	12.57	27.28	3.88	3.53	4.04	3.03	3.03	3.03	0.99

* in Kina million

Table A12: Selected Macro Results when the Nominal Interest Rate is Shocked Additively in Simulation A12

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
	Model Name	*Economic Name*									
1	a1primgen	Tech Coefficient	-0.16	-10.64	-2.08	2.09	-7.23	-4.56	-1.12	2.14	3.36
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36
4	chie	Other Demand (Gov't)	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
5	d_avesub	Change in Ave Subsidy	0.76	-0.23	1.34	1.11	-2.92	0.01	-0.20	0.04	0.07
6	d_totsub	Change in Total Subsidy*	2678403	-898161	7274501	6131785	-13728188	41497	-1106373	182430	301832
7	del_unity	Homotopy Variable	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	deltab	Real Trade Balance*	66.63	0.04	1029.85	-375.95	73.61	116.53	-619.81	-251.94	-562.96
9	deltabn	Nominal Trade Balance*	214.00	152.26	1039.00	-360.98	86.84	130.70	-607.78	-244.38	-566.54
10	deltac	Current Account*	216.43	155.01	1039.14	-360.82	87.00	130.87	-607.61	-244.21	-566.71
11	efcreal	Agg Real Exports	4.80	11.20	0.71	-3.80	6.30	2.80	-8.20	-8.50	-9.10
12	epsilon1	GDP Deflator	16.22	3.87	36.01	5.64	6.44	8.97	6.48	10.30	7.88
13	epsilon2	K Goods Price Index	18.38	3.17	10.48	5.88	5.19	5.62	5.04	3.92	3.05
14	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
15	f2	Investment Shifter	-12.54	-13.09	-35.32	-7.98	-0.16	-7.90	-5.47	-4.59	-7.11
16	gdp	Nominal GDP	13.66	20.36	41.25	7.79	14.49	15.66	8.04	12.94	11.33
17	gdpr	Real GDP	-2.25	15.96	4.00	2.06	7.63	6.21	1.48	2.42	3.23
18	in	Agg Nominal Investment	12.35	-13.48	9.39	9.03	6.24	7.72	4.00	2.89	2.02
19	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
20	ksnew	Agg Capital Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	lw	Wage-Weighted Emp	-2.72	2.91	2.63	7.40	-4.50	2.94	2.15	13.53	17.12
22	mfcreal	Agg Real Imports	0.40	1.40	4.80	4.80	4.80	4.80	4.80	4.80	4.80
23	mn	Money Demand	9.71	22.74	47.12	8.47	14.63	15.53	7.79	12.68	10.94
24	p0toft	Terms of Trade	0.60	-9.63	37.91	-3.71	-2.11	2.49	-3.42	6.04	-1.34
25	phi	Nominal Exchange Rate	-22.12	-20.41	-0.85	-1.00	-1.00	-1.00	-1.00	-1.00	1.00
26	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
27	refg	Foreign Grant	22.12	20.41	0.85	1.00	1.00	1.00	1.00	1.00	-1.00
28	rn	Interest Rate	40.00	-14.60	-27.00	-5.00	-1.00	1.00	2.00	2.00	3.00
29	twistimp	Import Twist	19.31	-22.90	-24.55	-2.87	-26.20	-21.67	-7.65	-9.91	-15.96
30	twistlk	Labour Twist	-30.17	15.22	-3.97	10.46	3.54	5.45	6.06	21.10	25.39
31	xi4	Export Price Index	13.24	15.38	43.05	-0.29	1.85	5.58	-0.49	9.23	-0.37
32	xig	Other Dd Price Index	21.07	-5.00	15.43	6.45	4.36	5.66	6.30	4.20	4.27
33	xim	Import Price Index	12.57	27.28	3.88	3.53	4.04	3.03	3.03	3.03	0.99

* in Kina million

Table B6: Selected Macro Results when Other Demand (Government) Shocked Additively in Simulation B6

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
	Model Name	*Economic Name*									
1	a1primgen	Tech Coefficient	3.86	-7.50	-5.35	-5.42	-2.78	-2.87	-2.93	-2.99	0.83
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36
4	chie	Other Demand (Gov't)	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
5	d_avesub	Change in Ave Subsidy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	d_totsub	Change in Total Subsidy*	0.15	0.05	0.08	0.08	0.05	0.56	0.06	0.06	-0.05
7	deltab	Real Trade Balance*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	deltabn	Nominal Trade Balance*	86.00	26.93	60.72	30.36	29.08	30.58	33.31	34.75	25.11
9	deltac	Current Account*	87.93	26.87	61.73	30.92	29.72	31.36	34.23	35.81	26.30
10	efcreal	Agg Real Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	epsilon1	GDP Deflator	15.41	9.38	13.84	8.18	8.12	8.33	8.50	8.61	8.61
12	epsilon2	K Goods Price Index	17.56	-1.21	10.79	6.42	6.03	6.57	6.78	7.05	7.00
13	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
14	f2	Investment Shifter	-17.62	-28.95	-10.89	-7.69	-7.12	-6.47	-7.84	-7.53	-13.02
15	gdp	Nominal GDP	10.40	21.00	21.05	15.80	15.72	16.23	16.30	16.60	16.78
16	gdpr	Real GDP	-4.42	10.75	6.45	7.11	7.10	7.37	7.27	7.44	7.60
17	in	Agg Nominal Investment	11.57	-17.23	9.69	9.59	7.09	8.69	5.72	5.99	5.94
18	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
19	ksnew	Agg Capital Stock	0.69	-1.38	-0.93	-0.90	-0.44	-0.44	-0.44	-0.44	0.14
20	lw	Wage-Weighted Emp	-2.17	4.24	1.60	2.12	4.84	5.29	4.42	4.35	11.07
21	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	mn	Money Demand	10.40	21.00	21.05	15.80	15.72	16.23	16.30	16.60	16.78
23	p0toft	Terms of Trade	-14.25	-4.67	-10.25	-5.25	-5.03	-5.29	-5.75	-5.99	-4.36
24	phi	Nominal Exchange Rate	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
25	realwage	Real Wage	17.55	-0.48	7.91	4.00	4.41	5.16	5.82	6.32	6.68
26	refg	Foreign Grant	33.19	-53.79	-32.97	-31.89	-21.30	-21.72	-16.81	-15.03	-30.70
27	rn	Interest Rate	-22.74	3.66	7.98	8.28	10.95	11.31	9.32	8.82	21.54
28	twistimp	Import Twist	16.27	4.87	11.27	5.50	5.26	5.54	6.05	6.32	4.53
29	twistlk	Labour Twist	19.06	0.51	8.94	4.39	5.13	5.79	6.52	6.92	6.78
30	xi4	Export Price Index	16.27	4.87	11.27	5.50	5.26	5.54	6.05	6.32	4.53
31	xig	Other Dd Price Index	16.61	-2.95	13.52	5.90	6.19	6.49	7.06	7.32	3.59
32	xim	Import Price Index	27.43	24.85	0.86	1.01	1.01	1.01	1.01	1.01	-0.99

* in Kina million

Table B7: Selected Macro Results when Aggregate Exports and Individual Export Demand are Shocked Additively in Simulation B7

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
	Model Name	*Economic Name*									
1	a1primgen	Tech Coefficient	-0.11	-10.67	-4.59	1.71	-9.15	-3.94	-0.27	-1.14	-1.80
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36
4	chie	Other Demand (Gov't)	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
5	d_avesub	Change in Ave Subsidy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	d_totsub	Change in Total Subsidy*	0.10	0.23	0.11	0.00	0.15	0.09	-0.05	-0.04	-0.10
7	deltab	Real Trade Balance*	136.72	345.94	26.43	-128.38	206.71	98.49	-297.32	-283.37	-277.68
8	deltabn	Nominal Trade Balance*	234.07	410.79	137.08	-78.02	287.88	173.52	-246.02	-235.95	-241.31
9	deltac	Current Account*	237.22	410.87	138.53	-75.21	290.59	174.14	-245.27	-234.44	-239.96
10	efcreal	Agg Real Exports	4.80	11.20	0.71	-3.80	6.30	2.80	-8.20	-8.50	-9.10
11	epsilon1	GDP Deflator	14.08	9.65	14.14	8.23	8.37	8.26	8.22	8.51	8.68
12	epsilon2	K Goods Price Index	15.08	0.94	11.96	6.28	7.77	7.21	6.41	6.80	7.04
13	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
14	f2	Investment Shifter	-12.49	-32.53	-11.89	-4.01	-4.82	-5.88	-8.32	-6.58	-4.20
15	gdp	Nominal GDP	11.81	27.71	21.30	13.46	18.45	16.82	12.15	13.24	14.04
16	gdpr	Real GDP	-2.02	16.68	6.38	4.88	9.39	7.99	3.66	4.41	4.99
17	in	Agg Nominal Investment	9.19	-15.39	10.85	9.44	8.84	9.34	5.36	5.74	5.98
18	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
19	ksnew	Agg Capital Stock	0.33	-0.01	-1.09	-0.40	-1.31	-0.25	-1.98	-2.04	-2.33
20	lw	Wage-Weighted Emp	-4.86	5.23	2.27	7.81	-1.64	5.02	5.85	4.13	3.02
21	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	mn	Money Demand	11.81	27.71	21.30	13.46	18.45	16.82	12.15	13.24	14.04
23	p0toft	Terms of Trade	-0.15	0.03	0.06	0.08	-0.08	-0.01	0.01	0.00	-0.01
24	phi	Nominal Exchange Rate	-14.57	-7.40	-9.98	-4.86	-7.58	-6.12	-4.50	-5.58	-6.44
25	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
26	refg	Foreign Grant	28.58	0.56	10.24	17.90	14.69	2.94	3.43	6.70	5.61
27	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	twistimp	Import Twist	37.60	-61.51	-31.41	-12.40	-25.12	-25.52	-21.96	-13.03	-3.16
29	twistlk	Labour Twist	-23.18	4.50	6.90	15.11	0.89	12.11	13.58	9.38	5.60
30	xi4	Export Price Index	16.53	7.94	11.00	5.16	8.03	6.45	4.69	5.86	6.81
31	xig	Other Dd Price Index	14.83	-0.04	11.00	5.79	5.86	5.78	6.37	6.95	7.27
32	xim	Import Price Index	16.70	7.91	10.93	5.07	8.11	6.46	4.68	5.87	6.82

* in Kina million

Table B8: Selected Macro Results when Exports Prices are Shocked Additively in Simulation B8

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
						Percentage Change (unless where indicated)					
	Model Name	*Economic Name*									
1	a1primgen	Tech Coefficient	0.81	-9.86	-4.65	5.92	-9.19	-4.45	-2.02	-3.55	-2.02
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36
4	chie	Other Demand (Gov't)	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
5	d_avesub	Change in Ave Subsidy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	d_totsub	Change in Total Subsidy*	0.07	0.21	0.42	0.01	0.15	0.10	0.09	-0.07	-0.16
7	deltab	Real Trade Balance*	-836.16	177.56	544.09	-230.50	195.32	190.67	-225.89	-64.85	-239.61
8	deltabn	Nominal Trade Balance*	-748.16	156.57	544.27	-190.94	219.77	206.48	-200.19	-63.15	-228.80
9	deltac	Current Account*	-744.57	157.50	545.31	-187.54	216.93	206.20	-199.25	-62.97	-227.60
10	efcreal	Agg Real Exports	4.80	11.20	0.71	-3.80	6.30	2.80	-8.20	-8.50	-9.10
11	epsilon1	GDP Deflator	-10.31	10.60	29.54	6.65	8.85	10.18	8.77	10.86	8.78
12	epsilon2	K Goods Price Index	20.78	7.25	9.48	9.48	6.98	5.80	6.20	4.61	6.28
13	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
14	f2	Investment Shifter	48.70	-25.63	-30.37	12.51	-1.93	-10.92	-6.72	-16.94	-7.32
15	gdp	Nominal GDP	-12.41	32.57	38.73	12.25	19.92	19.51	12.72	15.64	14.09
16	gdpr	Real GDP	-2.31	20.14	7.33	5.29	10.28	8.58	3.67	4.37	4.93
17	in	Agg Nominal Investment	14.64	-9.99	8.40	12.73	8.04	7.90	5.15	3.57	5.22
18	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
19	ksnew	Agg Capital Stock	0.52	0.12	-1.14	0.33	-1.39	-0.36	-2.29	-2.38	-2.34
20	lw	Wage-Weighted Emp	-3.18	7.15	1.83	7.65	-1.24	2.44	1.45	1.19	1.93
21	mfcreal	Agg Real Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	mn	Money Demand	-12.41	32.57	38.73	12.25	19.92	19.51	12.72	15.64	14.09
23	p0toft	Terms of Trade	-31.84	-2.53	22.96	-4.50	1.15	3.93	0.68	6.64	0.22
24	phi	Nominal Exchange Rate	-34.96	-10.65	0.03	-10.85	-7.75	-3.13	-4.93	-0.47	-4.94
25	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
26	refg	Foreign Grant	32.60	6.40	6.65	20.50	-14.24	-1.63	5.62	1.00	6.67
27	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	twistimp	Import Twist	238.62	-56.82	-54.23	45.26	-23.04	-25.36	-10.33	-29.21	-3.64
29	twistlk	Labour Twist	9.35	-2.61	-8.99	13.23	1.29	2.06	3.38	0.94	2.67
30	xi4	Export Price Index	4.55	8.95	22.92	7.03	9.55	7.25	5.86	7.14	5.40
31	xig	Other Dd Price Index	1.89	6.75	16.12	7.85	5.54	6.93	7.14	7.17	7.28
32	xim	Import Price Index	50.41	11.74	-0.03	11.99	8.31	3.22	5.15	0.47	5.17

* in Kina million

Table B9: Selected Macro Results when Aggregate Imports and Import Prices are Shocked Additively in Simulation B9

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
	Model Name	*Economic Name*									
1	alprimgen	Tech Coefficient	0.66	-10.03	-2.76	5.84	-7.75	-3.45	-0.99	-2.59	-1.22
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36
4	chie	Other Demand (Gov't)	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
5	d_avesub	Change in Ave Subsidy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	d_totsub	Change in Total Subsidy*	0.15	0.29	0.14	0.20	0.14	0.10	-0.03	0.01	-0.06
7	deltab	Real Trade Balance*	-560	110	375	-405	-3.71	3.75	-426	-279	-469
8	deltabn	Nominal Trade Balance*	-410	116	373	-372	2.98	6.36	-431	-281	-511
9	deltac	Current Account*	-406	117	375	-368	-0.30	5.92	-430	-281	-509
10	efcreal	Agg Real Exports	4.80	11.20	0.71	-3.80	6.30	2.80	-8.20	-8.50	-9.10
11	epsilon1	GDP Deflator	-1.53	8.43	27.00	5.14	7.16	9.66	8.12	11.28	8.30
12	epsilon2	K Goods Price Index	19.19	5.18	10.54	9.96	7.98	6.49	6.91	5.28	7.07
13	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
14	f2	Investment Shifter	21.27	-23.30	-23.71	16.18	6.43	-6.28	-1.92	-13.84	-3.23
15	gdp	Nominal GDP	-3.91	27.52	32.33	8.00	15.66	16.78	9.67	13.88	11.69
16	gdpr	Real GDP	-2.42	17.80	4.33	2.74	8.00	6.56	1.45	2.36	3.16
17	in	Agg Nominal Investment	13.13	-11.76	9.44	13.22	9.05	8.60	5.85	4.23	6.01
18	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
19	ksnew	Agg Capital Stock	0.48	0.10	-0.78	0.33	-1.15	-0.21	-2.22	-2.36	-2.36
20	lw	Wage-Weighted Emp	-3.87	6.22	1.72	8.31	-1.00	2.99	1.85	1.84	2.65
21	mfcreal	Agg Real imports	0.40	1.40	4.80	4.80	4.80	4.80	4.80	4.80	4.80
22	mn	Money Demand	-3.91	27.52	32.33	8.00	15.66	16.78	9.67	13.88	11.69
23	p0toft	Terms of Trade	-22.26	-4.27	19.54	-6.85	-1.79	1.89	-1.27	4.57	-1.74
24	phi	Nominal Exchange Rate	-37.42	-9.36	0.55	-10.13	-7.72	-3.09	-4.88	-0.50	-5.05
25	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
26	refg	Foreign Grant	36.43	10.05	9.90	20.50	-15.00	-2.39	4.60	2.00	9.30
27	rn	Interest Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	twistimp	Import Twist	153.95	-51.31	-34.91	56.91	1.39	-11.56	4.72	-18.35	7.15
29	twistlk	Labour Twist	-6.38	2.15	-6.82	16.61	2.94	3.36	4.97	1.54	4.93
30	xi4	Export Price Index	8.36	7.63	22.39	6.17	9.53	7.21	5.84	7.18	5.52
31	xig	Other Dd Price Index	6.95	3.63	16.36	7.12	5.12	6.81	7.11	7.31	7.25
32	xim	Import Price Index	37.97	12.37	2.44	13.85	11.50	5.23	7.19	2.51	7.37

* in Kina million

Table B10: Selected Macro Results when the Nominal Interest Rate is Shocked Additively in Simulation B10

	Variable		1998	1999	2000	2001	2002	2003	2004	2005	2006
			Percentage Change (unless where indicated)								
	Model Name	*Economic Name*									
1	alprimgen	Tech Coefficient	0.69	-10.10	-2.90	5.62	-7.84	-3.51	-1.02	-2.63	-1.24
2	aggl	Agg Employment	-2.29	2.55	1.00	1.00	1.00	2.00	1.00	1.00	1.00
3	cr	Agg Real Consumption	-1.80	0.90	0.36	0.36	0.36	0.36	0.36	0.36	0.36
4	chie	Other Demand (Gov't)	-5.20	21.20	9.30	9.30	9.30	9.30	9.30	9.30	9.30
5	d_avesub	Change in Ave Subsidy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	d_totsub	Change in Total Subsidy*	0.24	0.07	0.16	0.01	0.11	0.10	0.01	-0.03	-0.02
7	del_unity	Homotopy Variable	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	deltab	Real Trade Balance*	-560	110	376	-405	-3.86	3.81	-426	-279	-469
9	deltabn	Nominal Trade Balance*	-410	116	374	-372	2.87	6.45	-431	-281	-511
10	deltac	Current Account*	-406	118	375	-368	-0.01	6.70	-432	-282	-511
11	efcreal	Agg Real Exports	4.80	11.20	0.71	-3.80	6.30	2.80	-8.20	-8.50	-9.10
12	epsilon1	GDP Deflator	-1.36	8.28	26.96	5.13	7.16	9.67	8.12	11.29	8.30
13	epsilon2	K Goods Price Index	19.96	4.47	10.30	9.93	8.02	6.52	6.93	5.30	7.09
14	epsilon3	Consumer Price Index	13.60	14.90	15.60	9.30	9.00	9.00	9.00	9.00	9.00
15	f2	Investment Shifter	42.79	-27.62	-37.12	12.30	5.69	-6.02	-0.81	-12.96	-1.15
16	gdp	Nominal GDP	-3.75	27.33	32.29	7.99	15.66	16.78	9.67	13.88	11.69
17	gdpr	Real GDP	-2.42	17.78	4.33	2.74	8.00	6.57	1.45	2.36	3.16
18	in	Agg Nominal Investment	13.85	-12.37	9.21	13.19	9.09	8.63	5.87	4.25	6.03
19	ir	Agg Real Investment	-5.20	-16.20	-1.00	3.00	1.00	2.00	-1.00	-1.00	-1.00
20	ksnew	Agg Capital Stock	0.49	0.08	-0.81	0.29	-1.16	-0.21	-2.21	-2.35	-2.35
21	lw	Wage-Weighted Emp	-3.74	6.04	1.58	8.09	-1.01	2.94	1.83	1.82	2.60
22	mfcreal	Agg Real Imports	0.40	1.40	4.80	4.80	4.80	4.80	4.80	4.80	4.80
23	mn	Money Demand	-7.15	29.84	37.84	8.67	15.80	16.65	9.42	13.61	11.30
24	p0toft	Terms of Trade	-22.26	-4.27	19.58	-6.84	-1.80	1.89	-1.28	4.58	-1.75
25	phi	Nominal Exchange Rate	-37.45	-9.35	0.58	-10.17	-7.69	-3.09	-4.88	-0.50	-5.04
26	realwage	Real Wage	-12.81	-11.70	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
27	refg	Foreign Grant	35.86	15.38	3.15	20.01	-13.51	1.33	-4.35	-5.31	0.78
28	rn	Interest Rate	40.00	-14.60	-27.00	-5.00	-1.00	1.00	2.00	2.00	3.00
29	twistimp	Import Twist	157.77	-52.54	-35.73	55.91	0.52	-11.56	4.83	-18.29	7.37
30	twistlk	Labour Twist	-6.54	2.09	-6.73	16.36	2.91	3.33	4.91	1.55	4.81
31	xi4	Export Price Index	8.40	7.63	22.40	6.23	9.48	7.21	5.82	7.18	5.50
32	xig	Other Dd Price Index	7.18	3.53	16.22	7.09	5.12	6.81	7.12	7.30	7.26
33	xim	Import Price Index	38.03	12.36	2.40	13.90	11.46	5.23	7.18	2.51	7.36

* in Kina million

Appendix E: Industry Results - Problems Observed in set A simulations and Three Rectifications

This appendix discusses three problems concerning industry results in set A simulations. These are, first, the volatility in rates of export subsidies, second, the volatility of labour demand in the mineral industries and third, volatility in output, labour demand and investment in agriculture sector industries.

Volatility in Rates of Export Subsidies: Fixed by increasing for some industries the Elasticity of Substitution between Primary Factors

In the results of the set A simulations there is much volatility in the power of the export subsidy for many commodities, in particular for export commodities and notably minerals. In some years the value of the total mineral export subsidy exceeds the total value of mineral exports. An important characteristic of the mineral industries is that they are very capital-intensive. In the short run, the capital stock is fixed. Suppose that in a given simulation we want to increase exports of gold in a forecasting closure in which exports are exogenous. If the industry is going to increase its exports of gold, its output of gold must increase, and in order to increase its output of gold, it has to increase its use of labour given that capital is fixed. However, in our original model, the constant elasticity of substitution (CES) between primary factors is very low, namely 0.5. This implies that the supply curve is very steep. For a modest increase in output there has to be a large increase in the gold price. The exogenous price shock under the closure is not sufficiently high to induce the required increase in output. Therefore, the export subsidy has to increase in order to hit the export target.

The low CES implies that even if one of the factors becomes relatively expensive (say, capital) and the other (say, labour) becomes relatively cheap, there would not be much substitution between the two. Hence there is much volatility in the export subsidy, with sharp increases when the price of gold is low and sharp decreases when the price of gold is high. These large changes are required to sustain a given level of output and exports.

To damp the volatility in export subsidies, we increased the primary factor substitution for the mineral industries as well as for forestry, the other industry with high volatility in changes in export subsidies. For these commodities, we increased the CES for primary factors from 0.5 to 2.0. An intuitive justification for the higher CES for primary factors in the mineral and forestry industries is that they are initially very capital-intensive. There is room for flexibility in their use of labour with the given capital.

With the higher elasticities of substitution between primary factors for these commodities, the supply curve is now less steep. For a given increase in output to be realized, the increase in export price is now relatively less. Consequently, even if the exogenous export price is not the required price, the export subsidy now does not have to change to the same degree as before. After making this rectification to our model, we obtained more plausible results for changes in the rates of export subsidies and the change in the total subsidy in the simulations in set B compared with those in set A.

Volatility in Labour Demand in the Mineral Industries: Fixed by assuming very large (excess) initial stocks of the capital & land composite in the mineral industries, allowing for changes in the rate of utilization of the capital & land composite, and by switching off the dynamic investment-capital relationships in their industries

The key mineral export industries are very capital-intensive and, as we explain below, this leads to high volatility in their demand for labour. Capital is rigid in the short run and the low share of labour in total factor usage for these industries means that demand for labour has to increase/decline very sharply for moderate increases/declines in output to be realized. Algebraically, in percentage change form, output (y) is a function of factor-share-weighted labour (l), a capital and land composite ($s_{k\&ld}k \& ld$), and technical change (a):

$$y = s_l l + s_{k\&ld} k \& ld + a \quad . \tag{1.1}$$

Consider crude oil as the example and assume that labour factor value equals 34 and capital & land value equals 462.

Suppose the output of crude oil declines by 22.0 per cent and a is 2.39 per cent. Since $k\&ld$ is fixed and l makes up 6.9 percent only of the total factor value in the crude oil industry, l is required to decline by 355.8 percent.

$$-22 = \frac{34}{496} * l + \frac{462}{496} * k \& ld + a$$

As $k\&ld$ is zero

$$l = \frac{y-a}{s_e} \tag{1.2}$$

$$l = (-22 - 2.39) \div \left(\frac{34}{496}\right) = -355.8 \quad .$$

This illustrates why there is a lot of volatility in the demand for labour in key export industries in some simulations.

A decline of more than one hundred per cent (as in the example above) is not possible and we amend the model to rule out such a result. Specifically, we assume that in mineral industries in PNG both capital and land are initially very large. This is consistent both with their shares in total factors and with physical evidence. In other words, we assume that initially in these industries there is excess capacity in the current stock of capital and land and some of it is not utilized. If output has to increase, more of the land is dug and more of the existing capital is used. The percentage change in the use of the land and capital is proportional (α) to the required increase in the activity level (output). In this way, the composite of land and capital is not constant in the short run. Algebraically, equation (1.1) is rewritten as

$$y = s_{k\&ld}\alpha y + s_l l + a \tag{1.3}$$

where

$$\alpha y = k\,\&\,ld$$

giving

$$y = (1 - s_l)\alpha y + s_l l + a \quad .$$

Using the crude oil example as before, we now find

$$y = \left(1 - \frac{34}{496}\right)\alpha y + s_l l + a \quad .$$

Reorganising, this gives

$$l = \frac{\left[y\left(1 - \alpha + \frac{34}{496}\alpha\right) - a \right]}{s_l} \quad . \tag{1.4}$$

If α is set at 0.9,

$$l = \left[-22\left(1 - 0.9 + 0.9\frac{34}{496}\right) - 2.39 \right] * \frac{496}{34} = -86.8 \quad ,$$

The result on the percentage change in industry labour demand is now possible.

However, there are still two problems. First, the percentage changes in labour and percentage changes in the capital and land composite are quiet different when they should be very similar. Second, we still observe considerable volatility in capital and investment growth for the mineral industries.

To address the first problem, we further increase the assumed value for α. When α is set at 1.0, factor demand for the two factors (labour and the capital/land composite) are the same, but factor demand by the industry *other minerals* is volatile. With α set at 0.95, factor demands for *other minerals* are less volatile. We therefore settle for a value for α of 0.95.

In order to reduce volatility in capital and investment growth in the mineral industries, we switched off the dynamic investment-capital relationship for these industries. This is done by dropping variable *ff_kj*, the shifter that adjusts the industries start-of-year capital stocks, and adding two new variables, a shifter in the new equation for capital supply for mineral industries, *f2mine*, and a shifter in the new equation for land supply for mineral industries, *fmine*. The two new shifters are swapped with the shifter in the equation for opening capital stock, *d_f_kj*. Investment and capital growth are now linked to the activity level in each year, but they no longer play a role in the year-to-year linking of the capital stock.

Volatility in Output, Labour Demand and Investment in Agriculture Sector Industries: Fixed by increasing the CET for agricultural products produced by more than one agricultural industry and by increasing the CET in multi-product agricultural industries

Some agricultural products are produced by more than one industry. In our set A simulation results we observed instability in allocation of output between industries producing the same commodity. For example, we observed instability in the allocation of the production of copra between *copra-plantation* and *smallholding-copra* industries. Further, some agriculture industries are multi-product industries, and in our set A simulation results we observed instability in their composition of output. For example, there is instability in the *smallholding-copra* industry in its choice between producing copra, fruits & vegetables and non-ruminant livestock. We address these problems by making two rectifications to our model.

In our initial model, the multi-product *smallholding* exporting industries had low constant elasticities of transformation (CET set at 2). This did not allow sufficient flexibility in these industries to switch between commodities. Consequently, when a reduction in copra export was introduced, there could be a small reduction only in copra output in the *smallholding copra* industry because output of the other two goods could not move much given the low CET. Output was given in the *smallholding copra* industry and so most of the variation had to be borne by the *plantation copra* industry. In our revised model, we increased CET to 10 in multi-product agriculture industries. With the higher CET, *smallholding copra* has greater flexibility in its copra production and so takes some pressure off the *plantation copra* industry. The *plantation copra* industry no longer has to make large changes in its copra output to satisfy an exogenous export change.

We overcome the multi-product industry problem by increasing the CET from 2 to 10. This helps address the multi-industry products problem. When labour is allotted a high proportion of factor payments, there is much volatility in labour demand and also volatility of output. To reduce the overall output volatility in the *smallholding* industry we reallocate the factor payment by giving more to land and less to labour. In this way, when demand for vegetables and livestock increases and demand for copra decreases, the *smallholding* industries find that expansion in vegetables and livestock offsets the reduction in copra to a greater extent than it did before. The increase in the CET and the resultant increased flexibility saves the plantation copra industry from collapsing.

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