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The Economy-wide Effects of Reducing Rent-Seeking Activity: Tax Evasion in a Developing Country

A thesis submitted for the degree of
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Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Summary

The first objective of this study was to construct a partial equilibrium model for rent-seeking activity in the context of tax evasion. This objective is addressed in Chapters 2 to 4, where we developed a model describing the demand for and the supply of rent-seeking services and illustrated its application. The second objective was to develop ORANI-RSA, an economy-wide model which incorporates rent-seeking behaviour developed in the earlier chapters. As in the earlier chapters, ORANI-RSA was used to analyse the impacts of a cut in the tax rate on income from capital. ORANI-RSA produces short- and long-run macro and economy-wide projections, which are differentiated by different treatments of the consumption function, the government budget and the ownership of capital.

The application of the partial equilibrium rent-seeking model reveals that, in the context of partial equilibrium, the cut in the capital income tax rate reduces firms' demand for rent-seeking services. This leads to a reduction in the quantity of rent-seeking supplied and hence a reduction in the resources used in its production. The impact of the policy on efficiency is unambiguously positive.[1] Whether government revenue rises or falls depends on the extent to which users of rent-seeking services succeed in reducing their tax payments.

The analysis provided by the partial equilibrium model of rent-seeking, however, has ignored at least four major points: (i) the impact that resources released from the service providing sector would have on the size of the rest of the economy; (ii) the long-run impact of the policy change on the stock of capital which in turn will impact on the size of the tax base; (iii) the effect of the cut in capital income tax on government spending; and (iv) the next round impacts of (i), (ii) and (iii) on the economy at large.

The short-run application of ORANI-RSA, which essentially addresses only point (i), indicated that reducing the rate of tax on income from capital makes the economy more competitive (as shown by the growth performance of exports) and generates a better use of the available economic resources. The latter is mainly due to the shrinkage of the service providing industry, which produces rent-seeking services.

[1] Of course, this partial equilibrium result abstracts from any feedbacks from reduced government revenue onto the production of public goods. Nevertheless, in the general equilibrium results summarised below, GDP at social cost increases unambiguously.

The policy forces the service providing industry to release some of the labour it previously used and leads to an improvement in real GDP measured at both private and social costs. The reduction in demand for rent-seeking services also leads to a fall in the rentals on the influence of privileged labour.

All four points ignored in the application of the partial equilibrium are addressed in the long-run applications of ORANI-RSA. They identify an important mechanism in explaining how the impact of the cut in capital income tax on government tax collection can be partly off-set by resources re-allocation within the economy. In the general equilibrium context, the size of the economy, and hence the size of taxable GOS, is not determined only by the size of the available inputs/resources, but also by how these resources are allocated between sectors within the economy. The projections generated in a simulation in which the domestic and foreign shares of capital ownership are assumed unchanged, indicate that the policy reform stimulates an even a stronger resource allocation towards a more competitive exporting sector in the long run. The service providing industry, which shrinks due to the reduction in the demand for rent-seeking services and the cut in government spending, releases labour and capital to be used by exporting industries and others. The strong performance of the main exporters stimulates higher investment and capital stocks in these industries. Relative to the base case, aggregate capital stocks in the economy increase. This increase, however, is too small to off-set the reduction of government revenue due to the cut in the capital income tax rate. Thus the policy reform, under the constant share of capital ownership assumption, leads to a larger improvement in GDP than in the short run.

The second long-run simulation, where a more conservative assumption on the financing of the change in the capital stock (due to the shock) is adopted, indicates that the policy change leads to a shrinkage of privately valued GDP, but to a slight improvement in GDP at social cost. The first result is due to the fall in government and households' consumption, which off-sets the rises in real investment and in the balance of trade. Compared to the previous long-run simulation where households' consumption increases, here households' income is dominated by the reduction in labour income generated by the shrinkage of the labour intensive service providing industry. The small rise in GDP at social cost occurs because the reduction in the production of rent-seeking services releases resources which are employed to produce output with a positive social valuation.

Declaration

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma in any university or equivalent institution, and that to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

[redacted]

Edimon

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Chapter I
Introduction

1.1 Relevance of rent-seeking activity

Rent seeking activity is costly to the economy when it becomes widespread. Since such activity generally is a by-product of government regulation, its size in the economy will depend on the amount of regulation in place. Almost all means of generating government revenue, including income taxes, tariffs and licence allocations, will attract certain types of rent-seeking activity (see Tullock, (1967); Krueger (1974); Bhagwati *et al.* (1984); Mohammad and Whalley (1984); Tollison (1987) and Pederson (1995)). Buchanan (1980) and Tullock (1980) argued that the best way to limit rent-seeking is by limiting the size of the government.

The arguments for the reduction of the size of the government, however, are posed in far more general terms than avoidance of the ill effects of rent-seeking activity. According to the classical economists, Pareto–efficient allocation of resources will emerge in a competitive economy. They suggest that the role of government should be limited to efficiently dealing with various types of market failures and externalities.

Government taxing and spending activity are not without cost to the economy. It is often argued that government expenditure can crowd out private investment (Branson, (1989), and that the publicly owned assets so produced are less socially valuable then the private assets forgone. Income tax introduces distortions, inefficiency and disincentive effects to the economy (Musgrave and Musgrave 1989). The same, but to different extents, is true for other types of taxes.

Some policy makers in both developed and developing countries seem to have been convinced by these arguments. Some argued in Australia during the *Fightback* campaign that, government under the Labour Party was over-expanded (Dee, 1989). The proponents of the Liberal/National (i.e., conservative) *Fightback* campaign argued that the bloated size of government was hampering the growth of the Australian economy (Brooks, 1993). The conservative government which won office in 1996 did introduce widespread cuts in the rate of government outlay.

The issue is slightly different in developing countries. The size of government is not only determined by the size of its outlay, but more importantly by the amount of regulation. It is often the case that many of the regulations are created in a less than democratic process. Together with slack law enforcement, the highly regulated environment provides a good ground for many types of rent-seeking activities to flourish.

The World Bank (1997) listed several relevant examples of such regulations in Indonesia. All imported cars are generally subjected to high sales tax and customs duties. In 1996 the government introduced a regulation to exempt the Timor Putra corporation from sales tax and import duties for all imported cars with an engine capacity of less than 1600cc, provided that such cars achieved 60 percent local content within three years. This policy discriminated between producers and helped channel resources to a less experienced company whose principal asset was its close connection to the Presidency.

Government regulation is also present in the form of extensive non-tariff barriers on agricultural products. Mandated import monopolies apply in the case of rice and rice flour, sugar, wheat and wheat flour, soybeans, onions, shallots, garlic, leeks and etc. The government agency BULOG has exclusive rights in these products. Government also allocates import monopolies on petroleum and other oil and gas products, as well as on fertiliser, cloves, and insecticides. For some of these commodities, the monopoly rights were given to privileged citizen.

In Indonesia, natural resources such as water, minerals and forests are ultimately controlled by the government. In the case of forests, the allocation of concessions has been far from competitive. As a result, some concession holders have been able to acquire the right to areas between 1.5 to 3.496 million hectares (*Kompas,* 22 September 1998). As a comparison, the size of one of the most populous provinces in Indonesia (West Java) is only about 3 million hectares.

To the extent that the Indonesian experience is representative of other developing nations, it is clear that an urgent priority in many such countries should be to curtail rent-seeking activity by reducing the volume of regulations that encourage rent-seeking and inefficiency.

1.2 A short overview of previous research on rent-seeking activity

Since the concept of rent-seeking was introduced, it has developed into a major research program, achieving an almost dominant role in the theory of public choice, and attaining a significant foothold in the literature of economics, law and political science (Rowley and Tullock 1987). In this thesis, however, we do not attempt a detailed review of the rent-seeking literature. Rather, we will give a brief overview of a sparse selection of articles in rent-seeking research. These articles have been chosen for their relevance to this thesis.

The concept of rent-seeking itself was introduced to economics by Tullock (1967). He defined rent-seeking activity as a socially costly pursuit of transfer. He argued that the resources spent to capture and to resist a transfer were a form of social cost, because they have a positive opportunity cost elsewhere in the economy. Tullock's ideas are considered as the beginning of the public choice branch of rent-seeking analysis (Colander, 1984).

In the public choice literature, the institutional setting plays a central role since rent-seeking occurs primarily through the political process. According to Buchanan (1980), agents' efforts in trying to maximise returns on their own opportunities may produce either socially beneficial or socially bad outcomes, depending on the institutional setting in which the effort takes place. Entrepreneurs who maximise profit in an unregulated market usually bring about a socially good outcome because in the absence of externalities such effort tends to produce genuine social surplus. In this setting, profit attracts other profit-seekers to enter the market and as this entry proceeds, excess profits initially present tend to be reduced to zero in the long-run. Profit-seeking, therefore, generates the dynamic which motivates agents to allocate resources optimally. This in turn creates additional outputs at lower prices to the economy.

Now, without changing the agent's motivation (profit maximisation), consider an institutional setting of a regulated market or one in which direct political allocation takes place. In this setting the entrepreneur's actions (rent-seeking) will involve social waste. This is because the imperative which motivates agents to compete (and hence to allocate resources efficiently) is blocked. In the latter setting non-market types of competition replace market competition in allocating resources. While non-market competition may reduce or dissipate the existing profit, it does not produce any additional output, nor does the price of the product(s) produced by the entrepreneur fall. That is, rational economic behaviour in this institutional setting may artificially inflate the prices of certain goods and services relative to others, leading to resource misallocation in the economy at large. Resources spent by the entrant to capture the potential profit and by the incumbent to protect the existing profit, therefore, are wasteful spending.

In the presence of rent-seeking activity, the welfare cost arising from a tariff is much larger the standard Harberger welfare triangle. According to Tullock, resources spent in rent-seeking activity are often more substantial than the waste as evaluated by the Harberger measure.

The assumption that the entry of new rent-seekers will dissipate the whole potential profits is crucial in the measurement of rent-seeking cost. In the case where entry is not possible, the existing (monopoly) profit simply becomes a transfer from consumers to the rent-seeking incumbent firms and to the regulators who protect them. This is often the case when the potential competitors are politically too small to compete with the incumbent rent-seekers. This type of rent-seeking may be typical of developing countries, where the distribution of endowments required for such activity is skewed. In this case, the cost of rent-seeking will be less than Tullock's estimate.

Other economists not associated with public choice also have contributed extensively to the analysis of rent-seeking. Krueger (1974), who invented the phrase *rent-seeking*, developed a more formal model of rent-seeking analysis and presented some empirical estimates on the size of the loss from quota policies in India and Turkey. Bhagwati *et al.* (1984) extended the domain of rent-seeking analysis and developed more of its potential for dealing with issues which traditionally had not been viewed in such terms. They pointed out that rent-seeking is very pervasive, and could also include tariff-seeking, tariff evasion and a variety of other restriction-seeking activities, all of which were termed 'directly unproductive activities' (DUP) by them. Such activities yield pecuniary returns to those involved but produce no direct output to the economy. This implies a distinction, not currently recognised in national accounting procedures, between the privately valued of output and the output at social cost (a theme to which we return in chapter 8).

Mohammad and Whalley (1984), by following Krueger's procedure of approximation but with a much wider scope, re-examined the cost of rent-seeking in India. In addition to the cost associated with rent-seeking opportunities that are created by tariffs and quotas, they also computed the costs of rent-seeking which arise from extensive distortions in the goods market, and from controls in capital and labour markets. They suggested that a conservative estimate of the annual losses due to rent-seeking activity is between 30 and 40 percent of GNP, which is much larger than Kreuger's earlier figure (7 percent of GNP).

Tollison (1987) and Pederson (1995) apply the spirit of the concept to the field of taxation. Others — to name a few, Allingham and Sandmo (1972), Stiglitz (1985), Yitzhaki (1987) and Weigel *et al.* 1987) — have applied a rent-seeking a concept similar to the one used by Tollison and Pederson and call it tax evasion. According to Tollison, once the rent-seeker is in control of a certain rent, he will be prepared to spend resources to protect it from eroding. The introduction of an excise tax, for example, reduces producers' surplus. To prevent the surplus from eroding, the rent-seeker may engage in lobbying and in the limit spend as much as the potentially lost surplus. This rent-protection activity may exacerbate the allocative distortion due to the tax.

Pederson introduces rent-seeking into tax analysis by modeling the interaction between government and private agents. The government is assumed to serve the interests of those private agents who compete through rent-seeking activity. Private agents who succeed in rent-seeking activity obtain a return in the form of a tax reduction. Some resources are wasted in the process; rent-seeking activity, therefore, is good for the successful agent but not for the economy as a whole.

Unlike Tullock, Bhagwati *et al.* elaborate their idea within a theoretical general equilibrium framework, where DUP activity can be categorised as endogenous or exogenous. In their model, when DUP is exogenously specified, the implication of DUP for positive analysis is tantamount to introducing an essentially non-traded sector with zero output but positive input.

From the way it is defined, it is clear that a strict partial equilibrium framework cannot be used to capture the full impact of rent-seeking activity; the social cost (waste) arises from the fact that resources which can be employed more productively in some sector of the economy are used instead to procure wealth transfer (Brooks and Heijdra (1987)).

General equilibrium provides a better framework for analysing the welfare implications of rent-seeking activity. This is because it captures both the first and the second round impacts of rent-seeking. In the first round, successful rent-seeking will transfer wealth from other agents to the rent-seekers. The first round not only redirects resources into socially wasteful activity, but it also sets in train disturbances in relative prices. These occur in the second round where prices among domestic commodities are distorted, as well as the relative prices of domestic and foreign commodities. In both cases, resources are encouraged to flow in directions which are socially sub-optimal.

These changes of relative price will alter the output of each industry differently. This in turn will change the composition of output in the economy. The cost of rent-seeking in the general equilibrium may be reflected by the changes in exports (because of lower international competitiveness of the local economy), government consumption, imports and the GDP of the economy.

1.3 The contribution of the thesis

As noted earlier, a general equilibrium framework is necessary in analysing the full impact of rent-seeking activity. We found Baghwati's idea of adding rent-seeking as a type of non-tradeable commodity to the economy methodologically appealing, and have implemented it within ORANI-RSA — a computable general equilibrium model with rent-seeking activity extension. As suggested by its name, the main model belongs to the ORANI[1] class of models. Unlike the model of Baghwati *et al.*, the emphasis in this thesis is on a numerical model that in principle could provide quantitative results for an existing economy. The qualification 'in principle' is required because of the dearth of suitable data on rent-seeking, which, like the 'black economy' in general, is usually well hidden.

The rent-seeking activity (RSA) extension is developed to accommodate a simple type of tax evasion involving the purchase of rent-seeking services from an influential provider. Rent-seeking services are treated as a non-tradeable commodity

[1] ORANI is a CGE model for Australian economy (Dixon, Parmenter, Sutton and Vincent, 1982).

produced by a multi-product service-providing industry. The size of rent-seeking services demanded is endogenously determined.

Unlike Pederson, we do not model inter-firm/industry rivalry in rent-seeking. We do allow different industries that engage in rent-seeking to have different 'productivity' in the use of rent-seeking services. By this we mean that for the same monetary input different industries succeed to varying degrees in their efforts to avoid/evade tax payments.

In addition to the rent-seeking activity innovation, ORANI-RSA (unlike the original ORANI) is built around a Social Accounting Matrix (SAM). Compared to ORANI, it has a more complete mapping of incomes. Value added created by labour and capital in production is mapped to other agents; namely: households, government and the rest of the world. The model also takes into account all transfers between agents. With a complete income mapping, it is possible to construct equations to represent budgets (revenue, expenditures and saving) of all agents.

With these additional features, ORANI-RSA is capable of providing a richer analysis of policies related to rent-seeking activity. For example, when the model is implemented to analyse the impact of a cut in capital income tax, it will compute the impact of such a policy on: (a) the government budget; (b) other agents' budgets; (c) production of rent-seeking services; and on (d) macroeconomic as well as sectoral aggregates. If government is assumed to adopt a balanced budget policy, then the cut in capital income tax will lead to a reduction of government expenditure. The same policy, however, will affect other agents (households and the rest of the world) in an opposite way. The cut in capital income tax increases their revenue, which in turn will increase either their expenditures and/or saving.

In ORANI-RSA, a reform involving a cut in the tax rate on capital income will reduce the demand for, and hence the supply of, rent-seeking activity. Thus the model will also be able compute the size of the reduction of resources employed by the service-providing industry and thereby freed for more productive employment elsewhere. The overall impact of this policy will be reflected in macroeconomic aggregates such as real GDP, exports, the balance of trade, and the competitiveness of the economy.

Officially compiled SAMs do not include rent-seeking activity. In this thesis, we elaborate a method for endogenously generating data to approximate the size of rent-seeking activity, provided that the values of the parameters and the exogenous variables representing the regulatory setting can be estimated. At this stage, however, ORANI-RSA uses hypothetical data. One reason for this is that since ORANI-RSA is still in an early stage of its development, estimates for the values of the parameters used in the rent-seeking part of model are not yet available for any country. The hypothetical data base, however, has been designed to share some salient features of a typical developing country with extensive rent-seeking activity.

1.4 Outline of the thesis

In Chapter 2 we derive the demand for rent-seeking services. In an economic environment with zero rent-seeking activity, we generally assume that firms/industries simply maximise gross profit by choosing the most efficient combination of inputs at any given output level and with given input prices. The tax on profits is taken as given and does not enter into firms' input decision making as it simply reduces gross profit to after-tax profit. In an environment where rent-seeking activity is pervasive, this often is not the case. Rent-seeking activity presents a firm with two alternatives; (i) to pay tax in full or (ii) to engage in certain activity to reduce its tax burden. This activity, therefore, introduces both costs and additional profits, in terms of tax reduction, to the firm. We assume that the typical firm in each industry takes such activity seriously, and hence it needs to consider a second level of decision making, in which additional profit net of rent-seeking costs is maximised.

In Chapter 3 we outline the supply side of rent-seeking activity. It is assumed that rent-seeking services are provided by a service-providing sector. This sector engages in joint production of (legitimate) services which are sold to government, and (possibly illegitimate) rent-seeking services which are sold to the private sector (industries). No attempt is made to further elaborate a more complicated theory of government behaviour in this chapter: its role is simply to purchase (legitimate) public services from the service providers. Such services may consist of public administration, defence, education and the provision of other public goods.

In Chapter 4 we combine the demand and the supply sides of the rent-seeking model developed in Chapters 2 and 3. We specify the standard closure and then implement a stand-alone version of the rent-seeking model to analyse the impact of an exogenous cut in the rate of profits tax and a reduction in the price of legitimate public services. The results of the experiment demonstrate the need for integrating the stand-alone version of the rent-seeking model into a larger economy-wide model to capture the full impact of the policy change.

This integration occurs in Chapter 5, where we present the theoretical structure of ORANI-RSA. We discuss how the structure of ORANI-RSA differs from the standard ORANI-G model. All of the new equations are discussed in detail. The standard equations which have been clearly elaborated elsewhere are not listed in this chapter. The complete equations of the model are listed in Appendix C for ready reference.

In Chapter 6, we present a number of adjustments made in integrating the stand-alone version of the rent-seeking model into the economy-wide model. The adjustments include changes to notation and in the dimensions of the rent-seeking model.

In Chapter 7 we discuss the construction of the hypothetical data base used to calibrate ORANI-RSA. In the first part of this chapter, we outline the steps introduced to change a balanced Social Accounting Matrix of South Africa to make it more typical of developing countries in general. We then elaborate a method to generate additional data for the rent-seeking extension of the model. In the last part of the chapter we list the values of the parameters. Most are taken from the recent literature of general equilibrium models for developing countries.

In Chapter 8 we present and interpret the results of a hypothetical reform to cut the capital income tax rate. The government is assumed to adopt a balanced budget policy so that the cut in capital income tax will affect government expenditure accordingly. Simulations are conducted for both the short and the long run. In the short run, although investment takes place, it does not add to industries' useable capital stocks (which are exogenously fixed). In the long run, industries' investment is allowed to change their capital stocks, which adjust to keep the rates of return at the level required before the policy change.

In the last Chapter we summarise the major lessons learned from ORANI-RSA and offer concluding remarks. We also suggest where improvements can be made in future research in the field.

Chapter II
The Demand for Rent-Seeking Services

2. 1 Introduction

In this chapter we develop a model describing the demand for rent-seeking services used in minimising tax payment. We then apply the model to tax reform analysis. Unlike Pederson, we do not model inter-firm rivalry in rent-seeking. Instead we assume from the beginning that agents engaging in the activity have different productivity. By this we mean that for the same monetary input different firms succeed to varying degrees in their efforts to avoid/evade tax payments.

Our interest is to examine the reactions to the change in tax policy of agents whose productivity in rent-seeking activity differs. A model to accommodate these differences is developed in section 2.2. Assumptions on the objectives pursued by the government in implementing tax policy are also set out in this section. Using a hypothetical data set, the relevance of the model to the tax reform analysis is illustrated in section 2.3. An interesting by-product of this exercise is that we are able to derive a tax revenue schedule which has elements in common with the Laffer curve proposed by Arthur B. Laffer (1979). However, unlike the Laffer curve whose existence depends on the magnitude of the supply elasticities of labor with respect to the net wage (Rosen 1988), the revenue schedule we derive in this exercise is determined by the taxpayers' marginal benefit in engaging in rent-seeking activity. In the section 2.4 we elaborate a more general form of the rent-seeking model, in which a constant returns to scale variant is derived.

2.2 A simple model

2.2.1 The private sector

In an economic environment with zero rent-seeking activity, we generally assume that firms simply maximise gross profit by choosing the most efficient combination of inputs at any given output level and with given input prices. The tax on profits is treated as a lump sum expropriation and therefore does not enter into firms' input decision making as it simply reduces gross profit to after-tax profit. This is not realistic in an environments where rent-seeking activity is widespread. The possibility of rent-seeking presents a firm with two alternatives: (i) to pay tax in full; or (ii) to purchase rent-seeking services in an attempt to reduce its tax burden. Hence rent-seeking introduces both new costs and new benefits, in terms of tax reduction, to the firm. Consequently, profit maximisation now occurs within a two-stage framework: in the first, conventional cost minimisation takes place at any given level of output; in the second, decisions about rent-seeking are taken.[1]

The firms in this model are assumed to take rent-seeking activity (hereafter called RS) seriously and hence to engage in these two levels of decision making, the first with respect to ordinary inputs and the second with respect to rent-seeking and tax reduction. For simplicity it is assumed that the levels of output and of attainable pre-tax profit are independent of rent seeking activity. At this stage, no further explanation is necessary with respect to the firm's first level profit maximisation problem. In the following, therefore, we focus just on the firm's second level profit maximisation problem, taking the firm's pre-tax profit level as given.

[1] The separability assumption used here is crucial to the structure of the model. Introducing interactions between the production structures of conventional production and of rent-seeking would be highly speculative and is best left for later research.

Having maximised gross profit with respect to ordinary inputs, we assume that firms are also maximising net-profit by engaging in RS. The firm's objective function at this second stage is assumed to be:

$$U = u(\Pi) \quad , \qquad \text{E2.1}$$

where Π is after-tax profit. Because tax evasion is a risky activity, net profit is assumed to be a stochastic variable. We assume that the function u (Π) is the statistical expectation of Π (written below as $E(\Pi)$); that is, we assume firms maximise expected after-tax profit.

Equation E2.1 implies that it is the after-tax profit alone that determines the firm's utility. Two main alternatives are available to the firm in maximising its utility. Firstly, it may simply pay the full tax so that it gets the following after-tax profit:

$$\Pi(0) = Q_H - T \quad , \qquad \text{E2.2}$$

where

$$Q_H = H/P_H \quad . \qquad \text{E2.3}$$

P_H is the unit price of the profit and Q_H is real profit. H and T respectively are gross nominal profit and the profit tax calculated according to the official schedule.

Secondly, the firm may engage in RS and obtain expected net-profits as follows:

$$E(\Pi(z)) = Q_H - B(z)\,T - M(z) - J(R)\,G \quad , \qquad \text{E2.4}$$

where $0 \leq B \leq 1$ is the effective tax quotient after engaging in RS, z is the real input used in RS and $M(z)$ is nominal value of resources spent on rent-seeking. R denotes the firm's stock of political influence. J is the probability of being fined for engaging in RS and is assumed to depend on the endowment of political influence, which in turn also depends on z (to be explained below). G is the amount the firm has to pay if convicted of tax evasion.

Since this second choice involves uncertainty, we need to choose an assumption on the firm's attitudes toward risk. This choice of assumption will reveal the shape of the firm's objective function defined in E2.1, which in turn will affect the firm's expected utility derived from engaging in RS. In this model we assume that firms are risk-neutral. In terms of a firm's objective function, it means that equation E2.1 is a twice-differentiable function and its first and second derivatives are positive and zero, respectively. The assumption also implies that firm is indifferent between $\Pi(0) = \$ 500$ and expected $\Pi(z) = \$ 500$. Note that this assumption could be relaxed to accommodate risk-averse or risk-loving behaviour.

It is clear that a necessary condition for RS to take place – that is, for z to exceed zero – is:

$$E(\Pi(z)) > \Pi(0) \quad . \qquad \text{E2.5}$$

For the necessary condition E2.5 to be satisfied, the expected tax reduction obtained by the firm must not be less than the amount of resources transferred to RS, taking into account the expected cost of being fined[2]. Assuming that the price of z and the amount of fine G are given, we can obtain the optimum value of z (and thence the additional net profit) by maximising $E(\Pi)$ with respect to z. Before we do this task ,

[2] The inclusion of a fine in E2.4 implies that rent-seeking is illegal. Of course many legal tax-minimisation mechanisms also exist, particularly in developed countries. In the case where rent-seeking is legal, the cost of fines can be removed from equation E2.4. Such a change will simplify the specification of the firm's demand for rent-seeking, without altering its main implications.

however, we need to discuss how each component of E2.4 is defined. The next sub-sections cover such discussion.

2.2.1 (a) Effective tax quotient schedule

In this model we assume that B is a modified logistic function of the RS input z. This type of function has been used in economic applications, such as financial information analysis, population growth and market share estimations. The essential qualitative feature of the logistic function is that for small values of z, it resembles an exponential function, while for large values of z, it levels off and approaches closer and closer to a limiting value. It is easy to set the function up with parameters that result in a declining, rather than a rising, curve. This is the approach followed here in specifying the B(z) schedule.

In equation E2.6 we define the dependence of B on z ($0 \leq B \leq 1$). In the chosen functional form it can be expressed as:

$$B = \theta_1 + \frac{(1-\theta_1)(1+A)}{1+Ae^{\gamma z}} , \qquad \text{E2.6}$$

where A is a constant and γ is a technological parameter related to the effectiveness of the rent-seeking input z. The parameter θ_1 is the minimum tax quotient, which means that even if firms use a very large z ($z \rightarrow \infty$), they can only reduce B to θ_1. The constant A is for calibration purposes and does not have any economic interpretation. It is designed only to make the function produce the value of B = 1 when z is zero, to represent the case where the firm does not engage in rent-seeking activity. The value of γ is positive. As z gets indefinitely large, B tends towards θ_1. The higher the value of γ, the more efficient is the rent-seeking technology of the firm, meaning that using the same quantity of input z, the firm is able to obtain higher benefits in terms of tax reduction. In addition, equation E2.6 implies B decreases at a decreasing rate as z increases, meaning that the first few rent-seeking inputs are much more productive in reducing B than the subsequent inputs (see Figure 2.1).

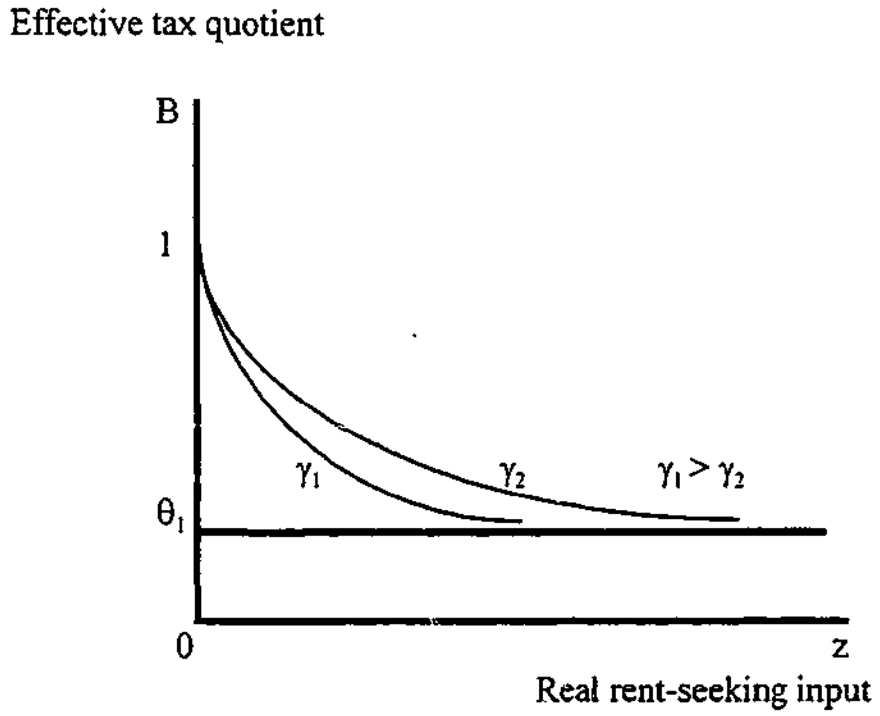

Figure 2.1: Two hypothetical schedules showing different productivity in rent-seeking activity. The firm whose parameter is γ_1, is more efficient than the firm with parameter γ_2.

2.2.1 (b) Cost of rent-seeking activity

It is assumed that the price of z faced by all firms is the same and is independent of the quantity of RS done by the firm. This assumption can be relaxed later after we introduce the supply side of the rent-seeking model[3]. The nominal value of resources transferred by each firm into rent-seeking activity (M) therefore depends solely on the firm's choice of z.

[3] Trougout this thesis we actually maintain the assumption that purchasers of RS are price takers. In the general equilibrium exrention in latter chapters, the agents purchasing RS are representative of industries (rather than ffirms), and hence *ex post* the price of RS can be inffluenced by the demands of individual industries.

The relationship between M and z is defined in equation E2.7, where P_Z is the price of z.

$$M = P_Z z \qquad \text{E2.7}$$

2.2.1 (c) Schedule of fines for tax infringements

The expected fine schedule has two elements, the nominal amount of fine (G) and the probability of being fined (J). G is normally set by law and hence is given to all firms. It leaves firms with only one channel with which to minimise the expected fine, that is, to lower the probability of being fined (J).

In this model J is assumed to be a modified logistic function of the political influence possessed by firms (log R). The choice of the stock of political influence R as the determinant of J is based on the characteristics of the developing countries for which we design the model. It is assumed that firms with a large stock of political influence are more likely to be able to ensure that enforcement of the tax law is slack than are less influential firms. It is reasonable in such a case to assume J is determined by R, as shown in equation E2.8.

$$J = \theta_2 + \frac{(1-\theta_2)(1+Q)}{1+Qe^{\alpha R}} \qquad \text{E2.8}$$

The constant Q in E2.8 serves the same function as A in E2.6 so that it does not have an economic interpretation. The parameter θ_2 is the risk floor or minimum probability of being fined, meaning that even if firms happen to have very large R ($R \rightarrow \infty$), they can only reduce J to θ_2. Parameter α has a positive value and measures the effectiveness of firms' technology in reducing J. The higher value of α, the more efficient is the firm in reducing J. Using the same quantity of R, a firm with a higher value of α is able to obtain a higher benefit in terms of a lower probability of being fined. As shown in Figure 2.2 the higher the value of α, the sooner the J schedule becomes close to the θ_2 line.

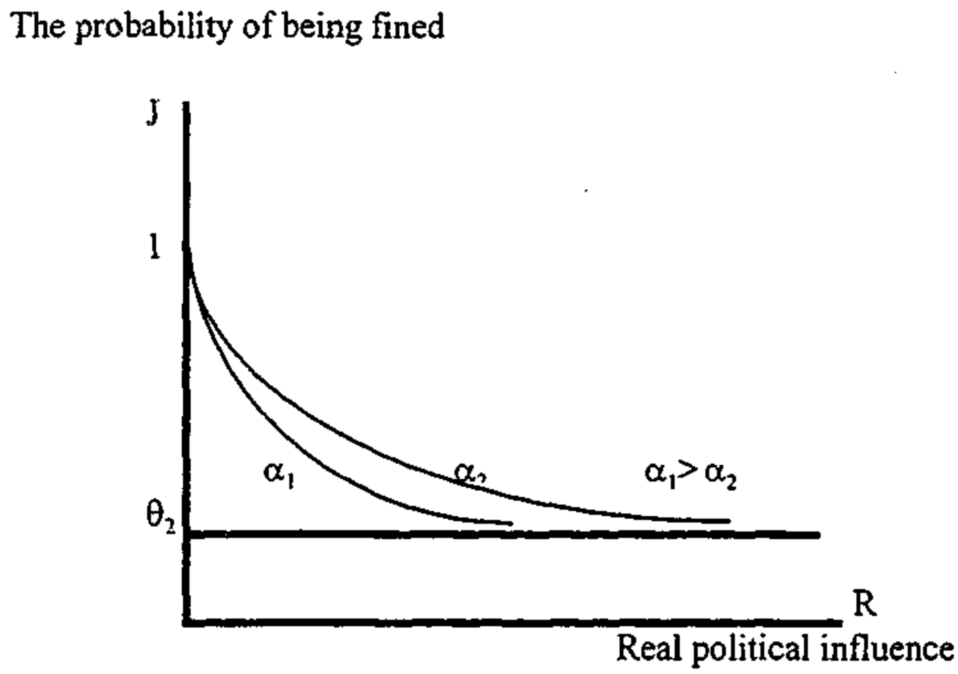

Figure 2.2: Two hypothetical schedules showing different productivity in reducing the probability of being fined. The firm whose parameter is α_1, is more efficient than the firm with parameter α_2.

Further we assume that R is to be determined by z, the real amount of resources the firm spends in Rent-seeking activity. The version of the model presented here is designed to describe the behaviour of established firms in a stationary equilibrium. In such circumstances the flow of resources devoted to RS balances the natural attrition (or 'depreciation') of the stock of political influence. Thus

$$R(t+1) = R(t)(1-\delta) + z(t) \quad . \qquad \text{E2.9}$$

With $R = R(t+1) = R(t)$, this implies

$$R = z/\delta \quad . \qquad \text{E2.10}$$

An important point to note about RS is that real inputs z produce strictly joint products: (i) the reduction in the effective tax rate (described by the schedule B(z)), and (ii) the reduced probability of incurring a fine (described by the schedule J(R)). There is no sense in which the expenditure M can be split between these two: all of M produces both effects simultaneously.

2.2.1 (d) The optimum spending on rent-seeking input

Having defined all elements of E2.4 we can now turn to the firm's optimum spending on input z. It can be derived by taking the first derivative of E(Π) and then setting it to zero as follows:

$$\frac{dE(\Pi)}{dz} = -\frac{dB}{dz}T - \frac{dM}{dz} - \frac{dJ}{dR}\frac{dR}{dz}G = 0 \qquad \text{E2.11}$$

By taking the first derivative of E2.6, E2.7, E2.10 with respect to z and E2.9 with respect to R and then substituting them into E2.11 we get the following condition:

$$\frac{dE(\Pi)}{dz} = -\frac{-\gamma(B-\theta_1)^2Ae^{\gamma z}}{(1-\theta_1)(1+A)}T - P_Z - \frac{-\alpha(J-\theta_2)^2Qe^{\alpha R}}{(1-\theta_2)(1+Q)\,\delta}G = 0\,. \qquad \text{E2.12}$$

Equation 2.12 can be rearranged to obtain the following form:

$$P_Z = \frac{\gamma(B-\theta_1)^2Ae^{\gamma z}}{(1-\theta_1)(1+A)}T + \frac{\alpha(J-\theta_2)^2Qe^{\alpha R}}{(1-\theta_2)(1+Q)\,\delta}G\,. \qquad \text{E2.13}$$

Equation E2.13 implies that to optimise spending on rent-seeking, the firm employs input z up to the point where the marginal cost of using an additional unit (P_Z) equals the marginal joint benefit obtained from the reduction of B and J. The latter benefits, namely those due to the reduction in the effective tax quotient and to the reduced probability of being fined, are the two right-hand terms of E2.13.

2.2.2 The government

Ideally a nation's constitution effectively guides government in designing economic and other policies so that they will benefit at least a majority of people in the society. In designing tax policy, for example, government is mandated to maximise some version (possibly vague) of the society's welfare function as set out in the constitution. Once a tax system is set up along these lines, it needs to be effectively implemented. It needs to be ensured that each member of the society pays his/her share as specified in the tax law. This is important because the enforcement of the tax law often leads to a prisoner's dilemma situation, where society is certainly better off if all pay tax, but an individual taxpayer is also better off if he alone does not pay tax.

A theoretical development of the topic which endogenises the behaviour of agents associated with 'the government' – politicians and bureaucrats – is outside the scope of this thesis (and indeed may lie outside the domain of economics). We simply assume that at any given time there is some set of corrupt officials/politicians with given endowments of influence and power. As suggested by recent events in South East Asia, this is not necessarily an equilibrium configuration in any long-term sense; however the other agents in the model take it as given. This set of corrupt agents and their associated spheres of influence (whether involving police, army or other enforcement agencies) at any given point of time exhibits heterogeneity. This heterogeneity plus the information costs of identifying and establishing a relationship with the "right" contact explains the differing productivities of RS inputs realised by different firms.

2.3 Relevance of the model to tax reform analysis

2.3.1 The data and parameters

The last century has witnessed a remarkable reduction of the role of progressive income tax in the government revenue system of many countries. The main reason for this turn around is a growing realisation of a number problems associated with progressive income tax such as high administrative and compliance costs, high economic distortions and lowered tax morality. These problems are shared internationally despite substantial differences in the economic, social and tax structures of the countries (Tanzi, 1991, 1995). In an attempt to remedy the defects of progressive income tax many countries have reformed their tax systems toward simpler and lower tax rates, particularly the maximum marginal rate. To provide neutrality between income sources, a uniform rate is imposed on all income irrespective of sources. In addition, this strategy is often accompanied by a broad-based consumption tax such as a value-added tax.

The model set out in the previous section is specifically designed to explain the impact of a capital income tax reform alone; therefore, the consumption tax component of contemporay reforms will be excluded the analysis presented in this section. Before the model can be applied, first we need to obtain a realistic condensation of taxpayers income and tax share distributions. At this stage, we have not obtained sufficient of the required data to construct a taxpayer's income distribution and the corresponding tax share distribution. A hypothetical data set, therefore, is employed to illustrate the relevance of the model to the analysis of tax reform.

The hypothetical data presented in Table 2.1 is constructed to share some of the main characteristics of the country under examination. The country's GDP is assumed to be distributed to seven different representative groups of taxpayers, comprising three types of firms (F1-F3) and four types of individuals (I1-I4) as shown in column (1) of Table 2.1. Each representative group is constructed according to the tax rate applicable to the average income of its member. Taxpayers belonging to F1, for example, pay tax at the rate of 50 percent, while those belonging to I1 pay at the rate of 35 percent.

We further assume that only taxpayers belonging to F1 and F2 have political influence and hence engage in rent-seeking activity, while the rest, except I4, pay tax in full. I4 represents the group of taxpayers whose income is either too low or untraceable. Therefore, as seen in Table 2.1, taxpayers belonging to groups F1 and F2 have large and equal share in income, 20 percent each. This highly concentrated distribution reflects an economy where the pyramid of wealth is closely associated with political influence.

Table 2.1
Taxpayers income and rate distribution

Representative Taxpayers	*Income Distribution (1)*	*Pre-Reform Tax rate (2)*	*After-Reform Tax rate (3)*
F1	30	50	35
F2	30	50	35
F3	20	50	35
I1	25	35	25
I2	20	25	15
I3	15	15	10
I4	10	0	0
Total	150	-	-

Having constructed the required data, we next need to assign some value for parameters employed in the model. We assume that both firms face the same price of rent-seeking input (P_Z), the same amount of fine if convicted (G), the same minimum tax quotient (θ_1) and the same minimum probability of being fined (θ_2) as shown in Table 2.2. Firm F2, however, is assumed to be twice as productive as F1 in rent-seeking activity. This is shown by the value of parameters γ, α and δ for the two firms presented in the last three columns of Table 2.2.

Table 2.2
The value parameters and exogenous variables of the model

Firm	P_Z	A	Q	θ_1	θ_2	G	δ	γ	α
F1	1	1	1	0.2	0.1	2T	0.50	0.5	0.5
F2	1	1	1	0.2	0.1	2T	0.25	1	1

The implication of the different firms' productivity with respect to the effective tax quotient schedule (B) and the probability of being fined (J) is demonstrated in Figure 2.3 and 2.4, respectively.

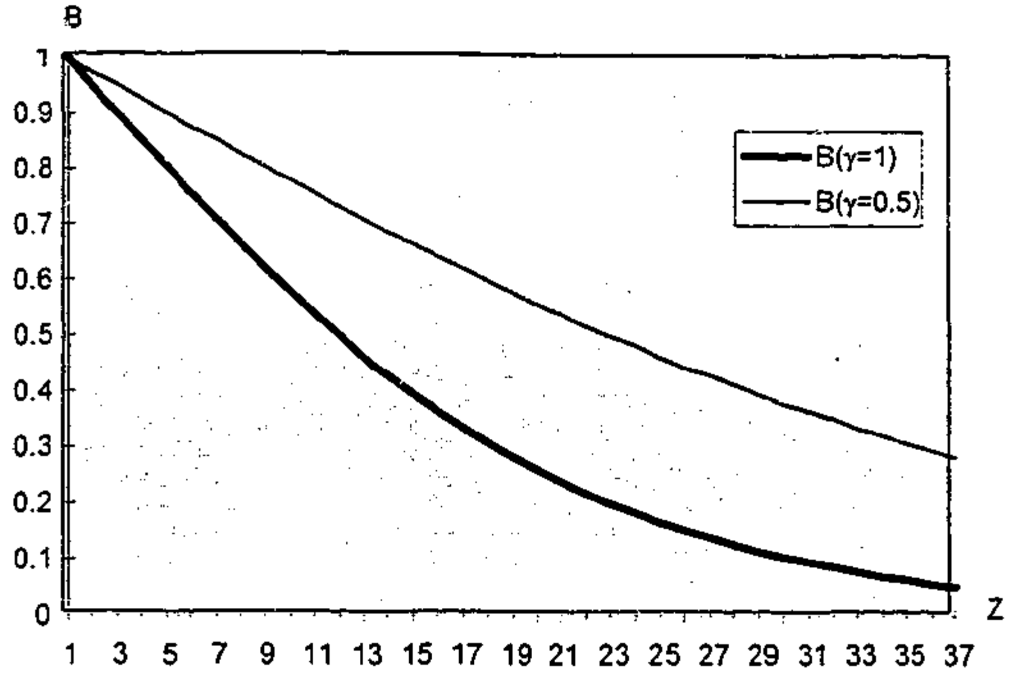

Figure 2.3 Two effective tax schedules for F1 and F2. It is assumed that F2 (with $\gamma = 1$) is more productive than F1 (with $\gamma = 0.5$) in reducing the effective tax quotient

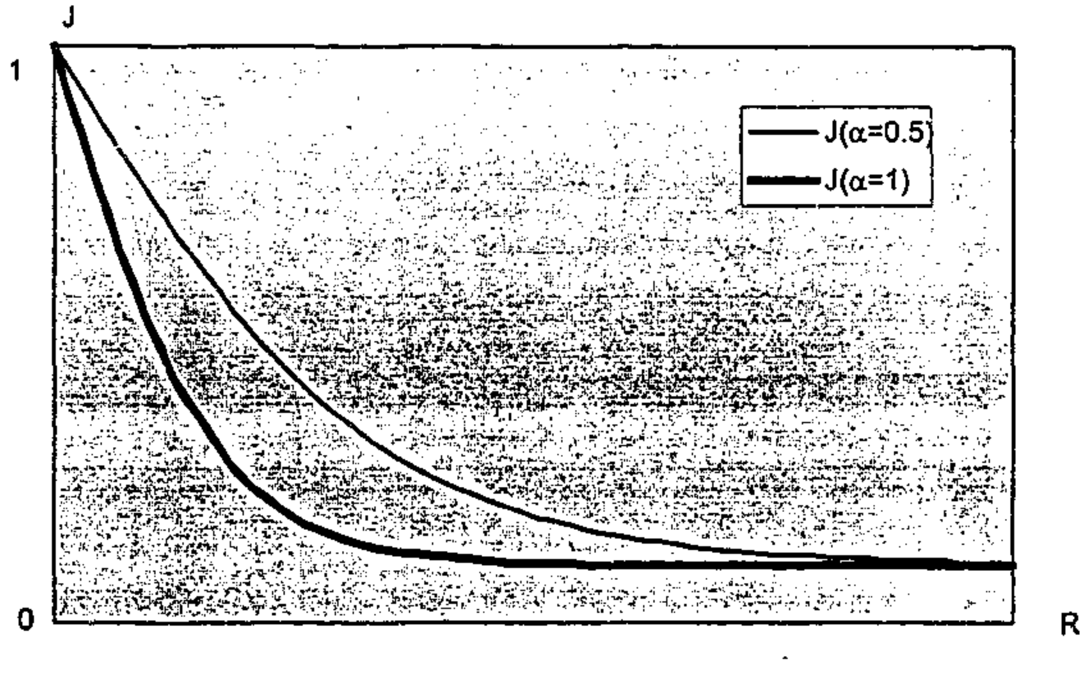

Figure 2.4 Two probability of being fined (J) schedules for F1 and F2. It is assumed that F2 (with $\alpha = 1$) is more productive than F1 (with $\alpha = 0.5$) in reducing the probability of being fined.

2.3.2 Simulations of tax policy changes

To reveal the impact of the tax reform we implement the following steps. Firstly, we put the data and the assigned value of the parameters into the model to obtain the base-case solution. This solution gives us the government revenue from income tax and the amount of resources spent on RS in the pre-reform period (see row 1 and 3 in Table 2.4).

Having constructed the base-case solution, we then conduct three simulations (summarized in Table 2.3) introducing different shocks.

Table 2.3
Summary of tax reform simulation shocks

Run	Definition
1	Reduction in Statutory tax rates (see Table 2.1)
2	As in run 1 but with a reaction in the supply of rent-seeking services which reduces their price by 30 percent.
3	As in run 1 but with tax enforcement strengthened as reflected in a rise in the parameter θ_2 from 0.1 to 0.25. (θ_2) is the lowest probability of being detected and fined if a firm engages in RS.

The first simulation (Run 1) introduces the first shock, which consists of the changes in the tax rates presented in Table 2.1, to the base-case. In the second simulation we incorporate the reaction of the RS supplier to the first shock. Since the model as yet does not contain a mechanism to endogenize such a reaction, for the time being we must write an exogenous scenario. Here we simply assume that the supplier reduces the price of RS input from 50 to 35. In short, the second shock is Run 1 *plus* the change in the price of RS input. In the third simulation we incorporate the possibility of improving the enforcement of tax law; this is done by re-running the first simulation with an increased value of θ_2 (0.25).

The responses of F1 and F2 to the first shock are presented in Tables 2.4 and in Figures 2.5 and 2.6. While tax reform makes it is no longer profitable for F1 to engage in RS, it is not the case for F2. Given the price of z, tax reform increases F1's EΠ(z) from 16.85 to 19.30, which, however, is smaller than Π(0), the profit if F1 does not engage in RS (19.50), and hence does not satisfy the condition set out in inequality (2.5). As to the case of F2, the tax reform increases its profit from 19.87 to 22.04, which remains well above Π(0) – see Table 2.4.

If we allow the supplier of RS to make price adjustment after the reform, the result of the second simulation indicates that both F1 and F2 will remain engaging in RS (see Table 2.5). However, if government is able to improve tax enforcement by increasing by 150 percent the probability that offenders will be fined both F1 and F2 will quit RS and pay their full tax liabilities (see Table 2.6 and Figures 2.5 and 2.6).

Table 2.4
The impact of tax reform on firms' decisions (Run 1)

Firms	*T*	*z*	*Π(0)*	*Π(z)*	*B*	*j*
F1	0.5	5.3	15	16.85	0.306	0.109
F1	0.35	4.7	19.50	19.30	0.339	0.116
F2	0.5	3.1	15	19.87	0.269	0.100
F2	0.35	2.7	19.50	22.04	0.301	0.100

Table 2.5
The impact of tax reform on firms' decisions (Run 2)

Firms	*T*	*z*	$\Pi(0)$	$\Pi(z)$	*B*	*j*
F1	0.5	5.3	15	16.85	0.306	0.109
F1	0.35	5.4	19.50	21.06	0.301	0.108
F2	0.5	3.1	15	19.87	0.269	0.100
F2	0.35	3.2	19.50	23.06	0.263	0.100

Table 2.6
The impact of tax reform on firms' decisions (Run 3)

Firms	*T*	*z*	$\Pi(0)$	$\Pi(z)$	*B*	*j*
F1	0.5	5.3	15	16.85	0.306	0.109
F1	0.35	4.6	19.50	16.21	0.348	0.265
F2	0.5	3.1	15	19.87	0.269	0.100
F2	0.35	2.7	19.50	18.89	0.301	0.250

Table 2.7
Tax collected by income group in Run 1, 2 & 3

Taxpayers	*Income Distribution*	*Tax Collected Pre-Reform*	*Tax Collected After Reform (Run 1)*	*Tax Collected After Reform (Run 2)*	*Tax Collected After Reform (Run 3)*
F1	30	4.59	10.5	3.16	10.5
F2	30	4.04	3.16	2.76	10.5
F3	20	10	7	7	7
I1	25	8.75	6.25	6.25	6.25
I2	20	5	3	3	3
I3	15	2.25	1.5	1.5	1.5
I4	10	0	0	0	0
Total	150	34.63	31.41	23.67	38.75

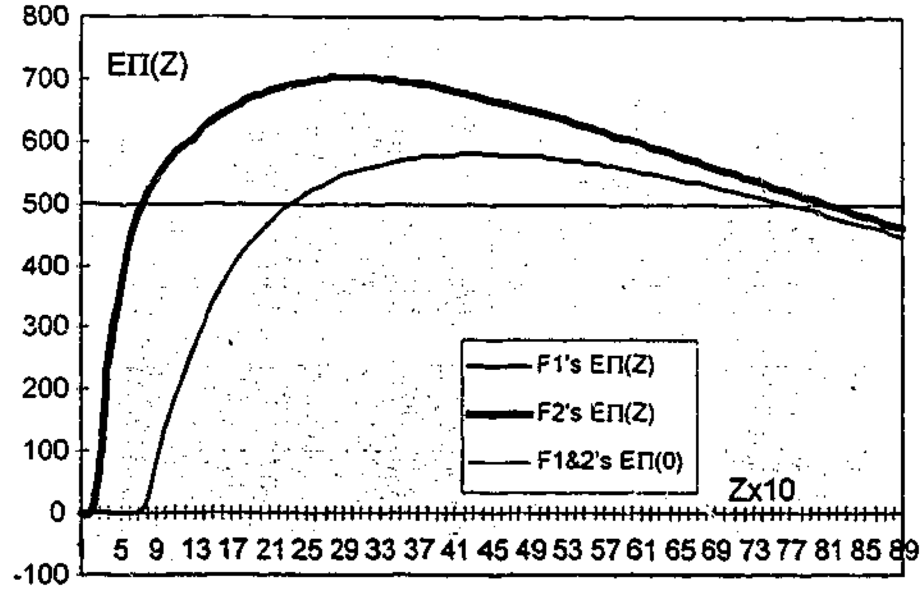

Figure 2.5 Firms' profit schedules before tax reform. Both F1 and F2 engage in RS and receive positive additional profit shown by F1's EΠ(Z) and F1's EΠ(Z) > F1&F2's EΠ(0).

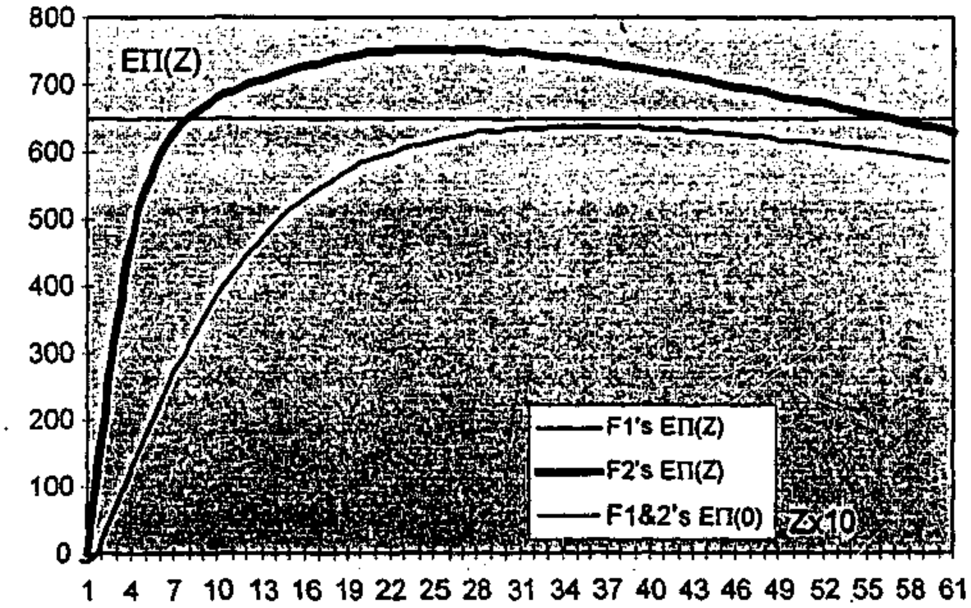

Figure 2.6 Firms' profit schedules after tax reform. F2 remains engaging in RS and receive positive additional profit shown by F2's EΠ(Z) > F1&F2's EΠ(0).
F1 quits RS as F1's EΠ(Z) < F1&F2's EΠ(0).

The impact of tax reform can be evaluated using various criteria; the most common way, however, is to see to what extent the reform objectives are actually achieved. The main objectives are (i) to increase efficiency by reducing distortion; (ii) to enhance horizontal equity between income sources; (iii) to reduce the compliance cost; and (iv) to broaden the tax base in order to increase tax revenue (Boskin and McLure 1989).

As to the revenue implications of the reform, Arthur B. Laffer (1979) asserted that if a country is operating in the prohibitive range (the downward-sloping portion of Laffer curve), a reduction of the tax rate will lead to an increase in government revenue. Whether a country is operating in the prohibitive range or not is an empirical question, for it depends on the magnitude of the supply elasticity of labour/capital with respect to the net wage/returns. The majority of the empirical findings do not seem to support Laffer's assertion. Using a general equilibrium framework, Fullerton (1982) suggests that the US economy would be operating in the prohibitive range only if the labour supply elasticity were as high as four, which is much higher than most existing estimates.

Our simulations indicate that the reduction of tax rates broadens the tax base by the inclusion of F1's full income (Run 1). The broadened tax base, however, is not sufficient to cover the loss of tax revenue from the reduction of the tax rates across income groups (see the fourth column of Table 2.7). In Run 3, where the tax reduction is implemented with a better tax law enforcement, the tax collections are broadened by better than doubling of both F1's and F2's tax payments (see run 3 the last column of Tables 2.7).

Table 2.8
Government revenue schedule in Run 1* and Run 3*

Tax Rate	*Total Tax Rev. from F1 & F2 in Run 1*	*Total Tax Rev. from F1 & F2 in Run 3*
0.10	6	6
0.15	9	9
0.20	8.34	12
0.25	10.10	15
0.30	12.11	18
0.35	13.66	21
0.40	7.42	24
0.45	8	17.32
0.50	8.63	19.04

* Note that in Run 1 we use the initial value of parameters as presented in Table 4.2, while in Run 3 the value of θ_2 is increased to 0.25.

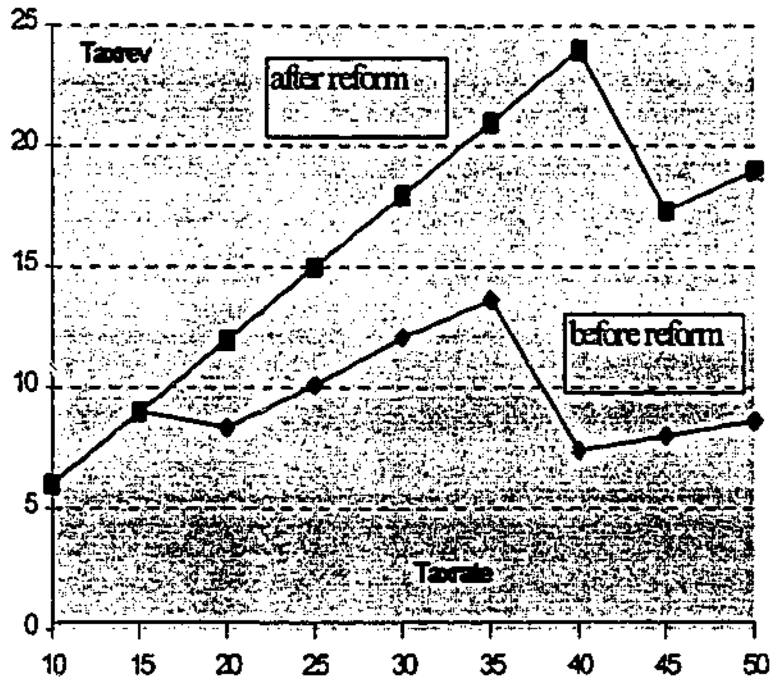

Figure 2.7 Revenue curves before and after tax reform

Figure 2.7 shows government revenue potted against the tax rate in two different environments: a low (base case) and a high degree of tax enforcement (Run

3). The curves, which show some similarity with Laffer's, are not smooth because they are derived from a very small number of representative taxpayers. As the number of taxpayers increases, the curves will become smoother and possibly conform more closely to Laffer's speculation. At a glance, figure 2.7 seems to indicate that before the reform the country under examination is operating in the prohibitive range. At the tax rate of 50 percent, as shown on the base case revenue curve, the country is operating at a tax rate well beyond the value that maximises tax collection.

The results presented above, therefore, seems consistent with Laffer's hypothesis (see also Table 2.7). It is important to note, however, that we use a different mechanism in deriving our results. While Laffer's hypothesis depends on the magnitude of the supply elasticity of labour/capital with respect to the net wage/returns, our finding is explained by the marginal benefit taxpayers obtain from rent-seeking activity. This marginal benefit determines firm's decision as to whether to engage in or to quit RS, which in turn affects the effective tax base. The higher the benefit taxpayers obtain from engaging in RS, the more likely it is that the country will be operating in the prohibitive range. Provided that the supply side of RS does not respond to the tax reform package, the reduction of the tax rate will reduce taxpayers' benefits from RS. It induces some taxpayers to quit RS and hence extends the effective tax base. In our framework, therefore, whether or not a country is operating in the prohibitive range does not depend on the magnitude of labor/capital supply elasticities. Rather it depends on the size and effectiveness of rent-seeking activity by taxpayers engaging in such activity.

As regards to horizontal equity, it is achieved only in Run 3, where F1 and F2 receive identical incomes and pay identical tax. It is not achieved in Run 1 because it remains profitable for F2 to engage in rent-seeking even after the sharp reduction of the tax rate; that is F2 pays only one third as much tax as F1 even though both forms have identical pre-tax incomes. The different behaviour and outcomes for the two firms is explained by F2's superior productivity in rent-seeking activity. In Run 2, in which a substantial fall in the price of RS occurs the model predicts that the dispersion between F1 and F2, measured in ratio of tax paid to the statutory tax liability, does not deviate greatly from the base case.

2.4 A more general form of the model

The analysis presented in the previous section is based on a partial equilibrium model in which the demand side alone is considered. Most variables related to the supply of rent-seeking services are assumed to be exogenously determined. The same is true for the tax base (income of the firms and individuals). The analysis, therefore, does not capture the full impacts of the reforms since it does not account for the second round (e.g., output, employment, and efficiency) effects of the change in the tax structure, which in turn change the tax base in the economy.

To fully capture those second round effects two tasks need to be accomplished. The first is to develop the supply side of rent-seeking services (outlined in the next chapter) to capture part of the output and efficiency effects. The reduction in the tax rate is expected to improve the allocation of resources because it leads to a reduction in the production of rent-seeking services.

Having completed the first task, we get the complete rent-seeking model (demand + supply). This model, however, still does not contain any mechanism to explain how the economy-wide outputs and hence the tax base is generated. Therefore, the second task is to embed the completed model into a larger economy-wide general equilibrium model which contains such a mechanism. Some adjustments may, however, be needed before we are able to integrate the rent-seeking model within a larger economy-wide model.

The majority of general equilibrium models, including the economy-wide model within which this rent-seeking model is to be embedded, use constant returns to scale (CRTS) in the production structure of the model. This is because the properties of the CRTS production function significantly reduce the burden of calibrating the model, and allow easier validation of the correct coding of the model (e.g., homogeneity tests). Under CRTS properties, most coefficients required for the model can be derived from cost and sale shares, which can easily be obtained from input-output tables. The CRTS properties also simplify the task of interpreting the model.

The demand side of the rent-seeking model set out in the previous section does not have CRTS properties[4]. The presence of scale effects makes the rent-seeking model slightly at odds with the economy-wide model within which it is to be embedded. Some interpretation problems and unnecessary difficulties may occur during the development of the fully integrated model because the two component models do not share common CRTS properties. To avoid this problem we need to make the specification of the rent-seeking model more general, that is, to make the specification more flexible so that it possible for the model to have either scale effects or CRTS properties.

[4] While the rent-seeking model is homogenous in prices – when all prices change by the same percentage, all the quantities stay constant – the model is not homogenous on the real side. When real profit Q_H is multiplied by two, the new optimum quantity of Z demanded is less than twice of the old one. The model, therefore, exhibits increasing returns to rent-seeking. Moreover, at least over a range of values of Q_H, the degree of the scale effect is higher as Q_H increases.

This task can be accomplished by redefining equations E2.6 and E2.8, the sources of the scale effect. We replace E2.6 by the following equation;

$$B^* = \theta_1 + \frac{(1-\theta_1)(1+A)}{1+Ae^{\gamma L_B}} \qquad \text{E2.6'}$$

where

$$L_B = \varepsilon_B Z + (1-\varepsilon_B)(Z/Q_H), \qquad 2.6''$$

and $0 \leq \varepsilon_B \leq 1$. Equation E2.6' has CRTS properties when $\varepsilon_B = 0$ and returns to the initial specification when $\varepsilon_B = 1$.

In the same way we can redefine equation E2.8 as:

$$J = \theta_2 + \frac{(1-\theta_2)(1+Q)}{1+Qe^{\alpha L_J}} \qquad 2.8'$$

where

$$L_J = \varepsilon_J R + (1-\varepsilon_J)(R/Q_H) \ , \qquad 2.8''$$

and similarly 2.8' will have CRTS properties if ε_J is set to zero and increasing returns to scale when $\varepsilon_J > 1$. With this specification we can now incorporate CRTS as a special case into the model by simply setting values of both ε_B and ε_J to zero.

The revision of the model introduces two new equations (2.6" and 2.8"), two variables (L_B, L_J) as well as two parameters (ε_B and ε_J). It also alters the first-order condition for optimal use of rent-seeking services. The complete model after modification is presented in Table 2.8. The model now has 12 equations and 15 variables.

We have checked the CRTS variant of the model numerically. If we run the same simulations using the previous data base, now both representative firms F1 and F2 receive negative profits from rent-seeking activity. This result can be explained as follows. In the context of the previous initial data and parameter sets (Table 2.1 and 2.2), the negative profit problem arises because the value of the variable generating the reduction in tax payments in the CRTS model (L_B=Z/Q_H) is much smaller compared to the value of the variable used in the previous model (Z). With small L_B, rent-seeking activity only slightly reduces both B and J, and hence it does not generate positive profit.

Fortunately, the task of restoring the results presented in section 2.3.2 is very straightforward. With ε_J set equal to 0, it can be accomplished by simply re-scaling the productivity parameters α and γ as follows.

$$\alpha' = \alpha Q_H \quad , \qquad \text{E2.15}$$

where α' is the new parameter required for the CRTS variant of the model and α is parameter used in the previous non-CRTS model. The same is true for γ,

$$\gamma' = \gamma Q_H \ , \qquad \text{E2.16}$$

where γ' is the new parameter required for the CRTS variant of the model and γ is parameter used in the previous non-CRTS model.

Following E2.15 and E2.16, if we use the model to run the same simulations as those performed in the section 2.3.2 using the value of α' = γ' = 15 for F1 and α' = γ' = 30 for F2 we will obtain exactly the same results as those presented in the Tables 2.4 - 2.8.

Table 2.9 Equations of the CRTS rent-seeking model

Equations	Description
(4.1) $Q_H = H/P_H$	Real profits
(4.2) $\Pi(0) = H - T$	After-tax profit with no RS
(4.3) $T = tH$	Tax liabilities
(4.4) $E(\Pi(Z)) = H - B(Z_D)\,T - M(Z_D) - J(R)\,G$	After-tax profit with RS
(4.5) $B = \theta_1 + \dfrac{(1-\theta_1)(1+A)}{1 + Ae^{\gamma L_B}}$	Effective tax quotient
(4.6) $L_B = \varepsilon_B Z + (1 - \varepsilon_B)(Z_D/Q_H)$	Normalised RS input
(4.7) $M = P_Z Z_D$	Value of RS services
(4.8) $J = \theta_2 + \dfrac{(1-\theta_2)(1+Q)}{1 + Qe^{\alpha L_J}}$	Probability of incurring fine
(4.9) $L_J = \varepsilon_J R + (1 - \varepsilon_J)(R/Q_H)$	Normalised political influence
(4.10) $G = gT$	Nominal fine for tax evasion
(4.11) $R = Z_D/\delta$	Stock of political influence
(4.12) $P_Z = \dfrac{\gamma(1-\theta_1)B^2Ae^{\gamma L_B}}{(1-\theta_1)(1+A)}(T/Q_H) + \dfrac{\alpha(1-\theta_2)J^2Qe^{\alpha L_J}}{(1-\theta_2)(1+Q)\,\delta}(G/Q_H)$	First-order condition for optimal use of RS

Number of equations = 12, Number of Variables = 17

Table 2.10 Variables in demand side of the rent-seeking model*

Variables	Description
H	Nominal profit before-tax
P_H	Price of profit
$\Pi(0)$	After-tax nominal value of profit with no RS
Q_H	Before-tax real profits
T	Tax liability
t	Official tax rate (proportion)
$E(\Pi(Z_D))$	Expected after-tax nominal value of profit with RS
Z_D	Rent-seeking services demanded
B	Effective tax quotient
M	Value of RS services
P_Z	Price of rent-seeking services
J	Probability of incurring fine
G	Nominal fine for tax evasion
g	Fine multiplier – the multiple of the original tax liability that must be paid as a fine
R	Stock of political influence
L_B	Normalised RS input
L_J	Normalised political influence

Number of variables = 17

*In the partial equilibrium closure of this sub-model, the five exogenous variables are: H, P_H, t, P_Z and g.

Chapter III
The Supply of Rent-seeking Services

3.1 Introduction

This chapter is set out to elaborate the supply side of rent-seeking services. We start the specification of the model by introducing three types of agent involved on the supply side of rent-seeking activity; they are the private sector, government and services providers. Agents in the private sector, whose behaviour has been described in the demand side of the model, purchase rent-seeking services from the service providers. The latter engage in the joint production of (legitimate) services which are sold to government, and (possibly illegitimate) rent-seeking services which are sold to the private sector.

Government is assumed simply to purchase the (legitimate) public services from the service providers; such services may consist of public administration, defence, education and the provision of other public goods. At this stage no attempt is made to further elaborate a more complicated theory of government behaviour. Therefore, the model to be constructed below concentrates on the behaviour of the third agent in the model – the service providers. These are an abstraction that is meant to capture the behaviour of a (possibly large) portion of the civil service, army, police force, plus some private sector activities where the clientele is either the government or those seeking to influence the government. In the last section of the chapter, we examine the salient features of the supply side sub-model in partial equilibrium qualitative analysis.

3.2 The model

3.2.1 Main behavioural assumptions

As already noted, we assume that the service providers supply legitimate public services (S_G) to the government as well as (possibly illegitimate) rent-seeking services (Z) to the private sector.

The service providers' production frontier is assumed to take the following CET form:

$$N_T^{-\rho} = \Lambda^{-\rho}(\mu S_G^{-\rho} + \beta Z^{-\rho}) \qquad \text{E3.1}$$

where N is service providers' production capacity, S_G is the quantity of public services and Z is the quantity of rent-seeking services provided. The elasticity of transformation between S_G and Z is given by $\tau = 1/(1+\rho)$ where $\rho < -1$ and $\mu + \beta = 1$. The transformation elasticity is always negative to ensure that the production possibility frontier for service providers is concave viewed from the origin as shown in Figure 3.1.

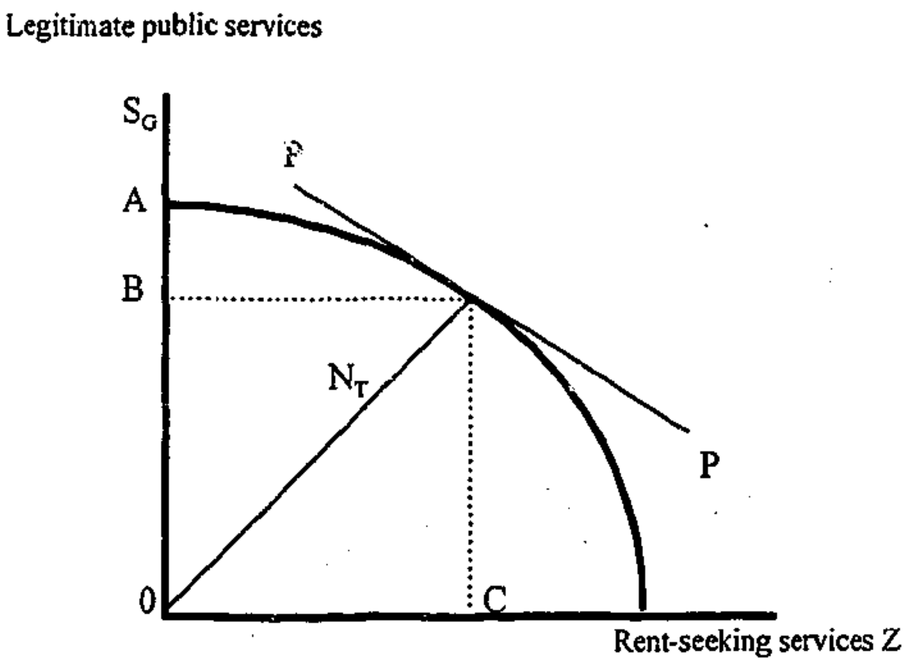

Figure 3.1 Production possibilities frontier for public and rent-seeking services.

Since the quantity of public services purchased by government is exogenous to the service providers, S_G is given at OB. If we assume competition in this sector so that the service providers take the prices of both S_G and Z as given, so that the slope of the price line PP in Figure 3.1 therefore is constant, then the service providers' net revenue maximisation decision can be formulated as follows:

$$\text{Maximise net revenue} = S_G P_G + Z P_Z - N_T P_N \qquad \text{E3.2}$$

subject to equation E3.1, where P_G, P_Z and S_G are all given. P_G and P_Z are the prices of public and rent-seeking services, respectively. $N_T P_N$ is the joint cost of providing both services: it is the product of the quantity of inputs N_T and the price paid for those inputs.

The solution to the service providers' profit maximisation problem can be derived in two steps:

(i) finding the ratio of optimal S_G/Z from the given P_G/P_Z and the parameters of CET function specified in equation E3.1,

(ii) finding the capacity N_T subject to the optimal Z, given P_G/P_Z and S_Z.

To work out the first step, we know that the optimum solution must satisfy the following condition:

$$\left.\frac{\partial S_G}{\partial Z}\right|_{N_T \text{ is const}} = -\frac{P_Z}{P_G} \qquad \text{E3.3}$$

Taking the total differential of equation E3.1, we obtain:

$$d(N_T^{-\rho}) = \Lambda^{-\rho}\{\mu\, d(S_G^{-\rho}) + \beta\, d(Z^{-\rho})\} \qquad \text{E3.4}$$

The trade-off between S_G and Z at a fixed level of N_T ($dN_T = 0$) can be found from

$$0 = \mu(-\rho)\, S_G^{-(\rho+1)}\, dS_G + \beta(-\rho) Z^{-(\rho+1)}\, dZ\,, \qquad \text{E3.5}$$

which is a restatement of E3.4 when N_T held fixed. From equation E3.5 we can find the differential quotient dS_G/dZ and take the limit as $dZ \rightarrow 0$, obtaining the marginal rate of transformation:

$$\frac{\partial S_G}{\partial Z} = \frac{-\beta Z^{-(\rho+1)}}{\mu S_G^{-(\rho+1)}} \quad . \qquad \text{E3.6}$$

Equating E3.6 and E3.3, we can solve for the optimum output ratio as a function of the output price ratio:

$$S_G/Z = \left[(\mu\, P_Z)/(\beta P_G)\right]^{\tau} \quad . \qquad \text{E3.7}$$

This completes the first step. By rearranging E3.7 we can also derive the supply of rent-seeking service as follows:

$$Z = S_G \left[(\mu\, P_Z)/(\beta P_G)\right]^{-\tau} \quad . \qquad \text{E3.8}$$

Hence

$$d \ln Z = d \ln S_G - \tau\,(d \ln P_Z - d \ln P_G) \quad . \qquad \text{E3.9}$$

Since τ is negative, the quantity of Z supplied by the service provider is positively related to its price P_Z, *ceteris peribus.*

The remaining task of finding the value of N_T that is consistent with producing the optimal quantity of Z at the lowest cost can be accomplished by first rearranging equation E3.1 into:

$$N_T = \Lambda \, (\mu S_G^{-\rho} + \beta Z^{-\rho})^{-1/\rho} \quad . \qquad \text{E3.10}$$

Then, by substituting the supply of rent-seeking services from E3.8 into equation E3.10, we get the desired solution for N as follows:

$$N_T = \Lambda(S_G^{-\rho} \{ \mu + \beta([\mu P_Z]/[\beta P_G])^{\rho\tau} \})^{-1/\rho} \quad . \qquad \text{E3.11}$$

As regard to P_N, the price of N_T, dual to the CET transformation function set out in equation E3.1 is the following unit revenue function:

$$P_N = 1/\Lambda \, [\mu^{\tau} P_G^{\rho\tau} + \beta^{\tau} P_Z^{\rho\tau}]^{1/\rho\tau} \quad . \qquad \text{E3.12}$$

Because we model the service provider as a price-taker who operates under constant returns to scale, E3.12 represents the service providers' unit revenue in providing public and rent-seeking services. In terms of proportional changes E3.12 becomes:

$$d \log P_N = share_G \, d \log P_G + share_Z \, d \log P_Z \quad , \qquad \text{E3.13}$$

where $share_G$ and $share_Z$ respectively are the shares in total revenue of S_G and Z.

3.2.2 The determinants of production capacity N

In the previous section we have demonstrated how the service providers supply public services to the government and rent-seeking services to the private sector. We have not discussed how the service providers obtain the capacity to produce both public and rent-seeking services. This section is devoted to discussing this issue. First we assume that the capacity to produce, N_P, is a CES function of two types of labour,

$$N_P = \Omega[\kappa L_1^{-\lambda} + \nu L_2^{-\lambda}]^{-1/\lambda} \quad , \qquad \text{E3.14}$$

where L_1 is ordinary labour and L_2 is privileged labour. Both κ and ν are positive parameters with $\kappa + \nu = 1$. The substitution elasticity between the two types of labour is $\phi = 1/(1+\lambda)$, where $\lambda > -1$.

Dual to the CES production function set out in equation E3.14 is the following unit cost of producing N_P, which is an aggregate of the unit cost of the two types of labour:

$$C_P = (1/\Omega)[\kappa^{\phi} P_1^{\lambda\phi} + \nu^{\phi} P_2^{\lambda\phi}]^{1/\lambda\phi} \quad , \qquad \text{E3.15}$$

where P_1 is the economy-wide hourly wage rate for ordinary labour and P_2 is the price per hour of privileged labour endogenous to this part of the model.

Further we assume zero pure profit in the production of N_P, so that

$$P_N = C_N \quad , \qquad \text{E3.16}$$

and also assume that all the N_P produced is transformed into the production of legitimate public services (S_G) and rent-seeking services (Z), so that the following equation also holds:

$$N_P = N_T \quad . \qquad \text{E3.17}$$

It is necessary in the base case that $P_2 > P_1$ because it is assumed that the privileged labour is able to appropriate rent. We also assume that the endowment of privileged labour, people in "connection", is exogenously set at L_2. In general, rent-seeking activity withdraws some resources from productive activity. In this model we allow such possibility through the transfer of L_1 from other sectors into the service providing sector where it is used (in part) to produce rent-seeking services. A summary of the production structure is shown in Figure 3.2.

Note that with N_2 exogenously fixed, the rental per privileged member of the service-providing sector, P_2 will be endogenous in most closures of the model. It is assumed that there are sufficient barriers to entry (viz., lack of appropriate "connections"), to ensure that the existence of high returns to privileged labour ($P_1 > P_2$) does not lead to an increase in L_2 such as to equalise the returns to the two types of labour.

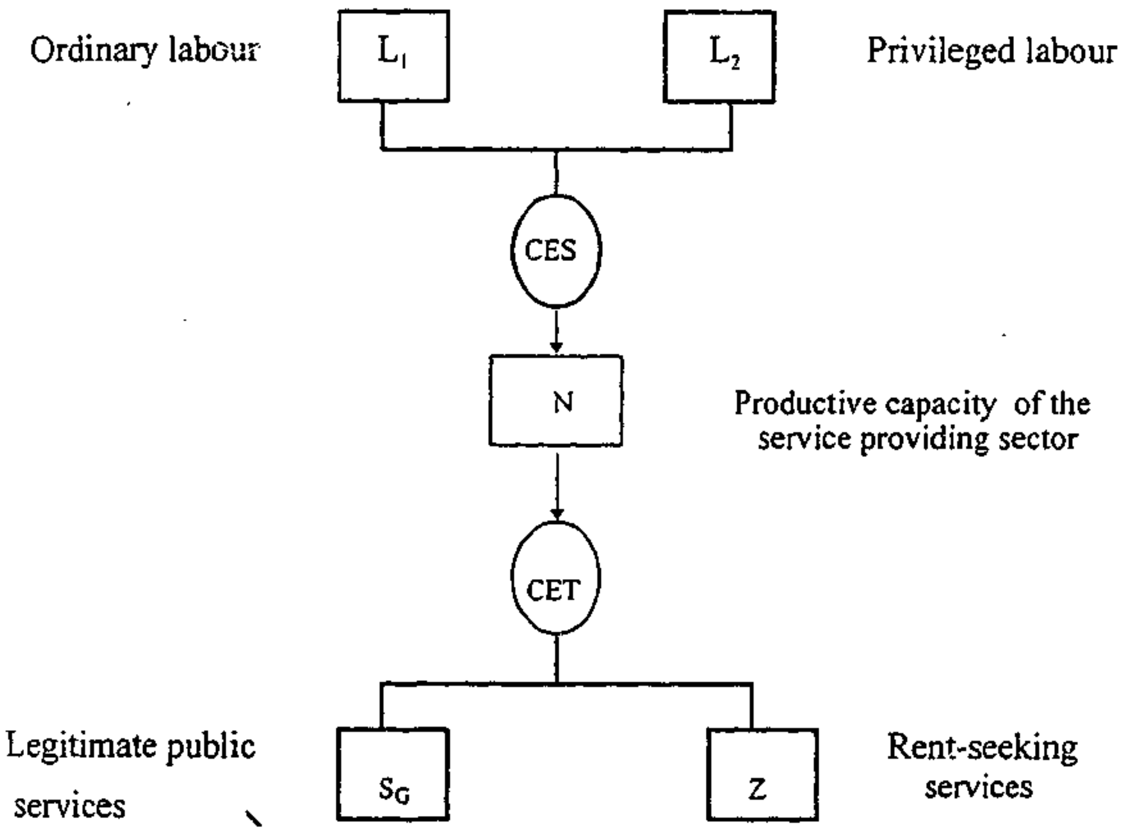

Figure 3.2 The structure of production of the service providing sector. ($N = N_T = N_P$).

3.2.3 Qualitative partial equilibrium analysis

To illustrate the behaviour of the supply system set out in the previous section, in the following we show how the model responds to various changes in the exogenous variables. The core of the supply system presented in Table 3.1 consists of seven equations, (3.8), (3.10 -11), and (3.14 -17), and 12 variables.

Table 3.1 Equations of the supply side of the rent-seeking model

Equations	Description
(3.8) $Z_s = S_G [(\mu P_Z)/(\beta P_G)]^{-\tau}$	Supply of RS
(3.10) $N_T = \Lambda [\mu S_G^{-\rho} + \beta Z_S^{-\rho}]^{-1/\rho}$	Service providers' aggregate production capacity
(3.11) $P_N = 1/\Lambda[\mu^{\tau} P_G^{\rho\tau} + \beta^{\tau} P_Z^{\rho\tau}]^{1/\rho\tau}$	Unit revenue of from service provision
(3.14) $N_P = \Omega[\kappa L_1^{-\lambda} + \nu L_2^{-\lambda}]$	Aggregate input used by Service providers
(3.15) $C_P = 1/\Omega[\kappa^{\phi} P_1^{\lambda\phi} + \nu^{\phi} P_2^{\lambda\phi}]^{1/\lambda\phi}$	Unit cost of inputs to service provision
(3.16) $P_N = C_N$	Zero pure profits
(3.17) $N_P = N_T$	Input-Output identity
Number of equations = 7, number of variables = 12	

Table 3.2 Variables of the supply side of the rent-seeking model

Variables	Description
P_Z	Price of RS
Z_S	Supply of RS
N_T	Service providers' aggregate production capacity
S_G	Legitimate public services
N_P	Aggregate input use by service providers
P_N	Unit price of N
P_G	Price of legitimate public services
C_P	Unit cost of N
L_1	Ordinary labour
L_2	Privileged labour
P_1	Hourly wage of ordinary labour
P_2	Hourly wage of privileged labour
Number of variables = 12	

Table 3.3 Alternative sets of exogenous variables for the supply side

Closure I	Closure II
S_G	Z
P_G	P_G
P_Z	N_T
L_1	L_1
P_1	P_1

Thus, to partially solve the model – that is, to solve for just the supply side given the values of variables determined on the demand side – five variables must be declared exogenous. Two alternatives sets for the exogenous variables are presented in Table 3.3. As seen in the first closure, S_G, P_G and P_Z are exogenous. With this set of exogenous variables, for example, we can show the effect of an increase in the demand for public services (S_G) holding prices of both public and rent-seeking services (P_G and P_Z) constant. Figure 3.3 illustrates how the equilibrium is restored after the increase in S_G.

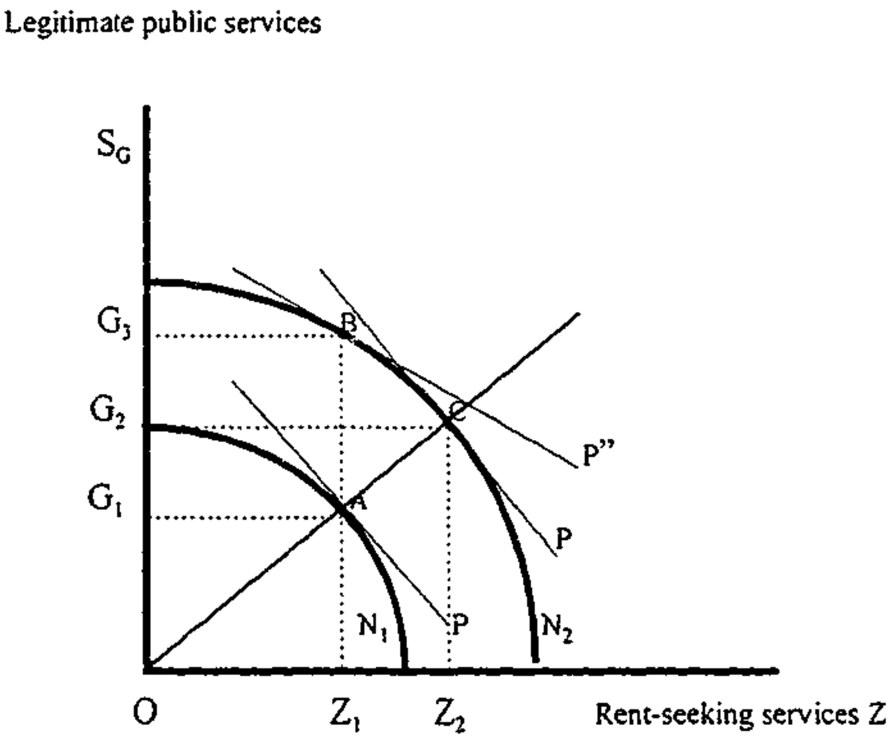

Figure 3.3 .Production of RS where S_G increases, but both P_Z and P_G are constant.

The initial equilibrium is at point A of the constant capacity curve N_1. Note that given the homothetic nature of the CET transformation function E3.1, at each level G_i (i = 1, ...) of public services there is only one point at which each iso-capacity the curve is tangential to a line depicting the given price ratio and all such points lie on a ray through the origin. After the increase in S_G from G_1 to G_2, A is no longer an equilibrium. In fact, at the given price ratio and production capacity N_1, there is no equilibrium point that can accommodate the G_2 level of public service. The production capacity has to increase to N_2 to attain a new equilibrium at point C. Therefore, as shown in the Figure 3.3, if there is no change in the price ratio (P_G/P_Z), an increase of S_G will cause both Z and N to increase proportionately to S_G.

The employment impact of the shock is demonstrated in Figure 3.4. The increase in the production capacity from N_1 to N_2 requires additional labour to be absorbed into the services providing sector. However, since we assume that the endowment of L_2 is fixed, the required additional labour inputs are all met by L_1. Therefore, as shown in the figure, the employment of L_1 increases by AC. Notice also that relative prices change in favour of privileged labour.

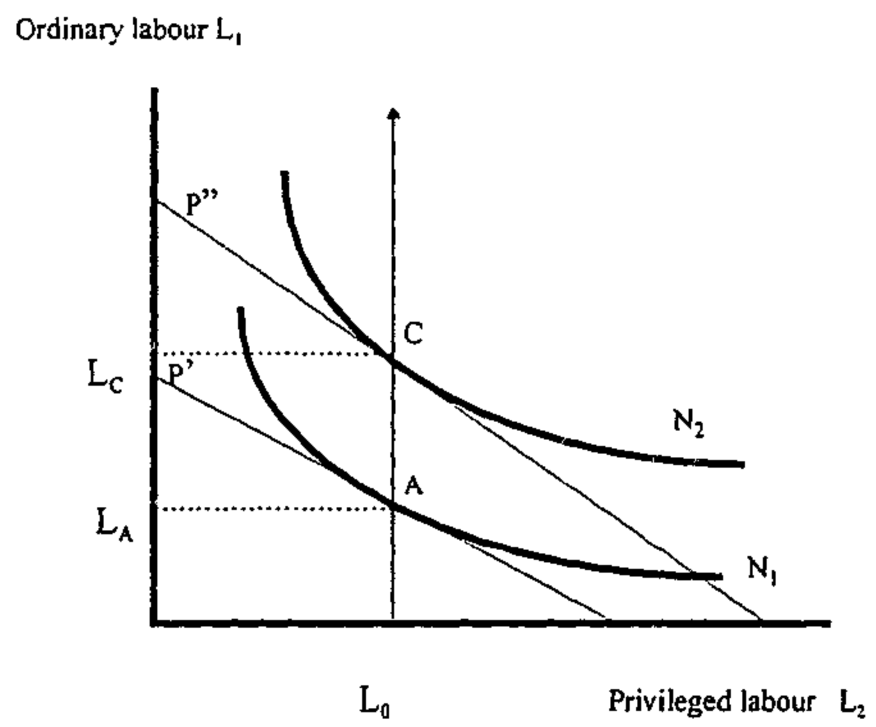

Figure 3.4 The employment impact of the changes in the provision of public services

The conclusion that an increase in public services will lead to an increase in rent-seeking services may not be desirable from the efficiency point of view. An efficiency-oriented policy maker may prefer to see the size of rent-seeking services decrease or at least stay constant at Z_1. To accommodate this case, we need to swap some of the exogenous variables. First, swap S_G with Z and then set $Z=Z_1$. Second, suppose we want to see the size of the impact of a change in rent-seeking activity on the other variables in the supply sub-model. In other words, given the same increase in production capacity (from N_1 to N_2) as previously – and therefore, the same additional commitment of resources to the services providers – we are interested to know by how much S_G will increase if we do not allow the production of rent-seeking services to increase as in the first case. This requires N to be exogenous at the level N_2. The choice of the first two exogenous variables implies that point B in Figure 3.3 is the desired equilibrium. To allow B to be an equilibrium, the price ratio has to change. Graphically, it can be seen that in order for the price line to be tangent to the curve N_2 at point B, P_Z has to fall relative to P_G. Here we choose to keep P_G exogenous as before and hence we have to free P_Z by making it endogenous. The reduction in the price of rent-seeking services changes the price ratio to the one represented by P". As shown in Figure 3.3, now the volume of public services increases from G_1 to G_3, which is larger than the exogenous increase that took place in the first case.

The absolute employment impact of the second case is the same as in the first case. However, since the supply of rent-seeking service is exogenously set, in the second case all additional labour is absorbed into production of the additional S_G.

Now consider a third case where government wants to lower the price of public services but to maintain a high level of public service. For the time being, assume that the price of rent-seeking service is rigid downward. In this case, as illustrated in Figure 3.5, the choice of exogenous variables (S_G, P_G, and P_G) is similar to the first case. The initial equilibrium is at point A, with G_1 and Z_1 levels of public and rent-seeking services, respectively. The policy of lowering P_G where P_Z is rigid leads to a change in the price ratio from P to P". The potential new equilibrium after the reduction of P_G is at point B. This, however, does not allow a constant level of public services at G_1, for it can only support such services at the level of G_2. As a result, the capacity to produce has to increase to N_3 to restore a new equilibrium at C. The unintended result of the policy to maintain a high level of public service at the lowered price is a large increase in the production of rent-seeking services (Z_1Z_3).

From the way we set up the model, for a large enough cut in P_G, it is certain that $N_3 > N_2$. The employment impact of the third case, therefore, will be larger than both the first and the second cases when a cut of sufficient size is made in the price of legitimate public services. In contrast to the second case, here we assume that the supply of legitimate public services is exogenously determined. Therefore, all additional labour absorbed into the service providing sector is used to produce extra rent-seeking services.

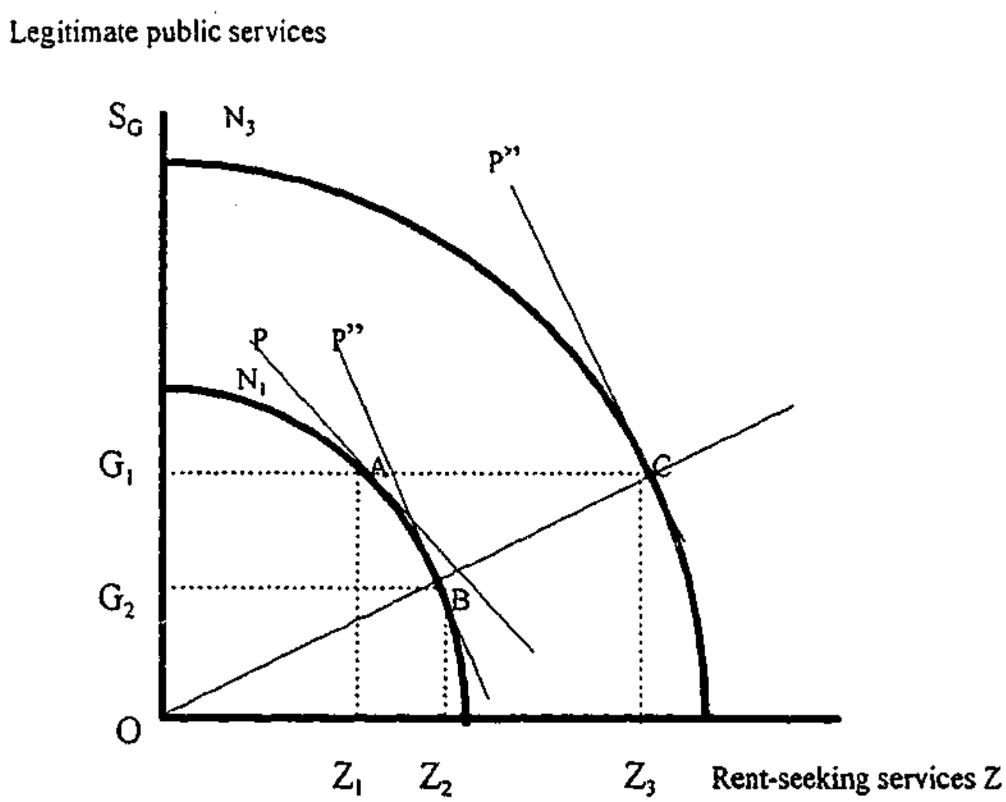

Figure 3.5 Production of RS where P_G decreases, S_G is constant and P_Z is rigid downward.

Under the assumption of competitive price taking behaviour by service providers, there would be a feedback (from the demand side of the model) in which P_Z would fall in response to the expansion in Z. What the above partial equilibrium analysis with fixed P_Z suggests, however, is that a relaxation of the competitive assumption concerning the pricing of Z makes it more likely for government 'thrift' in the provision of public services to have the unintended effect noted above.

Chapter IV
The Standard Closure of the Rent-seeking Model

4.1 Introduction

In the next stage of the study, we will embed the rent-seeking sub-model (demand and supply) developed in earlier chapters into an economy-wide model. Before such a step is taken, we need to examine the properties of the sub-model. This chapter is designed for that purpose. In the next section we describe the closure of the sub-model. Then we provide an illustrative application of it.

4.2 The closure

The complete equations and variables of the rent-seeking model are reprinted in Tables 4.1 and 4.2. With the exception of market clearing equation E4.20, all are taken from Tables 2.9-10 of chapter 2 and 3.1-2 of chapter 3. Because we have not introduced an industry dimension, the size of the model is still relatively small, involving 20 equations and 28 variables, (see Tables 4.1 and 4.2). At this stage, in order to solve the model numerically, we need to set the value of eight (=28 - 20) variables exogenously. There is more than one way of selecting the variables on the exogenous list. In Table 4.4 we have shown one standard choice.

The first variable in the list is P_H, which we set as a numeraire. The second variable is nominal gross profit (H). This is a natural choice because so far the rent-seeking model, which is to be a sub-model of a larger model, contains no equation describing how H is generated. This variable, therefore, cannot be endogenous. (However, when this rent-seeking model is embedded within a larger economy-wide model which contains a mechanism on how H is generated, then it can be endogenous.) Note that with P_H chosen as the numeraire, choosing H as exogenous is tantamount to setting real profits Q_H exogenously.

The choice of exogenous variables is also partly determined by what we use the model for. As has been stated earlier, our current objective is to analyse the impact of tax reform in the presence of rent-seeking activity. In this case it is, therefore, necessary to put some variables related to the instruments of tax reform on the exogenous list. The official tax rate (t) and the fine multiplier (g) are suitable candidates. The first will accommodate changes in the tax rate while the second will allow us to simulate changes in penalties, a major instrument in the government's tool kit for enforcing tax policy.

Earlier in chapter 3 we assumed that the government purchases legitimate public services from service providers and also sets both their price and quantity. This assumption implies that both the price (P_G) and the quantity (S_G) of legitimate public services are exogenous to the service providers. Choosing both P_G and S_G as exogenous variables also implies that a change in the supply of rent-seeking services due to a certain shock may affect the quantity of resources used by the service providers ($N=N_P=N_T$) but not the supply of legitimate public services. This choice of exogenous variables will not cause the model to be over-determined as long as we allow P_Z, Z and N to adjust in a manner which accommodates the government's settings of P_G and S_G. As shown in Figure 4.1, given both P_G and S_G, the equilibrium can change from A to B as long as P_Z, Z and N can adjust to the shocks.

In producing both S_G and P_G, service providers use ordinary (L_1) and privileged labour (L_2) as inputs. In this model we do not have any equation describing the supply of either type of labour. We assume that the supply of privileged labour

(L_2) is fixed exogenously, while its wage rate is determined endogenously. As regards to the ordinary labour, we assume its wage equals to the economy-wide hourly wage rate, which is exogenous to the rent-seeking model.

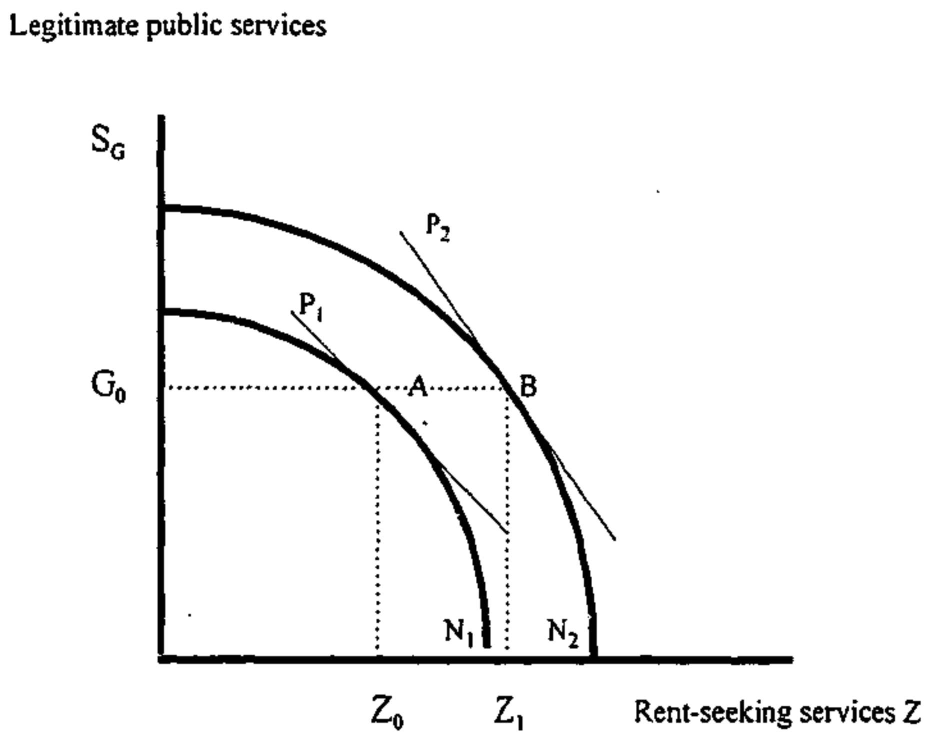

Figure 4.1 A Closure for the model when both P_G and S_G are set exogenously

From the way it is structured, it can be seen that the model is recursive. The demand side determines the optimum demand for Z and then it is assumed that this optimum is met by the supply side. The reverse does not apply since the supply side of the model does not have any mechanism to determine the optimum Z from the viewpoint of the client firms using rent-seeking services. The supply side is mainly designed to assess the allocative impact of rent-seeking activity, which withdraws resources from the rest of the economy.

This withdrawal can occur in two ways. First, potential production of legitimate public services can be diverted to produce rent-seeking services at a given resource commitment (N) to the service providing sector. Second, resources can be drawn into latter sector (N↑) from the rest of the economy. Elaborating the second type of resource cost requires the integration of the sub-model described in this chapter into a larger economy-wide model.

Table 4.1 Equations of the rent-seeking model

Equations	Description
(a) Demand side	
(4.1) $Q_H = H/P_H$	Real profits
(4.2) $\Pi(0) = H - T$	After-tax profit with no RS
(4.3) $T = tH$	Tax liabilities
(4.4) $E(\Pi(Z_D)) = H - B(Z_D)\,T - M(Z_D) - J(R)\,G$	After-tax profit with RS
(4.5) $B = \theta_1 + \dfrac{(1-\theta_1)(1+A)}{1 + Ae^{\gamma L_B}}$	Effective tax quotient
(4.6) $L_B = \varepsilon_B Z_D + (1 - \varepsilon_B)(Z_D/Q_H)$	Normalised RS input
(4.7) $M = P_Z Z_D$	Value of RS services
(4.8) $J = \theta_2 + \dfrac{(1-\theta_2)(1+Q)}{1 + Qe^{\alpha L_J}}$	Probability of incurring fine
(4.9) $L_J = \varepsilon_J R + (1 - \varepsilon_J)(R/Q_H)$	Normalised political influence
(4.10) $G = gT$	Nominal fine for tax evasion
(4.11) $R = Z_D/\delta$	Stock of political influence
(4.12) $P_Z = \dfrac{\gamma(1-\theta_1)B^2Ae^{\gamma L_B}}{(1-\theta_1)(1+A)}(T/Q_H) + \dfrac{\alpha(1-\theta_2)J^2Qe^{\alpha L_J}}{(1-\theta_2)(1+Q)\,\delta}(G/Q_H)$	First-order condition for optimal use of RS
(b) Supply side	
(4.13) $Z_S = S_G[(\mu P_Z)/(\beta P_G)]^{-\tau}$	Supply of RS
(4.14) $N_T = \Lambda[\mu S_G^{-\rho} + \beta Z_S^{-\rho}]^{-1/\rho}$	Service providers' aggregate production capacity
(4.15) $P_N = 1/\Lambda[\mu^{\tau} P_G^{\rho\tau} + \beta^{\tau} P_Z^{\rho\tau}]^{1/\rho\tau}$	Unit revenue of from service provision
(4.16) $N_P = \Omega[\kappa L_1^{-\lambda} + \nu L_2^{-\lambda}]$	Aggregate input used by Service providers' capacity
(4.17) $C_P = 1/\Omega[\kappa^{\phi} P_1^{\lambda\phi} + \nu^{\phi} P_2^{\lambda\phi}]^{1/\lambda\phi}$	Unit cost of inputs to service provision
(4.18) $P_N = C_N$	Zero pure profits
(4.19) $N_P = N_T$	Input-Output identity
(c) Market clearing	
(4.20) $Z_D = Z_S$	Market clearing for RS

Number of equations = 20, Number of Variables = 28

Table 4.2 Variables of the rent-seeking model

Equations	Variables	Description
(a) Demand side		
	H	Nominal profit before-tax
	P_H	Price of profit
	$\Pi(0)$	After-tax nominal value of profit with no RS
	Q_H	Before-tax real profits
	T	Tax liability
	t	official tax rate (proportion)
	$E(\Pi(Z_D))$	Expected after-tax nominal value of profit with RS
	Z_D	Rent-seeking services demanded
	B	Effective tax quotient
	M	Value of RS services
	P_Z	Price of rent-seeking services
	J	Probability of incurring fine
	G	Nominal fine for tax evasion
	g	Fine multiplier – the multiple of the original tax liability that must be paid as a fine
	R	Stock of political influence
	L_B	Normalised RS input
	L_J	Normalized political influence
(b) Supply side		
	Z_S	Supply of RS
	N_T	Service providers' aggregate production capacity
	S_G	Legitimate public services
	N_P	Aggregate input use by service providers
	P_N	Unit price of N
	P_G	Price of legitimate public services
	C_P	Unit cost of N
	L_1	Ordinary labour
	L_2	Privileged labour
	P_1	Hourly wage of ordinary labour
	P_2	Hourly wage of privileged labour

Number of variables = 28

Table 4.3 Parameters of the rent-seeking model

Equations	Parameter	Description
(a) Demand side		
(4.4,12)	A	Designed to be = 1
	γ	Technological coefficient in reducing tax quotient
	θ_1	Minimum tax quotient (the floor for B)
(4.8,12)	Q	Designed to be = 1
	α	technological coefficient in reducing probability of being fined
	θ_2	Minimum probability of being fined (the floor for J)
(4.11,12)	δ	Depreciation rate of the stock of political influence
(4.6)	ε_B	Parameter used to normalise RS input
(4.9)	ε_J	Parameter used to normalise political influence
(b) Supply side		
(4.10,11,12)	μ	Distribution parameter for legitimate public services
(4.10,11,12)	β	Distribution parameter for rent-seeking services supplied
(4.10,12)	τ	Transformation elasticity between legitimate public services and RS services
(4.11,12)	ρ	$\rho = -(1 - 1/\tau)$
(4.11,12)	Λ	General productivity (Hicks neutral) coefficient in production of aggregate capacity in service providing sector
(4.16,17)	κ	Distribution parameter for ordinary labour input
(4.16,17)	ν	Distribution parameter for privileged labour input
(4.17)	ϕ	Transformation elasticity between legitimate ordinary and privileged labour
(4.16,17)	λ	$\lambda = -(1 - 1/\phi)$
(4.16,17)	Ω	General productivity (Hicks neutral) coefficient in transformation frontier of service providing sector.

Table 4.4 A standard closure of rent-seeking model – list of exogenous variables

Variables	Descriptions
P_K	Numeraire
H	Nominal before-tax profit
t	official tax rate
g	Fine multiplier
S_G	Supply of legitimate public services
P_G	Price of legitimate public services
L_2	Supply of privileged labour
P_1	Hourly wage of ordinary labour

4.3 Illustrative simulation

4.3.1 A reduction in the tax rate

Having specified the rent-seeking model in full and its standard closure, we now need first to assign some values to the parameters, and then some initial values to the exogenous variables to generate a base solution to the model. As far as the demand side is concerned, we use the same set of parameter values as the ones used for representative firm 2 (F2) in Chapter 2. Firm 2 is chosen because it is a more productive rent-seeker, and hence continues to engage in rent-seeking activity even after tax reform measures are introduced. As regards to the parameters of the supply side of the model, a simple set of values is chosen for illustrative purposes. The values of all parameters are presented in Table 4.5. The initial values for exogenous variables are in the first column of Table 4.6. The shocked values for exogenous variables introducing a reduction in the tax rate from 50 to 35 percent are presented in the second column of the same table.

Table 4.5 The values of the parameters*

Equations	Parameter	Value
(a) Demand side		
(4.5,12)	A	1
	γ	30
	θ_1	0.20
(4.6)	ε_B	0
(4.8,12)	Q	1
	α	30
	θ_2	0.10
(4.9)	ε_J	0
(4.11,12)	δ	0.15
(b) Supply side		
(4.13,14,15)	μ	0.35
(4.13,14,15)	β	0.65
(4.13,14)	τ	- 10
(4.14,15)	ρ	- 1.1
(4.13,14)	Λ	2
(4.16,17)	κ	0.6
(4.16,17)	ν	0.4
(4.17)	ϕ	3.5
(4.16,17)	λ	1.4
(4.16,17)	Ω	3

*Strictly speaking, only one element of each pair (τ,ρ) and (ϕ, λ) can be considered a parameter, but all four are included here for convenience.

Table 4.6 The initial and the shocked values for exogenous variables for tax cut shock

Variables	Initial value	Tax cut
P_H	1	1
H	30	30
t	**0.50**	**0.35**
g	2	2
S_G	10	10
P_G	1	1
L_2	2	2
P_1	1	1

Table 4.7 Solution for the rent-seeking model under standard closure

Variables	Initial solution	Tax cut	Percentage change
(a) Demand side			
H	30	30	0.00
T	15	10.5	-30
Π(0)	15	19.5	30
E(Π (Z))	18.131	20.626	13.76
Z	2.545	2.133	-16.19
B	0.316	0.369	16.77
M	4.121	3.394	-17.64
J	0.100	0.100	0.00
G	30	21	-30
R	16.965	14.220	-16.18
P_Z	1.620	1.591	-1.79
(b) Supply side *			
N	10.359	10.044	-5.21
L_I	11.102	8.004	-27.90
P_N	1.340	1.333	0.00
P_Z	3.608	3.582	0.00

Table 4.7 presents the initial and the shocked values of endogenous variables. From the variables on the demand side we can see that 30 units of (nominal and real) profit are available before tax. Before the tax rate change, the representative firm pays 15 units as income tax if it does not participate in rent-seeking activity. The firm, however, is assumed to engage in rent-seeking since it is able to increase its after-tax profit to 18.131 units. This involves spending 4.121 units to purchase rent-seeking inputs Z to reduce the effective tax quotient to only 31.6 percent. This means that the average tax rate actually paid is reduced from 50 percent to 15.80 (=50 x 0.316), percent. From the supply side we can see that the service providers require 10.359 units of production capacity (N) to provide 10 units of legitimate public services and

2.545 units of rent-seeking services. This level of production capacity is obtained by employing 2 and 11.102 units of privileged and ordinary labour, respectively.

The reduction of the tax rate increases after-tax profit with no rent-seeking activity from 15 to 19.5 units, for now it pays only 10.5 units as tax. Rent-seeking activity, however, still offers higher after-tax profit, 20.626 units. The representative firm continues to engage in rent-seeking activity but to a slightly lesser extent. The firm purchases only 2.133 units of Z (previously 2.545) to reduce its effective tax quotient to 36.9 percent. This means that the average tax rate actually paid after the reduction of the statutory tax rate is reduced from 35 percent to 12.91 percent. As shown in Table 4.7, the change in the tax rate, which leads to a reduction in the use of rent-seeking services, causes N to adjust downward slightly, meaning that the service providers need a lower level of production capacity to produce the new levels of public and rent-seeking services.

4.3.2 A cut in the price of legitimate public services

A common budgetary policy recommended by international institutions to many developing countries is to cut "excessive" government expenditure. Since public investment expenditure is usually considered essential for further economic growth, the natural choice is to cut (or at least not to increase) current expenditure, particularly public servants' wages. Governments generally are reluctant to cut public service employment and hence often attempt to cut real salaries while leaving employment and nominal salaries intact (Ul Haque and Sahay 1996).

To a limited extent this type of budgetary policy can be captured by the standard closure of our model presented earlier. The reduction of public servants' salaries in real terms can be accommodated by reducing the price of legitimate public services (P_G) whilst requiring their quantity (S_G) to stay constant. This should reduce government expenditure and so reduce the budget deficit. The values of the exogenous variables chosen to represent this case are presented in Table 4.8. The solutions for endogenous variables in levels and in percentage changes are in the second and the third columns of Table 4.9, respectively.

Table 4.8 The initial and the shocked values of the exogenous variables to simulate reduced price of legitimate public services

Variables	Initial value	Tax cut
P_H	1	1
H	30	30
t	0.50	0.50
g	2	2
S_G	10	10
P_G	1	0.75
L_2	2	2
P_1	1	1

The reduction of the price of legitimate public services does not change the after-tax profit with no rent-seeking activity (15 units). The representative firm continues to engage in rent-seeking activity because it offers higher after-tax profit, 19.185 units. The firm now purchases 12.37 percent more units of Z to reduce its effective tax quotient to 28.60 percent. This means that the average tax rate actually paid after the reduction in the price of legitimate public services is reduced from 35 percent to 10.01 percent. As shown in Table 4.9, the reduction in the price of legitimate public services causes a reduction in the price of rent-seeking services, which leads to an increase in their use. This in turn causes N to adjust upward, meaning that after a reduction in the price of public services the service providers need a higher level of production capacity to produce the new level of rent-seeking services demanded. Firms now have more political influence in the steady state because of the proportionality assumed to exist between Z and R (see equation 4.11 in Table 4.1).

Table 4.9 Solution for the rent-seeking model under a reduction in the price of legitimate public services

Variables	Initial solution	Tax cut	Percentage change
(a) Demand side			
H	30	30	0.00
T	15	15	0.00
$\Pi(0)$	15	15	0.00
$E(\Pi(Z))$	18.131	19.185	5.81
Z	2.545	2.860	12.37
B	0.316	0.286	-9.49
M	4.121	3.516	-14.68
J	0.100	0.100	0.00
G	30	30	0.00
R	16.965	19.185	13.09
P_Z	1.620	1.229	-24.14
(b) Supply side			
N	10.359	10.992	3.63
L_1	11.102	16.127	45.26
P_N	1.340	1.008	-24.78
P_2	3.608	2.263	-37.28

If the service providing sector is (socially) less efficient than the rest of the economy, the release of some resources from this sector is desirable. Thus the tax reduction studied above brings about an efficiency improvement to the economy through an increase of resources available to the (socially) more productive sectors of the economy. Table 4.9, on the other hand, shows that a decrease in the price of legitimate public services leads to undesirable efficiency effects for it tends to attract more resources into the service providing sector. This efficiency loss would, in a broader context, need to be compared with whatever benefits are perceived to flow from budgetary restraint. Finally (and again in the context of a larger framework), the relative efficiency of this particular type of fiscal restraint would need to be assessed against alternatives.

4.3.3 Revenue impact of a tax cut and a reduction in the price of legitimate public services

One essential element of applied tax evasion analysis is to find the relationship between the tax rate and the degree of taxpayers' participation in tax evasion (Jung 1994). Clotfelter (1983) found that to what extent one evades tax is strongly correlated with the source of one's income. The reduction of the tax rate increases firms' willingness to pay tax, shown by the larger tax quotient B. It is common to suppose that the major form of tax evasion is the under-reporting of taxable income. On this interpretation, the tax cut also leads to an increase in the percentage of income reported by the firms, 36.9 percent ((100/35)x11.07) compared to previously 31.60 percent ((100/50)x9.48). However, the larger income being reported is not sufficient to increase the representative firm's effective tax payments (see Table 4.10). As a result, tax reduction reduces government tax revenue collected from the firms.

Table 4.10 Revenue impact of tax rate reduction

Tax rate in percent (t)	*Tax quotient (B)*	*Effective tax ($E = t \times B$)*	*Tax revenue ($T_R = E \times T$)*	*Equiv.Reported* income*
50	0.316	15.80	4.74	9.48
35	0.369	12.91	3.87	11.07

* The equivalent reported income is the income which would yield the actual tax revenue shown in column 4 if the firm paid the statutory tax rate.

In the context of this model, at a given price of rent-seeking services, the level of income reported to tax officials depends on taxpayers' productivity in rent-seeking activity as determined by the value of parameters γ and α in equations 4.5 and 4.8, respectively. Therefore, under some settings of the value of these parameters we can find three different cases where representative taxpayers with the same level of before-tax income (i) do not engage in rent-seeking activity in the first place (the values of both γ and α are very low, for example < 10); (ii) engage in rent-seeking when the tax rate is high but quit it when the tax rate is reduced (the values of both γ and α are moderate such as 15), and (iii) engage in rent-seeking irrespective of the tax rate (the values of both γ and α are > 15).

The representative taxpayers belonging to (i) report their full income whether the tax rate is low or high. The reduction of tax rate will, therefore, reduce government revenue collected from this group of taxpayers. The representative taxpayers in group (ii) report part of their income when the tax rate is high but declare it in full when the tax rate is reduced. If the increase in the reported income leads to additional tax collection which outweighs the reduction of tax revenue due to the reduction in the tax rate, it is possible to find that the reduction of the tax rate will increase government revenue collected from this group. In the third case, the reduction of the tax rate, as already shown in Table 4.10, increases the percentage of income being reported but not sufficiently to increase government revenue.

Note however, that this stand-alone version of the rent-seeking model has ignored the impact that resources released from the service providing sector would have on the size of the rest of the economy (and therefore on the size of the tax base). In particular, the reduction of N from 10.359 to 10.044 (column 2 of Table 4.7 and 4.9) would result in higher initial total factor payments in a fully integrated model that allows feedbacks from the service providing sector to the economy at large.

As regards to the reduction in the price of legitimate public services, since it leads to an increase in the production of rent-seeking services, it reduces firms' effective tax rate from 15.80 to 10.01 percent, which, under a constant statutory tax rate (t) of 50 percent, is equivalent to a reduction in the percentage of income being reported from 31.60 (=100 × 9.48/30) to 20.02 percent (=100 × 6.00/30). This reduces government revenue from 4.74 to 3.00 units (see Table 4.11). The increase in the production of rent-seeking services requires the service provider to commit a larger amount of resources N to produce the new level of capacity. Thus the policy to cut the price of legitimate public services has an efficiency effect which is in tension with the intention of the tax reduction.

Table 4.11 Revenue impact of the reduced price of public services

Price of RS	*Tax rate in percent (t)*	*Tax quotient (B)*	*Effective tax ($E = t \times B$)*	*Tax revenue ($T_R = E \times T$)*	*Equiv. Reported income*
1	*50*	0.316	15.80	4.74	9.48
0.75	*50*	0.286	10.01	3.00	6.00

Chapter V
The Theoretical Structure of ORANI-RSA

5.1 Introduction

The purpose of this chapter is to provide the theoretical structure of ORANI-RSA. The bulk of ORANI-RSA's equations strongly resemble the generic version of ORANI (Horrige *et al.* 1998). Since the generic ORANI, ORANI-G, is well documented in the reference cited above, our description of the model provided in this chapter is confined to its salient features. The general equations of ORANI-G are not listed in this chapter, but are documented in Appendix A for ready reference. However, the equations representing the new features introduced into the generic model to obtain ORANI-RSA are derived and discussed in detail.

5.2 Theoretical structure of ORANI-RSA

As suggested by the name, ORANI-RSA is adapted from ORANI, a computable general equilibrium (CGE) model of the Australian economy (Dixon, Parmenter, Sutton and Vincent, 1982). The RSA suffix stands for rent-seeking activity, a new feature embedded into the model. Unlike ORANI, ORANI-RSA does not, strictly speaking, belong to the Johansen-type of CGE model because it is written as a mixed system of linear equations (where almost all of the variables are in percentage changes form[1]) and equations in their original non-linear form. The advantages of using such a mixed approach are set out in (Harrison, Pearson, Powell and Small, 1994). Nevertheless, the ORANI-style architecture dominates.

[1] The exceptional cases concern those few variables (such as the trade balance) which can pass through zero. In these cases, the variables appearing in the system are ordinary changes.

Generally, the equations of a typical member of the ORANI model family can be classified into six main groups:

(i) a group of equations describing industry demands for primary factors and intermediate inputs;

(ii) a group of equations describing final demands for commodities;

(iii) a group of equations describing the demand for margins, which are goods and services needed to facilitate the transfer of commodities from the producers to the users;

(iv) a group of pricing equations which, in purely competitive CGE models, sets the pure profits from all activities to zero;

(v) a group of market clearing equations for commodities and primary factors;

(vi) a group of miscellaneous equations defining GDP, aggregate employment and the consumer price index.

In ORANI-RSA two other groups of equations are added,

(vii) a group of equations describing rent-seeking activity;

(viii) a group of equations for income mapping.

The economic theory underpinning each of the first six groups of equations is outlined briefly in the next sub-sections. A detailed implementation of equations in group (vii) is then discussed in the following sub-section.

5.2.1 ORANI-RSA's data base

In order to incorporate rent-seeking activity into the standard ORANI, we classify the industries in the model into two broad categories, namely, ordinary industries and the service providing industry. There are five ordinary industries; trade-exposed, export-oriented, import-oriented, margins and non-tradeables. These industries are the users of rent-seeking services. The service providing industry produces legitimate public services and rent-seeking services.

		Absorption Matrix					
		1	2	3	4	5	6
		Producer	Investors	Household	Export	Other	Change in Inventories
	Size	I	I	2	1	1	1
Basic Flows	C×S	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margin	C×S×M	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	C×S	V1TAX	V2TAX	V3TAX	V4TAX	V5MAR	n/a
Labour	O	V1LAB					
Capital	1	V1CAP					
Land	1	V1LND					
Other Costs	1	V1OCT					

C = Number of Commodities
I = Number of Industries

S = 2; Domestic, Imported
O = Number of Occupation Types

M = Number of Commodities used as margins

Figure 5.1 ORANI-RSA flows database

The structure of transactions involving the agents and industries is shown in Figure 5.1. As indicated in the column, the model recognises five types of agent, namely, producers (1), investors (2), households (3), the foreigner who purchases exported commodities (4), and governments (5). The model also make a provision for changes in inventories (6).

The first row identifies the basic value of commodities, domestically produced and imported, purchased by each agent. The second row shows the value of margins (transport and trade) used to transfer commodities from producers to users. Commodity sales taxes payable on purchases by each agent are listed in the third row.

Rows 4 to 6 show the costs of the three primary factors used in production: labour, capital and land. The next row, other cost, covers various miscellaneous expenses aside from the primary factor costs.

To see the new features of the model, we need to disaggregate the rows for producers and for households, as well as the labour row. One of the households represents a group of privileged persons who receive part of their income from the sale of rent-seeking services to producers. Moreover, the structure of transactions between the service providing industry and other agents is different in many ways from that involving only the ordinary industries described earlier. The first commodity produced by the service providing industry, legitimate public services, is not used by producers as an intermediate input or for capital formation. Nor is it purchased by the household or exported. Indeed, legitimate public services are purchased only by the government. Consequently, for legitimate public services all the entries in the first row of Figure 5.1 are zero, except for V5BAS. Legitimate public services are not subjected to sales taxes, nor do they involve margins. The same is true for rent-seeking services. All entries for commodities produced by the service providing industry in the tax and margin rows, therefore, are also zero.

The second commodity produced by the service providing industry, rent-seeking services, is used only by producers. To produce the two commodities, the service providing industry employs ordinary and privileged labour, the elements of V1LAB. This industry does not require the use of land so that the entry for V1LND is zero. It is also important to note that privileged labour is not used by the ordinary industries: V1LAB for ordinary industries contains no element of privileged labour.

5.2.2 Industry behaviour

In the ORANI class of CGE models, industries are assumed to: (i) minimise cost by choosing the right mix of inputs: (ii) maximise revenue by choosing the right output bundles; and (iii) operate in a competitive market for both outputs and inputs. These assumptions are also adopted for the ordinary and the service providing industries in ORANI-RSA. Note though that an element of monopoly power for privileged labour is incorporated by the choice of closure – in the standard closure, the endowment of such labour is fixed and scarce enough in the base case to earn a shadow price exceeding the wage rate of ordinary labour.

5.2.2 (a) The ordinary industries' production structure

In practice an industry may use several inputs at many different stages of the production process and at the same time may produce a number of outputs. This complex production structure may be difficult to model, because an extensive set of parameters is required to represent the behaviour of the industry at every stage of the process; such a set is often not available. In ORANI (also in ORANI-RSA) the industry's production structure is simplified by using a series of separability assumptions to break it into a sequence of nests (Horridge *et al.* 1993, p. 95). This type of assumption reduces the number of estimated parameters required in implementing the model. The assumed production structure is illustrated in Figure 5.2

Industries' input demands are derived from cost-minimising behaviour. As shown in Figure 5.2, the industry (producer) minimises costs by choosing its input mix, subject to a three-tiered constant-returns-to-scale input technology. At the top level, it is assumed that commodity composites, primary-factor composites and 'other cost' tickets are combined using a Leontief function. This assumption implies that all inputs are used in fixed proportions since substitution between input composites or between composites and other costs is not allowed, there being no role of for relative input prices under this technology.

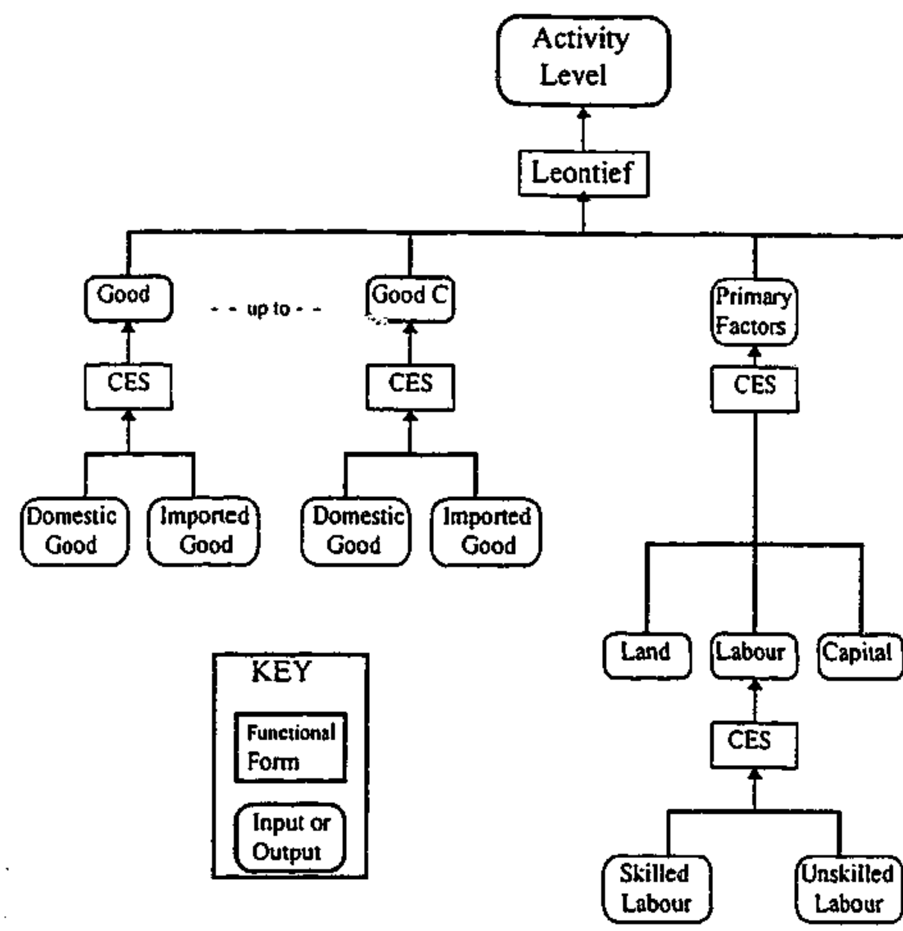

Figure 5.2 production structure of ordinary industry in ORANI-RSA

At the next level, to capture the idea of imperfect substitutability between domestic and imported goods, the two inputs differentiated by source are combined using a CES (constant elasticity of substitution) production function to form commodity composites (Armington, 1969). For each generic commodity I (I = 1,..., c), the industry optimises the mix of the domestic and imported components so as to minimise cost subject to the CES technology used to form the (generic) commodity composites. The demands for land, labour and capital are also derived by minimising the cost of the primary factor composite formed according to the CES technology.

The last level of the input technology is only applicable to labour. As in the case of the second level, composite labour is a CES aggregate of skilled and unskilled labour. The demands for labour in the two skill categories are derived by minimising labour cost subject to this technology.

5.2.2 (b) The service providing industry's production structure

The production structure of the service providing industry is different from the ordinary industries due to a different input demand schedule as shown in Figure 5.2. The service providing industry still minimises costs by choosing its input mix, subject to a three-tiered constant-returns-to-scale input technology. At the top level, it is assumed that primary factor composites and other costs are combined using a Leontief production function.

At the second level, the demands for labour and capital are derived by minimising the cost of a CES aggregate of them. At the last level, the demands for the components of the labour composite are derived by minimising total labour cost subject to a CES function which aggregates the three types of labour: skilled and unskilled ordinary labour and privileged labour.

In principle, all industries may produce a number of domestic commodities. Industries maximise revenue by choosing their output composition subject to a CET (constant elasticity of transformation) production frontier. The CET function is identical to the CES, except that the value of the transformation elasticity in the CET case has the opposite sign to the value of the substitution elasticity in the CES function. In ORANI-RSA, as shown by Figure 5.3, multi-production is confined only to the service providing industry. The ordinary industries produce only one output.

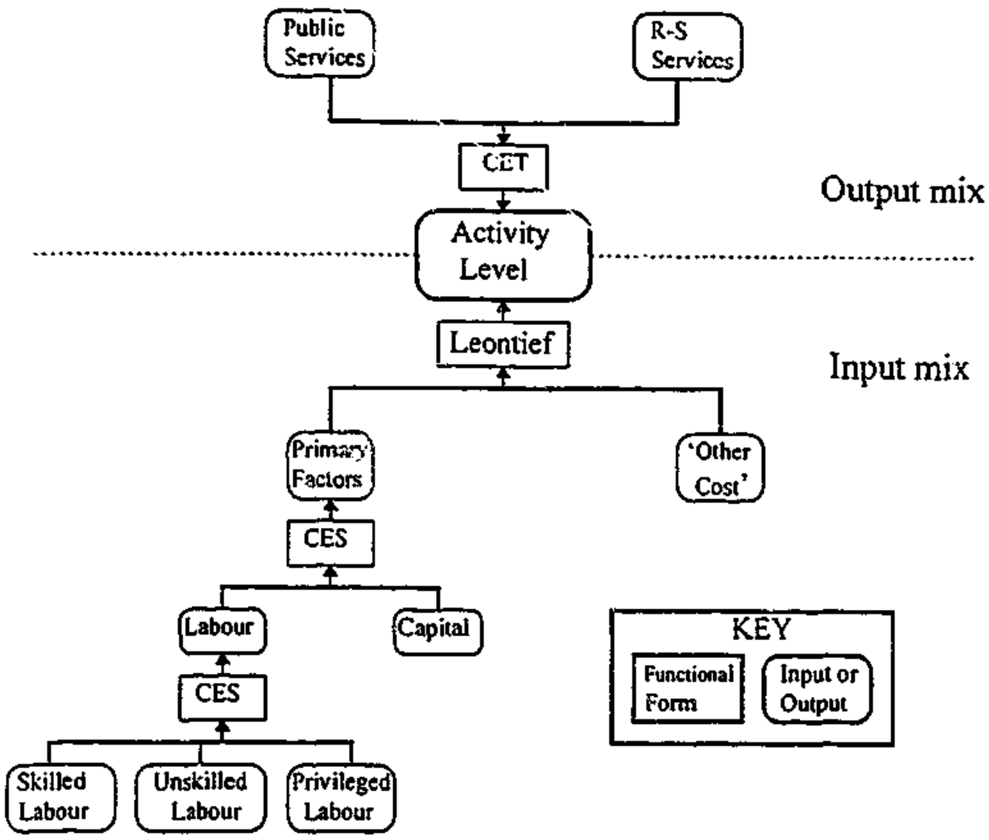

Figure 5.3 Production structure of the service providing industry in ORANI-RSA

5.2.3 Final demand

Four sources of final demand are identified in an ORANI class CGE model: household consumption, investment/capital creation, 'other demand' (representing government consumption) and exports. This is the classification of final demand adopted in input-output tables, the main source of the model's database.

5.2.3 (a) Household consumption

Unlike in ORANI-G where households are represented by a single representative, ORANI-RSA distinguishes two types of households, each of which maximises utility. The nesting of households' utility structure is illustrated in Figure 5.3. Each household maximises utility by allocating its budget across Armington composite commodities. In this specification, households are allowed to respond to changes in the relative prices of domestic and foreign commodities by substituting between domestic and imported goods in the same input-output category (Armington, 1969).

At the top level, the composite commodities are split into subsistence and 'luxury' demands by using a Stone-Geary utility function. The subsistence demand for a composite commodity does not respond to relative prices and is fixed on a per capita basis. Thus only exogenous changes in population and/or in taste, change this component of demand. The luxury (above subsistence) parts enter each household's utility function as a Cobb-Douglas aggregate. Thus the share of the luxury component of demand for each commodity in supernumerary expenditure remain constant under changes in income and prices.

Household demands derived from the utility maximising scenario specified in Figure 5.4 follow the Linear Expenditure System, in which household expenditure on any given Armington composite is a linear function of both prices and incomes.

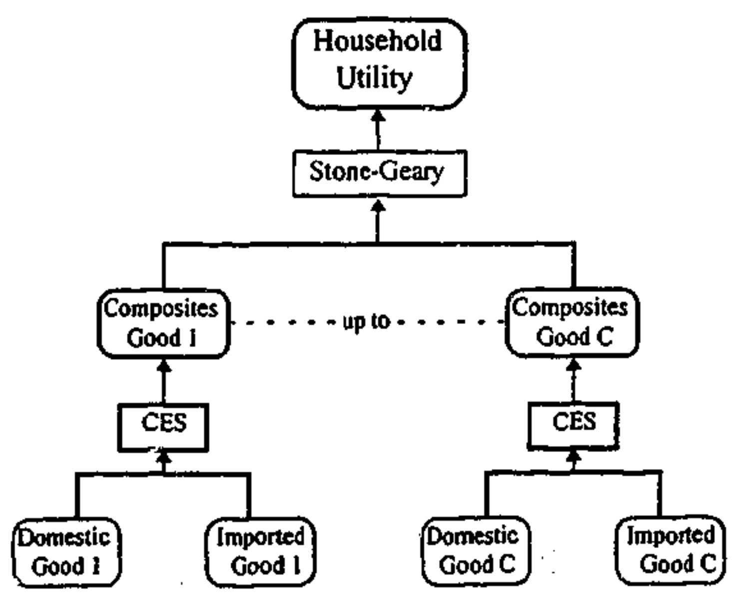

Figure 5.4 The structure of household utility

The households are disaggregated into two types according to their main source of income. Households which earns their incomes from the services of ordinary labour and capital belong to the ordinary household category. The privileged household receives all of its income from the service of privileged labour and from capital. In the implementation of the model, the two household types are assumed to have different consumption patterns which result in different import preferences.

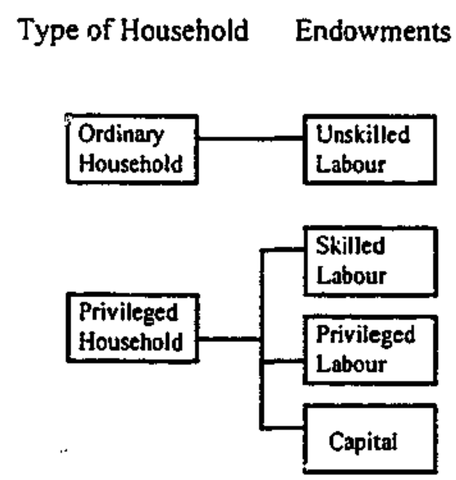

Figure 5.5 The definition of household types

5.2.3 (b) Investment

Figure 5.6 illustrates the nesting structure for capital creation. A new unit of fixed capital used in industry j is constructed according to a two-tiered technology. At the top level, each industry minimises cost by choosing the composite goods subject to a Leontief production function. This assumption again implies that all composite goods are used in fixed proportions and no substitution is allowed between composite goods. At the next level, composite goods are assembled from domestic and imported goods according to a CES technology to minimise unit cost. At this level, substitution between domestic and imported goods is possible (Armington, 1969). As revealed by the Figure 5.6, primary factors are not used in capital creation.

Having discussed the capital creation technology, it is now in order to elaborate how many units of the created capital (investment) are allocated to each industry. This investment allocation theory is essential to the understanding of the short and the long-run behaviour of the industry, which is chosen through the model's closure. Therefore, it will be helpful to provide a brief outline of the theory below.

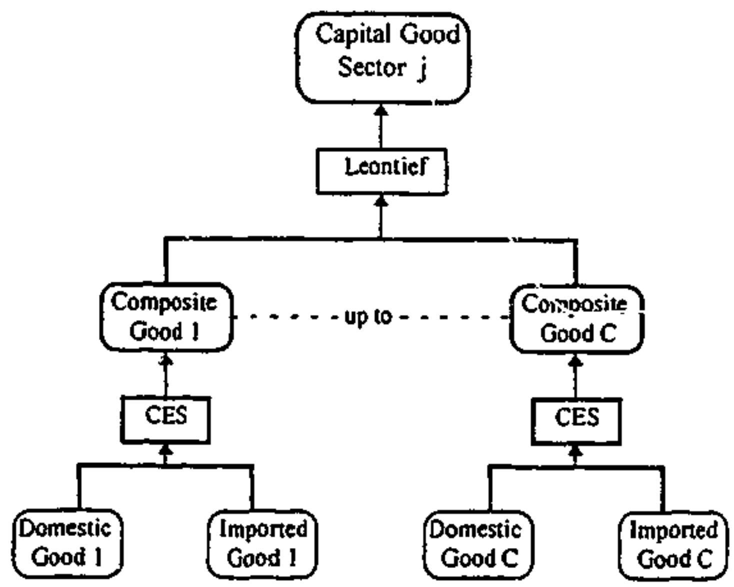

Figure 5.6 The structure of capital creation

The ORANI investment theory is developed by using the following essential assumptions.

1) The current net rate of return on fixed capital in industry *i* is

$$R_i(0) = (P1CAP(i)/P2TOT(i)) - D(i) \qquad \text{E5.1}$$

where D(i) is the fixed depreciation rate, P1CAP(i) and P2TOT(i) are the rental price and the cost of a unit of capital in industry *i*, respectively. The rental price is defined as the cost of procuring the services of a unit of capital for industry *i* for a unit time period, while the cost of capital is the production cost of a unit of capital for industry *i* as discussed earlier in the capital creation technology.

2) Investors are cautious about the impact of the expansion of the capital stock on the rate of return of capital. This is shown by a reduction in the expected rate of return (R_i^*) following an expansion of capital stocks.

More compactly, assumption (2) can be expressed in equation E5.2 and Figure 5.6.

$$R_i^* = R_0(i)[K_1(i)/K_0(i)]^{-\beta(i)} \qquad \text{E5.2}$$

where $\beta(i)$ is a positive parameter representing the elasticity of the expected rate of return to the planned end-of-period capital stocks $K_1(i)$. An increase of $K_1(i)$ by 1 percent is expected to reduce the rate of return by $\beta(i)$ percent. $K_0(i)$ is the current level of capital stocks. As shown in Figure 5.7, if capital stock is maintained at the current level, where $K_1(i)/K_0(i) = 1$, the expected rate of return would be $R_0(i)$, which is the solution value of this variable in the current period. However, if investment is expanded to the level where $K_1(i)/ K_0(i) = A > 1$, then the investor will behave as if the expected rate of return (for the period following the current one) has fallen to B.

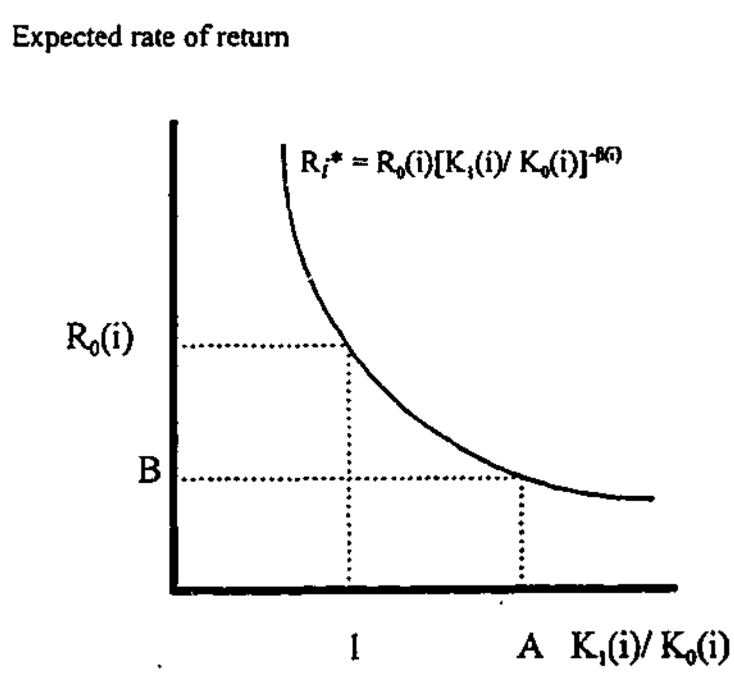

Figure 5.7 Expected rate-of-return schedule for industry i
(The figure is taken from Dixon *et al.*, 1982.)

3) Aggregate nominal investment expenditure Y_I is allocated across all industries to equate the expected rate of return to a common value Ω.

Assumption (3) leads to the following equation:

$$R_0(i)[\,K_1(i)/\,K_0(i)]^{-\beta(i)} = \Omega \qquad \text{(all i)} \qquad \text{E5.3}$$

4) Planned capital stock is the sum of current capital stock, take away depreciation, plus investment.

This identity can be written as:

$$K_1(i) = K_0(i)(1\text{-}D(i)) + Y(i) \qquad \text{E5.4}$$

where Y(i) is (gross) investment expenditure by industry *i*.

The investment theory can be reduced to two main equations. The first is simply equation E.5.1, which in percentage change form becomes:

$$\text{r1cap(i)} = (\text{p1cap(i)} - \text{p2tot(i)})\text{Q(i)} \qquad \text{E5.1'}$$

where:

r1cap(i) is the percentage (not percentage point) change of the rate of return to capital in industry i;

p1cap(i) is the percentage change in the rental price of a unit of capital to industry i;

p2tot(i) is the percentage change in the construction price of a unit of capital for industry i;

Q(i) is the ratio of the gross to the net rate of return to industry i, given the assumed constant rate of depreciation on capital D(i).

The second equation is derived by substituting the percentage change form of E5.3 into the percentage change form of E5.4 and adding a shift term finv(i) to get:

$$x2tot(i) = x1cap(i) + B(i)(r1cap(i) - omega) + finv(i) \qquad \text{E5.5}$$

where:

$B(i) = 1/(\beta(i)\Delta(i))$;

where $\Delta(i)$ is the ratio of investment in the initial period to capital stock in the following year ($\Delta(i) = Y(i)/ K_1(i)$) ;

x1cap(i) is the percentage change (i.e., deviation from the base case) in the capital stock $K_0(i)$;

r1cap(i) is the percentage (not percentage point) change in the current rate of return of investment in industry i;

omega is the percentage change in the expected economy wide rate of return (Ω);

For some industries where the mechanism elaborated above is considered not appropriate, such as public industries, the investment rule is as follows:

$$Y(i) = (I_R)^{s2(i)} F_2(i) \qquad \text{E5.6}$$

where $I_R = Y\_I/E_2$ is real investment, E_2 is the capital goods price index. $s_2(i)$ and $F_2(i)$, respectively are a parameter and a shift variable to allow a more flexible handling of investment.

In percentage change form E5.6 becomes:

$$x2tot(i) = s_2(i)i_R + f_2(i) \qquad \text{E5.6'}$$

If the parameter $s_2(i)$ is set to one, E5.6' implies that $f_2(i)$ will represent the percentage change in investment in industry *i* relative to aggregate investment of the entire private sector. On the other hand, if $f_2(i)$ is set exogenously to zero, then x2tot(i) will equal with i_R and the industry i will maintain its share of real investment.

It is important to note that the ORANI investment theory explains only the allocation of aggregate investment across industries. Although the theory is sufficient for a static computable general equilibrium model, it is not a formal investment theory, which is capable of explaining the long-run behaviour of the economy.

In the context of static general equilibrium models, short and long-run investment analyses are commonly incorporated through the choice of closure. In a standard short-run closure (Dixon *et al.*, 1981) the change in the industry's capital stock (x1cap(i)) is set to zero and the change in aggregate investment (x2tot_i) is exogenously determined. This closure implies that the short-run refers to a period of time where a shock has affected the investment undertaken by industries, but the investment has not yet been translated into changes in the industries' capital stocks. With the short-run closure equation E5.5 is reduced to E5.7 since x1cap(i) is exogenously set to zero.

$$x2tot(i) = B(i)[r1cap(i) - omega] \qquad E5.7$$

Equation E5.7 states that the exogenously set aggregate investment (x2tot_i) is distributed to each industry (x2tot(i)) so as to ensure that the change in the expected rate of return (omega) is the same for all industries, given that the current rate of return in each industry is allowed to change endogenously following E5.1.

In the long-run (Vincent, 1980) aggregate investment becomes endogenously determined and industries' current rates of return on capital are exogenously determined. If a country's capital and commodity markets are small compared to the world market, then it cannot set its rate of return on capital or its balance of trade in the long-run. However, in addition to the current rate of return on capital, the balance of trade is also exogenously determined in Vincent's closure. In a more fully elaborated model, the trade balance would be endogenised by an explicit treatment of foreign debt, the servicing of which must be met by a balance of trade surplus (Horridge 1987).

5.2.3 (c) Export and 'other' demands

In ORANI-G, the foreigner's export demand is specified as a downward-sloping schedule. Export volume for each commodity is a declining function of its price in foreign currency. As shown in E5.8, the sensitivity of export volume to the change in its price is determined by an export demand elasticity parameter (ξ). Appropriate settings for this parameter allow flexible use of the equation. For example, in the case of a commodity where the country supplies only a small portion to the world market, a large negative value of the export elasticity can be assigned.

Equation E5.8 is the general form of the export demand function. It is equipped with quantity and price shift variables to accommodate horizontal and vertical shifts of export demand.

$$x4(c) = \xi(c) \times [p4(c) - phi - f4p(c)] + f4(c) + f4q\_c \qquad \text{E5.8}$$

where:

$x4(c)$ is the percentage change in the volume of export of commodity c;

$\xi(c)$ is the export elasticity parameter for commodity c;

$p4(c)$ is the percentage change in the domestic-currency price of export commodity c;

phi is the percentage change in the country's currency exchange rate (domestic $ per foreign $);

$f4p(c)$ is a shift variable to accommodate a vertical (price) shift of the export demand curve;

$f4q(c)$ is a shift variable to accommodate a horizontal (quantity) shift of the export demand curve; and

$f4q\_c$ is a shift variable to accommodate a uniform quantity shift in demand common to all commodities.

Commodities are divided into two sets, a 'traditional' export group and a 'non-traditional' export group. The importance of the definition is that for commodities with a substantial share of output exported (traditional), we 'trust' the model to endogenise exports, whereas for those in which exports are minor (non-traditional), we allow the model to do less. In fact, while the demand for non-traditional exports as a whole is endogenised by the model's downward-sloping export demand schedule for this aggregate, the composition of this export demand is exogenised because the aggregate is constructed using Leontief function. The later implies that:

$$x4(c) = x4\_ntrad \qquad \text{E5.9}$$

where $x4\_ntrad$ is a Leontief aggregate of non-traditional export commodities.

The aggregate export demand for commodities in the non-traditional category is given by:

$$x4\_ntrad = \xi\_ntrad \times [p4\_ntrad - phi - f4\_ntrad] \qquad \text{E5.10}$$

where:

ξ_ntrad is the aggregate export demand elasticity for non-traditional export commodities;

p4_ntrad is the percentage change in the aggregate (domestic-currency) price index for non-traditional export commodities;

f4_ntrad is a shifter used to allow flexibility in handling aggregate non-traditional exports.

As regards to other demand, no specific theory is developed in ORANI-G. It is represented only by a simple equation, which ties the government demand to real household demand and a shift variable. In a standard simulation, government demand for domestically produced and imported goods is assumed to move in line with households' real consumption. A shift variable is used to accommodate a shift in government demand, due (say) to a cut in government spending.

5.2.4 Demand for margin services

As shown in Figure 5.1, margin services are used to facilitate the flow of each commodity from its source to all using agents: producers, investors, households, government and foreigners (who demand exports). In ORANI-type models, it is assumed that, in the absence of technological change in margin service industries, the real demand for margin is in direct proportion to the commodity flow with which that margin is associated. For all types of demands except exports[2], margin services are used to facilitate the flow of both imported and domestically produced goods.

[2] The model does not allow the re-export of unprocessed imports.

5.2.5 The price system

In ORANI-type models, two types of prices are distinguished: basic values and purchasesers' prices. For domestically produced goods, basic value is defined as the price received by producers, excluding tax and margin services used to deliver these goods to users. For imported goods, basic value is the sum of the cif price and import duties. So sales taxes and margin costs are excluded from imports' basic price, tariffs are included; that is, the basic value price of an import is its 'landed duty-paid' price. Purchasers' prices for both imported and domestically produced commodities are the basic prices plus sales taxes and margin costs.

In deriving equations representing the model's pricing system, the following simplifying assumptions are adopted:

(i) Pure profit does not prevail in any economic activity (production, capital creation, distribution, exporting or importing);

(ii) Basic prices are uniform for all users and producing industries.

Assumption (ii) implies that if a difference in purchasing prices exists across users, this is entirely due to the differences in the sales tax and margin costs. In other words, while the basic price is the same for all users, the purchasers' price paid by each user can differ.

(iii) The margin services used to deliver goods to users do not themselves use margin services as an input (there are no margins on margins).

It is important to note that since constant returns to scale are assumed, the industry's per unit cost and per unit revenue are independent of its output (activity) level, being influenced only by the technology employed and the prices of commodities. With the above assumptions, the basic prices per unit of an industry's output (unit revenue) equals the total payment for the inputs needed to produce one unit of output (unit cost).

For the capital creation activity, the above assumptions imply that the per unit price of capital for a certain industry is simply its per unit construction cost. As has been elaborated earlier, in ORANI-type models capital is constructed by using imported and domestically produced goods. It is important to distinguish between the cost of constructing capital and the cost of using capital. The latter is defined as the gross (before depreciation) rental implied by the going rate of return on a unit of capital used in a certain industry.

Additional equations are usually introduced to allow for a more flexible handling of import tariffs. As regards to export commodities, the price paid by the foreigner at the port of exit includes the basic price, export tax/subsidy and the margin costs.

5.2.6 The market clearing equations

In ORANI-type models, a group of equations is specified to ensure that demand equals supply for domestically produced goods and primary factors. For domestically produced commodities, the total supply is sold to those who demands it for (i) intermediate inputs to current production; (ii) capital creation; (iii) household consumption; (iv) exports (v) government purchases; and for (vi) margin services.

For capital and land, one important assumption is made in short-run closures of the model: neither capital nor land is allowed to move between industries. With this assumption, the market clearing equations are simply set to equate the demand for capital and land to their respective supplies in each industry. Unlike capital and land, labour is assumed to be shiftable between industries in virtually all closures of the model. In ORANI-type models the supply side of the labour market is often underdeveloped, or absent altogether. The usual market clearing equation is replaced by an identity defining aggregate labour demand. The choice of closure can then imply either that the supply of labour is fully exogenous (as it is in most economic models), or alternatively, that labour is in infinitely elastic supply at an exogenous (real or nominal) wage rate. Thus, in one closure where the supply of labour is exogenously set at the full-employment level, the wage will adjust to bring labour demand to the full-employment level. In another closure where the real wage is set exogenously, the model will solve for the level of labour demand (employment) corresponding to this given wage level.

5.2.7 GDP, Balance of trade and other macro index equations

GDP is computed in the model from both the income and expenditure sides,. GDP from the income side is defined as the sum of all aggregate payments to labour, capital, land, other costs tickets, *plus* the aggregate value of indirect taxes (net of subsidies). On the other hand, GDP from the expenditure side is computed by summing up all aggregate expenditures – consumption, investment, purchases by government, inventory building and exports, *less* the cif value of aggregate imports. The two measures of GDP should always be the same.

To capture the position of the balance of trade a few steps are taken in ORANI model. First, an equation is specified to work out the aggregate use of imports at their foreign currency cost. Then another equation is constructed to account for aggregate foreign currency receipts from exports. Since the trade balance can be negative or positive and its value can change from negative to positive after certain economic changes (shocks), the balance of trade equation is specified in ordinary 'change' (rather than percentage change) form. This change, however, is conveniently expressed as a proportion of GDP (see excerpt in Appendix 1).

The model is also designed to produce a series of macroeconomic indexes, such as the consumer price (CPI) and capital price indexes. They are computed as a weighted averages of the percentage changes in the relevant purchases' prices. Examples are the CPI and the capital goods price indexes. The model is also equipped with a wage indexation equation, designed to allow the model user to link the change in the wage rate to the change in the CPI. This equation allows both full-wage indexation, where the real wage rate is fixed across occupations and industries, and zero wage-indexation, where there is no direct link between labour's nominal wage and the CPI. Partial wage indexation can also be implemented by an appropriate choice of the indexation parameter.

5.3 Additional features of ORANI-RSA

As has been stated earlier, ORANI-RSA has a more complete income mapping between agents and institutions in the model than ORANI-G. The standard ORANI input–output data base presented in Figure 5.1, therefore, needs to be extended to include such a mapping. The aggregate social accounting matrix (SAM), presented in Figure 5.8, has the required income mapping. It is a super-set of Figure 5.1 which provides a tabular snapshot of the economy at one point of time. As in the input output table, each cell in the SAM also represents the value of an economic transaction between a pair among the five basic institutions in the economy; namely: suppliers/producers, households, government, investors, and the rest of the world. Such transactions occur in the commodity, factor and capital markets. Each economic

	SIZE	PROD COST i	GOS ii	WAGES iii	HH EXPEND iv	GOVT EXPEND v	INVEST MENT vi	INVEN TORY vii	*ROW* viii	ROW TOTAL
		1	1	1	1	1	1	1	1	
1. USAGE OF LOCALLY PRODUCED GOODS AND SERVICES	1	V1BASD V1MARD V1MARM			V3BASD V3MARD V3MARM	V5BASD V5MARD V5MARM	V2BASD V2MARD V2MARM	V6BASD V6MARD	V4BASD V4MARD	SALES
2. GOS	1	V1OCT V1CAP V1LND				VGOVGOS			V*ROW*GOS	VGOS
3 WAGES	1	V1LAB								V1LAB
4. HOUSEHOLD INCOME	1		VGOSHOU	VLABINC	VHOUHOU	VGOVHOU			V*ROW*HOU	VHOUINC
5. GOVERNMENT INCOME	1	V1TAX- V1SUB+ V1TAR	VGOSGOV VRSGOSTAX VFINE		V3TAX V3TAR VHOUGOV	V5TAX V5TAR	V2TAX V2TAR		V4TAX VROWGOV	VGOVINC
6. GOODS&SERVICES FROM ROW	1	V1BASM			V3BASM	V5BASM	V2BASM	V6BASM		VOCIF
7. OTHER ROW INCOME	1		VGOSROW		VHOUROW	VGOVROW				VTRF*ROW*
8. COLUMN TOTAL	1	COSTS	GOSEXP	V1LAB	VHOUEXP	VGOVEXP	V2TOT	V6TOT	VROWEXP	Σ(8)
9. ROW TOTAL	1	SALES	VGOS	V1LABINC	VHOUINC	VGOVINC	0	0	V*ROW*INC*	Σ(9)
10. GROSS SAVING OR RESIDUAL (9 - 8)		0	GOS SAVING =VGOSSAV	0	HOUSE HOLD SAVINGS =VHOUSAV	GOVERN MENT SAVING =VGOVSAV	- V2TOT	- V6TOT	NET INVEST BY ROW =VROWSAV	VSAM CHECK = 0 Σ(9) - Σ(8)

Note : * V*ROW*INC = V0CIF + VTRFROW

Figure 5.8 Schematic representation of the aggregate ORANI-RSA SAM data base transaction represents a linkage between institutions, each institution's purchases being another institution's sale. The first row of Figure 5.8 records the purchases from domestic producers of domestically produced commodities (V1BASD) and their associated margins (V1MARD) by each agent identified in the column. Also included here are margins services (V1MARM) sourced locally and used to facilitate the flow of imported goods to domestic producers, households and other demand. The second and the third rows show the sources of gross operating surplus (GOS) and wages (V1LAB in Figure 5.1), with value added in the domestic economy shown in column (i). GOS comes from the use of both capital and land (V1CAP and V1LND in Figure 5.1) by industries, while WAGES (column iii) are the compensation for the usage of various types of labour by industries.

Row 4 identifies the sources of household income. Five main sources are shown in the SAM, namely, income from gross operating surplus (VGOSHOU), income from wages (VLABINC), transfers from other households (VHOUHOU), transfers from government (VGOVHOW) and transfers from the rest of the world (VROWHOU). Row 5 records government income, which comes mainly from various taxes imposed on agents or accounts identified by column, plus transfers from the rest of the world (VROWGOV).

Entries in row 6 are the usage of imported goods and services for intermediate inputs (V1BASM), for household consumption (V3BASM), for government consumption (V5BASM), for capital creation (V2BASM) and for inventory building (V6BASM). Row 7 records the transfer from agents (households and government) and accounts (GOS) to the rest of the world. In the case of the entry in column (ii), the payment represents GOS repatriated abroad to foreign owners of capital located in the domestic economy, while the wages entry in column (iii) represents labour income repatriated by foreign guest workers temporarily residing locally.

The SAM implies a budget constraint (income equals expenditure) for each agent identified in the column and hence for the whole economy. Each agent's income and expenditure are, respectively, recorded in the row sum and column sum. The last three rows (8-10) work out how these budget constraints are satisfied. A balanced SAM implies that: (i) demand for each commodity equals its supply; (ii) expenditure (plus saving) equals income for each agent in the model; and that (iii) costs exhaust revenue for producers.

A model of ORANI-G type includes a complete set of equations to describe rows 1 and 6, as well as parts of rows 2 and 3 of Figure 5.8. As stated earlier, the model does not have any equations to describe the complete income mapping to institutions (rows 4, 5 and 7 in Figure 5.8) and the institutions' budget constraints shown in rows 8, 9 and 10 of the same Figure.

In the following sub-section we will introduce a new set of accounting identities and behavioural equations to represent additional features of ORANI-RSA. The standard rules in writing the ORAN-G equations and formulas are also adopted in ORANI-RSA. All equations in this part of the model are linearisations, and all variables are either percentage changes or ordinary changes. All variable names are in lower-case. The corresponding coefficients representing the data flows in the bench-mark data set are in upper-case; such coefficients correspond to the levels values of variables with which they are associated. The bench-mark data set hence is an initial solution of the model in the levels.

For the mapping equations, the names of variables and coefficients differ only in the first character. To define an aggregation of a variable or a coefficient over a set, an underscore "_" with a suffix representing the corresponding set is appended to the end of the variable or coefficient. For example, the coefficient V1LAB(i,o) aggregated over set (i), industry, is written as V1LAB_I(o). Before proceeding further, a summary of the sets used in the main model given in Table 5.1.

Table 5.1 The sets used in the ORANI-RSA

Set Name (Subscript)	Elements (Subscript)	Description
COM (c)	TrdExpse, ExpOrnt, ImpOrnt, NonTrad, Margins, PubSrv, RntSrv	Types of commodities TrdExpse is the aggregate of commodities with a large share of both export and import in its sales. ExpOrnt is the aggregate of export oriented commodities ImpOrnt is the aggregate of import oriented commodities NonTrad is the aggregate of non-tradables commodities Margins is the aggregate of the commodities used for margins PubSrv is the aggregate of commodities provided by the service providing industry RntSrv is rent-seeking services provided by the service providing industry
IND(i)	TrdExpse, ExpOrnt, ImpOrnt, NonTrad, Margins, ServPrv	Types of Industries TrdExpse produces the commodities with a large share of both export and import in its sales. ExpOrnt produces the export oriented commodities ImpOrnt produces the import oriented commodities NonTrad produces non-tradables commodities Margins produces the commodities used for margins ServPrv produces both legitimate public goods and rent-seeking services
TRADEXP	TrdExpse	Traditional export
EXOGINV	ServPrv	Industry whose investment is exogenous

...continued

Table 5.1 ***continued***

Set Name (Subscript)	Elements (Subscript)	Description
ORDCOM	TrdExpse, ExpOrnt, ImpOrnt, NonTrad, Margins, PubSrv	Ordinary commodities
GOVCOM	PubSrv, RsSrv	Commodity produced by GOVIND
GOVIND	SrvPrv	Service providing industry
RSIND(r)	TrdExpse, ExpOrnt, ImpOrnt, NonTrad, Margins	Industries engaging in rent-seeking activity
SRC (s)	Sources	Imported and domestically produced
OCC (o)	Skilled (skl), Unskilled (uns), Privileged (prv)	Types of labour
HOU (h)	High (hi), Low (lo)	Types of household (hi) contains privileged and skilled labour, (lo) contain unskilled labour
MAR (m)	Margins	Margins commodities, trade and transport

5.3.1 Gross operating surplus (GOS)

Row 2 of Figure 5.8 identifies five sources of gross operating surplus. The total of the gross operating surplus from all sources is computed the following Formula:

$$VGOS = V1CAP\_I + V1LND\_I + V1OTC\_I + VROWGOS + VGOVGOS \qquad (F5.1)$$

The first three components of GOS are the rent from capital, from land and other cost tickets, respectively. VROWGOS is the GOS that comes from overseas and VGOVGOS is the interest on public debt paid by the government. Corresponding to F5.1 we can write the following linear equation to describe GOS:

$$VGOS*wgos = V1CAP\_I*w1cap\_i + V1LND\_I*w1lnd\_i + V1OTC\_I*w1otc\_I + VROWGOS*wrowgos + VGOVGOS*wgovgos \quad (E5.11)$$

The first three variables of the RHS of E5.11 come from the main model (ORANI-G). The last two variables are determined exogenously. Equation E5.1 states that the percentage change in the aggregate gross operating surplus (wgos) is a weighted average of the changes in gross operating surplus across sources. The base values for all of the coefficients used in E5.11 are obtained from row 2 of Figure 5.8. Note that the coefficients of F5.1 are also the corresponding values of the relevant levels variables. This implies that the levels equation used to compute aggregates households' income will be identical to F5.1. In the implementation within GEMPACK[1] of a linear model, levels equations are not used. Their role is replaced by Formulas. This is also true of the part of ORANI-RSA (currently under discussion) that is written as a linearised system.

Formula F5.2 describes the distribution of GOS to household, government, the rest of the world, income tax and fine payment due to rent-seeking activity:

$$VGOSEXP = VGOSHOU\_h + VGOSGOV + VGOSROW + VRSGOSTAX\_I + VFINE\_I \quad F5.2$$

The equation describing the distribution of the gross operating surplus corresponding to F5.2 can be written as:

$$VGOSEXP*wgosexp = VGOSHOU\_h*wgoshou\_h + VGOSGOV*wgosgov + VRSGOSTAX\_I*wrsgostax\_i + VGOSROW*wgosrow + VFINE\_I*wfine\_i \quad E5.12$$

[1]GEMPACK, a General Equilibrium Modelling Package, is the computer modelling platform used throughout this study to obtain general equilibrium results (see Harrison and Pearson, 1996).

The weights (coefficients) assigned to E5.12 are obtained from column (ii) of figure 5.8. Some portion of gross operating surplus is usually retained (GOSSAV) to be used as a source of future investment. GOSSAV is defined in the following Formula:

$$\mathrm{GOSSAV} = \mathrm{VGOS} - \mathrm{VGOSEXP} \qquad \text{F5.3}$$

F5.3 states that retained operating surplus is the residual of GOS after transfers to households, government and to the rest of the world have been made and the income tax applicable to GOS has been paid. The equation describing retained GOS is in ordinary change form and indexed to VGOS .

$$100*\mathrm{VGOS}*\mathrm{delisav} = \mathrm{VGOS}*\mathrm{wgos} - \mathrm{VGOSEXP}*\mathrm{wgosexp} - (\mathrm{VGOS} - \mathrm{VGOSEXP})*\mathrm{wgos} \qquad \text{E5.13}$$

Equation E5.13 implies that the change in retained earning (delisav) is expressed as a fraction of total gross operating surplus (VGOS).

To explain the behaviour of the transfer from GOS to other agents in the model, we need to define disposable GOS (VDISPGOS). As shown in F5.4 and E5.14, this transfer is found as a residual. It is simply the total GOS after the applicable tax (after rent-seeking) is deducted. Then we assume that the percentage change in the transfer from GOS to households, government and to the rest of the world move in line with the percentage change in disposable GOS (E5.15 -17):

$$\mathrm{VDISPGOS} = \mathrm{VGOS} - \mathrm{RSGOSTAX\_I} \qquad \text{F5.4}$$

$$\mathrm{VDISPGOS}*\mathrm{wdispgos} = \mathrm{VGOS}*\mathrm{wgos} - \mathrm{VRSGOSTAX\_I}*\mathrm{wrsgostax\_i} \qquad \text{E5.14}$$

$$\mathrm{wgoshou\_h} = \mathrm{wdispgos} \qquad \text{E5.15}$$

$$\mathrm{wgosgov} = \mathrm{wdispgos} \qquad \text{E5.16}$$

wgosrow = wdispgos E5.17

5.3.2 Households' income, expenditure and saving

The sources of households' incomes are identified in row 4 of Figure 5.8. Their totals are computed in Formula F5.5.

$$\mathrm{VHOUINC}(h) = \mathrm{VLABINC\_O}(h) + \mathrm{VGOSHOU}(h) + \mathrm{VHOUHOU\_Hf}(h) + \mathrm{VGOVHOU}(h) + \mathrm{VROWHOU}(h) \quad (h \in \{lo,hi\}) \qquad \text{(F5.5)}$$

Labour is assumed to be owned only by households and hence all wages are received by them. The following formula represents this assumption,

$$\mathrm{CHECK3}(o) = \mathrm{V1LABINC\_H}(o) - \mathrm{V1LAB\_I}(o) \quad (o \in \{usk,skl,prv\}) \qquad \text{(F5.6)}$$

where CHECK3 should always be zero for all occupations. The right-hand entities in Formulae (F5.6) are the sums across household types (_H) and across industries (_I) respectively of labour income earned by occupation. The mapping of income from occupations to households is shown in Table 5.2. The equality of the column and row totals in the south east corner of Table 5.2 validates Formula F5.6.

Table 5.2 The income mapping from occupations to households

OCC / HOU	Unskilled (uns)	Skilled (skl)	Privileged (prv)	Total
lo	V1LABINC (uns,lo)	V1LABINC (skl,lo)	1LABINC (prv,lo)	VLABINC_lo
hi	V1LABINC (uns,hi)	V1LABINC (skl,hi)	V1LABINC (prv,hi)	VLABINC_hi
Total	V1LAB_uns	V1LAB_skl	V1LAB_prv	V1LAB_I(o) = VLABINC_H(o)

The equation corresponding to F5.4 is;

$$\begin{aligned} \mathrm{VHOUINC(h)*whouinc(h)} = {} & \mathrm{VLABINC\_0(h)*wlabinc\_o(h)} + \mathrm{VGOSHOU(h)*wgoshou(h)} \\ & + \mathrm{VHOUHOU\_hf(h)*whouhou\_hf(h)} + \mathrm{VGOVHOU(h)*wgovhou(h)} \\ & + \mathrm{VROWHOU(h)*wrowhou(h)} \qquad (h \in \{lo,hi\}) \qquad \text{(E5.18)} \end{aligned}$$

As noted above, the first RHS variable, wlabinc_o(h), is determined in the main model, while the rest (except wgoshou, see E5.14) are determined in the following equations. As shown in E5.19 and E5.20, it is also assumed that both wgovhou and wrowhou move proportionally to nominal GDP. The percentage change in the transfer to one household type from the other is determined by the percentage change in the disposable income of the donor household (see E5.21). As shown in F5.7 and E5.22, households' disposable income is obtained by taking away income tax (whougov) from households' total income (whouseinc).

$$\mathrm{wgovhou(h)} = \mathrm{w0gdpexp} \qquad \text{(E5.19)}$$

$$\mathrm{wrowhou(h)} = \mathrm{w0gdpexp} \qquad \text{(E5.20)}$$

$$\mathrm{whouhou(hto,hfrom)} = \mathrm{wdispinc(hfrom)} \qquad \text{(E5.21)}$$

$$\mathrm{VDISPINC(h)} = \mathrm{VHOUINC(h)} - \mathrm{VHOUGOV(h)} \qquad \text{(F5.7)}$$

$$\begin{aligned} \mathrm{VDISPINC(h)*wdispicn(h)} = {} & \mathrm{VHOUSEINC(h)*whouinc(h)} \\ & - \mathrm{VHOUGOV(h)*whougov(h)} \qquad \text{(E5.22)} \end{aligned}$$

Having specified total households' income, we next need to collect their expenditure:

$$\begin{aligned} \mathrm{VHOUEXP(h)} = {} & \mathrm{V3TOT(h)} + \mathrm{VHOUHOU\_HTO(h)} \\ & + \mathrm{VHOUGOV(h)} + \mathrm{VHOUROW(h)} \qquad (h \in \{lo,hi\}) \qquad \text{F5. 8} \end{aligned}$$

where V3TOT(h), a coefficient from the main model, is a sum of the purchasers' price of domestically produced and imported goods and services over commodities. Using the elements listed in column (iv) of Figure 5.8, V3TOT(h) can be computed as:

$$V3TOT(h) = V3BASD\_C(h) + V3MARD\_C(h) + V3BASM\_C(h) + V3MARM\_C(h) + V3TAX\_C(h) + V3TAR\_C(h) \quad \text{F5.8'}$$

where V3BASD_C(h) + V3MARD_C(h) + V3TAX_C(h) is the purchasers' value of the domestically produced components of household consumption, and V3BASM_C(h) + V3MARM_C(h) + V3TAR_C(h) is the purchasers' value of the imported part. The other elements of F5.8 are transfers to the other household type (VHOUHOU), transfers to the government as income tax (VHOUGOV) and to the rest of the world (VHOUROW). The linear equation corresponding to F5.8 is as follows:

$$\begin{aligned} VHOUEXP(h)*whouexp(h) = {} & V3TOT(h)*w3tot(h) \\ & + VHOUHOU\_HTO(h)*whouhou\_hto(h) \\ & + VHOUGOV(h)*whougov(h) \\ & + VHOUROW(h)*whourow(h) \\ & (h \in \{lo,hi\}) \quad \text{E5.23} \end{aligned}$$

where the percentage change in the transfer from households to the government (whougov) is determined in the following equation:

$$whougov(h) = whousinc(h) + f\_inctaxrate(h) + f\_inctaxrate\_h \quad (h \in \{lo,hi\}) \quad \text{E5.24}$$

Equation E5.22 states that the income tax paid by each household is proportional to its income. The additional variables f_inctaxrate(h) + f_inctaxrate_h, respectively, are used to accommodate a household-type-specific and a uniform change in the income tax rate.

Having defined households' income and expenditure, their savings can now be computed by taking away expenditures from total income (F5. 9).

$$HOUSAV(h) = HOUINC(h) - HOUEXP(h) \quad (h \in \{lo,hi\}) \quad F5.9$$

E5.25 defines households' saving as a fraction of their income:

$$100*HOUINC*delhsav = VHOUINC*whouinc - VHOUEXP*whouexp$$
$$-(VHOUINC - VHOUEXP)*whouinc \quad (h \in \{lo,hi\}) \quad E5.25$$

If delhsav is declared exogenous and is not shocked, then the average propensity to consume is constant.

5.3.3 Government's income, expenditure and saving

The sources of government income are shown in row 5 of Figure 5.8. Total government income is computed in the following formula:

$$VGOVINC = V0TAX\_CSI - V1SUB\_I + VGOSGOV + VRSGOSTAX\_I + VFINE\_I$$
$$+ VHOUGOV\_H + VROWGOV \quad F5.10$$

V0TAX_CSI is a coefficient used in the main model to represent the total of indirect taxes collected on both imported and domestically produced commodities. Using the fifth row of Figure 5.8, V0TAX_CSI can be computed as follows:

$$V0TAX\_CSI = V1TAX\_CI + V1TAR\_CI + V5TAX\_C + V5TAR\_C$$
$$+ V3TAX\_CH + V3TAR\_CH + + V2TAX\_CI + V2TAR\_CI$$
$$+ V4TAX\_CH \quad F5.10'$$

As shown in F5.10 an increase in total subsidy (V1SUB_I) will reduce government income because it is treated as a negative tax in the model. Note that government also receives income from direct taxes, namely, income tax from households (VHOUGOV_H) and from the corporate sector (VRSGOSTAX_I) and fines due to rent-seeking activity (VFINE_I). The last tax is particularly important in this model because the corporate sector is assumed to engage in rent-seeking activity in an attempt to reduce its tax payment. With this assumption, the full treatment of the corporate tax requires the inclusion of the rent-seeking model developed in chapter 2, 3 and 4 into the standard ORANI-G (to be explained in detail in the later section). The corresponding equation to define government's income is:

```
VGOVINC*wgovinc = V0TAX_CSI*w0tax_csi + VGOSGOV*wgosgov
                  + VRSGOSTAX_I*wrsgostax_i -V1SUB_I*w1sub_I
                  + VFINE_I wfine_i
                  + VHOUGOV_H*whougov_h
                  + VROWGOV*wrowgov                              E5.26
```

The components of government expenditure are listed in column (v) of Figure 5.8). Formula F5.11 divides total government expenditure into two main groups of spending, current (VGOVCUR) and capital spending (VGOVCAP):

```
VGOVEXP = VGOVCUR + VGOVCAP                                      F5.11
```

The corresponding equation for total government spending is as follows;

```
VGOVEXP*wgovexp = VGOVCUR*wgovcur
                  + VGOVCAP_I*wgovcap_i                          E5.27
```

E5.27 states that the percentage change in government expenditure is a weighted average of the percentage changes in its current and capital spending. The government's current spending comprises government purchases of both domestically produced and imported goods (V5TOT), that part of gross operating surplus (VGOVGOS) accruing to government enterprises (representing the purchase by government of capital services), transfers to households (VGOSHOU) and to the rest of the world (VGOVROW). The total of government current spending is computed in the following formula:

$$\mathrm{VGOVCUR} = \mathrm{V5TOT} + \mathrm{VGOVGOS} + \mathrm{VGOVROW} + \mathrm{VGOVHOU\_H} \qquad \text{F5.12}$$

where V5TOT is a coefficient taken from the main model defined as the purchasers' value of domestically produced and imported goods and services. In terms of Figure 5.8 it can be computed as follows:

$$\mathrm{V5TOT} = \mathrm{V5BASD\_C} + \mathrm{V5MARD\_C} + \mathrm{V5BASM\_C} + \mathrm{V5MARM\_C} + \mathrm{V5TAX\_C} + \mathrm{V5TAR\_C} \qquad \text{F5.12'}$$

The equation corresponding to Formula F5.12 defines the government's total current spending:

$$\mathrm{VGOVCUR}*\mathrm{wgovcur} = \mathrm{V5TOT}*\mathrm{w5tot} + \mathrm{VGOVGOS}*\mathrm{wgovgos} + \mathrm{VGOVROW}*\mathrm{wgovrow} + \mathrm{VGOVHOU\_H}*\mathrm{wgovhou\_h} \qquad \text{E5.28}$$

Transfers by the government to the rest of the world are assumed to move in line with the GDP as shown in equation E.5.29:

$$\mathrm{wgovrow} = \mathrm{w0gdpexp} \qquad \text{E5.29}$$

Government spending on capital by definition is the sum of government investment expenditures. In any industry i the share of investment represented by capital formation by the government is denoted by GOVSHRINV(i). Then government investment in industry i, VGOVCAP(i), is given by

$$\mathrm{VGOVCAP(i)} = \mathrm{GOVSHRINV(i)}*\mathrm{V2TOT(i)} \qquad \text{F5.13}$$

where V2TOT(i) is the total investment in industry i. In most closures of the model it is anticipated that the share GOVSHRINV(i) would be exogenous and set to zero change.

Equation E5.30 merely adds government investment across industries:

$$VGOVCAP\_I*wgovcap\_i = \sum_{(i \in ind)} (GOVSHRINV(i)*V2TOT(i)*\{s2gov(i) + p2tot(i) + x2tot(i)\}) \qquad E5.30$$

where s2gove(i) is the percentage change in GOVSHRINV(i), p2tot(i) and x2tot(i), respectively, are the percentage changes in the price and quantity indexes of investments that have been defined in the main model.

Private investment is computed by taking away government investment from the sum of total capital formation V2TOT_I and inventory accumulation V6TOT_I (see Formula F5.14).

$$VPRIVCAP = V2TOT\_I - VGOVCAP + V6TOT\_I \qquad F5.14$$

V2TOT_I is already defined in the main model. Using the entry in the investment and inventory columns of Figure 5.8, V2TOT_I and V6TOT_I are computed as:

$$V2TOT\_I = V2BASD\_CI + V2MARD\_CI + V2BASM\_CI + V2MARM\_CI + V2TAX\_CI + V2TAR\_CI \qquad F5.14'$$

$$V6TOT\_I = V6BASD\_CI + V6MARD\_CI + V6BASM\_CI \qquad F5.14''$$

The following equation gives the percentage change of private investment corresponds to Formula F5.11:

$$VPRIVCAP*wprivcap = V2TOT\_I*w2tot\_i - VGOVCAP*wgovcap + V6TOT*w6tot \qquad E5.31$$

Having defined all elements of government income and expenditures, we can now compute government saving in the following formula;

$$VGOVSAV = VGOVINC - VGOVEXP \qquad F5.15$$

The corresponding equation to describe government saving (expressed as a fraction of government income) is as follows:

$$100*GOVINC*delgsav = VGOVINC*wgovinc - VGOVEXP*wgovexp - (VGOVINC - VGOVEXP)*wgovinc \qquad E5.32$$

5.3.4 The rest of the world's income, expenditure and savings

The income (from the local country) to *ROW* comes from two main sources: (i) the purchase of imported commodities by domestic residents (row six of Figure 5.8); (ii) transfers from government and domestic residents. This is supplemented by income to primary factors resident in the local country but owned by foreigner. Total income received by *ROW* can be computed as follows:

$$VROWINC = V0CIF\_C + VHOUROW\_H + VGOVROW + VGOSROW + VLABROW \qquad F5.16$$

All the RHS elements of F5.16 have been defined in the previous section, except V0CIF_C, which is the total cif value of imported commodities. Using the entries in row six of Figure 5.8, it is defined as:

$$V0CIF\_C = V1BASM\_C + V3BASM\_C + V5BASM\_C + V2BASM\_C + V6BASM\_C \qquad F5.16'$$

The corresponding equation to compute the total income accruing to the rest of the world is as follows:

VROWINC*wrowinc = VHOUROW_H*whourow_w
+ VGOVROW*wgovrow
+ V0CIF_C*v0fic_c
+ VGOSROW*wgosrow
+ VLABROW*wlabrow E5.33

On the spending side, the rest of the world spends some of its income to buy the exported domestic commodities. The rest of the world economy also pays some transfers to households and the government (see column (viii) of Table 5.8). The sum of this spending can be computed by the following formula:

VROWEXP = V4TOT + VROWGOV + VROWGOS + VROWHOW_H F.5.17

where V4TOT is the total value of exported commodities.

The equation describing exports is covered in the main model. In terms of Figure 5.8 total value of exports can be computed in Formula F5.18:

V4TOT = V4BASD_C + V4MARD_C + V4TAX_C F5.18

where V4BASD_C is the basic value of exports summed over commodities, V4MARD_C is the total margin services used by export commodities, and V4TAX_C is the sum of export taxes.

Having defined all elements of both income and expenditure, the saving by the rest of the world can be computed as:

VROWSAV = VROWINC - VROWEXP F5.19

which is simply the difference between rest of the world's income and expenditure. The corresponding equation to describe the rest of the world's saving is:

100*ROWINC*delrsav = VROWINC*wrowinc -VROWEXP*wrowexp
-(VROWINC - VROWEXP)*wrowinc E5.34

5.3.5 A Balance check for the database

As stated earlier, the model's data base also implies a budget constraint, income equals expenditure, for each agent identified in the economy. Therefore, a balanced data base implies that: (i) demand for each commodity equals its supply; (ii) expenditure (plus saving) equals income for each agent in the model; and that (iii) costs exhaust revenue for producers.

The balance of the database in the context of the SAM presented in Table 5.8 can be checked from the numbers appearing in the last column of row 10 (VSAMCHECK). The balance is achieved when VSAMCHECK is zero. It implies that the sum of saving across institutions is sufficient to finance the total investment activity undertaken by the country as shown in columns (vi) and (vii) of Figure 5.8.

To institute a built-in checking mechanism into the model, the following formula is introduced :

$$\text{VSAMCHECK} = \text{VHOUSAV\_H} + \text{VGOSSAV} + \text{VGOVSAV} - \text{VPRIVCAP} + \text{VROWSAV} \qquad \text{F5.20}$$

Note that VSAMCHECK includes only VPRIVCAP instead of the total investment (V2TOT + V6TOT). This is because the total investment also contains the investment undertaken by government. As shown in E5.27, the investment undertaken by government is counted as government spending, which implies that government saving presented in the last row of Figure 5.8 is computed after government investment is accounted for.

5.4 Incorporating rent-seeking behaviour

In the rent-seeking (RS) model elaborated in chapters 2, 3 and 4, no equation is specified to explain how gross profits – the origin of after rent-seeking profits – are generated. Within the limitation of the partial-equilibrium structure of this RS model, gross profits are always exogenously determined in all simulations. One objective of embedding the RS model into ORANI-G is to enable us to endogenise these gross profits. This will also provide a channel through which the impact of rent-seeking activity on the rest of the economy can be analysed.

ORANI-G contains equations to define and to describe how gross profits are generated. The term 'profits', however, is not used in ORANI-type models because zero pure profit is assumed in all activities. Instead, profits are recognised as a part of the value added generated by capital (Dixon *et al.*, 1982). In ORANI-RSA gross profits is defined as follows:

$$\text{PROFITS(i)} = \text{V1CAP(i)} + \text{V1LND(i)} + \text{V1OTC(i)} \qquad (i \in ind) \qquad \text{F5.21}$$

where V1CAP(i) and V1LND(i) respectively are the values added by capital and land in industry *i*. V1OTC(i) is other ticket costs[2].

From the way it is defined, it is clear that not all PROFITS(i) is taxable. It contains at least two untaxable components, namely, capital depreciation and retained earnings. Accurate information on the size of the untaxable component of profits at the industry level is often not available. A common way to estimate taxable profit in such circumstance is as follows:

[2] Notionally other cost tickets includes value added by working capital if the latter is not included elsewhere.

$$TXBPROFITS = TAXRATIO(i) \times PROFITS(i) \qquad (i \in ind) \qquad F5.22$$

where TAXRATIO(i) is an exogenously determined ratio of taxable profits to gross profits.

Having defined the taxable profits, this variable is ready to be fitted into equation E2.4 which describes the after rent-seeking profits. Then the demand side of the rent-seeking model will determine how much of these taxable profits: (i) go to government as tax revenue at a given tax rate; (ii) are used to purchase rent-seeking services in order to reduce tax payments and fines; (iii) are used to pay fines[3].

5.4.1 Labour market closure and consumption function

The supply side of the rent-seeking model will compute the required amount of resources (ordinary and privileged labour) used in the provision of rent-seeking services. Since labour supply is not explicitly modelled in ORANI-RSA, the following assumptions are adopted. In the short run, the supply of ordinary labour is assumed to be perfectly elastic and its real wage is exogenously determined. That is, there is surplus ordinary labour. For privileged labour, the opposite is assumed; namely that its supply is absolutely inelastic. With a fixed supply of privileged labour in the short run, the wage of this type of labour varies endogenously. These assumptions, together with the fixity of capital, mean that any change in the quantity of rent-seeking services produced by the service providing industry will change the employment of ordinary labour and wage of the privileged labour. As explained in the

[3] Fines are paid to the government. The RS model does not allow the fines paid in any particular year to be calculated: 'fines' here refer to an average over several years. The solution to the model is to be interpreted as referring to a 'typical' such year.

earlier section of this chapter, the income from the two types of labour are mapped to two different household types.

In the long run, employment by the three occupations (unskilled, skilled and privileged) is exogenously set to zero change. However, employment by industry is allowed to adjust endogenously. This implies that the existing labour can be re-allocated across industries following the change in trading conditions due to policy changes. Note, however, that privileged labour is specific to the service providing industry.

To provide another link between rent-seeking activity and the rest of the economy, we introduce the following consumption function:

$$w3tot(h) = f3tot(h) + f3tot\_h + wdispinc(h) \qquad E5.35$$

where w3tot(h) is nominal consumption by household h. f3tot(h) and f3tot_h are a specific and a uniform shifter of the household consumption.

Equation E5.30 implies that the change in the consumption of each household type is linked to the change in the relevant disposable income. It is important to note that the revenue generated by rent-seeking activity is mapped to households' incomes. With this structure in the model, the second round effect of rent-seeking activity can now be captured. Any change in rent-seeking activity that will affect household's incomes will also affect their consumption.

5.4.2 GDP at social cost

The question of how GDP is computed is crucial in ORANI-RSA. Similar to Bhagwati *et al.* (1984), here rent-seeking services are merely used for the purposes of redistributing output; that is to reduce the tax payments of certain agents. The production of rent-seeking services does not correspond to the production of social product. To a first approximation, it seems reasonable to value such services socially at zero. Note that resources, however, are used and wages are paid in the production of rent-seeking services. Consequently, GDP valued privately reckons them as a positive entry. There is, therefore, a wedge between the social and the private valuation of rent-seeking services[4]. Assuming that the social value of rent-seeking services is zero, we modify the existing (privately valued) GDP equation to define GDP at social cost as follows:

V0GDPSC*x0gdpsc = V0GDPEXP*x0gdpexp - RSUSE_I*p_RSUSE_I E5.36

where:

x0gdpsc is the percentage change in real GDP at social cost;

x0gdpexp is the percentage change in real GDP at private cost;

p_RSUSE_I is the percentage change in real value of rent-seeking services;

V0GDPEXP and V0GDPSC, respectively, are the initial value of GDP at private and social cost computed from the data base. RSUSE_I is the initial value of the aggregate usage of rent-seeking services. Note that V0GDPEXP is the sum of V0GDPSC and RSUSE_I.

In the same way, the GDP price index at social cost is defined as:

V0GDPSC*p0gdpsc = V0GDPEXP*p0gdexp - RSUSE_I*p_PORSSRV_I E5.37

where:

p0gdpexp is the GDP price index computed at private cost;

---

[4] Note that the distinction between private and social GDP can also be applied to many other sectors of the economy such as those involving environmental externalities and non-marketed household activities. These other sources of divergence between private and social GDP are ignored in the present study.

p0gdpsc is the GDP price index computed at social cost; and

p_PORSSRV_I is the percentage change in the price of rent-seeking services;

Using E5.36 and E5.37, the percentage change in nominal GDP at social cost can be computed as follows:

$$w0gdpsc = x0gdpsc + p0gdpsc \quad \text{E5.38}$$

Chapter VI
Integrated rent-seeking model, ORANI-RSA

6.1 Introduction

As noted earlier, ORANI-RSA is constructed by embedding the rent-seeking model and a set of mapping equations into a standard ORANI-G model. The TABLO language for the implemented model is contained in Appendix A. Naturally, when combining two working models, some adjustments need to be made. This chapter address the steps taken to adjust the rent-seeking model developed in chapters 2, 3 and 4 so that it meshes with the ORANI-G core model.

6.2 Adjustment in the notation and equations

Each variable of the rent-seeking model was represented by a very simple symbol in Chapter 4. All variables were scalars so that no subscripts representing additional dimensions were necessary. This was done for convenience in algebraic manipulations required in deriving the final form of the equations. The main model (ORANI-G *plus* the mapping equations), on the other hand, uses a multiple-letter type of notation for variables with a number of running indices necessitated by the variables' dimensions. In embedding the rent-seeking sub-model into the main model, the former's notation and dimensions are adjusted to follow the conventions in the main model.

In chapter 4, although a number of firms demanded rent-seeking services, since there were no feedbacks from the behaviour of one firm onto the operating environment of other firms, the solution for each firm could be computed separately. In ORANI-RSA, however, this assumption is no longer valid, and the solutions for all agents must be computed simultaneously. Table 6.1 presents the rent-seeking sub-model in the old as well as in the new notation. All equations identified by (a) at the end of its identifier are the original equations taken from Table 4.1 in Chapter 4, while those identified by (b) are the same equation in the new notation and with new dimensions. The concordance of the variables and the parameters is presented in Tables 6.2 and 6.3.

Note that not all original equations of the sub-model need to be incorporated into the main model because the same type of equation may already exist in the main model. In the case of the 'ordinary' industries, the demand for labour, pricing and market clearing are cases in point (see E6.16-20). In the case of equations defining aggregates, of course, the existing equation in the main model must be modified to incorporate the new entities added in the sub-model.

All the supply-side equations of the rent-seeking model already exist in general form in the main model. All the supply side equations of the rent-seeking model exist in general form in the main model. The latter allows for the possibility that any or all industries produce more than one product. In ORANI-RSA, the service providing industry therefore can be accommodated by assigning the appropriate parameters to the special case in which the industry maker i takes the value "SrvPrv". In term of ORANI-RSA TABLO code (Appendix A), this is in fact the only element of the industry subset GOVIND and is the only multi-product industry. The commodities produced by this industry, legitimate public service "PubSrv" and rent-seekinf services "RsSrv", are the only elements of the commodity subset GOVCOM.

To illustrate how the equation in the sub-model fits the existing equation in the main model, we reprint the percentage-change form of the CET supply equation for commodities by industries in the main model:

q1(c,i) = x1tot(i) - SIGMAOUT(i)*[p0com(c) - p1tot(i)]   E6.14'

where:

q1(c,i) is supply of commodity c by industry i;

x1tot(i) is activity level of industry i;

p0com(c) is the basic price of domestic commodity c;

p1tot(i) is average price received for its output by industry i, defined as follows:

MAKE_C(i)*p1tot(i) = sum(c, COM, MAKE(c,i)*p0com(c))   E6.14''

where: MAKE(c,i) is a coefficient representing the share of commodities produced by industries. Apart from the column involving i = "SrvPrv", and the rows involving c = "RsSrv" and c = "pubSrv", there is a 1:1 correspondence between industries and commodities, and this part of MAKE matrix is diagonal. The above supply equation E6.14' thus implies that for all industries other than service providing (the only multi-product industry in ORANI-RSA) q1(i) = x1tot(i). This is because p1tot(i) = p0com(i) as implied by the value of coefficients in the MAKE matrix.

For the service providing industry, the change in its activity level is determined as an aggregate of the changes in the supply of both rent-seeking services and legitimate public services. The composition of its output is determined by the relative price of both commodities produced by the sector as shown in Equation E6.14'. The input demand equations, such as the use of labour (and capital) by the service providing industry, match the equations in the main model in a similar way. For example, the share of privileged labour in the wage bill of ordinary industries is zero.

As shown in Table 6.2, all equations involving the demand side for rent-seeking services are written in levels form (in capital letters), while the corresponding equations in the supply side are in percentage change form (in lower-case letter). This choice was made because the mathematics of the supply side is very standard in the ORANI literature, where such equations have traditionally been written in percentage change form. The decision to keep the levels form for the demand side was prompted by the release of GEMPACK 5.2[1], in which the TABLO language allows a mixture of percentage change and levels representations.

In the mixed TABLO approach, although some of the equations are written in levels form, Gempack linearises them automatically. Since the results are the same whether the model is written in linear, levels or in mixed form, this approach is often more convenient and prevents unnecessary errors that may occur in deriving the percentage-change form of complex expressions.

[1]Harrison and Pearson (1993) GEMPACK user documentation Vol. 1, section 3-43. See also [1]Harrison and Pearson (1996) and Harrison *et al.*(1994).

Table 6.1 Modified equations of the rent-seeking model*

Identifier	Equations	Number	Description
Demand side			
(E6.1a)	$Q_H = H/P_H$		Real profits
(E6.1b)	*Already covered in the main model*		
(E6.2a)	$\Pi(0) = H - T$		After-tax profit with no rent-seeking activity
(E6.2b)	NORSGOS = TXBGOS - TAXLIAB	R	
(E6.3a)	$T = tH$		Tax liabilities
(E6.3b)	TAXLIAB = TAXRATE*TXBGOS	R	
(E6.4a)	$E(\Pi(Z_D)) = H - B(Z_D)\,T - M(Z_D) - J(R)\,G$		After-tax profit with rent-seeking activity
(E6.4b)	RSGOS = TXBGOS - (TAXQUOT*TAXLIAB) - WRSUSE - (PFINED*VFINE)	R	
(E6.5a)	$B = \theta_1 + \dfrac{(1-\theta_1)(1 + A)}{1 + Ae^{\gamma L_B}}$		Effective tax quotient by industry
(E6.5b)	TAXQUOT = TQFL + [(1-TQFL)*(1+TQPAR)]/ 1+TQPAR*$e^{(TQCOEF*LOFTQ)}$	R	
(E6.6a)	$L_B = \varepsilon_B Z_D + (1 - \varepsilon_B)(Z_D/H)$		Normalized RS input by industry
(E6.6b)	LOFTQ = E1TQ*XRSUSE + (1-E1TQ)*(XRSUSE/ TXBGOS)	R	
(E6.7a)	$M = P_Z Z_D$		Value of rent-seeking services used by industry
(E6.7b)	WRUSE = PORS*XRSUSE	R	
(E6.8a)	$J = \theta_2 + \dfrac{(1-\theta_2)(1 + Q)}{1 + Qe^{\alpha L_J}}$		Industry's probability of incurring fine
(E6.8b)	PFINED = PFFL +[(1-PFFL)*(1+PFPAR)]/ 1+PFPAR*$e^{(PFCOEF*LOFPF)}$	R	

...*continued*

Table 6.1 *Continued*

Identifier	Equations	Number	Description
(E6.9a)	$L_J = \varepsilon_J R + (1 - \varepsilon_J)(R/H)$		Normalized political influence by industry
(E6.9b)	LOFPF = E1PF*POLINF + (1-E1PF)*(POLINF/ TXBGOS)	R	
(E6.10a)	$G = gT$		Nominal fine for tax evasion by industry
(E6.10b)	VFINE = FINEMP*TAXLIAB	R	
(E6.11a)	$R = Z_D/\delta$		Stock of political influence by industry
(E6.11b)	POLINF = XRSUSE/POLDPRC	R	
(E4.12a)	$P_Z = \dfrac{\gamma(1-\theta_1)B^2Ae^{\gamma L_B}}{(1-\theta_1)(1+A)}(T/H) + \dfrac{\alpha(1-\theta_2)J^2Qe^{\alpha L_J}}{(1-\theta_2)(1+Q)\,\delta}(G/H)$	R	First-order condition for optimal use of rent-seeking services
(E6.12b)	P0RS = BIT1*BIT2 + BIT3*BIT4	R	
where	BIT1 = {TQCOEF*[(1-TQFL)*TAXQUOT^2]* TQPAR*e$^{(TQCODF*LOFTQ)}$}/ (1-TQFL)(1+TQPAR)		
	BIT2 = TAXLIAB*TXBGOS		
	BIT3 = {PFCOEF*[(1-PFFL)*PFINED^2]* PFPAR*e$^{(PFCODF*LOFPF)}$}/ (1-PFFL)(1+TQPAR)*POLDPRC		
	BIT4 = VFINE/TXBGOS		
Supply side			
(E6.13a)	$Z_s = S_G\,[(\mu P_Z)/(\beta P_G)]^{\tau}$		Aggregate supply of rent-seeking services
(E6.13b)	[*Already covered in the main model*	R	*Total output of commodities*
(E6.14a)	$N_T = \Lambda\,[\mu S_G^{-\rho} + \beta Z_S^{-\rho}]^{-1/\rho}$	I	Service providers' aggregate production capacity
(E6.14b)	[*Already covered in the main model*	R	*Supply of commodities by industries*

...continued

Table 6.1 *Continued*

Identifier	Equations	Number	Description
(E6.15a)	$P_N = 1/\Lambda[\mu^{\tau} P_G^{\rho\tau} + \beta^{\tau} P_Z^{\rho\tau}]^{1/\rho\tau}$	I	Unit revenue of from service provision
(E6.15b)	[*Already covered in the main model*	R	*Aggregate price received by industries*
(E6.16a)	$N_P = \Omega[\kappa L_1^{-\lambda} + \nu L_2^{-\lambda}]$	I	Aggregate input used by service providers
	[*Already covered in the main model*	R	*Aggregate labour input of ordinary industries*]
(E6.17a)	$C_P = 1/\Omega[\kappa^{\phi} P_1^{\lambda\phi} + \nu^{\phi} P_2^{\lambda\phi}]^{1/\lambda\phi}$	I	Unit cost of inputs to service provision
(E6.18a)	$P_N = C_N$	I	Zero pure profits for service providing industry
	[*Already covered in the main model*	R	*Zero pure profits for ordinary industries*]
(E6.19a)	$N_P = N_T$	I	Input-Output identity
	Already covered in the main model		
Market clearing			
(E6.20a)	$Z_D = Z_S$	I	Market clearing for RS
	[*Already covered in the main model*	R	*Market clearing for ordinary industries*]

(a) The original equations taken from Table 4.1 in Chapter 4.
(b) The equations used in the integrated model. R is the number of ordinary industries using rent-seeking services.
* Every variable, coefficient and parameter denoted by an alpha numeric mnemonic (e.g., NPROFIT,XRUSE) and appearing in the integrated model (i.e. in equations carrying the (b) subscript), carries an industry subscript which has been suppressed here for legibility.

Table 6.2 Concordance of notations for the variables of the rent-seeking model

Equations	Variables in Ch. 4	Variables in integrated model	Number	Description
Demand side				
(E6.1,4,6,9,12,14)	H	TXBGOS	R	Nominal before-tax profit by industry
	P_H	*not required*		Price of profits
(E6.2)	$\Pi(0)$	NORSGOS	R	After-tax nominal value of profit with no RS by industry
	Q_H	*not required*		Before-tax real profits
(E6.3,4)	T	TAXLIAB	R	Tax liability by industry
(E6.3)	t	TAXRATE	R	Official tax rate (proportion) paid by industry
(E6.4)	$E(\Pi(Z_D))$	RSGOS	R	Expected after-tax nominal value of profit with RS by industry
(E6.6,7,11,20)	Z_D	XRSUSE	R	Rent-seeking services demanded by industry
(E6.5,12)	B	TAXQUOT	R	Effective tax quotient by industry
(E6.4,7)	M	WRSUSE	R	Value of RS services used by industry
(E6.7,12)	P_Z	P0RSSRV	R	Price of rent-seeking services paid by industry
(E6.8,12)	J	PFINED	R	Probability of the industry incurring fine
(E6.4,12)	G	VFINE	R	Nominal fine paid by industry for tax evasion
(E6.10)	g	FINEMP	R	Fine multiplier – the multiple of the original tax liability that must be paid as a fine
(E6.9,11)	R	POLINF	R	Stock of political influence by industry
(E6.5,6)	L_B	LOFTQ	R	Normalized RS input by industry
(E6.8,9)	L_J	LOFPF	R	Normalized political influence by industry
Supply side				
(E6.13,14,20)	Z_S	q1("RsSrv")	1	Percentage change in the supply of RS
(E6.14)	N_T	x1tot("SrvPrv")	1	Service providers' aggregate production capacity

...continued

Table 6.2 *Continued*

Equations	Variables' in Ch. 4	Variables' in integrated model	Number	Description
(E6.13,14)	S_G	q1("PubSrv")	1	Output of legitimate public services
(E6.16,19)	N_P	x1lab("SrvPrv")	1	Aggregate input use by service providers
(E6.15,18)	P_N	p1tot_o("SrvPrv")	1	Unit price of capacity in service providing
(E6.13,15)	P_G	p0com("SrvPrv")	1	Price of legitimate public services
(E6.17)	C_P	p1lab_o("SrvPrv")	1	Unit cost of labour in service providing
(E6.16)	L_1	x1lab("ord","SrvPrv")	1	Ordinary labour used by service providing
(E6.16)	L_2	x1lab("Prv","SrvPrv")	1	Privileged labour used by service providing
(E6.17)	P_1	p1lab("Ord","SrvPrv")	1	Hourly wage of ordinary labour used by service providing
(E6.17)	P_2	x1lab("Prv","SrvPrv")	1	Hourly wage of privileged labour used by service providing

Table 6.3 Nomenclature for parameters of the rent-seeking model

Equations	Parameters' in Ch.4	Parameters' in integrated model	Number	Description
Demand side				
(E6.4,12)	A	TQPAR	R	Designed to be = 1
	γ	TQCOEF	R	Technological coefficient for 'efficiency' of firms in reducing tax quotient
	θ_1	TQFL	R	Minimum tax quotient (the floor for B)
(E6.8,12)	Q	PFPAR	R	Designed to be = 1
	α	PFCOEF	R	Technological coefficient for 'efficiency' of firms in reducing probability of being fined
	θ_2	PFFL	R	Minimum probability of being fined (the floor for J)
(E6.11,12)	δ	POLDPRC	R	Depreciation rate of the stock of political influence
(E6.6)	ε_B	E1TQ	R	Parameter used to normalise RS input
(E6.9)	ε_J	E1PF	R	Parameter used to normalise political influence
Supply side				
(E6.10,11,12)	μ	MAKE_I("PubSrv")	I	Distribution parameter for legitimate public services
(E6.10,11,12)	β	MAKE_I("RsSrv")	I	Distribution parameter for rent-seeking services supplied
(E6.10,12)	τ	OUTPUTSIGMA	I	Transformation elasticity between legitimate public services and RS services
(E6.11,12)	ρ	ρ = -(1 - 1/OUTPUTSIGMA)	I	Exponent in CET function

...continued

Table 6.3 *Continued*

Equations	Parameters' Old name	Parameters' new name	Number	Description
(E6.11,12)	Λ	a1prim("SrvPrv")	1	General productivity (Hicks neutral) coefficient in production of aggregate capacity in service providing sector
(E6.16,17)	κ	V1LAB("Ord", "SrvPrv")	1	Distribution parameter for ordinary labour input
(E6.16,17)	ν	V1LAB("Prv", "SrvPrv")	1	Distribution parameter for privileged labour input
(E6.17)	ϕ	SIGMALAB("SrvPrv")	1	Substitution elasticity between unskilled, skilled and privileged labour
(E6.16,17)	λ	$\lambda = -(1 - 1/\phi)$	1	Exponent in CES function
(E6.16,17)	Ω	a1lab("SrvPrv")	1	General productivity (Hicks neutral) coefficient in technology of service providing sector

Chapter VII
The ORANI-RSA Database

7.1 Introduction

The theoretical structure of the ORANI-RSA model was outlined in the earlier chapters. The model extends ORANI-G to include: (i) a more complete income mapping from value added to incomes, expenditure and saving of the agents recognized in ORANI-RSA; and (ii) rent-seeking activity which reduces taxes paid on profits but which involves payments to the provider of rent-seeking services. ORANI-G uses a standard input-output database, from which a large number of coefficients are calculated, and some parameters which usually are estimated empirically. The first extension introduced to ORANI-G requires additional data from a social accounting matrix (SAM), which is essentially a superset of an input-output table. The second extension (introducing rent-seeking activity) requires new share coefficients and behavioural parameters that previously did not exist in the standard ORANI-G database.

In assembling additional data for the rent-seeking part of the model we are faced with two main problems: (i) the standard SAM of any country does not explicitly account for the type of rent-seeking activity modelled in the previous chapters; (ii) the required parameters cannot be estimated due to data unavailibility. In general equilibrium modelling, the standard way of overcoming such problems is by using a 'best guess' value collected from the existing literature. Unfortunately, however, although a number of studies have tried to estimate the size of rent-seeking activity in the economy (Krueger, 1974), the concept is applied in a framework different from this study. It does not seem practicable, therefore, to calibrate our model to any known empirical estimates of the behavioural parameters involved in rent-seeking activity. Therefore, we choose to proceed by using a hypothetical database. This chapter outlines how the ORANI-RSA hypothetical database is constructed.

7.2 The hypothetical database

The simplest way of constructing a plausible hypothetical database is by modifying one that is constructed from real data. The hypothetical database used to run ORANI-RSA is constructed from a balanced South African social accounting matrix obtained from Mark Horridge. Originally this database was used for the IDC-GEM model (Horridge *et. al* 1994). In its original form, it has a very detailed dimension with 103 sectors, 10 household types, 5 racial groups and 4 occupations, *plus* regional disaggregation. For the purpose of this study a simpler version is considered sufficient. The following changes are introduced to reduce the dimensions of the existing SAM:

(i) regional disaggregation is deleted;

(ii) racial disaggregation is eliminated;

(iii) the number of occupations is reduced to just three – unskilled, skilled and privileged labour;

(iv) the number of household types is reduced from five to two;

(v) the number of commodities is reduced to seven;

(vi) the number of industries is reduced to six.

The shares in value added of primary factors in the original database were considered not representative of a typical country where the rent-seeking theory developed in the earlier chapters is appropriate. Before the aggregations on commodities and industries were carried out, a series of shocks was implemented to the original database to form a new one with factor proportions and trade shares considered more appropriate for a typical developing country prone to rent-seeking.

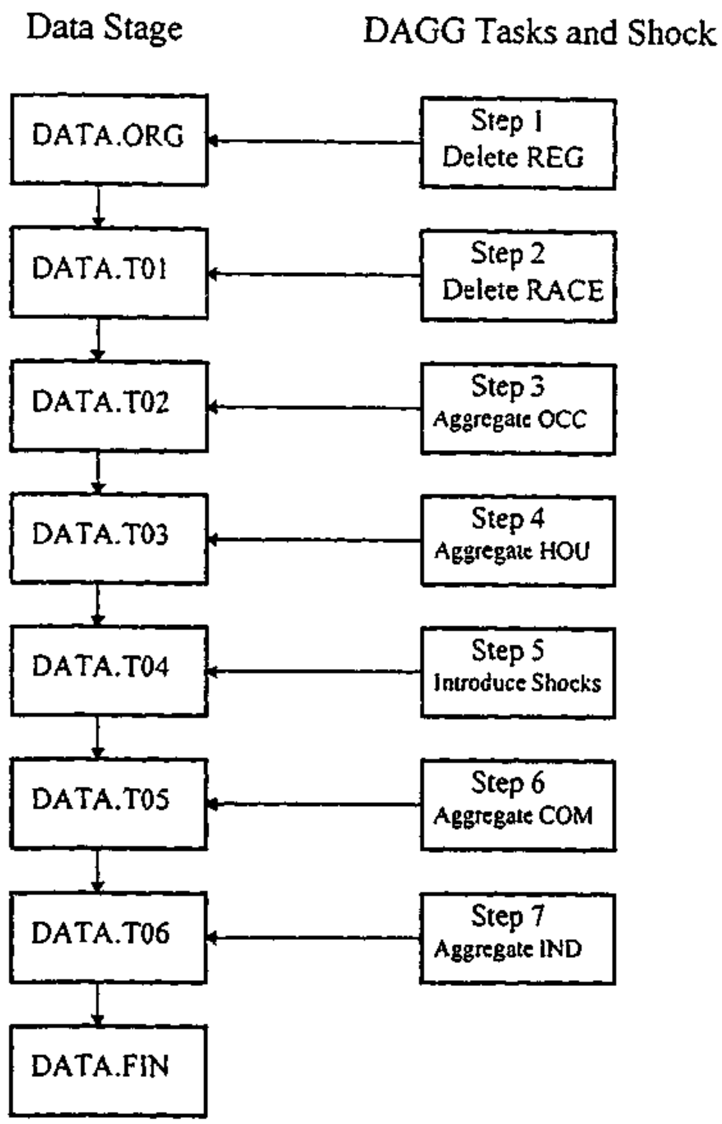

Figure 7.1 Summary of ORANI-RSA's database construction

The task of simplifying the dimensions of the original database is completed by using DAGG[1]. A summary of the steps taken in transforming the IDCGEM database (DATA.ORG) into the ORANI-RSA database (DATA.FIN) is presented in Figure 6.1. Task (i) is completed by eliminating the regional dimension from all relevant matrices in the original database (DATA.ORG). This task creates a temporary database without regional dimension, DATA.T01. The next task is completed by eliminating the race dimension from DATA.T01 to create another temporary database DATA.T02, which is a smaller header array file without the race dimension. The aggregation of occupations (OCC) is implemented on DATA.T02, producing DATA.T03 with a smaller number of occupations. The next step aggregates the number of household types from five in DATA.T03 to two in DATA.T04.

As noted above, before aggregating commodities and industries, the structure of the original database needs to be adjusted. On looking at the shares of value added by primary factors (V1CAP, V1LAB and V1LND), it is found that in aggregate the share of labour is much larger than that of capital. The ratio of the value added by labour to that of capital (V1LAB_IO/ V1CAP_I) is 1.626, which implies that value added by labour exceeds that of capital by 62.6 percent. These characteristics of the database are not typical of the countries for which the theoretical structure of rent-seeking activity outlined in the previous chapters was developed. A common characteristic of such a country with extensive rent-seeking activity is a larger share of capital in value added. A reasonable value for the ratio of value added by labour to that added by capital for such a country is around 0.6 to 0.8 (that is, value added by labour should be about 60 to 80 percent of value added by capital). In the context of ORANI-RSA, the larger the size of value added by capital ('profits'), the larger will be the impact of rent-seeking activity on the rest of the economy.

To make the database a better proxy for a country with extensive rent-seeking activity, when using ORANI-G with a complete income mapping, we introduce a series of shocks to DATA.T04 to reverse the ratio of labour to capital value added

[1] DAGG is a FORTRAN program wrtten by Mark Horridge. It is designed to perform various data operations, such as aggregating, disaggregating, remapping and other tasks, on header array data files.

from 1.626 in the original database (DATA.ORG) to around 0.6 in the final database (DATA.FIN).

To implement the above shock efficiently, first a 'twist' variable representing a cost-neutral technical change is introduced (see Dixon *et al.* , 1998, p. 243). This variable (twistlab) appears in the equations describing the demand for primary factors in the model's TABLO file; it is interpreted as the percentage change in the ratio of labour to capital. The equations now become:

$$\begin{aligned} \text{x1lab\_o}(i) - \text{a1lab\_o}(i) - \text{a1lab\_io} = {} & \text{x1prim}(i) - \text{SIGMA1PRIM}(i)*\{\text{p1lab\_o}(i) \\ & + \text{a1lab\_o}(i) + \text{a1lab\_io} - \text{p1prim}(i)\} \\ & + \{1 - \text{LABSHR}(i)\}*\text{twistlab} \\ & (i \in \text{IND}) \qquad \text{E6.1} \end{aligned}$$

$$\begin{aligned} \text{x1cap}(i) - \text{a1cap}(i) = {} & \text{x1prim}(i) - \text{SIGMA1PRIM}(i)*\{\text{p1cap}(i) + \text{a1cap}(i) \\ & - \text{p1prim}(i)\} - \text{LABSHR}(i)*\text{twistlab} \qquad (i \in \text{IND}) \quad \text{E6.2} \end{aligned}$$

$$\begin{aligned} \text{x1lnd}(i) - \text{a1lnd}(i) = {} & \text{x1prim}(i) - \text{SIGMA1PRIM}(i)*\{\text{p1lnd}(i) + \text{a1lnd}(i) \\ & - \text{p1prim}(i)\} - \text{LABSHR}(i)*\text{twistlab} \qquad (i \in \text{IND}) \quad \text{E6.3} \end{aligned}$$

where:

x1prim and p1prim(i) are, respectively, the percentage changes in quantity and in the price of primary factors (in general) in industry i;

x1lab_o(i), x1cap(i) and x1lnd(i) are the percentage changes in the demand for labour, capital and land in industry i;

a1lab_o(i), a1cap(i) and a1lnd(i) are labour–, capital– and land–augmenting technical changes in industry i;

$p1lab\_o(i)$, $p1cap(i)$ and $p1lnd(i)$ respectively are the percentage changes in the wage of labour, and in the rental prices of capital and land in industry i; and $LABSHR(i) = V1LAB\_O(i)/(TINY+V1PRIM(i))$ is the share of labour in total value added by primary factors in industry i[2].

To change the capital intensity of the economy represented by the database, the variable twistlab is exogenously set to an appropriate value. In implementing the shock, all primary factor prices – namely, labour wages by occupations (p1lab_i(o)), and land and capital rentals by industries (p1cap(i)) and (p1lnd(i)) – are exogenously fixed. The same is true for all augmenting technical change variables. Assume that all the above exogenous variables are set to zero change; then Equations E6.1-2 can be reduced to:

$$x1lab\_o(i) = x1prim(i) + SIGMA1PRIM(i)*p1prim(i) - \{1 - LABSHR(i)\}*twistlab \quad (i \in IND) \qquad E6.1'$$

$$x1cap(i) = x1prim(i) + SIGMA1PRIM(i)*p1prim(i) + LABSHR(i)*twistlab \quad (i \in IND) \qquad E6.2'$$

Subtracting E6.1' from E6.2', it can seen that twistlab essentially is:

$$twistlab = x1lab\_o(i) - x1cap(i) \quad (i \in IND) \qquad E6.4$$

Given labour's wage and the rental price of capital are fixed in nominal terms, a change in the quantity ratio of labour to capital implies a change in the composition of nominal value added. E6.4, therefore, implies that a negative shock on twistlab(i) will reduce the labour/capital ratio and hence will reduce the ratio of nominal value added by labour to that by capital. More complete implications of the above assumptions are summarised in Figure 6.2. All variables that are exogenous and endogenous for the purpose of creating our new database are depicted in rectangles and ovals, respectively. The direction of causation is indicated by the arrows.

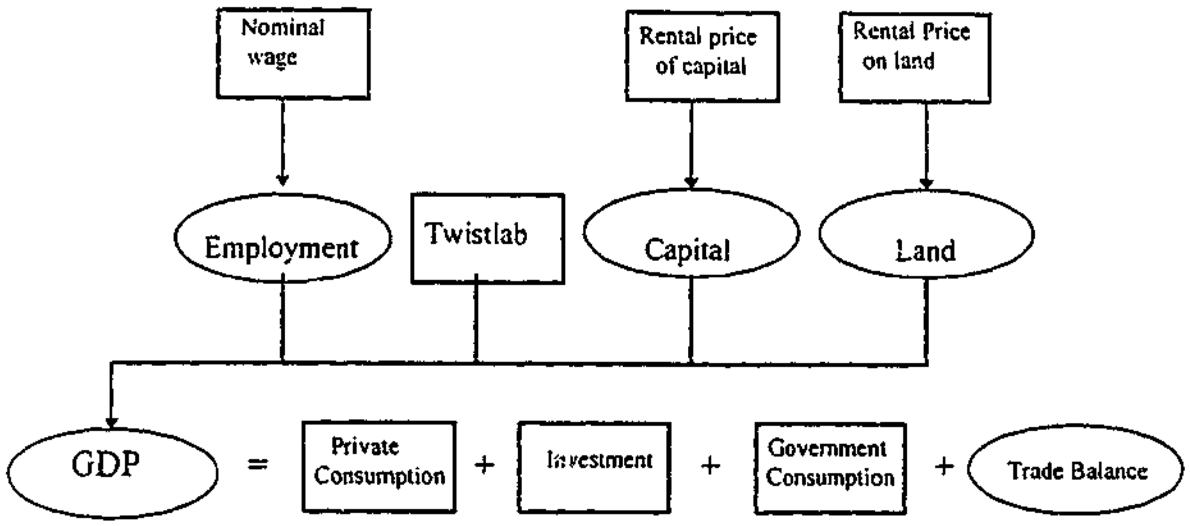

Figure 7.2 The macroeconomic environment assumed for calibration

To achieve a targeted ratio of nominal value added of 0.6, for example, the labour/capital ratio would need to be shocked by approximately -63.1 percent (which is computed from 1.626 (1 + twistlab/100) = 0.6; yielding twistlab = -63.1).

Since domestic absorption (aggregate private (households') consumption + investments + government demand) is also exogenously determined (see Figure 6.2), it is clear that the shock on the supply side (twistlab) will be fully absorbed by the endogenous adjustment of the trade balance to satisfy the GDP identity. If the shock increases (reduces) GDP, the balance of trade must adjust toward surplus (deficit). In

[2] The term TINY represents a very small arbitrary number whose role is to preclude division by zero if it should turn out that V1PRIM(i) is zero in some database for some i.

this exercise, the balance of trade moves slightly toward surplus[3]. The size of the change in the balance of trade, however, does not warrant any further shocks to adjust the demand side.

After reaching the appropriate composition of value added, the commodities and industries were aggregated to form an initial database DATA.FIN. Seven commodities and six industries are considered sufficient for the purpose of this study and they are shown in Table 7.1. Aside from changing the composition of value added, the shocks introduced into the original database also changed the tradeability status of some commodities. As well, some formerly capital-intensive commodities are now found in the list of exported commodities.

After completing the aggregation, two more data corrections are needed to before DATA.FIN is ready to be used in ORAN-IRSA. First, all of the commodity initially produced by the public sector industry in the original data base is counted in the new data base as output of commodity PubSrv by the service providing industry (SrvPrv). The data for this industry's other output, RsSrv, is hypothetical, being generated by the sum over using industries of the demands for it generated by the rent-seeking sub-model (discussed in section 7.3 below). Data in the rest of the RsSrv row, V1MAR, V1TAX and V2-V6BAS, is replaced by zero, since it is assumed in the model that the rent-seeking services commodity (RsSrv) is used only 'in production'[4], is not taxable, and requires no margins.

[3] The trade balance records a surplus of 0.13 percent of GDP.

[4] RsSrv is not a conventional input to production; none of it is required to produce commodities. It is an input, however, to the production of after-tax rentals of capital.

Table 7.1 Commodity and industry classification

Commodity/Industry Name	Commodity/Industry Subscript	Description
COM(c)	TrdExpse, ExpOrnt, ImpOrnt, NonTrad, Margins, PubSrv, RsSrv	*Types of commodities:* TrdExpse is the aggregate of commodities where both imports and exports individually exceed twenty percent of the total supplies of such (Armington composite) commodities. ExpOrnt is the aggregate of commodities where exports represent more than 15 percent of total supply of such (composite) commodities. ImpOrnt is the aggregate of commodities where imports represent more than 15 of total supply of such (composite) commodities. NonTrad is the aggregate of commodities where both imports and exports individually are less than 15 percent of the total supplies of such (Armington composite) commodities Margins is the aggregate of the domestically produced commodities used for margins PubSrv is legitimate public services provided by the service providing sector RsSrv is rent-seeking services provided by the service providing sector.
IND(i)	TrdExpse, ExpOrnt, ImpOrnt, NonTrad, Margins, ServPrv	*Types of Industries:* TrdExpse is the aggregate of industries production TrdExpse commodities ExpOrnt is the aggregate of industries producing ExpOrnt commodities ImpOrnt is the aggregate of industries producing ImpOrnt commodities NonTrad is the aggregate of industries producing NonTrad commodities Margins is the aggregate of the industries producing margins services ServPrv is the aggregate of industries producing both legitimate public goods and rent-seeking services

The inclusion of the hypothetical data, however, would disturb the balance the database – that is: (a) cost would no longer equal sales; and (b) GDP from the income side would no longer equal GDP from the expenditure side. In particular, adding the new values to V1BAS ("RsSrv") changes the cost for each industry, but changes the sales of only one industry (SrvPrv).

To avoid this problem, an amount matching the value entered for V1BAS ("RsSrv") for each industry is taken from its V1LAB counterparts. In this way, although the change will slightly alter the ratio of labour to capital cost, it does not disturb the cost side of the database. The sales side of industry SrvPrv and GDP from income side, however, are now off balance by as much as the newly added value for V1BAS ("RsSrv"). Although we seem to have more problems, both can be corrected simultaneously simply by reducing government consumption on PubSrv (V5BAS) by as much as V1BAS ("RsSrv").

Second, after completing aggregation, we found that the entries in V1BAS ("PubSrv"), V2BAS ("PubSrv") and V3BAS ("PubSrv") are not zero. This violates the convention in ORANI-type models, where public services are entirely purchased by government (that is, they should all appear in V5BAS). To correct this problem, the entries in V2BAS ("PubSrv") and V3BAS are moved to V5BAS.

In the case of V1BAS the cost totals for industries will be preserved if the unwanted (but relatively small) intermediate sales of public services to industries are arbitrarily reclassified as sales of other commodities. Thus intermediate sales of public services, V1BAS("PubSrv"), to industries 1 through 6, were reclassified as sales of commodities 1 through 6 respectively, thus adding to the total sales of each of these commodities. To restore the balances of sales with cost, sales from stocks of each commodity were reduced by an offsetting amount. Stocks were then reduced to zero by running a simulation using the complete ORANI-RSA, in which the change in each stock was shocked by the respective negative of its total size. .

The main features of the final database DATA.FIN is presented in Tables 7.2 and 7.3.

Table 7.2
The cost shares of inputs in industries

Cost shr / Industry	IntDom (1)	IntImp (2)	Margin (3)	Ind Tax (4)	Lab (5)	Cap (6)	Lnd (7)	Prod Tax (8)	Total (9)
TrdExpse	43.68	8.69	2.78	0.18	9.59	31.25	3.83	0.00	100
ExpOrnt	39.07	6.74	2.98	1.87	11.64	34.39	3.31	0.00	100
ImpOrnt	42.57	12.24	3.26	0.65	11.04	30.23	0.00	0.00	100
NonTrad	46.33	7.45	3.28	2.69	12.77	26.52	0.96	0.00	100
Margins	38.21	4.45	2.00	1.95	17.37	36.01	0.00	0.00	100
SrvPrv	33.28	5.49	1.64	2.49	48.46	8.64	0.00	0.00	100

Table 7.3
The sales shares of commodities

Sales Shr / Commodities	Interm (1)	Invest (2)	HouseH (3)	Export (4)	GovGE (5)	Stocks (6)	Margins (7)	Total (8)
1 TrdExpse	33.22	0.28	3.74	62.75	0.00	0.00	0.00	100
2 ExpOrnt	41.83	0.24	3.85	54.08	0.00	0.00	0.00	100
3 ImpOrnt	59.14	12.31	19.34	9.20	0.00	0.00	0.00	100
4 NonTrad	54.24	10.99	31.22	3.55	0.00	0.00	0.00	100
5 Margins	18.90	0.00	17.14	3.31	0.00	0.00	60.65	100
6 PubSrv	0.00	0.00	0.00	0.00	100.00	0.00	0.00	100
7 RsSrv	100.00	0.00	0.00	0.00	0.00	0.00	0.00	100

From the industry's cost structure (Table 7.2), it can be seen that all industries spend more on domestically produced intermediate inputs (1) than on the corresponding imported commodities (2). Intermediate inputs are the largest component of costs for all industries except the service providing industry. Except for the service providing industry (SrvPrv) (which spends 48 percent of its total cost on labour), all industries spend more on capital than on labour. Other items of cost, such us imported intermediate inputs (2), indirect taxes (4) and production taxes (8), do not have a large share in costs (in fact, the last mentioned is zero).

As regards to sales, the first two commodities (trade exposed and export oriented), export 63 and 54 percent of their outputs, respectively. From their export shares, it may not seem reasonable to disaggregate these two commodities in this way. However, the share of imports in the sales of the trade exposed commodity is much higher than for the export oriented commodity. Moreover, by disaggragating these two export commodities, we can assign different export elasticities to represent their respective roles in the formation of prices in the world market.

Both import oriented and non-traded goods are sold more than 50 percent to intermediate inputs. Households consume, respectively, 31.22 and 19.34 percent of the sales of non-traded and import oriented commodities. Public services are entirely purchased by the government (5) and rent-seeking services are entirely used in 'production' (1) — see footnote 4 above.

7.3 The database for the rent-seeking sub-model

Unlike the initial (levels) solution for the modified ORANI-G, the initial solution for the rent-seeking extension is not taken from the SAM. The only coefficient (or initial value for a variable in a levels equation) derived from the SAM is the value of taxable profits (see Formula F5.21 in Chapter 5). As outlined in Chapter 2, given the value of taxable profits and the values of other exogenous variables, the rent-seeking sub-model can be used to solve for all its endogenous variables, provided estimates of the behavioural parameters are available. (The later are discussed are discussed in section 7.4 below).

The initial solution for calibration purposes was generated by using *Solver* in Microsoft Excel 5.1 (Table 7.4).

Table 7.4
The initial solution for the demand side of ORANI-RSA rent-seeking extension

Industries / *Vatiables*	*TrdExpse (1)*	*ExpOrnt (2)*	*ImpOrnt (3)*	*NonTrad (4)*	*Margins (5)*
*POLDPRC**	0.20	0.20	0.10	0.20	0.10
*TQCOEF**	25.00	25.00	50.00	40.00	35.00
*PFCOEF**	25.00	25.00	50.00	40.00	35.00
*TAXRATE**	0.50	0.50	0.50	0.50	0.50
*FINEMP **	2.00	2.00	2.00	2.00	2.00
RSGOS	4190.93	14413.59	12444.30	36983.93	17365.89
PFINED	0.10	0.10	0.10	0.10	0.10
TAXQUOT	0.28	0.28	0.24	0.25	0.26
LOFTQ	0.12	0.12	0.07	0.09	0.09
LOFPF	0.58	0.58	0.73	0.43	0.93
*PORSSRV**	1.00	1.00	1.00	1.00	1.00
V1BAS(RsSrv)	753.61	2191.68	1280.80	4561.66	2385.72

Note: * indicates an exogenous variable, the rest are endogenous.
See Table 6.2 for description of each variable.

First, all equations on the demand side of the sub-model are encoded into Excel. Then an objective function is defined as the sum (over equations) of squared differences between the right- and the left-hand sides of the equations. Given the assumed values of exogenous variables and the parameters, Excel can give the values for endogenous variables. The above procedure, however, produces the solution for only one industry at a time. To produce the complete set of data for five industries assumed to engage in rent-seeking activity, the procedure is repeated five times. The values of exogenous variables are adjusted in each run, to reflect the assumption made for each industry. For example, the values of TQCOEF and PFCOEF imply that the import oriented industry (3) is much more productive in using rent-seeking services to avoid tax as is the export oriented industry (1). The stock of political influence of the trade exposed industry depreciates twice as fast as that of the export oriented industry.

As explained in chapter 6, essentially all equations of the supply side of rent-seeking services have their counterparts in the main model ORANI-G (before its integration). Two adjustments, however, have been implemented. First, in ORANI-RSA, privileged labour appears as a new occupation. Second, eventhough the sub-model of rent-seeking developed in Chapters 2-4 did not include capital among the primary factors used by the service providing sector, it is assumed in the integrated model ORANI-RSA that this sector also uses capital. This concords with the fact that, in the main model, the public services sector uses capital in producing the public service commodity.

The initial solution for all variables on the supply side, except for privileged labour, is already in the data base DATA.FIN. The value for the privileged labour V1LAB("PrvLab") is created by reallocating some value from skilled labour

V1LAB("Skl"), thus preserving the total of V1LAB. To obtain the initial employment by occupation, the wage rate of unskilled labour is assumed to be one third and one sixth of that received by skilled and privileged labour, respectively. The base-case solution for all variables in the supply side is presented in table 7.5.

Table 7.5
The initial solution for the supply side of ORANI-RSA rent-seeking extension

Variable	*Value*
PubSrv	69,949.90
PERSON("UnSkl")	13,963
PERSON("Skl")	5,454
PERSON("PrvLab")	1,607

7.4 The value assigned to the parameters of ORANI-RSA

All parameters required in implementing ORANI-RSA are listed in Table 7.6. Their values are drawn from the existing literature of computable general equilibrium models (CGE) for developing countries (Vincent, 1986; Bandara, 1989; Navqi, 1994; Buetre, 1996). This literature suggests that the value of the substitution elasticity between primary factors centers around 0.5. The same values has been assigned for substitution between skill categories. In this study, we are also interested in conducting long-run simulations. A larger value (1) is assigned for this purpose.

As regards to the elasticity of substitution between imported and domestic goods, the rule of thumb suggested by the literature would put relatively small numbers (0.5, say) for competition between the two sources of capital goods; intermediate values for domestic/import competition in the case of material inputs to current production (1.0, say); and relatively large values for competition between domestic and imported consumer goods (5.0, say). In ORANI-RSA, public services, margins and rent-seeking services are not substitutable for imports; therefore, an arbitrary small value of the substitution elasticity (0.1) is assigned[5].

For the values of export demand elasticities, the small country assumption is generally adopted in most CGE models for developing countries. The world's prices for most commodities are not sensitive to changes in exports of the country considered in the model. Hence, a high value (-20) is assigned to the export demand elasticity for all commodities. In ORANI-RSA, the same value (-20) is used for the trade exposed commodity, but a larger value (-2) for the export oriented commodity, which is considered to be the traditional export of the country. For this commodity, it is assumed that exports are sufficiently large (as a proportion of world demand) for this country to have a moderate degree of market power. For the rest of the commodities whose exports are aggregated and effectively exogenized, a much smaller value (-0.02) is used, implying that their aggregate export quantity is not sensitive to the change in the export price.

ORANI-RSA adopts the standard ORANI investment theory. The implementation of the theory requires us to specify the value of two parameters: the product of the elasticity of the expected rate of return to the planned end-of-period capital stocks ($\beta(i)$) with the ratio of investment in the solution year to capital stock in the following year ($\Delta(i)$); and the ratio of gross to the net rate of return to industry

[5] In any event, the share of imports in the total supplies of these commodities in the data base are zero.

Q(i). The relevant values are presented in Table 7.6. Note that the theory of investment as set out in Chapter 5 does not require separate values for β(i) and Δ(i), since only their product affects behavioural equation expressed in percentage-change form.

The other parameters in the bottom of the table are used for the rent-seeking parts of the model. As has been explained in Chapter 2, both TQPAR and PFPAR are designed to have the value 1. These parameters do not have an economic interpretation. TQFL (0.25) is the minimum tax quotient (the floor for B). It provides a limit to the extent rent-seeking activity can reduce the tax quotient. PFFL is the minimum probability of being fined (0.1). It is the counterpart of TQFL for the probability of the industry being fined from engaging in rent-seeking activity. The last two parameters, E1TQ and E1PF, are assigned values (both zero) which ensure that the rent-seeking extension exhibits constant returns to scale properties.

Table 7.6 Parameters of ORANI-RSA

Parameter	Value	Description
Primary factor substitution		
SIGMA1LAB	0.5	Short-run elasticity substitution between types of labour*
SIGMA1LAB	1	Long-run elasticity substitution between types of labour
SIGMA1PRIM	0.5	Short-run elasticity substitution between primary factors*
SIGMA1PRIM	1	Long-run elasticity substitution between primary factors
Elasticity transformation		
SIGMA1OUT	0.4	Elasticity transformation in the service-providing industry

...continued

Table 7.6 *Continued*

Parameter	Value	Description
Armington elasticities		
SIGMA1	1	Elasticity of substitution between domestic and imported intermediate goods used as intermediate inputs
SIGMA2	0.5	Elasticity of substitution between domestic and imported goods used for investment
SIGMA3	5	Elasticity of substitution between domestic and imported goods consumed by households
Export demand elasticities		
EXP_ELAST	-20	Export demand elasticity for trade exposed commodity
EXP_ELAST	-2	Export demand elasticity for export oriented commodity
EXP_ELAST_NT	-0.02	Export demand elasticity for the aggregate export of other commodities
Investment parameters		
β(i).Δ(i)	3	Product of the elasticity of expected rate of return to the planned end-of-period capital stocks with the ratio of investment in the solution period to capital stock in the following period
Q(i)	2	The ratio of the gross to the net rate of return to industry
Rent-seeking parameters		
TQPAR	1	Designed to be always 1
TQFL	0.25	Minimum tax quotient (the floor for B)
PFPAR	1	Designed to be always 1
PFFL	0.1	Minimum probability of being fined (the floor for J)
E1TQ	0	Parameter used to normalise RS input
E1PF	0	Parameter used to normalise political influence

Note: *Used only in the short-run closure

Chapter VIII
The Closure of ORANI-RSA and an Illustrative Application

8.1 Introduction

In this chapter we apply ORANI-RSA to evaluate a hypothetical cut in the rate of capital income tax. Essentially, this policy change is similar to the one introduced in chapters 2 to 4 in the context of the partial equilibrium model developed there. The implication, however, is slightly different in the general equilibrium context. The cut in the capital income tax rate may reduce government income. This, in a balanced budget environment, will lead to a cut in government spending.

Three simulations are presented in this chapter. The first simulation evaluates the short-run impact of a ten percent cut in the capital income tax rate. The second examines the long-run impact of the same hypothetical policy change, assuming that the average propensity to consume out of disposable income is fixed. Because this treatment does not control for the asset positions of domestic residents, a third simulation is necessary. So the last simulation re-evaluates the long-run effects of the policy change in an environment where the impact of the change on the capital stock owned by domestic households is sterilised.

Before proceeding, two conceptual issues in accounting need to be clarified: (a) the impact of the convention used to handle rent-seeking services in the construction of ORANI-RSA's data base on the implication for changes in welfare measured in GDP; and (b) the importance of sterilising endogenous movements in assets when making inferences about changes in welfare attributable to changes in real consumption (Higgs and Powell 1992).

In an ordinary social accounting matrix, the cost of rent-seeking services is generally not visible. In the ORANI-RSA data base, rent-seeking services are visible and are treated as a commodity. Their production, therefore, contributes to GDP (as conventionally measured) in the same way as the production of other ordinary commodities. It is important to note, nevertheless, that rent-seeking services in ORANI-RSA do not correspond to the production of social product — they are merely used by producers to minimise the amount of tax that they pay. This amounts to a redistribution of gross operating surplus without any addition to the size of the social cake. Economic resources (capital and labour), however, are used up in this process.

It is appropriate in this case to account for the wedge between social and private valuation of rent-seeking services. To a first approximation it seems reasonable to give negative or zero social value to such services, although they have positive private value. In ORANI-RSA we define two types of GDP, namely, GDP at private cost and GDP at social cost. GDP at private cost is the conventionally valued GDP which counts rent-seeking services as a positive entry. GDP at social cost, on the other hand, values rent-seeking services at zero. If there is a fall in the production of rent-seeking services in the economy, *ceteris peribus*, then the gap by which the privately valued GDP exceeds the socially valued GDP will have fallen.

As regards to the second accounting point, ORANI-RSA gives an almost complete account of the flows in the economy, but has very little detail on the stocks. In order to provide a reliable long-run measure of the welfare effects of the policy change, proper accounting is necessary[1]. Two alternative assumptions on the ownership of the capital stock are used to address the problem.

In the first alternative, it is assumed that the share of domestic ownership of capital does not change after the shock. The plausibility of this (admittedly arbitrary) assumption is left to the reader's judgement; its role here is to provide enough behavioural detail about domestic thrift to enable the model to be closed. Note that the 'long run' as defined here does not necessarily imply indefinite sustainability, so movements in domestic assets observed under this alternative may not be viable if not corrected in some longer time frame.

In the second alternative, we assume that the stock (not the share) of capital owned by domestic residents is fixed. The implication of this assumption is that all of the new capital stock entering or leaving the economy due to the policy change is attributed to foreigners (a similar assumption but in a dynamic framework is adopted in Dixon and Rimmer 1998). This means that the effects of the policy change on the assets position of the domestic private sector have been sterilised. Hence real private consumption gives a good measure of domestic welfare provided changes in the publicly provided goods can be ignored.

In the prototype ORANI-G model on which ORANI-RSA is based, publicly provided goods do not enter the utility function of the representative private household. Thus the treatment above is consistent with the underpinnings of the model. Nevertheless it should be realised that a better treatment would be to put a

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[1] The issue is not as prominent in short-run applications of ORANI-RSA where the stock of capital is generally assumed to be exogenously fixed. Even here, however, it is theoretically possible that the change in spending by domestic residents might be partially financed by sales/purchases of their equity in the (fixed) physical capital stock.

positive private value on the legitimate public services recognized in ORANI-RSA. This qualification applies to the interpretation of the results for real consumption reported below under the second alternative.

8.2 Closures for ORANI-RSA

A necessary but not sufficient condition for most CGE models to be solvable is that m-n variables (where m and n are the numbers of variables and equations, respectively) need to be declared exogenous. In many cases when both m and n are a large number, the task of specifying the list of exogenous variables can be very cumbersome. This is especially so when large models (with many thousands or even millions of scalar variables) are expressed in their original structural form.

A more efficient alternative is to condense the model before attempting to solve it (Harrison and Pearson 1994). Essentially, condensing the model is to reduce its size by: (a) substituting out some of the endogenous variables; and (b) omitting exogenous variables that are not to be shocked in the current application of the model. This will reduce the size of both m and n substantially. Note that the solution for the endogenous variables which have been substituted out can still be generated by back solving. When GEMPACK is used to solve the model, the command to execute the task of condensing it is generally stored in an input file. In this way, the list of the omitted variables can be altered according to the need in each application of the model.

The current dimensions of ORANI-RSA are 2330 variables and 1630 equations. This size is small compared to standard ORANI-style CGE models since ORANI-RSA is designed to contain only enough commodities and industries to illustrate the essential mechanisms involved. In its original form, to solve the model

699 (= 2329 - 1630) variables would need to be declared exogenous. After condensation, however, the numbers of variables and equations are reduced to 676 and 494 respectively. The stored input file, ORANIRSA.STI, which lists the variables that are substituted out or omitted, is presented in Appendix D.

Essentially ORANI-RSA can be closed in many ways. Two sets of alternatives are presented in Table 8.1 below and in Table 8.2 in section 8.4; these represent short- and long-run economic environments.

Table 8.1
The short-run closure of ORANI-RSA (First simulation)

Variables	Size	Description
Primary factors		
x1cap	I	All sectoral capital
x1lnd	I	All sectoral agricultural land
employ_i("Skl")	1	Employment of skilled labour
f1lab_i("UnSkl")	1	Real wage shifter for unskilled labour
employ_i("PrvLab")	1	Employment of privileged labour
Technical changes		
twistlab	1	Twist on ratio of capita to labour ratio
a1cap	I	Capital augmenting technical change
a1lab_o	I	Labour augmenting technical change
a1lab_io	1	Uniform labour augmenting tech. change
a1lnd	I	Land augmenting technical change
a1prim	I	All factor augmenting technical change
a1tot	I	All inputs augmenting technical change
a2tot	I	Neutral technical change – investment
Agents' expenditure		
x3tot	H	Real private consumption expenditure
x2tot_i	1	Aggregate real investment expenditure
x5tot	1	Real 'other demands' (government)
delx6	C,S	Real demands for inventories
f5	C,S	Government demand shifter
s2gov	I	Share of government investment
finv	I	Shift variable for sectoral investment

...continued

Table 8.1 *Continued*

Variables	Size	Description
Exports demand		
f4p	C	Price shifter of traditional exports
f4q	C	Quantity shifter of traditional exports
f4q_ntrad	1	Quantity shifter of non-traditional exports aggregate
f4p_ntrad	1	Price shifter of non-traditional exports aggregate
Tax rates		
f0tax_s	C	General sales tax shifter
f1tax_csi	1	Uniform shifter of tax on intermediate usage
f2tax_csi	1	Uniform shifter of tax on investment usage
f3tax_cs	1	Uniform shifter of tax on household usage
f5tax_cs	1	Uniform shifter of tax on government usage
t0imp	C	The power of tariff
f4tax_trad	1	Uniform tax shifter of traditional exports
f4tax_ntrad	1	Uniform tax shifter of non-traditional exports
f_inctaxrate	H	Income tax shifter
f_inctaxrate_h	1	Overall income tax shifter
f1oct	I	Real unit cost of 'other cost tickets'
f1sub	I	Real unit cost of subsidy
Rent-seeking part of the model		
p_FINEMP	R	Fine multiplier
p_PFCOEF	R	Productivity in reducing probability of being fined
p_TQCOEF	R	Productivity in reducing tax quotient
p_POLDPRC	R	Depreciation rate of political endowment
p_CAP_TAXRATE	R	Capital tax rate
Numeraire and foreign prices		
phi	1	Nominal exchange rate (numeraire)
pf0cif	C	C.I.F foreign currency import prices

...continued

Table 8.1 *Continued*

Variables	Size	Description
Population Size		
q_h	1	Shifter allowing exogenous change in population without changing its composition according to household types
Total Variables	2CS + 5C + 12I + 5R + 2H + 18 = 182 *	

- Note : I indicates the number of elements in the set IND (here 6); C indicates the number of elements in the set COM (here 7) ; S indicates the number of elements in the set SRC (here 2); R indicates the number of elements in the set RSIND (here 5); and H indicates the number of elements in the set HOU (here 2). These sets are defined in chapter 5, Table 5.1.

8.2.1 Short-run closure

Most variables presented in Table 8.1 represent the standard short-run closure of ORANI. The only difference is the addition of a few variables to the list from the rent-seeking extension. In this short-run closure all variables introduced in the mapping extension are endogenous.

As regards the primary factors, it is assumed that although investment may take place, it does not in the short-run add to the useable capital stock of the industry, which is exogenously fixed. In the case of labour, it is assumed that unskilled labour is in excess supply at the going real wage, but skilled labour is in limited supply. Hence, the real wage rate for unskilled labour is assumed exogenous, which implies that its nominal wage rate is fully indexed to the consumer price index, while for skilled labour, it is the employment level that is exogenously determined (Dee, 1991). The same is assumed for the privileged labour in most applications of the model.

The variable twistlab allows technical change of a type that would change the capital/labour ratio at a fixed factor price ratio. We are not here interested in simulating technical change, and so twistlab is exogenous and is not shocked. Indeed, no technical change variable is explained by any equation in the model. Hence, they are a natural choice for exogenous variables in both short and long run applications. The same is true for the tax rates and the tax shifters. In some fiscal simulations, however, these variables can be endogenised to achieve certain macroeconomic targets, such as government revenue.

The presence of some variables from the rent-seeking extension in the exogenous list is essential. It allows variables such as tax rates on profits and fines on tax evasion to feed through from the rent-seeking extension into the core model, thus generating economy-wide effects that change the environment in which rent-seeking takes place.

In ORANI-RSA, the only regulation assumed to attract rent-seeking activity is the tax on capital income. In this closure, the capital income tax rate is set exogenously, whilst the size of rent-seeking activity is determined endogenously. Another variable on the exogenous list, the fine multiplier p_FINEMP, can be used to simulate a change in the penalties for tax evasion. Both p_PFCOEF and p_TQCOEF essentially are variables representing technological change in the effectiveness of rent-seeking activity. The variable p_POLDPRC is the rate of depreciation in the industry's endowment of political influence.

As regards to agents' expenditures, notice that the aggregate consumption shifter is not included in the exogenous list. With the consumption shifter endogenous, the consumption function is essentially deactivated and household consumption is set exogenously. With this closure ORANI-RSA will reproduce the standard short run core ORANI-G results, where no consumption function is installed. The consumption shifter f3tot will adjust endogenously to any shocks which may affect household disposable income.

Government consumption is also assumed to be unchanged by the shock in the short-run. The same is true for real aggregate investment. However, the model allows for re-allocation of the fixed aggregate investment across industries following the change in the endogenously determined rates of return on capital.

The nominal exchange rate is used as the numeraire. The foreign currency price of imports is naturally exogenous since it is determined in the rest of the world. The same assumption is made for all shifter variables related to the demands for the country's exports, all of which are determined outside of the model. With household, government and aggregate investment expenditures exogenously fixed in real terms, the balance of trade becomes the main determinant of the change in GDP. Since the nominal exchange rate and foreign-currency prices of traded goods are virtually fixed[2], the impact on GDP of the change in the domestic price level, which reflects the competitiveness of the country, will be prominent in this short-run closure.

8.2.2 Long-run closure

The number of variables declared exogenous is the same in both short- and long-run closures. The long-run closure is usually constructed by swapping some of the variables declared exogenous in Table 8.1 with some of the previously endogenous variables. These swaps, which reflect changes in the assumptions adopted

[2] Foreign-currency import supply prices and export demand prices are fixed at the initial vector of trade volumes. Because export demand schedules may be downward sloping, however, actual foreign-currency prices of exports can change endogenously.

about capital stocks, the labour market, households and government consumption, are presented in Table 8.2.

Table 8.2
The long-run closure of ORANI-RSA (second simulation)

Variables	Size	Description
Primary factors		
r1cap	I	Current rate of return on fixed capital
x1lnd	I	All sectoral agricultural land
omega	1	Economy-wide capital rate of return expected for the period following the period simulated
employ_i("Skl")	1	Employment of skilled labour
employ_i("UnSkl")	1	Employment of unskilled labour
employ_i("PrvLab")	1	Employment of privileged labour
Technical changes		
The same as in the short-run closure		
Agents' expenditure		
f3tot	H	Shift term for consumption expenditure
f5tot	1	Overall shift term for government demand
delx6	C,S	Real demands for inventories
f5	C,S	Government demand shifter
s2gov	I	Government shares in industries' investment
finv	I	Shift variable for sectoral investment
Export demands		
The same as in the short-run closure		
Tax rates		
The same as in the short-run closure		
Rent-seeking part of the model		
The same as in the short-run closure		

...continued

Table 8.2 *Continued*

Variables	Size	Description
Numeraire and foreign prices		
The same as in the short-run closure		
Population size		
The same as in the short-run closure		
Total Variables	2cs + 5c + 12i + 5r + 2h + 18 = 182 *	

As has been elaborated in section 5.5.2, as far as the industry capital stocks are concerned, the 'long run' implies that a sufficient time has elapsed for investment to have an impact on industries' useable capital stocks. It is generally assumed that the percentage change in the level of investment expenditure x2tot(i) by industries matches the corresponding percentage change in capital stocks x1cap(i). This assumption results in the long-run growth rates of industries being unaffected by any shock, but of course the absolute and relative sizes of industries do respond to shocks. In terms of the investment equation reprinted from equation 5.5:

$$x2tot(i) - x1cap(i) = finv(i) + B(i)(r1cap(i) - omega) \quad \text{E8.1}$$

The assumption that x2tot(i) = x1cap(i) can be enforced by declaring both r1cap(i) and omega exogenous and setting them to zero. This is because finv(i) is generally exogenous (and set to zero) in both short- and long-run closures. Therefore, as shown in Table 8.1 and 8.2, x1cap(i) and x2tot_i are swapped with r1cap(i) and omega, respectively. With this closure, if we want to run a simulation involving a shock to capital's rate of return, both r1cap(i) and omega should be shocked by the same amount.

Real wages for all types of labour are assumed to be flexible in the long run. The previously exogenous real wage rate for unskilled labour f1lab_i("UnSkl") is swapped with the variable representing its employment level employ_i("UnSkl"). With this labour market closure, effectively the employment of all occupational categories is now exogenously determined. Unemployment can be prevented from rising above its (exogenous) natural level by the endogenous adjustment of wages.

In the long-run closure, the consumption function is activated by allowing consumption by the three household types to respond endogenously to the change in their respective disposable incomes. This effect is achieved by swapping real consumption x3tot with the consumption shifter f3tot.

ORAIN-RSA, like most models in the ORANI family, does not have any theory explaining real government consumption. As a rule, this variable is indexed to aggregate real household consumption. As noted above, household consumption is endogenized in this long-run closure. In case we want household and government consumption to change at different rates, the indexation link between them has to be broken. For this purpose, the government expenditure shifter f5tot has to be exogenous, while the government expenditure x5tot is freed to vary endogenously.

8.3 Illustrative application of ORANI-RSA

The partial equilibrium impact of a cut in capital income tax has been discussed in Chapter 4. In the presence of rent-seeking activity, the reduction of the capital income tax rate reduces both the price of and the demand for rent-seeking services. The cut does increase firms' willingness pay tax. It is, however, not sufficient to prevent government revenue collected from capital income tax from falling. It is important to note that this conclusion is derived from an analysis which considers only the initial impact of the tax cut. The analysis did not take into account the linkages between firms' trading environments and the economic impact of the reduction of government income.

Linkages play an important role in economics. In one way or another, every part of the economy is linked with every other part (Dixon *et al.* 1982). The impacts of the cut in the capital income tax go beyond the initial impact mentioned above. The change in the price of rent-seeking services affects the whole list of prices in the economy. The change in relative prices changes the composition of output in the economy. The reduction of government income in the long run will be translated into a cut in government spending. This on its own may lead to a reduction in output of the industries selling to the government.

The strength of ORANI-RSA is its ability to carry an analysis much further than the initial impact of the tax cut by accommodating most important linkages in the economy. As has been presented in the model's closures in Table 8.1 and 8.2, the linkages in the short-run are different from those in the long-run. In this section, we present both the short- and the long-run impacts of the reduction in capital income tax. The impacts are divided into macro and industry results.

8.3.1 Short-run impact a 10 percent cut in the capital income tax

8.3.1 (a) Macro results

The hypothetical policy change introduced in the short-run application of ORANI-RSA is a 10 percent cut in the percentage of capital income tax p_CAP_TAXRATE. The tax rate in the base case solution of the model is 50 percent.

The 10 percent reduction in p_CAP_TAXRATE means that the tax rate in the shocked solution is 45 (=50-(10/100)×50) percent.

The hypothetical policy change introduced above comes from the rent-seeking part of ORANI-RSA. In tracing its various impacts to the economy, we start from its initial impacts and then proceed to the next round impacts. As noted earlier, consistent with the theory developed in Chapters 2-4, the initial impact of the shock is the reductions in: (i) the quantity of rent-seeking services demanded; (ii) the price of rent-seeking services and (iii) the government revenue collected from capital income tax. Since under the assumptions adopted in the short-run closure, government expenditure is fixed, the change in government revenue will not impact on the economy in this closure. The reduction in the quantity of rent-seeking demanded will affect output and employment in the service providing industry. A detailed discussion of industry effects will be presented in the next sub-section.

A 10 percent cut in the capital income tax uniformly reduces the price of rent-seeking services by 4.62 percent. In ORANI-RSA, rent-seeking services as treated as a commodity used as an input in the production of after-tax 'profit' by the producers of other commodities. Since the purchase of rent-seeking services must be financed out of sales, the cost of such services is passed into the price of each ordinary industry's product. In this setting, the reduction in the price of rent-seeking services naturally will reduce the production cost of all other commodities. This leads to a reduction in the domestic prices as shown by investment, consumer and export price indexes in Table 8.3.The reduction in domestic prices makes the country's exports more competitive in the world market. As for imports, since the foreign-currency prices of imported goods are unchanged and the numeraire in the nominal exchange rate, households and investors will gain by substituting the domestically produced commodities for their imported counterparts. As shown in Table 8.3, while exports increase by 0.03 percent, imports decline by 0.32 percent. This improves the balance of trade position by 0.03 percent of GDP.

Table 8.3
The impact of a 10 percent cut in the capital income tax rate on macro variables

Variables	Descriprion	percent
p0gdpsc	GDP price index - at social cost	0.0931
x0gdpsc	Real GDP at social cost	0.1502
p0gdpexp	GDP price index - Expenditure side (conventional)	-0.0755
x0gdpexp	Real GDP from expenditure side (conventional)	0.0732
delB	(Balance of trade)/GDP	0.0004
x0cif_c	Import volume index, C.I.F. weights	-0.1670
p1cap_I	Average capital rental	0.0304
x1cap_I	Aggregate capital stock	0.0000
p2tot_I	Aggregate investment price index	-0.1592
x2tot_I	Aggregate real investment	0.0000
p3tot_h	Consumer price index	-0.1883
x3tot_h	Aggregate real household consumption	0.0000
p4tot	Exports price index	-0.1002
x4tot	Export volume index	0.1399
p5tot	Government price index	0.3671
x5tot	Real Government Consumption	0.0000
p0toft	Terms of trade	-0.1002
employ_io	Aggregate employment	0.0151
realwage	Average real wage	-0.0519
wgovinc	Government income	-2.7701
delgsav	Gov Saving/Gov income	-0.0366
delrsav	ROW saving/ROW income	0.0013
del1sav	GOS saving/ GOS income	0.0082

The impact of the cut in the capital income tax rate on real GDP can be computed using the following GDP identity ;

$$x0gdpexp = S_{DA}\,DomAbs + (S_{X4TOT}\,x4tot - S_{X0CIFC}\,x0cif\_c) \qquad E8.2$$

where S_{DA}, S_{X4TOT} and S_{X0CIFC} are the shares of domestic absorption, exports and imports, respectively. The level variables corresponding to DomAbs is the sum of aggregate real household consumption, real government consumption, and aggregate investment. The percentage change in these three aggregates, x3tot, x5tot and x2tot_I are all exogenously set to zero. We note from the data base that the shares of exports and imports in GDP are 0.2838 and 0.2004, respectively. This gives us a value for x0gdpexp of approximately 0.075 percent.

The employment effects of the policy are presented in Table 8.4. Since the employment levels for both skilled and privileged labour are exogenously set to zero, the employment impact of the cut in the capital income tax appears only in unskilled labour. As in most neoclassical models, the output of the economy is a function of the use of the primary factors of production. In this closure the supply of all primary factors other than unskilled labour is exogenous and set to zero change. The employment of unskilled labour, therefore, has to increase in order to accommodate the increase in GDP.

The last row of Table 8.3 shows the effects of the cut in the capital income tax rate on the structure of saving in the economy. In ORANI-RSA total investment is financed by the savings of households, government, industries and the saving from the rest of the world. The change in policy causes the fraction of gross operating surplus (GOS) saved by industries to increase (delisave > 0) and the fraction of government income saved by the government to fall (delgsav < 0). The increase in industries' propensity to save occurs because the positive impact of reduced tax payments on saving is proportionately grater than the rise in GOS generated by the filip to the capital rental prices. Saving for each agent in ORANI-RSA is defined as income *minus* expenditure. Given an exogenously fixed level of government expenditure, the cut in the capital income tax causes a fall in the government's income[3] and its propensity to save.

At the fixed level of employment for both skilled and privileged labour, the real wage for skilled labour increases by 0.0320 percent, while the real wage for privileged labour declines by 0.811 percent. The rise in the real wage for skilled labour is driven by the increase of output in the ordinary industries, which expand due to export expansion and import substitution. The reduction in the real wage of privileged labour is due to the contraction of the service providing industry – the only industry employing privileged labour – as a result of the reduction in the demand for rent-seeking services following the hypothetical policy change.

Table 8.4
The short-run labour market effect of a 10 percent cut in the capital income tax rate

Occupational categories	Employment(a)	Real wages
Skilled Labour	0	0.0320
Unskilled labour	0.0965	0
Privileged Labour	0	-0.8111

(a) Quantity index based on wage-bill weights

Table 8.5
The short-run effect of a 10 percent cut in the capital income tax rate on households

Household categories	Nominal income from labour (1)	Households price index (2)	Real income from labour (1-2)
Household (Lo)	-0.15209	-0.19008	0.03799
Household (Hi)	-0.36195	-0.18504	-0.17691

As has been described in section 5.3.2, the income received by unskilled labour is mapped to the household Lo, while the incomes of both skilled and unskilled labour are mapped to household Hi. From Table 8.5, it can be seen that, as

[3] In this closure, government spending is fixed in real terms. The corresponding price index also falls.

far as income received from labour is concerned, in the short-run household Lo gains from the hypothetical policy change. The opposite is true for household Hi due to the large reduction of the real wage of privileged labour.

8.3.1 (b) The economy-wide industry results

This subsection is concerned with the implication of the hypothetical cut in the capital income tax rate at the industry level. We describe the effect on each industry and suggest the explanation for the variation of the results across industries. The projections for each industry's output, investment, capital rate of return and employment are presented in Table 8.6. The projections for the exports of commodities are given in Table 8.7. In terms of output levels, all industries other than service providing gain from the policy change. The trade exposed industry, however, records the largest growth in output, with the export oriented industry in the second place. These output results are driven mainly by the increased exports of the commodities produced by these industries. In tracing the rationale for the expansion of exports for these two commodities, it is useful to refer back to the equation 5.8. In ORANI-RSA, the exports of the trade exposed and export oriented commodities are modelled to depend on the purchasers' price of exports (see column 2 of Table 8.7). Since the nominal exchange rate (phi) and both the price and the quantity export shifters (f4p and f4q) are exogenous and set to zero, the export projections for the trade exposed and the export oriented commodities can be computed by multiplying the relevant change in purchasers' price by the corresponding export elasticity. The values of the export price elasticity assigned to trade exposed and to export oriented commodities are -20 and -2, respectively. These parameter values imply that the exports of the trade exposed commodity are very sensitive to changes in price. A small improvement in the cost of production of this commodity will lead thus to a large increase in the quantity exported.

Table 8.6
The short-run impact of a 10 cut in the capital income tax rate on industries' output, investment, capital rate of return and employment

Industries	*Output*	*Invest ment*	*Capital rate of return*	*Employ ment (a)*	*Nominal wages*
Trade Exposed	0.171	0.370	1.550	0.788	-0.179
Export Oriented	0.133	0.217	1.082	0.567	-0.177
Import Oriented	0.054	-0.033	0.321	0.201	-0.172
Non Tradeable	0.031	-0.078	0.184	0.099	-0.166
Margins	0.039	-0.075	0.193	0.120	-0.163
Service Providing	-0.269	0.000	-0.975	-0.317	-0.368

(a) Quantity index based on wage-bill weights

Table 8.7
The short-run impact of a 10 cut in the capital income tax rate on exports of each commodity

Commodities	*Export Volumes*	*Purchase price of Trad export*	*Purchase price of Non Trad export*
Trade Exposed	0.210	-0.011	n.a
Export Oriented	0.177	-0.088	n.a
Import Oriented	0.004	n.a	-0.197
Non Tradeable	0.004	n.a	-0.197
Margins	0.004	n.a	-0.197
Public Services	0.004	n.a	-0.197
Rent-seeking services	0.004	n.a	-0.197

The hypothetical tax cut causes: (i) capital and land rentals to increase in some industries; (ii) nominal wages to decline in all industries; (iii) the price of all domestic commodities used as intermediate inputs in the production of export commodities to decrease substantially. In addition, the trade exposed commodity requires a substantial quantity of imports in its production (50 percent) and hence benefits from substituting (cheaper) domestically produced commodities for imports. The combined effects of (i), (ii), (iii) and the substitution effects lead to a reduction of the price of exports.

The remaining commodities (the so-called 'non-traditional exports') are exported via a fixed proportion aggregate for which overseas demand is very inelastic (demand elasticity = 0.002). This treatment reflects the assumption that exports of these commodities are determined by other exogenous variables (such as f4q_ntrad) rather than the price. Table 8.7 reveals the insensitivity of aggregate exports from this group to price changes.

As regards to imports, at a fixed activity level the change in demand for each commodity by agents in ORANI-RSA is determined by: (i) import shares; (ii) import-domestic substitution elasticities; and (iii) the change in relative prices. From the data base we note that, on average, 15 percent of materials usage comes from imported sources. Capital formation, on average, uses materials which are 19 percent imported. About 10 percent of household consumption comes from imported sources. The Armington (substitution) elasticities assigned for producers, investors, and households are 1, 0.5 and 5, respectively. As noted earlier, the domestic price for most commodities declines following the policy change and the price of imports is exogenously set to zero change[4]. The combined effects of (i), (ii) and (iii) explain the reduction of aggregate imports demanded by the economy despite the countervailing influence of the (small) increase in domestic output as measured by conventional GDP.

The stronger growth performance of both the trade exposed and the export oriented industries makes the rate of return on capital in these industries relatively into higher than the rest. This encourages the shift of investment from the other industries both of them. Note that there is no shift of investment from the service providing industry, however, because investment there is treated differently from the rest of the industries. It is linked to aggregate real investment, which is exogenous and set to zero change in this short-run closure. The rate of return in this industry, however, is reduced substantially due to the contraction of its output.

The pattern of change in employment by industry is similar to the output changes. The largest employment increase is recorded in the trade exposed industry. The service providing industry releases 0.32 percent of its labour force (quantity index based on wage-bill weights) following the contraction of its output.

The reduction in the capital income tax rate increases the size of taxable gross operating surplus (p_TXBGOS). This increase comes from the rise in the rentals for both capital and land, since the stock of capital x1cap and of land x1lnd are exogenously set to zero in the short run. (In the long-run closure, where the stock of capital is allowed to change, the cut in the capital income tax rate will cause a larger change in the taxable gross operating surplus – to be explained in the next section.)

The after-tax profits (p_RSGOS) of each industry increase after the tax cut. This mainly comes from a reduction in both the tax rate and in the price of rent-seeking services (p_PORSSRV). The tax quotient (p_TAXQUOT) of each industry increases after the tax cut, indicating that the industries expend less effort in their attempt to reduce tax payments after the tax rate is lowered. As a result, the tax that is actually paid by each industry (p_RSGOSTAX) is reduced by about 8 percent (less

[4] The prices of imports are fixed in foreign currency. In this closure, however, the numeraire is the nominal exchange rate, and hence import prices in domestic currency do not change.

than the size of the tax cut, 10 percent). Note that the increase in the tax quotient is more prominent in the trade exposed and the trade oriented industries. This result comes from the assumption adopted in ORANI-RSA that both industries are less productive in rent-seeking activity, which is shown in a smaller initial value for the variables TQCOEF, PFCOEF and POLDPRC (see Table 7.4 in the previous Chapter). The implication of the assumption can be better explained using figure 8.1.

Table 8.8
The short-run impact of a 10 cut in the capital income tax rate on the tax paid by industries[a]

Industries: / Variables	Trade exposed	Export oriented	Import oriented	Non Trade able	Margins
p_TXBGOS Taxable GOS	0.608	0.389	0.029	-0.067	-0.043
p_RSGOS Disposable[b] GOS	4.126	3.860	2.959	2.987	3.090
p_PFINED Prob. of being fined	0.000	0.000	0.000	0.000	0.000
p_TAXQUOT Tax quotient	1.922	1.922	1.259	1.296	1.457
p_PORSSRV Price of rent-seeking (RS) services	-4.418	-4.418	-4.418	-4.418	-4.418
p_RSUSE Use of RS Services	-1.703	-1.918	-1.987	-1.928	-2.013
p_RSGOSTAX Tax paid	-7.712	-7.913	-8.841	-8.894	-8.728

(a) p_ indicates a percentage change (relative to base case). The GOS variable and the price of rent-seeking services are in nominal term.
(b) GOS less taxes less expenditure on rent-seeking services.

Due to its better productivity in rent-seeking activity, the non-traded industry initially operates at C with tax quotient close to the floor (0.2). After the cut in the capital income tax rate, the industry reduces its use of rent-seeking services and operates at point D. On the other hand, the export oriented industry, which has a lower productivity in rent-seeking activity reflected in the smaller value of the variables TQCOEF, PFCOEF and POLDPRC, initially is operating at A with a higher tax quotient. The tax cut increases its tax quotient more than the non-traded industry (see also Table 8.8) because the industry is operating in a steeper part of the tax quotient schedule. Note that the trade exposed and the export oriented industries are assigned exactly the same values for variables TQCOEF, PFCOEF and POLDPRC in the data base. This explains why the effects of the tax cut on their tax quotient p_TAXQUOT and their use of rent-seeking services p_RUSE are identical. In terms of Figure 8.1, they are operating on the same tax quotient schedule.

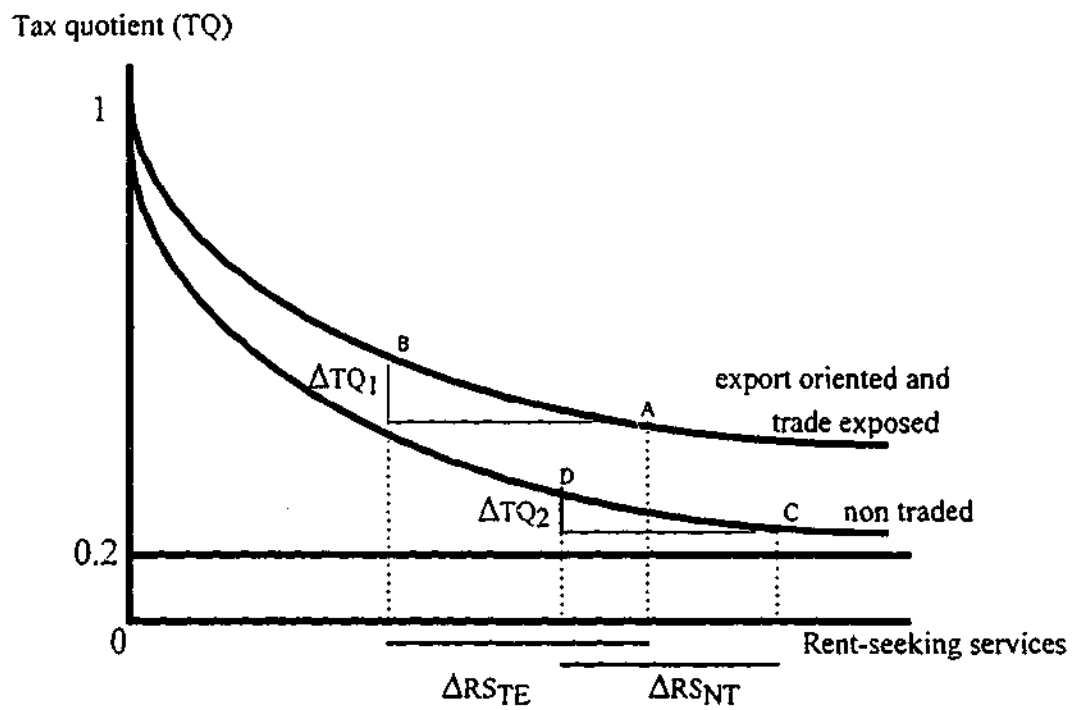

Figure 8.1 Tax quotient change for trade exposed and non traded industries

Every industry engaging in rent-seeking activity reduces its use of rent-seeking services after the tax cut. The policy, therefore, leads to a reduction in the production of rent-seeking services, and hence reduces resources absorbed by the service providing industry.

8.3.2 Long-run impact of a 10 percent cut in the capital income tax (second and third simulation)

The crucial underlying assumptions in computing the long-run effects of the hypothetical policy change, as already presented in Table 8.2, are:

(i) All elements of aggregate expenditures are allowed to change. The trade balance, household consumption and investment adjust endogenously.

Government consumption is reduced exogenously (by 3.285 percent in simulation 2 or by 3.564 percent in simulation 3) to compensate for the reduction of government income as a result of the cut in the capital income tax. This results in a very good approximation to a balanced budget.

(ii) Employment by occupation is exogenously fixed to zero change. Employment by industry is free to change endogenously. This implies that labour can be re-allocated following the changes in the trading conditions faced by different industries after the policy change.

(iii) Capital stocks are no longer fixed exogenously, but adjust so as to restore the rates of return that prevailed prior to the shock. Thus the improvement in the operating environment of an industry that shows up in its rate of return in the short-run will appear instead as a larger capital stock in the long run.

(iv) For all industries other than the service providing industry, capital is linked to investment. This reflects the assumption that the shock's long-run consequences for these industries are confined to their absolute and relative sizes, and do not impinge on long run rates of growth — see Dixon, Parmenter and Rimmer (1984). For the service providing industry, investment is indexed to the aggregate level of investment.

(v) Ideally, in examining the long-run welfare impact of a policy change via a flow variable such as real consumption, it is necessary to sterilise the capital account. The capital account in not modelled rigorously in ORANI-RSA. Under the current setting of the model and its data base, it is not possible to sterilised the capital account completely. Two alternative assumptions are adopted as regards to the ownership of the capital stock. First, the share of domestic and foreign capital is fixed (in simulation 2) and second, the stock of domestic capital is fixed (in simulation 3). The quantitative implications of each assumption are discussed in the sub-section 8.3.2 (b) and 8.3.2 (c).

The long-run macro results of the policy change with fixed shares of domestic and overseas capital are presented in Table 8.9. The economy-wide impacts are given in Tables 8.10-13. The long-run macro results of the policy change with a fixed stock of domestically owned capital are presented in Table 8.14 and the economy wide effects are given in Tables 15-18.

8.3.2 (a) The long-run macro results

As noted above the hypothetical policy change introduced in this long-run simulation is a combined reduction in the capital income tax rate and in government consumption to obtain a balanced government budget (the variable delgsav representing government saving should be close to zero following the introduction of the policy change; its computed value is 0.000067). If the shock changes the stock of capital, it is assumed it will not affect the proportion owned by domestic residents. In other words, the shock does not change the share of domestic and foreign capital. This is implied by the behavioural equations in ORANI-RSA, where the flow of capital rental to both domestic and foreign residents is proportional to total disposable (after tax) gross operating surplus.

The initial impact of the shocks is the reductions in: (i) the quantity of rent-seeking services demanded; (ii) the price of rent-seeking services and (iii) government spending, which in ORANI-RSA's current data base is wholly is concentrated in public services produced by the service providing industry.

Second and later round effects change relative prices in the economy. The hypothetical policy change buys a 0.9 percent reduction in the consumer price index (see Table 8.9). The long-run price impact of the cut in the tax rate is much more prominent than it was in the short-run, because the aggregate price effects of the reduction in the price of rent-seeking services are reinforced by the price effects of the cut in government expenditure. In addition, the policy also leads to a reduction of aggregate household consumption by 0.45 percent due to the reduction in the household nominal disposable income.

Table 8.9
The long-run impact of 10 percent cut in capital income tax on macro variables with balanced budget

Variables	Descriprion	ntaxcut1
p0gdpsc	GDP price index - at social cost	-1.288
x0gdpsc	Real GDP at social cost	0.335
p0gdpexp	GDP price index - Expenditure side	-1.295
x0gdpexp	Real GDP from expenditure side	0.207
delB	(Balance of trade)/GDP	0.010
x0cif_c	Import volume index, C.I.F. weights	-0.738
p1cap_I	Average capital rental	-0.754
x1cap_I	Aggregate capital stock	0.232
p2tot_I	Aggregate investment price index	-0.788
x2tot_I	Aggregate real investment	0.513
p3tot_h	Consumer price index	-0.913
x3tot_h	Aggregate real household consumption	-0.449
p4tot	Exports price index	-0.856
x4tot	Export volume index	3.371
p5tot	Government price index	-1.959
x5tot	Real Government Consumption	-3.284
p0toft	Terms of trade	-0.856
employ_io	Aggregate employment	0.000
realwage	Average real wage	-1.531
wgovinc	Government income	-3.594
delgsav	Gov Saving/Gov income	0.000
delrsav	ROW saving/ROW income	-0.027
del1sav	GOS saving/ GOS income	0.008

This result is generated by the consumption function activated in this long-run simulation. This gives a further explanation for the fall in the price of consumption. Note that the fall in real consumption does not necessarily imply a fall in domestic welfare, since the balance of trade improves. This improvement means that domestic residents have a better asset position as a result of the shock. The beneficiaries of the reduction in the domestic price level are the exporting industries. Aggregate exports increase by 3.4 percent. The reduction in the domestic price level (despite the rise in real activity) leads to a decline in aggregate imports by 0.74 percent. Together these improvements imply that the balance of trade improves by 1 percent of GDP.

As has been shown in the short-run application of ORANI-RSA in which the capital stocks are held constant, the hypothetical policy changes, creates an opportunity for exporters, which increases the rate of return to capital in the exporting industries. The opposite is true for the industries adversely affected by the policy (see Table 8.6). As discussed above, the additional shock due to the cut in government spending introduced in the long-run simulation creates even larger export opportunities.

It will have been noted that there was relatively little movement in the rate of return to the exporting industries in the short-run simulation; there, however, government consumption was set exogenously to zero change. If the reduction in government consumption seen in the long-run simulation had been injected as a shock into the short-run simulation, there would have been larger rises in the rate of return of exporting industries. In this long-run closure the rate of return on capital is exogenously set to zero. To satisfy this condition, capital stocks in these industries, which gain from the policy, have to increase. For the major exporter, this increase is substantial.

Table 8.10
The long-run impact of a 10 cut in the capital income tax rate on industry's output, capital stocks and employment

Industries	Output	Capital stocks	Employ ment(a)	Nominal wages
Trade Exposed	9.336	9.957	11.404	-2.086
Export Oriented	1.386	1.133	2.526	-2.089
Import Oriented	0.336	-0.053	1.410	-2.100
Non Tradeable	0.094	-0.342	1.010	-2.114
Margins	0.210	-0.254	1.176	-2.118
Service Providing	-3.259	-4.979	-2.950	-3.013
Rent-seeking	-3.102	-	-	-
Public Services	-3.285	-	-	-

(a) Quantity index based on wage-bill weights

For all but the service providing industry, capital stocks are linked to investment in the long run. Table 8.10 shows that capital stocks (and hence investment) increase by 10 and 1.1 percent respectively in trade exposed and export oriented industries, but decline elsewhere. With the exception of the service providing industry, these falls are small, ranging from about 0.1 to 0.4 percent. Note, however, that the declining industries are much larger than the exporting ones. The average of all five results is + 0.52 percent. The investment result for the sixth industry, service providing, is set to equal to this value in the current closure. The combined effects of the reductions in the government and household consumption, on the one hand, and the improvement in the balance of trade and the aggregate investment on the other, gives a 0.21 percent improvement in real GDP as conventionally measured.

It is important to note that this GDP result depends on the assumption on the behaviour of the investment in the service providing industry, which by assumption moves with the aggregate investment in the rest of the economy. This implies that the impact of the contraction of the service providing industry following the policy change is not translated into a reduction in the level of investment in that industry. Relative to base case, investment in the service providing industry increases despite the shrinkage in its output. This investment boosts the improvement in GDP relative to what would occur if the service providing industry were treated in the same way as the other industries.

As noted earlier, the GDP conventionally measured at private cost does not properly take into account the change in the production of rent-seeking services. The same shock generate a 0.34 improvement in GDP valued at social cost, which is larger than the improvement in GDP at the private cost. This is because the reduction in the production of rent-seeking services is associated with an expansion of activities which produce a product having a positive social valuation.

With employment in each occupation fixed exogenously to zero change, the declines in real wage rates shown in Table 8.11 imply that the cut in capital income tax under balanced budget is unfriendly to labour, i.e., that labour incomes fall in real terms. To some extent this has already been reflected in the consumption results reported above. Why is the hypothetical policy change unfriendly to labour in this closure? The cut in the capital income tax via its budgetary impact causes the government to contract its purchases of legitimate public services by 3.29 percent. Combined with the fall of 3.10 percent in the demand for rent-seeking services, the drop in the demand for public services causes the output of the service providing sector to contract by 3.26 percent. This industry is the most labour intensive of all industries (see Table 8.12).

Table 8.11
The long-run labour market effect of a 10 cut in the capital income tax rate

Occupational categories	*Employment*	*Real wages*
Skilled Labour	0.000	-1.232
Unskilled labour	0.000	-1.164
Privileged Labour	0.000	-5.007

Table 8.12
The share of labour by occupations in total value added by primary factors

Industries	*Share of skilled labour (1)*	*Share of Unskilled labour (2)*	*Share of privileged labour*	*Share of (1) + (2)*
Trade Exposed	6.44	15.35	0.00	21.79
Export Oriented	8.01	15.55	0.00	23.56
Import Oriented	13.35	13.43	0.00	26.78
Non Tradeable	22.56	9.20	0.00	31.76
Margins	25.36	7.24	0.00	32.60
Service Providing	34.91	29.79	20.20	64.70

Thus a (perhaps unexpected) consequence of the configuration of the ORANI-RSA data base is that the capital income tax cut causes a major change in the composition of the economy which makes labour *effectively* more abundant despite the increase of 0.23 percent in the capital stock.

The impact of the policy on the structure of saving is similar to the short run results, except that now government saving does not change (delgsav = 0) since the balanced government budget assumption is imposed in the long run. The policy causes the fraction of gross operating surplus (GOS) saved by industries to increase (delisave > 0).

8.3.2 (b) Long-run economy-wide results with constant ownership of shares

The long-run projections for each industry's output, capital stocks, employment and nominal wages are presented above in Table 8.10. The long-run projections for the exports of commodities are given in Table 8.13. The driving force behind these long-run industry results is essentially similar to that of the short-run. The main source of output improvement comes from trade exposed and export oriented industries. The size of output changes are much larger than they were in the short-run because the government's balanced budget assumption imposed in this long-run simulation generates larger reductions in domestic and export prices. As shown in Table 8.13, a 0.55 percent reduction in the purchasers' price for the trade exposed commodity leads to 11.6 percent increase in export quantity. This in turn stimulates overseas demand for (and the output of) the trade exposed commodity. The same is true for the export oriented industry, but to a lesser extent due to its smaller export elasticity. The import oriented industry also gains from the reduction in the domestic price level, because this fall in costs improves its competitiveness against imports.

Table 8.13
The long-run impact of a 10 cut in the capital income tax rate on exports of each commodity

Commodities	Export Volumes	Purchase price of Trad export	Purchase price of Non Trad export
Trade Exposed	11.586	-0.547	n.a
Export Oriented	1.874	-0.924	n.a
Import Oriented	0.020	n.a	-0.970
Non Tradeable	0.020	n.a	-0.970
Margins	0.020	n.a	-0.970
Public Services	0.020	n.a	-0.970
Rent-seeking services	0.020	n.a	-0.970

The output of the service providing industry contracts by more than 3 percent (compared to only 0.27 percent in the short-run). This result is partially explained by the balanced budget assumption on the government side, which leads to a real cut of 3.29 percent in government spending. As noted earlier, in ORANI-RSA's current data base, government spending is wholly concentrated in public services produced only by the service providing industry, and the revenue collected from capital income tax comprises 30.3 percent of total government income. The other product produced by this industry, rent-seeking services, declined by a comparable percentage (3.10 percent).

The long- and short-run effects of the hypothetical policy change on the price of rent-seeking services differs substantially. In the short run, the price of rent-seeking service declines by 4.4 percent, compared to only 1.4 percent in the long run. Note that the service providing industry produces two commodities, public and rent-seeking services. In the short-run, the supply of public services is essentially fixed exogenously following the exogenously fixed government consumption. In such a setting, the adjustment following the reduction in the demand for rent-seeking services is dominated by the reduction in the prices of rent-seeking services. In the long-run closure, the policy change reduces the demand for both commodities produced by the service providing industry. As a result, the price of the public and the rent-seeking services decline by 1.99 and 1.50 percent, respectively. By contrast with the short-run closure, the transformation effect in this case is small.

In this long-run simulation, employment by occupation is exogenously set to zero change. Employment by industry, however, is free to change endogenously. This implies that labour can be re-allocated following the changes in the trading conditions faced by different industries after the policy change. Table 8.11 shows the relocation of employment following the policy changes. The service providing industry releases almost 3 percent of its labour force. This is enough to increase employment in other industries by a large percentage, particularly the trade exposed and the export oriented, because the service providing industry employs a large proportion (36 percent) of the labour force, compared to 2.2 and 8.4 percent used by the trade exposed and the export oriented industries, respectively.

The long-run effects of the hypothetical policy change on the variables representing the rent-seeking part of the model differ significantly from the short-run projections (compare Table 8.14 to Table 8.8).

Table 8.14
The long-run impact of a 10 cut in the capital income tax rate on the tax paid by industries[(a)]

Industries / *Variables*	*Trade exposed*	*Export oriented*	*Import oriented*	*Non Trade able*	*Margins*
p_TXBGOS Taxable GOS	9.080	0.384	-0.720	-1.125	-0.967
p_RSGOS Disposable[(b)] GOS	14.179	3.644	2.027	1.650	1.883
p_PFINED Prob. of being fined	0.001	0.001	0.000	0.000	0.000
p_TAXQUOT Tax quotient	2.975	2.975	1.823	2.006	2.202
p_PORSSRV Price of rent-seeking (RS) services	-1.495	-1.495	-1.495	-1.495	-1.495
p_RSUSE Use of RS Services	5.261	-3.131	-3.573	-3.931	-3.874
p_RSGOSTAX Tax paid on GOS	1.092	-6.967	-9.019	-9.228	-8.908

(a) p_ indicates a percentage change (relative to base case). The GOS variable and the price of rent-seeking services are in nominal term.
(b) GOS less taxes less expenditure on rent-seeking services.

This is because both capital stocks and capital rental are endogenously determined in the long run, compared to only capital rental in the short run. Because rates of return are exogenously set to zero, however, variation in rental prices are muted by comparison with those in capital stocks.

The changes in capital stocks and rental prices are translated directly into the taxable gross operating surplus p_TXBGOS[5]. The capital rental on average declines by 0.79 percent. For the trade exposed and export oriented industries (which experience a large increase in their capital stocks) taxable gross operating surplus (GOS) increases by 9 and 0.38 percent, respectively. Unlike the other industries, the trade exposed industry actually uses more rent-seeking services. This is due to the large increase in its taxable GOS.

In the context of the partial equilibrium model presented in Chapters 2-4, whether the cut in the capital income tax will increase or decrease government revenue collected from the tax depends on taxpayers' productivity in rent-seeking activity. Some taxpayers engage in rent-seeking activity when the tax rate is high and then quit after the tax rate is reduced. The increase of tax revenue from such taxpayers could compensate for the reduction of tax collection from others so that the cut in the capital income tax may lead to an increase in government revenue. A large cut in the tax rate (30 percent), however, is necessary to achieve this result. The same mechanism cannot be replicated in the simulations using ORANI-RSA. This is because all taxpayers/ industries are assumed to remain engaging in rent-seeking activity after the cut in capital income tax. Note, however, that by increasing the number of representative agents in each industry in ORANI-RSA beyond the current single agent, similar effects may be obtainable in future research.

The application of ORANI-RSA, however, identifies an important mechanism in explaining how the impact of the cut in capital income tax on government tax collection can be partly off-set by resources re-allocation within the economy. In the

[5]See equation decribing TXBGOS in Excerpt 37 of Appendix A.

general equilibrium context, the size of the economy, and hence the size of taxable GOS, is not only determined by the size of the available inputs/resources, but also by how the resources are allocated between sectors within the economy. This proposition was not taken into account in the partial equilibrium analysis presented in the earlier chapters.

The large increase in its taxable GOS following the introduction of the hypothetical policy change leads to an increase in the capital income tax (p_RSGOSTAX) actually paid by the trade exposed industry. The export oriented industry pays slightly more capital income tax after the policy. The rest of the industries pay less capital income tax than the amount they paid prior to the policy change. In aggregate, government revenue collected from capital income tax declines by 8.2 percent, 1.8 percentage points less than the size of the tax cut. The larger the relative size of the expanding industries within the economy, the better will be the impact of the tax cut in income tax on the government revenue. In this simulation, the relative size of the trade exposed industry is very small, employing only 2.8 and 5 percent of the economy's labour force and capital, respectively. The export oriented industry is larger, using 8.4 and 16.5 percent of the labour force and capital, respectively. However, the size of change in the taxable GOS of these two expanding industries is not large enough to off-set the reduction of government tax collection from other industries.

8.3.2 (c) **Long-run effects of a 10 percent cut in the capital income tax with sterilisation of effects on domestic assets**

The results presented in the sub-section 8.3.2 (b) are based on the assumption that the hypothetical policy change does not affect the share of capital ownership. Implicit in the above assumption is that the domestic share of ownership in all industries is also the same as the aggregate share in the economy. Although this assumption is a good starting point when a complete ownership data base is not available, it hardly represents reality. The capital stock in the service providing industry and other non-traded industries is often dominated by domestic residents.

A more conservative assumption on the financing of the change in the capital stock due to the shock is adopted in this sub-section. It is assumed that the domestic residents (households) maintain the same level of domestically-owned capital stock after the shock as before it. To accommodate this assumption, the equation describing how the income of domestic households is generated (See Excerpt 53 in Appendix A) must be modified. This group's income from capital in the version of ORANI-RSA used above in 8.3.2 (b) included a component due to the change in the quantity of capital owned and a component due to the change in the rental on that capital. In the new treatment (E8.3'), only the latter is included. The resulting equation for pre-tax income is:

$$\begin{aligned} VHOUINCA(h)*whouinca(h) = {} & VLABINC\_0(h)*wlabinc\_o(h) + VGOSHOU(h)*p1cap\_i \\ & +VHOUHOU\_hf(h)*whouhou\_hf(h)+VGOVHOU(h)*wgovhou(h) \\ & + VROWHOU(h)*wrowhou(h) \qquad (h \in \{lo,hi\}) \qquad (E8.3') \end{aligned}$$

where whouinca(h) represents adjusted households' income which excludes income due to the change in the quantity of capital but includes the change in its rental price; wgoshou is transfers from GOS to households, (wgovhou and wrowhou are transfers from government and the rest of the world to households, respectively); whouhou represents transfers to one household type from the other; VHOUINCA is a coefficient representing the initial value of appropriately defined household income in the model's data base.

The new consumption function is:

$$w3tot(h) = f3tota(h) + f3tot\_h + wdispinca(h) \qquad (h \in \{lo, hi\}) \qquad (E8.4')$$

where w3tot(h) is households' nominal consumption; wdispinca(h) is (adjusted) households' disposable income[6]; and the variable f3tota represents the average propensity to consume. This variable is exogenously set to zero in SIM3, implying that the whole of the impact of the change in the households' incomes generated by the shock will be manifest in changed households' consumption. With this assumption in place, all of the change in the capital stock is attributed to foreigners.

After altering the behavioural equations as presented above, the model is then used to compute the impact of the hypothetical policy change introduced in sub-section 8.3.2 (b). The macro impact of the shock is presented in Table 8.15 and the industry results are given in Tables 8.16 to 18. Note that the size of the cut in the government spending in this case is higher, namely, 3.654 percent.

The initial impacts of the shock are essentially the same as those in sub-section 8.3.2 (b), namely the reductions in: (i) the quantity of rent-seeking services demanded; (ii) the price of rent-seeking services; and (iii) government spending, which in ORANI-RSA's current data base is wholly concentrated in public services produced by the service providing industry. As noted earlier, the policy change leads

[6] wdispinca(h) is the after-tax analogue of winchoua(h) introduced above.

to a shrinkage in the service providing industry. In this simulation, the industry contracts by 3.6 percent, slightly more than the contraction in the previous simulation because the balanced budget assumption requires a larger cut in government spending. As will be discussed later in this sub-section, the second round impact of the shock is a larger reduction in households' consumption. This leads to a reduction in government income received from the indirect tax on consumption.

Table 8.15
The long-run impact of a 10 percent cut in the capital income tax on macro variables with sterilised capital account

Variables	Descriprion	ntaxcut1
p0gdpsc	GDP price index - at social cost	-1.879
x0gdpsc	Real GDP at social cost	0.010
p0gdpexp	GDP price index - Expenditure side	-1.894
x0gdpexp	Real GDP from expenditure side	-0.120
delB	(Balance of trade)/GDP	0.016
x0cif_c	Import volume index, C.I.F. weights	-1.741
p1cap_I	Average capital rental	-1.138
x1cap_I	Aggregate capital stock	-0.160
p2tot_I	Aggregate investment price index	-1.190
x2tot_I	Aggregate real investment	0.170
p3tot_h	Consumer price index	-1.380
x3tot_h	Aggregate real household consumption	-2.054
x3tot(Lo)	Real consumption of household Lo	-1.693
x3tot)hi)	Real consumption of household Hi	-2.393
p4tot	Exports price index	-1.283
x4tot	Export volume index	5.174
p5tot	Government price index	-2.692
x5tot	Real Government Consumption	-3.654
p0toft	Terms of trade	-1.283
employ_io	Aggregate employment	0.000
realwage	Average real wage	-2.118
wgovinc	Government income	-4.659
delgsav	Gov Saving/Gov income	0.000
delrsav	ROW saving/ROW income	-0.048
del1sav	GOS saving/ GOS income	0.008

As the employment level is exogenously set to zero change, the shrinkage of the service providing industry (which employs a large proportion of the labor force) causes labour's real wage to decline. In turn, this leads to a reduction of households' incomes and hence households' consumption. In the simulation presented in the previous section, however, households' consumption is reduced only by 0.45 percent, compared to 2.05 percent in the current simulation. The reduction in the price of rent-seeking services combined with a larger reduction in households' and government demand reduce domestic costs and prices. The consumer and the export price indexes decline by 1.38 and 1.28 percent, respectively. Naturally, a more competitive domestic price is good for the balance of trade, which improves by 1.6 percent of GDP (compared to only 1 percent in the previous simulation).

Looking at conventional GDP for the expenditure side, we see that there have been expansion in real investment and in balance of trade, but that government and private consumption have fallen. The net result of the policy change is that GDP at private cost shrinks by 0.12 percent, compared to an improvement of 0.20 percent in the previous section. GDP at social cost, however, slightly improves (by 0.01 percent). This is because the reduction in the production of rent-seeking services release resources which are employed to produce output with a positive social valuation.

The pattern of industry results differs slightly from the results presented in the previous section. Similar to the previous simulation, the exporting industries gain significantly from the policy changes due to the reduction in the domestic cost. Due to a larger decline in the purchasers' price of exports, the export volumes of the trade exposed and the export oriented industry, respectively, rise by 17.9 and 2.8 percent (Table 8. 17), compared to rises of 11.6 and 1.4 percent in the previous simulation. The import oriented industry contracts by 0.06 percent, compared to a 0.3 percent expansion in the last simulation. This is because the substitution effect generated by the fall in domestic prices is dominated by the negative income effect caused by the reduction in labour income.

Table 8.16
The long-run impact of a 10 cut in the capital income tax rate on industry's output, capital stocks and employment

Industries	Output	Capital stocks	Employ ment(a)	Nominal wages
Trade Exposed	14.1819	15.1787	17.3005	-2.9923
Export Oriented	1.8769	1.5117	3.4930	-3.0106
Import Oriented	-0.0619	-0.6261	1.4974	-3.0759
Non Tradeable	-0.5990	-1.2656	0.7505	-3.1630
Margins	-0.5395	-1.2374	0.9194	-3.1909
Service Providing	-3.6312	-5.8411	-3.2330	-4.0821
Rent-seeking	-3.654	-	-	-
Public Services	-3.488	-	-	-

(a) Quantity index based on wage-bill weights

Table 8.17
The long-run impact of a 10 cut in the capital income tax rate on exports of each commodity

Commodities	Export Volumes	Purchase price of Trad export	Purchase price of Non Trad export
Trade Exposed	17.8980	-0.8199	n.a
Export Oriented	2.8289	-1.3851	n.a
Import Oriented	0.0295	n.a	-1.4269
Non Tradeable	0.0295	n.a	-1.4269
Margins	0.0295	n.a	-1.4269
Public Services	0.0295	n.a	-1.4269
Rent-seeking services	0.0295	n.a	-1.4269

The non-traded industry is heavily domestically oriented and does not benefit substantially from import competitiveness of the domestic economy, but it suffer negative income effects from the collapse in the private and public consumption, output is down by 0.6 percent. Margins benefits from the expansion of activity in the trade exposed and export oriented industries, but suffers from the declines in output elsewhere. The balance is negative, with margins output declines by 0.5 percent.

Table 8.18
The long-run impact of a 10 cut in the capital income tax rate on the tax paid by industries

Industries / Variables	Trade exposed	Export oriented	Import oriented	Non Tradeable	Margins
p_TXBGOS Taxable GOS	13.7904	0.3772	-1.6245	-2.4363	-2.3009
p_RSGOS Disposable[a] GOS	19.9503	3.6914	0.9677	0.1689	0.3465
p_PFINED Prob. of fined	0.0006	0.0006	0.0000	0.0000	0.0000
p_TAXQUOT Tax quotient	2.6952	2.6952	2.0538	1.8176	2.0759
p_PORSSRV Price of rent-seeking (RS) services	-2.2696	-2.2696	-2.2696	-2.2696	-2.2696
p_RSUSE Use of RS Services	10.1660	-2.8199	-4.8080	-4.9553	-5.0116
p_RSGOSTAX Tax paid	5.1717	-7.2258	-9.6428	10.5967	-10.2451

(a) GOS less taxes less expenditure on rent-seeking services

As regards to the rent-seeking part of the model, the policy change increases taxable gross operating surplus for the expanding industries but decreases the surplus for the contracting ones. As in the previous simulation, a large increase in its taxable surplus in the trade exposed industry leads to an increase in its demand for rent-seeking services. The tax paid by the trade exposed industry increases only by 5.17 percent, compared to a 13.7 increase in its taxable surplus. For the export oriented industry, a slight increase in its taxable surplus is not sufficient to drive up its demand for rent-seeking services. All contracting industries use less rent-seeking services as their taxable surpluses decrease, the net result being an economy-wide reduction in the demand for rent-seeking services by 3.65 percent. The aggregate government revenue collected from capital income tax declines by 8.85 percent, compared to a decline by 8.2 percent in the previous simulation.

It is important to note that the above results are highly dependent on specific features of the data base. These features are again prominent in determining the size of changes in GDP and in government revenue collected from the capital income tax. The industries which expand under the tax shock are relatively small compared to those which contract. The impacts of resource re-allocation stimulated by the hypothetical policy change, which shows the strength of general equilibrium analysis, would have been much larger, had the size of the exporting industries been larger in ORANI-RSA's data base.

8.4 Summary of major findings

The application of the partial equilibrium rent-seeking model reveals that, in the context of partial equilibrium, the cut in the capital income tax rate reduces firms' demand for rent-seeking services. This leads to a reduction in the quantity of rent-seeking supplied and hence a reduction in the resources used in its production. The impact of the policy on efficiency is unambiguously positive. The effect on government revenue collected from capital income tax depends on the privately valued productivity of representative firms in rent-seeking activity. In the context of the partial equilibrium model, at a given price of rent-seeking services, the level of income on which tax is assessed by tax officials depends on taxpayers' productivity in rent-seeking activity. Based on their productivity, representative taxpayers with the same level of before-tax income will decide (i) not to engage in rent-seeking activity in the first place if their productivity is low; (ii) to engage in rent-seeking when the tax rate is high but quit when the tax rate is reduced if their productivity is moderate; and (iii) to engage in rent-seeking irrespective of the tax rate if they are very productive in their use of rent-seeking services.

The representative taxpayers belonging to (i) report their full income whether the tax rate is low or high. A reduction in the tax rate will, therefore, reduce government revenue collected from this group of taxpayers. The representative taxpayers in group (ii) report part of their income when the tax rate is high but declare it in full when the tax rate is reduced to a sufficiently low proportion of income. If the increase in the reported income leads to additional tax collection which outweighs the reduction of tax revenue due to the reduction in the tax rate, it is possible to find that the reduction of the tax rate will increase government revenue collected from this group. In case (iii), the reduction of the tax rate does increase the percentage of income being reported but it is not sufficient to increase government revenue from the group.

Note however, that the analysis provided by the partial equilibrium model of rent-seeking has ignored at least four major points: (i) the impact that resources released from the service providing sector would have on the size of the rest of the economy; (ii) the long-run impact of the policy change on the stock of capital which in turn will impact on the size of the tax base; (iii) the effect of the cut in capital income tax on government spending; and (iv) the next round impacts of (i), (ii) and (iii) on the economy at large.

The short-run application of ORANI-RSA essentially address only point (i). In this simulation (SIM1), the tax reduction is introduced into an environment where capital stock in each industry, as well as government and household consumption, are set to zero change. In this setting, the benefit of the policy change is received in the form of better competitiveness of the economy shown by the performance growth of exports and a better use of the available economic resources. The latter is due to the shrinkage of the service providing industry, which produces rent-seeking services. The policy forces the service providing industry to release some of the ordinary labour it previously used and leads to a reduction in the real wages paid to privileged labour. This re-allocation of resources generates an improvement of 0.15 percent in real GDP measured at social cost, which is larger than the improvement in conventionally measured GDP because of the wedge between private and social valuation introduced by rent-seeking behaviour.

In the long-run application of ORANI-RSA, we free the capital stocks to adjust endogenously, but set the aggregate level of employment by occupation to zero change. The government consumption is reduced to compensate for the reduction of government income as a result of the cut in the capital income tax. In the first long-run simulation (SIM2), households' consumption is assumed to adjust endogenously following the change in household income due to the shock so as to preserve a constant average propensity to consume. Note that although the level of employment by occupation is exogenously set to zero change, the level of employment by industry is allowed to adjust endogenously. In this way, we allow the shock to affect the distribution of the ordinary labour force across industries[7]. With this closure, ORANI-RSA will address all four points ignored in the application of the partial equilibrium.

The projections generated in SIM2 indicate that the policy reform stimulates an even a stronger resource allocation towards a more competitive exporting sector. The service providing industry, which shrinks due to the reduction in the demand for rent-seeking services and the cut in government spending, releases almost 3 percent of its labour force to be used by exporting industries and others. Relative to the base case, the service providing industry also loss almost five percent of its capital stock. The strong performance of the main exporters stimulates higher investment and

[7] Priveleged labour remains tied to the industry producing rent-seeking services.

capital stocks in these industries. In aggregate, capital stocks in the economy increase by 0.23 percent. Overall, the hypothetical policy change leads to an improvement of GDP conventionally measured by 0.2 percent and of GDP at social cost by 0.33 percent.

This long-run application of ORANI-RSA identifies an important mechanism in explaining how the impact of the cut in capital income tax on government tax collection can be partly off-set by resources re-allocation within the economy. In the general equilibrium context, the size of the economy, and hence the size of taxable GOS, is not only determined by the size of the available inputs/resources, but also by how the resources are allocated between sectors within the economy. This proposition was not taken into account in the partial equilibrium analysis presented in the earlier chapters.

The increase in the capital stock, however, is too small off-set the reduction of government revenue due to the cut in the capital income tax rate. In aggregate, government revenue collected from capital income tax declines by 8.2 percent, 1.8 percentage points less than the size of the tax cut. This is because the size of the exporting industries which gain from the policy is relatively small compared to the rest of the industries which contract. Together, trade exposed and export oriented industries employ only 11.2 and 21.5 percent of the economy's labour force and capital, respectively. Therefore, the size of change in the taxable gross operating surplus of these two expanding industries is not large enough to off-set the reduction of government tax collection from other industries. The larger the relative size of these expanding industries within the economy, the better will be the impact of the cut in income tax on the economy at large and hence on the government revenue.

A more conservative assumption on the financing of the change in the capital stock due to the shock is adopted in SIM3. It is assumed that the domestic residents (households) maintain the same level of domestically-owned capital stock after the shock as before it. This means that real consumption gives a measure of the welfare of domestic residents since there is no change in their asset position. To accommodate this assumption, we modify the equation describing the generation of the income of domestic households. The modified equation generates *adjusted* households' income by excluding the component of income due to the change in the *quantity* of capital, but retaining the component due to the change in the rental on that capital. Then households' consumption is linked to the households' adjusted income so that these variables experience the same proportional deviation from base case.

The projections produced in SIM3 indicate that the net result of the policy change is that GDP at private cost shrinks by 0.12 percent, compared to an improvement of 0.20 percent in the previous simulation. This is a surprising result because it seems that domestic residents in SIM2 enjoy both greater ownership of assets *and* higher real consumption, whereas the whole point of SIM3 was these must be traded off. The higher balance of trade surplus recorded in SIM3 seems to indicate greater pessimism about debt servicing than SIM2. However, there is no explicit treatment of debt servicing, domestic saving or consumption along the path of adjustment to the long run in either simulation. Rectifying this is included below in Chapter 9 on the list of topics for further research.

GDP at social cost, however, slightly improves (by 0.01 percent) in SIM3. This is because the reduction in the production of rent-seeking services releases resources which are employed to produce output with a positive social valuation. The decline in GDP at private cost is caused by the fall in government and households' consumption, which off-sets the improvements in real investment and in the balance of trade. Households' consumption in SIM3 is reduced by 2.05 percent, compared to only 0.45 percent in SIM2. This is in line with the larger fall in SIM3 of domestic households' adjustment income. The latter is dominated by the reduction in labour income generated by the shrinkage of the labour intensive service providing industry. Thus, even though real GDP at social cost rises marginally, domestic residents do not gain.

The policy reform also stimulates a stronger resource allocation towards a more competitive exporting sector. The service providing industry, which shrinks due to the reduction in the demand for rent-seeking services and the cut in government spending, releases almost 3.23 percent of its labour force to be used by exporting industries and others. Relative to the base case, the service providing industry also losses 5.8 percent of its capital stock. The strong performance of the main exporters stimulates higher capital stocks in these industries. The stock of capital in the rest of the industries, however, declines due to the sharp reduction in domestic demand and the substitution effect in favour of labour. In aggregate, capital stocks of the economy decline by 0.16 percent. Following the assumption on the ownership of capital adopted in SIM3, this change in stock of capital is attributed to foreigners.

Chapter IX
Concluding Remarks and Agenda for Future Research

We started this research with the basic idea that rent seeking activity generally is a by-product of government regulation and hence that, its size in the economy depends on the amount of regulation in place. Almost all means of generating government revenue, including income taxes, tariffs and licence allocations, will attract certain types of rent-seeking activity (see Tullock, (1967); Krueger (1974); Bhagwati *et al.* (1984); Mohammad and Whalley (1984); Tollison (1987) and Pederson (1995)). Buchanan (1980) and Tullock (1980) argued that the best way to limit rent-seeking is by limiting the size of the government. The focus of this thesis is a specific form of rent-seeking, namely, attempts to avoid or evade the payment of taxes on income from capital.

We agree with Brooks and Heijdra (1987) that a general equilibrium framework is necessary to capture the full impact of rent-seeking activity where social cost (waste) arises from the fact that resources which can be employed more productively in some sector of the economy are used instead to procure wealth transfer. We therefore construct ORANI-RSA, an economy-wide model applied general equilibrium model with rent-seeking activity. Since the familiar input-output tables used for standard CGE models do not account for rent-seeking activity, we also need to construct a data base which recognises rent-seeking activity for ORANI-RSA.

The projections produced by ORANI-RSA do suggest that a cut in the intensity of regulation (i.e., the capital income tax rate) reduces the size of rent-seeking activity. The reform also stimulates re-allocation of resources which in turn generates a larger social product (as measured in GDP at social cost) both in the short– and in the long–run. In the context of ORANI-RSA, it is important to note, however, that the size of the economic improvement and who gains from it are determined by the initial configuration of the model's data base.

Both short- and long-run ORANI-RSA projections unambiguously suggest that the cut in capital income tax generates a gain to the exporting industries at the expense of the service providing industry. Surprisingly, however, the welfare of domestic residents (as measured by households' consumption) declines. Certain features of ORANI-RSA's data base are responsible for this result. The service providing industry (which jointly produces public and rent-seeking services) is labour intensive and employs a large proportion of the labour force. The exporting industries, in aggregate, are much smaller than the service providing industry, and are capital intensive. The cut in capital income tax under a balanced budget environment leads to a shrinkage of the service providing industry. This is because the long-run projections indicate that, although the improvement in the size of the economy generated by a better resource allocation does increase the tax base, it is not sufficient to off-set the reduction of government revenue collected from capital income tax due to the cut in the tax rate. The new trading environment forces the service providing industry to release some of its labour force to other industries. Under a labour market closure that keeps the level of employment by occupation exogenously fixed, the release of labour from the service providing industry stimulates re-allocation of labour across industries in the economy at a lower wages. With a fixed level of employment, the reduction of wage rates leads to a reduction in labour income.

In the long-run simulations, all wage rates fall. The reduction in labour wages together with the decline in the price of rent-seeking services following the policy change creates a cost advantage to the economy. At given foreign currency export and import prices, this stimulates exports, discourages imports and hence improves the economy's balance of trade. Since the exporting industries are capital intensive and relatively smaller, the large expansion in them, coupled with a moderate contraction in the service providing industry following the policy change, produces only a small aggregate improvement in the size of the economy.

It is unlikely that this real increase in the size of the economy represents a net benefit to domestic residents. Real consumption declined; this could only be construed as a net real benefit if the fall in current living standards was more than compensated for by an increase in assets. Whilst the overall capital stock did increase, we would need to know what happened to ownership before reaching a conclusion. But ownership is not modelled in ORANI-G nor in ORANI-RSA. Sterilising the asset account yields a long-run results in which it seems that the tax reform leaves domestic residents worse off. We speculate that this result is highly dependent on the initial data base.

The above considerations suggest two items requiring further research:

1. *An explicit treatment of foreign versus domestic ownership should be included in ORANI-RSA's data base. Whilst remaining within the comparative static framework, this would require at least the minimal accumulation dynamics first suggested by Dixon, Parmenter and Rimmer (1984) and followed up by Horridge (1987).*

2. *The ORANI-RSA data base should be reconfigured so that the service providing industry no longer employs so large a proportion of the total labour force; the labour/capital intensity of this industry could also be reduced.*

Since ORANI-RSA uses a hypothetical data base, some may doubt its reliability. We believe that to some degree it represents typical features of developing countries. We also learn from the application of ORANI-RSA, however, that the larger the relative size of the expanding industries within the economy, the larger will be the improvement in the size of the economy following the cut in the income tax rate. The impact of the same policy on households could be different if the factor intensities of the booming and the contracting industries were reversed.

Apart from the above, other more fundamental data-base issues need resolving. Rent-seeking services in general are not visible in a standard input-output table. ORANI-RSA with its new features requires rent-seeking costs to be visible. This challenges existing conventions of national accounting. Presumably illegal and underground-economy payments show up in the accounts as distorted records of legal and above-ground transactions. How to move from such a conventional set of accounts to a data base along the lines of ORANI-RSA's is a major item for future work:

3. *There needs to be devised a method of accounting for rent-seeking transactions that allows an informative data base for an ORANI-RSA style model to be generated from conventional input-output accounts and side estimates of the magnitude of rent-seeking.*

The cost of rent-seeking essentially is generated endogenously by the model. We need, however, to supply some parameters of model which in turn will determine the size of rent-seeking cost. These parameters have to be determined empirically in order to produce a reliable estimate of the size of rent-seeking used by each industry. In this thesis, it has only been possible to suggest illustrative values. Hence the following research need is clear:

4. *From the data base generated as an output of item 3 above, and from any other available data, the parameters of the sub-model for demand for rent-seeking services should be re-estimated and/or re-calibrated.*

In the context of the partial equilibrium model presented in Chapters 2-4, whether the cut in the capital income tax will increase or decrease government revenue collected from the tax depends on taxpayers' productivity in using rent-seeking services. Some taxpayers engage in rent-seeking activity when the tax rate is high and then quit after the tax rate is reduced. The increase of tax revenue from such taxpayers could compensate for the reduction of tax collection from others so that the cut in the capital income tax may lead to an increase in government revenue. This mechanism was not replicated in the simulations using ORANI-RSA where each industry consisted of just one representative firm. It turned out that all taxpayers/ industries remained engaging in rent-seeking activity after the cut in capital income tax. Hence we add to the list:

5. *More than one representative firm should be specified for each industry, and these firms should be allowed to differ in the private 'productivities' with which they use rent-seeking services.*

ORANI-RSA captures the accumulation of political stocks in a very simple and stylised way. Political influence is purchased as a by-product of the use of rent-seeking services. A full specification of the mode in which stocks of political influence are accumulated may lie outside the discipline of economics. However, at least a simple treatment of the stock of political influence accumulation in ORANI-RSA is needed:

6. *Equation for the accumulation of political influence, analogous to equations for investment in physical capital, could be introduced. A rate of return on this stock of political influence could be imputed, and related in an equilibrium relationship to the rate of return on ordinary capital.*

Recognising the weakness of GDP as a national welfare indicator under the current ORANI-RSA set up, we use households' consumption for this purpose, and attempt to sterilise movements in asset positions. The projections of the model suggest that a cut in the capital income tax rate does not necessarily lead to an improvement of domestic households' welfare in the long run. Note that the definition of household consumption is inherited from the ORANI tradition, and excludes publicly provided goods. If we extend the household utility function to include publicly provided goods, the cut in the capital income tax rate, which leads to a cut in government spending, would make households even worse off. In any event, publicly provided goods should not be excluded a priori from household welfare. So we add to our research agenda:

7. *The household utility function should be respecified to include publicly provided goods as an argument. 'Real consumption' should be redefined conformably with this utility function. As before, asset movements should be sterilised in welfare-analytic simulations. Welfare accounting should be done using the utility index for domestic households.*

Above we have made a distinction between GDP at social cost and privately valued GDP. No such distinction exists in the national accounting conventions. Yet clearly activity which merely transfers wealth for no good social purpose has a positive opportunity cost. These ideas need formalising:

8. *Augmenting item 3 above, accounting conventions need to be developed which distinguish between private and social valuation of activities included in activity indicators such as GDP. This work needs to be integrated with formal and rigorous analysis of welfare.*

Notwithstanding the need for more research, this thesis strongly suggests that "reforms" of the tax structure do not necessarily lead to improvements in the welfare of the domestic residents. The general equilibrium perspective reveals that initial patterns of ownership and factor intensities can interact with the sectoral composition of the economy to produce the contrary result. The ORANI-RSA data base is a case in point.

Appendix A: The TABLO Code of ORANI-RSA

```
File (new) SUMMARY  # Summary and checking data #;
File KDATA # Flows Data File #;

!*******************************************************!
```

! Excerpt 1 of TABLO input file: !
! Definitions of sets !

```
Set
 COM # Commodities #
(TrdExpse,ExpOrnt,ImpOrnt,NonTrad,Margins,PubSrv,
                    RsSrv); !c!

 IND # Industries #
(TrdExpse,ExpOrnt,ImpOrnt,NonTrad,Margins,SrvPrv); !i!

 SRC # Source of Commodities # (dom,imp); ! s !

 OCC # Occupations # (Skl,UnSkl,PrvLab); ! subscript o !

 MAR # Margin Commodities # (margins); ! subscript m !

 ORDCOM # Commodities other than RsSrv #
(TrdExpse,ExpOrnt,ImpOrnt,NonTrad,
                                 Margins,PubSrv) ; !oc!
 RSIND # Industries using rent-seeking #
                    (TrdExpse,ExpOrnt,ImpOrnt,NonTrad,Margins); !r!

Subset
 MAR is subset of COM;
 ORDCOM is subset of COM ;
 RSIND is subset of IND ;

Set
 NONMAR = COM - MAR; ! non - Margin Commodities ! ! n !
 RSCOM  = COM - ORDCOM;! rent-seeking services!!rs!
Set
 HOU # Income groupings # (Lo,Hi); ! subscript h !
 GOVCOM # COM Supplied by Serv. Provider # (PubSrv, RsSrv) ;
 GOVIND # Govt. Industry # (SrvPrv) ;


Subset
 GOVCOM is subset of COM ;
 GOVIND is subset of IND ;

Set ONEPROD = COM - GOVCOM ;
Subset ONEPROD is subset of IND ;

Mapping COM2IND from COM to IND;
Formula (All,c,GOVCOM) COM2IND(c) = $POS("SrvPrv",IND);
Formula (All,c,ONEPROD) COM2IND(c) = $POS(c,IND);

Set TRADEXP # Traditional Export Commodities #
(TrdExpse,ExpOrnt);

Subset TRADEXP is subset of COM;
```

```
Set NTRADEXP = COM - TRADEXP ; ! Nontraditional Export Commodities !

Set EXOGINV      # 'Exogenous' Investment Industries #
 (SrvPrv);
Subset EXOGINV is Subset of IND;
Set ENDOGINV = IND  - EXOGINV;
```

! Excerpt 2 of TABLO input file: !
! Variables relating to commodity flows !

```
Variable
! Basic Demands for commodities (excluding margin demands) !
(all,c,COM)(all,s,SRC)(all,i,IND)  x1(c,s,i)  # Intermediate basic
demands #;
(all,c,COM)(all,s,SRC)(all,i,IND)  x2(c,s,i)  # Investment basic
demands #;
(all,c,COM)(all,s,SRC)(all,h,HOU)  x3(c,s,h)  # Household basic
demands #;
(all,c,COM)(all,s,SRC)             x3_h(c,s) # Household basic
demands #;
(all,c,COM)                        x4(c)      # Export basic demands
#;
(all,c,COM)(all,s,SRC)             x5(c,s)    # Government basic
demands #;
(change) (all,c,COM)(all,s,SRC)    delx6(c,s) # Inventories demands
#;

(all,c,COM)(all,s,SRC)  p0(c,s)      # Basic prices by commodity and
source #;

! Technical or Taste Change Variables affecting Basic Demands !
(all,c,COM)(all,s,SRC)(all,i,IND)  a1(c,s,i) # Intermediate basic
tech change #;
(all,c,COM)(all,s,SRC)(all,i,IND)  a2(c,s,i) # Investment basic tech
change #;
!(all,c,COM)(all,s,SRC)(all,h,HOU)  a3(c,s,h) # Household basic taste
change #;!
(all,c,COM)(all,s,SRC)             f5(c,s)   # Government demand
shift #;

! Margin Usage on Basic Flows !
(all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                                  x1mar(c,s,i,m)# Intermediate margin
demands #;
(all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                                  x2mar(c,s,i,m)# Investment margin
demands #;
(all,c,COM)(all,s,SRC)(all,m,MAR) (all,h,HOU)
                                  x3mar(c,s,m,h)  # Household margin
demands #;
(all,c,COM)(all,s,SRC)(all,m,MAR)
                                  x3mar_h(c,s,m)  # Household margin
demands #;
(all,c,COM)(all,m,MAR)            x4mar(c,m)     # Export margin
demands #;
(all,c,COM)(all,s,SRC)(all,m,MAR) x5mar(c,s,m)  # Government margin
demands #;

! Technical Change in Margins Usage !
(all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                          a1mar(c,s,i,m)  # Intermediate margin tech
change #;
```

```
(all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                              a2mar(c,s,i,m)  # Investment margin tech
change #;
(all,c,COM)(all,s,SRC)(all,m,MAR) a3mar(c,s,m) # Household margin
tech change #;
(all,c,COM)(all,m,MAR)            a4mar(c,m)   # Export margin tech
change #;
(all,c,COM)(all,s,SRC)(all,m,MAR) a5mar(c,s,m) # Governmnt margin
tech change #;

! Powers of Commodity Taxes on Basic Flows !
(all,c,COM)(all,s,SRC)(all,i,IND)  t1(c,s,i)  # Power of tax on
intermediate #;
(all,c,COM)(all,s,SRC)(all,i,IND)  t2(c,s,i)  # Power of tax on
investment #;
(all,c,COM)(all,s,SRC)             t3(c,s)    # Power of tax on
household #;
(all,c,COM)                        t4(c)      # Power of tax on
export #;
(all,c,COM)(all,s,SRC)             t5(c,s)    # Power of tax on
government #;

! Purchaser's Prices (including margins and taxes) !
(all,c,COM)(all,s,SRC)(all,i,IND) p1(c,s,i)# Purchaser's price,
intermediate #;
(all,c,COM)(all,s,SRC)(all,i,IND) p2(c,s,i)# Purchaser's price,
investment #;
(all,c,COM)(all,s,SRC)(all,h,HOU) p3(c,s,h)# Purchaser's price,
household #;
(all,c,COM)                       p4(c)    # Purchaser's price,
exports $A #;
(all,c,COM)(all,s,SRC)            p5(c,s)  # Purchaser's price,
government #;
```

! Excerpt 3 of TABLO input file: !

! Variables for primary-factor flows, commodity supplies and import duties !

```
! Variables relating to usage of labour, occupation o, in industry i
!
(all,i,IND)(all,o,OCC)   x1lab(i,o)  # Employment by industry and
occupation #;
(all,i,IND)(all,o,OCC)   p1lab(i,o)  # Wages by industry and
occupation #;
(all,i,IND)              a1lab_o(i)  # Labor augmenting technical
change #;
(all,i,IND)(all,o,OCC)   f1lab(i,o)  # Wage shift variable #;
(All,o,OCC) person_i(o) # Aggregate Employment (Persons) #;

! Variables relating to usage of fixed capital in industry i !
(all,i,IND)  x1cap(i)      # Current capital stock #;
(all,i,IND)  p1cap(i)      # Rental price of capital #;
(all,i,IND)  a1cap(i)      # Capital augmenting technical change #;

! Variables relating to usage of land !
(all,i,IND)  x1lnd(i)      # Use of land #;
(all,i,IND)  p1lnd(i)      # Rental price of land #;
(all,i,IND)  a1lnd(i)      # Land augmenting technical change #;

! Variables relating to "Other Costs" !
(all,i,IND)  x1oct(i)      # Demand for "other cost" tickets #;
(all,i,IND)  p1oct(i)      # Price of "other cost" tickets #;
(all,i,IND)  a1oct(i)      # "other cost" ticket augmenting
```

```
technical change#;
(all,i,IND)  floct(i)        # Shift in price of "other cost" tickets
#;

! Variables relating to Subsidies !
(All,i,IND) x1sub(i) # Demand for Subsidy Units #;
(All,i,IND) p1sub(i) # Price of Subsidy Units #;
(All,i,IND) f1sub(i) # Shifts in Subsidy Rate #;

! Variables relating to commodity supplies, import duties and stocks
!
(all,c,COM)(all,i,IND)  q1(c,i)     # Output by commodity and
industry #;
(all,c,COM)             t0imp(c)    # Power of tariff #;
  (change)
(all,c,COM)(all,s,SRC)  fx6(c,s)    # Shifter on rule for stocks #;
```

! Excerpt 4 of TABLO input file: !
! Variables describing composite commodities !

```
! Demands for import/domestic commodity composites !
(all,c,COM)(all,i,IND)  x1_s(c,i)  # Intermediate use of imp/dom
composite #;
(all,c,COM)(all,i,IND)  x2_s(c,i)  # Investment use of imp/dom
composite #;
(all,c,COM)(all,h,HOU)  x3_s(c,h)  # Household use of imp/dom
composite #;
(all,c,COM)(all,h,HOU)  x3lux(c,h) # Household - supernumerary
demands #;
(all,c,COM)(all,h,HOU)  x3sub(c,h) # Household - subsistence demands
#;

! Effective Prices of import/domestic commodity composites !
(all,c,COM)(all,i,IND)  p1_s(c,i)  # Price, intermediate imp/dom
composite #;
(all,c,COM)(all,i,IND)  p2_s(c,i)  # Price, investment imp/dom
composite #;
(all,c,COM)(all,h,HOU)  p3_s(c,h)    # Price, household imp/dom
composite #;

! Miscellaneous vector variables !

(All,o,OCC) employ_i(o) # Employment by Occupation #;
(All,i,IND) employ_o(i) # Employment by Industry #;
(All,h,HOU) q(h) # Number of H'holds #;
(All,h,HOU) utility(h) # Utility per Household #;
(All,h,HOU) w3lux(h) # Nominal Supernumerary Expenditure #;
(All,h,HOU) w3tot(h) # Nominal Household Consumption #;
(All,h,HOU) f3tot(h) # Shift Term For Consumption #;
(All,h,HOU) f3tota(h) # Shift Term For adjusted Consumption #;
(All,h,HOU) p3tot(h) # Consumer Price Index #;
(All,h,HOU) x3tot(h) # Real Household Consumption #;

! Technical or Taste Change Variables for import/domestic composites
!
(all,c,COM)(all,i,IND)  a1_s(c,i)# Tech change, int'mdiate imp/dom
composite #;
(all,c,COM)(all,i,IND)  a2_s(c,i)# Tech change, investment imp/dom
composite #;
!(all,c,COM)(all,h,HOU)  a3_s(c,h)# Taste change, household imp/dom
composite #;
(all,c,COM)             a3lux(c) # Taste change, supernumerary
```

```
demands #;
(all,c,COM)             a3sub(c) # Taste change, subsistence demands
#;!
```

! Excerpt 5 of TABLO input file: !
! Miscellaneous vector variables !

```
Variable
(all,i,IND)  a1prim(i)       # All factor augmenting technical change
#;
(all,i,IND)  a1tot(i)        # All input augmenting technical change
#;
(all,i,IND)  a2tot(i)        # Neutral technical change - investment
#;
(all,i,IND)  employ(i)       # Employment by industry #;
(all,c,COM)  f0tax_s(c)      # General sales tax shifter #;
(all,o,OCC)  f1lab_i(o)      # Occupation-specific wage shifter #;
(all,i,IND)  f1lab_o(i)      # Industry-specific wage shifter #;
(all,c,COM)  f4p(c)          # Price (upward) shift in export demand
schedule #;
(all,c,COM)  f4q(c)          # Quantity (right) shift in export
demands #;
(All,c,COM)  p0com(c)        # Output price of locally-produced
commodity #;
(all,c,COM)  p0dom(c)        # Basic price of domestic goods =
p0(c,"dom") #;
(all,c,COM)  p0imp(c)        # Basic price of imported goods =
p0(c,"imp") #;
(all,i,IND)  p1lab_o(i)      # Price of labour composite #;
(all,i,IND)  p1prim(i)       # Effective price of primary factor
composite #;
(all,i,IND)  p1tot(i)        # Average input/output price #;
(all,i,IND)  p2tot(i)        # Cost of unit of capital #;
(All,c,COM)  pe(c)           # Basic price of export commodity #;
(all,c,COM)  pf0cif(c)       # C.I.F. foreign currency import prices
#;
(all,c,COM)  x0com(c)        # Output of commodities #;
(all,c,COM)  x0dom(c)        # Output of commodities for local market
#;
(all,c,COM)  x0imp(c)        # Total supplies of imported goods #;
(all,o,OCC)  x1lab_i(o)      # Employment by occupation #;
(all,i,IND)  x1lab_o(i)      # Effective labour input #;
(all,i,IND)  x1prim(i)       # Primary factor composite #;
(all,i,IND)  x1tot(i)        # Activity level or value-added #;
(all,i,IND)  x2tot(i)        # Investment by using industry #;
```

! Excerpt 6 of TABLO input file: !
! Scalar or macro variables !

```
Variable
(change) delB    # (Balance of trade)/GDP #;
a1lab_io # uniform Labor Augmenting Technical Change #;
!f1lab_io         # Overall wage shifter #;!
employ_io        # Aggregate Employment - Wage Bill Weights #;
person_io        # Aggregate Employment -Persons Weights #;
f1tax_csi        # Uniform % change in powers of taxes on
intermediate usage #;
f2tax_csi        # Uniform % change in powers of taxes on investment
#;
f3tax_cs         # Uniform % change in powers of taxes on household
usage #;
```

```
f3tot_h          # Ratio, consumption/GDP #;
f4p_ntrad        # Upward demand shift, non-traditional export
aggregate #;
f4q_ntrad        # Right demand shift, non-traditional export
aggregate #;
f4tax_ntrad      # Uniform % change in powers of taxes on nontradtnl
exports #;
f4tax_trad       # Uniform % change in powers of taxes on tradtnl
exports #;
f5tax_cs         # Uniform % change in powers of taxes on government
usage #;
f5tot            # Overall shift term for government demands #;
f5tot2           # Ratio between f5tot and x3tot #;
p0cif_c          # Imports price index, C.I.F., $A #;
p0gdpexp         # GDP price index, expenditure side #;
p0gdpsc          # GDP price index, expenditure side #;
p0imp_c          # Duty-paid imports price index, $A #;
p0realdev        # Real devaluation #;
p0toft           # Terms of trade #;
p1cap_i          # Average capital rental #;
p1lab_io         # Average nominal wage #;
p2tot_i          # Aggregate investment price index #;
p3tot_h            # Consumer price index #;
p4_ntrad         # Price, non-traditional export aggregate #;
p4tot            # Exports price index #;
p5tot            # Government price index #;
p6tot            # Inventories price index #;
phi              # Exchange rate, $A/$world #;
realwage         # Average real wage #;
w0cif_c          # C.I.F. $A value of imports #;
w0gdpexp         # Nominal GDP from expenditure side #;
w0gdpsc          # Nominal GDP from expenditure side #;
w0gdpinc         # Nominal GDP from income side #;
w0imp_c          # Value of imports plus duty #;
w0tar_c          # Aggregate tariff revenue #;
w0tax_csi        # Aggregate revenue from all indirect taxes #;
w1cap_i          # Aggregate payments to capital #;
w1lab_io         # Aggregate payments to labour #;
w1lnd_i          # Aggregate payments to land #;
w1prim_i         # Aggregate Primary Factor Payments #;
w1oct_i          # Aggregate "other cost" ticket payments #;
w1sub_i          # Aggregate Subsidy Payments #;
w1tax_csi        # Aggregate revenue from indirect taxes on
intermediate #;
w2tax_csi        # Aggregate revenue from indirect taxes on
investment #;
w2tot_i          # Aggregate nominal investment #;
w3tax_csh         # Aggregate revenue from indirect taxes on
households #;
w3tot_h          # Nominal total household consumption #;
w4tax_c          # Aggregate revenue from indirect taxes on export #;
w4tot            # $A border value of exports #;
w5tax_cs         # Aggregate revenue from indirect taxes on
government #;
w5tot            # Aggregate nominal value of government demands #;
w6tot            # Aggregate nominal value of inventories #;
x0cif_c          # Import volume index, C.I.F. weights #;
x0gdpexp         # Real GDP from expenditure side #;
x0gdpsc          # Real GDP from expenditure side, at social cost #;
x0imp_c          # Import volume index, duty-paid weights #;
x1cap_i          # Aggregate capital stock, rental weights #;
x1prim_i         # Aggregate output: value-added weights #;
x2tot_i          # Aggregate real investment expenditure #;
```

```
x3tot_h          # Real household consumption #;
x4_ntrad         # Quantity, non-traditional export aggregate #;
x4tot            # Export volume index #;
x5tot            # Aggregate real government demands #;
x6tot            # Aggregate real inventories #;
q_h              # Number of H'holds #;
```

! Excerpt 7 of TABLO input file: !
! Data coefficients relating to basic commodity flows !

```
Coefficient  ! Basic Flows of Commodities!
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1BAS(c,s,i)  # Intermediate
basic flows #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2BAS(c,s,i)  # Investment basic
flows #;
 (all,c,COM)(all,s,SRC)(all,h,HOU)  V3BAS(c,s,h)  # Household basic
flows #;
 (all,c,COM)                        V4BAS(c)      # Export basic
flows #;
 (all,c,COM)(all,s,SRC)             V5BAS(c,s)    # Government basic
flows #;
 (all,c,COM)(all,s,SRC)             V6BAS(c,s)    # Inventories basic
flows #;
Read
 V1BAS from file KDATA header "1BAS";
 V2BAS from file KDATA header "2BAS";
 V3BAS from file KDATA header "3BAS";
 V4BAS from file KDATA header "4BAS";
 V5BAS from file KDATA header "5BAS";
 V6BAS from file KDATA header "6BAS";
Update
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1BAS(c,s,i)  =
p0(c,s)*x1(c,s,i);
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2BAS(c,s,i)  =
p0(c,s)*x2(c,s,i);
 (all,c,COM)(all,s,SRC)(all,h,HOU)  V3BAS(c,s,h)  =
p0(c,s)*x3(c,s,h);
 (all,c,COM)                        V4BAS(c)      = pe(c)*x4(c);
 (all,c,COM)(all,s,SRC)             V5BAS(c,s)    = p0(c,s)*x5(c,s);

Coefficient (all,c,COM)(all,s,SRC) LEVP0(c,s) # Levels basic prices
#;
Formula (Initial) (all,c,COM)(all,s,SRC) LEVP0(c,s) = 1; ! arbitrary
setting !
Update   (all,c,COM)(all,s,SRC) LEVP0(c,s) = p0(c,s);
(change) (all,c,COM)(all,s,SRC)
       V6BAS(c,s) = V6BAS(c,s)*p0(c,s)/100 + LEVP0(c,s)*delx6(c,s);

Coefficient  ! Margin Flows!
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                                    V1MAR(c,s,i,m)  # Intermediate
margins #;
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                                    V2MAR(c,s,i,m)  # Investment
margins #;
 (all,c,COM)(all,s,SRC)(all,m,MAR)(all,h,HOU)
                                    V3MAR(c,s,m,h)    # Households
margins #;
 (all,c,COM)(all,m,MAR)             V4MAR(c,m)      # Export margins
#;
 (all,c,COM)(all,s,SRC)(all,m,MAR)  V5MAR(c,s,m)    # Government
margins #;
```

```
Read
 V1MAR from file KDATA header "1MAR";
 V2MAR from file KDATA header "2MAR";
 V3MAR from file KDATA header "3MAR";
 V4MAR from file KDATA header "4MAR";
 V5MAR from file KDATA header "5MAR";
Update
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                  V1MAR(c,s,i,m)   = p0dom(m)*x1mar(c,s,i,m);
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                  V2MAR(c,s,i,m)   = p0dom(m)*x2mar(c,s,i,m);
 (all,c,COM)(all,s,SRC)(all,m,MAR)(all,h,HOU)
                  V3MAR(c,s,m,h)     = p0dom(m)*x3mar(c,s,m,h);
 (all,c,COM)(all,m,MAR)
                  V4MAR(c,m)         = p0dom(m)*x4mar(c,m);
 (all,c,COM)(all,s,SRC)(all,m,MAR)
                  V5MAR(c,s,m)       = p0dom(m)*x5mar(c,s,m);
```

! Excerpt 8 of TABLO input file: !
! Data coefficients relating to commodity taxes !

```
Coefficient  ! Taxes on Basic Flows!
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1TAX(c,s,i) # Taxes on
intermediate #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2TAX(c,s,i) # Taxes on
investment #;
 (all,c,COM)(all,s,SRC)(all,h,HOU)  V3TAX(c,s,h) # Taxes on
households #;
 (all,c,COM)                        V4TAX(c)     # Taxes on export #;
 (all,c,COM)(all,s,SRC)             V5TAX(c,s)   # Taxes on
government #;
Read
 V1TAX from file KDATA header "1TAX";
 V2TAX from file KDATA header "2TAX";
 V3TAX from file KDATA header "3TAX";
 V4TAX from file KDATA header "4TAX";
 V5TAX from file KDATA header "5TAX";
Update (change) (all,c,COM)(all,s,SRC)(all,i,IND)
  V1TAX(c,s,i) = V1TAX(c,s,i)* [x1(c,s,i) + p0(c,s)]/100 +
     [V1BAS(c,s,i)+V1TAX(c,s,i)]*t1(c,s,i)/100;
Update (change) (all,c,COM)(all,s,SRC)(all,i,IND)
  V2TAX(c,s,i) = V2TAX(c,s,i)* [x2(c,s,i) + p0(c,s)]/100 +
     [V2BAS(c,s,i)+V2TAX(c,s,i)]*t2(c,s,i)/100;
Update (change) (all,c,COM)(all,s,SRC)(all,h,HOU)
  V3TAX(c,s,h) = V3TAX(c,s,h)* [x3(c,s,h) + p0(c,s)]/100 +
     [V3BAS(c,s,h)+V3TAX(c,s,h)]*t3(c,s)/100;
Update (change) (all,c,COM)
  V4TAX(c) = V4TAX(c)* [x4(c) + pe(c)]/100 +
     [V4BAS(c)+V4TAX(c)]*t4(c)/100;
Update (change) (all,c,COM)(all,s,SRC)
  V5TAX(c,s) = V5TAX(c,s)*[x5(c,s) + p0(c,s)]/100 +
     [V5BAS(c,s)+V5TAX(c,s)]*t5(c,s)/100;
```

! Excerpt 9 of TABLO input file: !
! Data coefficients relating to primary-factor flows !

```
Coefficient  ! Primary Factor and Other Industry costs!
 (all,i,IND)               V1CAP(i)     # Capital rentals #;
 (all,i,IND)(all,o,OCC)    V1LAB(i,o)   # Wage bill matrix #;
 (all,i,IND)(all,o,OCC)    PERSON(i,o)  # Person Labour matrix #;
 (all,i,IND)               V1LND(i)     # Land rentals #;
```

```
 (all,i,IND)                 V1OCT(i)    # Other cost tickets #;
 (all,i,IND)                 V1SUB(i)    # Other cost tickets #;
Read
 V1CAP from file KDATA header "1CAP";
 V1LAB from file KDATA header "1LAB";
 V1LND from file KDATA header "1LND";
 V1OCT from file KDATA header "1OCT";
 PERSON From File KDATA Header "PERS";
 V1SUB From File KDATA Header "1SUB";
Update
 (all,i,IND)                 V1CAP(i)    = p1cap(i)*x1cap(i);
 (all,i,IND)(all,o,OCC)  V1LAB(i,o)  = p1lab(i,o)*x1lab(i,o);
 (all,i,IND)                 V1LND(i)    = p1lnd(i)*x1lnd(i);
 (all,i,IND)                 V1OCT(i)    = p1oct(i)*x1oct(i);
 (All,i,IND)(All,o,OCC) PERSON(i,o) = x1lab(i,o);
 (All,i,IND) V1SUB(i) = p1sub(i)*x1sub(i);
```

! Excerpt 10 of TABLO input file: !
! Data coefficients relating to commodity outputs and import duties !

```
Coefficient (all,c,COM)(all,i,IND) MAKE(c,i) # Multiproduction matrix
#;
Read MAKE from file KDATA header "MAKE";
Update (all,c,COM)(all,i,IND) MAKE(c,i)= p0com(c)*q1(c,i);

Coefficient (all,c,COM) V0TAR(c)  # Tariff revenue #;
Read V0TAR from file KDATA header "0TAR";
Coefficient (all,c,COM) V0IMP(c) # Total basic-value imports of good
c #;
! V0IMP(c) is needed to update V0TAR: it is declared now and defined
later !
Update (change)  (all,c,COM)
   V0TAR(c) = V0TAR(c)*[x0imp(c)+pf0cif(c)+phi]/100 +
V0IMP(c)*t0imp(c)/100;

! Household and Labour Addups !

Coefficient
(All,c,COM)(All,s,SRC) V3BAS_H(c,s)# Households:Agg #;
Formula
(All,c,COM)(All,s,SRC) V3BAS_H(c,s) = Sum(h,HOU, V3BAS(c,s,h));
Coefficient
(All,c,COM)(All,s,SRC)(All,m,MAR) V3MAR_H(c,s,m) # Households:Agg #;
Formula
(All,c,COM)(All,s,SRC)(All,m,MAR) V3MAR_H(c,s,m) = Sum(h,HOU,
V3MAR(c,s,m,h));
```

! Excerpt 11 of TABLO input file: !
! Aggregates and shares of flows at purchasers' prices !

```
Coefficient ! Flows at Purchasers prices !
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1PUR(c,s,i)  # Intermediate
purch. value #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2PUR(c,s,i)  # Investment purch.
value #;
 (all,c,COM)(all,s,SRC)(all,h,HOU)  V3PUR(c,s,h)   # Households
purch. value #;
 (all,c,COM)                        V4PUR(c)      # Export purch.
value #;
 (all,c,COM)(all,s,SRC)             V5PUR(c,s)    # Government purch.
value #;
```

```
Formula
 (all,c,COM)(all,s,SRC)(all,i,IND)
  V1PUR(c,s,i)  = V1BAS(c,s,i)  + V1TAX(c,s,i)  + sum{m,MAR,
V1MAR(c,s,i,m) };
 (all,c,COM)(all,s,SRC)(all,i,IND)
  V2PUR(c,s,i)  = V2BAS(c,s,i)  + V2TAX(c,s,i)  + sum{m,MAR,
V2MAR(c,s,i,m) };
 (all,c,COM)(all,s,SRC)(all,h,HOU)
  V3PUR(c,s,h)    = V3BAS(c,s,h)  + V3TAX(c,s,h) + sum{m,MAR,
V3MAR(c,s,m,h) };
 (all,c,COM)
  V4PUR(c)      = V4BAS(c)      + V4TAX(c)      + sum{m,MAR,
V4MAR(c,m) };
 (all,c,COM)(all,s,SRC)
  V5PUR(c,s)    = V5BAS(c,s)    + V5TAX(c,s)    + sum{m,MAR,
V5MAR(c,s,m) };

Coefficient ! Flows at Purchaser's prices: Domestic + Imported Totals
!
 (all,c,COM)(all,i,IND)      V1PUR_S(c,i) # Dom+imp intermediate
purch. value #;
 (all,c,COM)(all,i,IND)      V2PUR_S(c,i) # Dom+imp investment purch.
value #;
 (all,c,COM)                 V1PUR_SI(c)  # Dom+imp intermediate
purch. value #;
 (all,c,COM)                 V2PUR_SI(c)  # Dom+imp investment purch.
value #;
 (all,c,COM)(all,h,HOU)      V3PUR_S(c,h) # Dom+imp households purch.
value #;
Formula
 (all,c,COM)(all,i,IND)      V1PUR_S(c,i)  = sum{s,SRC, V1PUR(c,s,i)
};
 (all,c,COM)(all,i,IND)      V2PUR_S(c,i)  = sum{s,SRC, V2PUR(c,s,i)
};
 (all,c,COM)                 V1PUR_SI(c)   = sum{i,IND, V1PUR_S(c,i)
};
 (all,c,COM)                 V2PUR_SI(c)   = sum{i,IND, V2PUR_S(c,i)
};
 (all,c,COM)(all,h,HOU)      V3PUR_S(c,h)  = sum{s,SRC, V3PUR(c,s,h)
};

Coefficient ! Source Shares in Flows at Purchaser's prices !
 (all,c,COM)(all,s,SRC)(all,i,IND)  S1(c,s,i) # Intermediate source
shares #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  S2(c,s,i) # Investment source
shares #;
 (all,c,COM)(all,s,SRC)(all,h,HOU)  S3(c,s,h)   # Households source
shares #;
Zerodivide Default 0.5;
Formula
 (all,c,COM)(all,s,SRC)(all,i,IND)  S1(c,s,i)  = V1PUR(c,s,i) /
V1PUR_S(c,i);
 (all,c,COM)(all,s,SRC)(all,i,IND)  S2(c,s,i)  = V2PUR(c,s,i) /
V2PUR_S(c,i);
 (all,c,COM)(all,s,SRC)(all,h,HOU)  S3(c,s,h)  = V3PUR(c,s,h) /
V3PUR_S(c,h);
Zerodivide Off;
```

! Excerpt 12 of TABLO input file: !
! Cost and usage aggregates !

```
Coefficient  ! Industry-Specific Cost Totals !
```

```
 (all,i,IND)  V1LAB_O(i)  # Total labour bill in industry i #;
 (all,i,IND)  V1PRIM(i)   # Total factor input to industry i#;
 (all,i,IND)  V1TOT(i)    # Total cost of industry i #;
 (all,i,IND)  V2TOT(i)    # Total capital created for industry i #;
 (all,o,OCC)  V1LAB_I(o)  # Total wages, occupation o #;

Formula
 (all,i,IND)  V1LAB_O(i)  = sum{o,OCC,  V1LAB(i,o) };
 (all,i,IND)  V1PRIM(i)   = V1LAB_O(i)+ V1CAP(i) + V1LND(i);
 (All,i,IND) V1TOT(i) = Sum(c,COM, V1PUR_S(c,i))
 + V1PRIM(i) + V1OCT(i) - V1SUB(i);

 (all,i,IND)  V2TOT(i)    = sum{c,COM,  V2PUR_S(c,i) };
 (all,o,OCC)  V1LAB_I(o)  = sum{i,IND,  V1LAB(i,o) };

Coefficient (all,c,COM) MARSALES(c) # Total usage for margins
purposes #;
Formula (all,m,MAR) MARSALES(m) =
   sum{c,COM, V4MAR(c,m) +
              sum{s,SRC, V3MAR_H(c,s,m) + V5MAR(c,s,m) +
                         sum{i,IND, V1MAR(c,s,i,m) +
V2MAR(c,s,i,m) }}};
Formula (all,n,NONMAR) MARSALES(n) = 0.0;

Coefficient (all,c,COM) DOMSALES(c) # Total sales to local market #;
Formula (all,c,COM)
   DOMSALES(c) = sum{i,IND, V1BAS(c,"dom",i) + V2BAS(c,"dom",i) }
    + V3BAS_H(c,"dom") + V5BAS(c,"dom") + V6BAS(c,"dom") +
MARSALES(c);

Coefficient (all,c,COM) SALES(c) # Total sales of domestic
commodities #;
Formula (all,c,COM) SALES(c) = DOMSALES(c) + V4BAS(c);

! Coefficient (all,c,COM) V0IMP(c) # Total basic-value imports of
good c #; !
! above had to be declared prior to V0TAR update statement!
Formula (all,c,COM) V0IMP(c) =
  sum{i,IND, V1BAS(c,"imp",i) + V2BAS(c,"imp",i) }
 + V3BAS_H(c,"imp") + V5BAS(c,"imp") + V6BAS(c,"imp");

Coefficient (all,c,COM) V0CIF(c) # Total ex-duty imports of good c #;
Formula (all,c,COM) V0CIF(c) = V0IMP(c) - V0TAR(c);
```

! Excerpt 13 of TABLO input file: !
! Income-Side Components of GDP !

```
Coefficient ! Total indirect tax revenues !
 V1TAX_CSI  # Total intermediate tax revenue #;
 V2TAX_CSI  # Total investment tax revenue #;
 V3TAX_CSH  # Total households tax revenue #;
 V4TAX_C    # Total export tax revenue #;
 V5TAX_CS   # Total government tax revenue #;
 V0TAR_C    # Total tariff revenue #;
 V0TAX_CSI  # Total indirect tax revenue #;
 (all,c,COM)(all,s,SRC) V3TAX_H(c,s)  # Total households tax revenue
#;
Formula
 V1TAX_CSI  = sum{c,COM, sum{s,SRC, sum{i,IND, V1TAX(c,s,i) }}};
 V2TAX_CSI  = sum{c,COM, sum{s,SRC, sum{i,IND, V2TAX(c,s,i) }}};
 V3TAX_CSH  = sum{c,COM, sum{s,SRC, sum{h,HOU, V3TAX(c,s,h) }}};
 V4TAX_C    = sum{c,COM,                      V4TAX(c) };
```

```
 V5TAX_CS    = sum{c,COM, sum{s,SRC,             V5TAX(c,s) }};
 V0TAR_C     = sum{c,COM,                        V0TAR(c) };
 V0TAX_CSI   = V1TAX_CSI + V2TAX_CSI + V3TAX_CSH + V4TAX_C + V5TAX_CS
+ V0TAR_C;
 (all,c,COM)(all,s,SRC) V3TAX_H(c,s)  = sum{h,HOU, V3TAX(c,s,h) };
Coefficient ! All-Industry Factor Cost Aggregates !
  V1CAP_I    # Total payments to capital #;
  V1LAB_IO   # Total payments to labour #;
  V1LND_I    # Total payments to land #;
  V1OCT_I    # Total other cost ticket payments #;
  V1SUB_I # total subsidies #;
  V1PRIM_I   # Total primary factor payments#;
  V0GDPINC   # Nominal GDP from income side #;
Formula
  V1CAP_I    = sum{i,IND, V1CAP(i) };
  V1LAB_IO   = sum{i,IND, V1LAB_O(i) };
  V1LND_I    = sum{i,IND, V1LND(i) };
  V1OCT_I    = sum{i,IND, V1OCT(i) };
  V1SUB_I    = sum{i,IND, V1SUB(i) };
  V1PRIM_I   = V1LAB_IO + V1CAP_I + V1LND_I;
  V0GDPINC   = V1PRIM_I + V1OCT_I + V0TAX_CSI- V1SUB_I ;
```

! Excerpt 14 of TABLO input file: !
! Expenditure-side components of GDP !

```
Coefficient ! Expenditure Aggregates at Purchaser's Prices !
 V0CIF_C   # Total $A import costs, excluding tariffs #;
 V0IMP_C   # Total basic-value imports (includes tariffs) #;
 V2TOT_I   # Total investment usage #;
(all,h,HOU) V3TOT(h)     # Total purchases by households #;
 V3TOT_H    # Total purchases by households #;
 V4TOT     # Total export earnings #;
 V5TOT     # Total value of government demands #;
 V6TOT     # Total value of inventories #;
 V0GDPEXP  # Nominal GDP from expenditure side #;
Formula
 V0CIF_C    = sum(c,COM, V0CIF(c) };
 V0IMP_C    = sum(c,COM, V0IMP(c) };
 V2TOT_I    = sum{i,IND, V2TOT(i) };
(All,h,HOU)
 V3TOT(h) = Sum(c,COM, V3PUR_S(c,h));
 V3TOT_H = Sum(h,HOU, V3TOT(h));
 V4TOT      = sum{c,COM, V4PUR(c) };
 V5TOT      = sum{c,COM, sum{s,SRC, V5PUR(c,s) }};
 V6TOT      = sum{c,COM, sum{s,SRC, V6BAS(c,s) }};
 V0GDPEXP   = V3TOT_H + V2TOT_I + V5TOT + V6TOT + V4TOT - V0CIF_C;

Coefficient CHECKGDP ;
Formula CHECKGDP = V0GDPINC - V0GDPEXP ;

Write
CHECKGDP to file SUMMARY header "CGDP" longname "GDPCHECK: should =
0";

Coefficient TINY # Small number to prevent singular matrix #;
Formula TINY = 0.000000000001;
```

! Excerpt 15 of TABLO input file: !
! Occupational composition of labour demand !

```
!$  Problem: for each industry i, minimize labour cost     !
!$           sum(o,OCC, P1LAB(i,o)*X1LAB(i,o) )            !
```

```
!$   such that  X1LAB_O(i) = CES( All,o,OCC: X1LAB(i,o) ) !

Coefficient (All,i,IND) SIGMA1LAB(i) # CES substitution between skill
types #;
Read SIGMA1LAB From File KDATA Header "SLAB";

Equation E_x1lab # Demand for labour by industry and skill group #
(All,i,IND)(All,o,OCC)
 x1lab(i,o) = x1lab_o(i) - SIGMA1LAB(i)*{p1lab(i,o) - p1lab_o(i)};

Equation E_p1lab_o # Price to each industry of labour composite #
(All,i,IND)
 {TINY + V1LAB_O(i)}*p1lab_o(i) = Sum(o,OCC,V1LAB(i,o)*p1lab(i,o));

Equation E_employ_i # Total Demand for labour of each skill #
(All,o,OCC)
 {TINY + V1LAB_I(o)}*employ_i(o) = Sum(i,IND,V1LAB(i,o)*x1lab(i,o));

Equation E_person_i # Total Demand (Persons) for labour of each skill
#
(All,o,OCC)
0 = Sum(i,IND,PERSON(i,o)*(person_i(o) - x1lab(i,o)));

Equation E_employ_o # employment by industry #
(All,i,IND)(TINY + V1LAB_O(i))*employ_o(i) =
Sum(o,OCC,V1LAB(i,o)*x1lab(i,o));
```

! Excerpt 16 of TABLO input file: !
! Primary factor proportions !

```
!$  X1PRIM(i) =                    !
!$    CES( X1LAB_O(i)/A1LAB_O(i), X1CAP(i)/A1CAP(i),
X1LND(i)/A1LND(i) ) !


Coefficient (All,i,IND) SIGMA1PRIM(i) # CES substitution, primary
factors #;
Read SIGMA1PRIM From File KDATA Header "P028";

Coefficient (All,i,IND) LABSHR(i) # share of labour in factor cost #;
Formula (All,i,IND) LABSHR(i) = V1LAB_O(i)/(TINY+V1PRIM(i))  ;
Variable twistlab # cost-neutral change in lab/cap ratio # ;

Equation E_x1lab_o # Industry demands for effective labour #
(All,i,IND) x1lab_o(i) - a1lab_o(i) - a1lab_io =
 x1prim(i) - SIGMA1PRIM(i)*{p1lab_o(i) + a1lab_o(i) + a1lab_io -
p1prim(i)}
 + {1 - LABSHR(i)}*twistlab ;

Equation E_p1cap # Industry demands for capital #
(All,i,IND) x1cap(i) - a1cap(i) =
 x1prim(i) - SIGMA1PRIM(i)*{p1cap(i) + a1cap(i) - p1prim(i)}
 - LABSHR(i)*twistlab ;

Equation E_p1lnd # Industry demands for land #
(All,i,IND) x1lnd(i) - a1lnd(i) =
 x1prim(i) - SIGMA1PRIM(i)*{p1lnd(i) + a1lnd(i) - p1prim(i)}
 - LABSHR(i)*twistlab ;

Equation E_p1prim # Effective price term for factor demand equations
#
(All,i,IND)(TINY + V1PRIM(i))*p1prim(i) =
 V1LAB_O(i)*{p1lab_o(i) + a1lab_o(i) + a1lab_io}
```

```
+ V1CAP(i)*{p1cap(i) + a1cap(i)} + V1LND(i)*{p1lnd(i) + a1lnd(i)};
```

! Excerpt 17 of TABLO input file: !
! Import/domestic composition of intermediate demands !

```
!$  X1_S(c,i) = CES( All,s,SRC: X1(c,s,i)/A1(c,s,i) ) !

Coefficient (all,c,COM) SIGMA1(c) # Armington elasticities:
intermediate #;
Read SIGMA1 from file KDATA header "1ARM";

Equation E_x1  # Source-specific commodity demands #
(all,c,COM)(all,s,SRC)(all,i,IND)
x1(c,s,i)-a1(c,s,i) = x1_s(c,i) - SIGMA1(c)*[p1(c,s,i)+a1(c,s,i)
                        - p1_s(c,i)];

Equation E_p1_s  # Effective price of commodity composite #
(all,c,COM)(all,i,IND)
p1_s(c,i) = sum{s,SRC, S1(c,s,i)*[p1(c,s,i) + a1(c,s,i)] };
```

! Excerpt 18 of TABLO input file: !
! Top nest of industry input demands !

```
!$  X1TOT(i) = MIN( All,c,COM: X1_S(c,i)/[A1_S(c,s,i)*A1TOT(i)],  !
!$                            X1PRIM(i)/[A1PRIM(i)*A1TOT(i)],     !
!$                            X1OCT(i)/[A1OCT(i)*A1TOT(i)] )   !

Equation E_x1_sA  # Demands for commodity composites #
(all,oc,ORDCOM)(all,i,IND)  x1_s(oc,i) - [a1_s(oc,i) + a1tot(i)] =
x1tot(i);


Equation E_x1prim  # Demands for primary factor composite #
(all,i,IND)  x1prim(i) - [a1prim(i) + a1tot(i)] = x1tot(i);

Equation E_x1oct  # Demands for other cost tickets #
(all,i,IND)  x1oct(i) - [a1oct(i) + a1tot(i)] = x1tot(i);

Equation E_x1sub # Demands for other cost tickets #
(All,i,IND) x1sub(i) = x1tot(i);


Equation E_p1tot # Zero pure profits in production #
(All,i,IND)
 (TINY + V1TOT(i))*{p1tot(i) - a1tot(i)} = Sum(c,COM,
V1PUR_S(c,i)*{p1_s(c,i)})
 + V1PRIM(i)*{p1prim(i) + a1prim(i)} + V1OCT(i)*{p1oct(i) + a1oct(i)}
 - V1SUB(i)*{p1sub(i) - a1tot(i)} !NB a1tot effect on subsidies
sterilized !;
```

! Excerpt 19A of TABLO input file: !
! Output mix of commodities !

```
Coefficient (all,i,IND) SIGMA1OUT(i) # CET transformation
elasticities #;
Read SIGMA1OUT from file KDATA header "SCET";

Equation E_q1  # Supplies of commodities by industries #
(all,c,COM)(all,i,IND)
q1(c,i) = x1tot(i) + SIGMA1OUT(i)*[p0com(c) - p1tot(i)];
```

```
Coefficient
 (all,i,IND) MAKE_C(i) # All production by industry i #;
 (all,c,COM) MAKE_I(c) # Total production of commodities #;
Formula
 (all,i,IND) MAKE_C(i) = sum{c,COM, MAKE(c,i) };
 (all,c,COM) MAKE_I(c) = sum{i,IND, MAKE(c,i) };

Equation E_x1tot # Average price received by industries #
(all,i,IND) MAKE_C(i)*p1tot(i) = sum{c,COM, MAKE(c,i)*p0com(c) };

Equation E_x0com # Total output of commodities #
(all,c,COM) MAKE_I(c)*x0com(c) = sum{i,IND, MAKE(c,i)*q1(c,i) };
```

! Excerpt 19B of TABLO input file: !
! CET between outputs for local and export markets !

```
Coefficient
 (all, c,COM) EXPSHR(c) # share going to exports #;
 (all, c,COM) TAU(c) # 1/elast. of transformation, exportable/locally
used #;
Zerodivide Default 0.5;
Formula
 (all,c,COM) EXPSHR(c) = V4BAS(c)/SALES(c);
 (all,c,COM) TAU(c) = 0.0; ! if zero, p0dom = pe, and CET is
nullified !
Zerodivide Off;

Equation E_x0dom  # supply of commodities to export market #
 (all,c,COM) TAU(c)*[x0dom(c) - x4(c)] = p0dom(c) - pe(c);

Equation E_pe     # supply of commodities to domestic market #
 (all,c,COM) x0com(c) = [1.0-EXPSHR(c)]*x0dom(c) + EXPSHR(c)*x4(c);

Equation E_p0com  # Zero pure profits in transformation #
 (all,c,COM) p0com(c) = [1.0-EXPSHR(c)]*p0dom(c) + EXPSHR(c)*pe(c);

! Map between vector and matrix forms of basic price variables !

Equation E_p0dom  # Basic price of domestic goods = p0(c,"dom") #
 (all,c,COM) p0dom(c) = p0(c,"dom");

Equation E_p0imp  # Basic price of imported goods = p0(c,"imp") #
 (all,c,COM) p0imp(c) = p0(c,"imp");
```

! Excerpt 20 of TABLO input file: !
! Investment demands !

```
!$  X2_S(c,i) = CES( All,s,SRC: X2(c,s,i)/A2(c,s,i) ) !

Coefficient (all,c,COM) SIGMA2(c) # Armington elasticities:
investment #;
Read SIGMA2 from file KDATA header "2ARM";

Equation E_x2  # Source-specific commodity demands #
(all,c,COM)(all,s,SRC)(all,i,IND)
x2(c,s,i)-a2(c,s,i) - x2_s(c,i) = - SIGMA2(c)*[p2(c,s,i)+a2(c,s,i) -
p2_s(c,i)];

Equation E_p2_s  # Effective price of commodity composite #
(all,c,COM)(all,i,IND)
p2_s(c,i) = sum{s,SRC, S2(c,s,i)*[p2(c,s,i)+a2(c,s,i)] };
```

```
! Investment top nest !
!$  X2TOT(i) = MIN( All,c,COM: X2_S(c,i)/[A2_S(c,s,i)*A2TOT(i)] ) !

Equation E_x2_s  # Demands for commodity composites #
(all,c,COM)(all,i,IND)  x2_s(c,i) - [a2_s(c,i) + a2tot(i)] =
x2tot(i);

Equation E_p2tot  # Zero pure profits in investment #
(all,i,IND) V2TOT(i)*(p2tot(i) - a2tot(i)) =
 sum(c,COM,  V2PUR_S(c,i)  *[p2_s(c,i)+a2_s(c,i)] );
```

! Excerpt 21 of TABLO input file: !
! Import/domestic composition of household demands !

```
!$ X3_S(c,i) = CES( All,s,SRC: X3(c,s)/A3(c,s) ) !

Coefficient (All,c,COM) SIGMA3(c) # Armington elasticities:
Households #;
Read SIGMA3 From File KDATA Header "3ARM";

Equation E_x3 # Source - Specific Commodity Demands #
(All,c,COM)(All,s,SRC)(All,h,HOU)
x3(c,s,h) = x3_s(c,h) - SIGMA3(c)*(p3(c,s,h) - p3_s(c,h));

Equation E_p3_s # Effective Price of Commodity Composite #
(All,c,COM)(All,h,HOU)
 p3_s(c,h) = Sum(s,SRC, S3(c,s,h)*(p3(c,s,h)));
```

! Excerpt 22 of TABLO input file: !
! Data and formulae for coefficients used in household demand equations !

```
Coefficient NUMCOM # number of goods #;
Formula NUMCOM = 1.0/Sum(c,COM,1.0);

Coefficient (All,c,COM)(All,h,HOU) V3LUX(c,h)
 # supernumerary expenditure commodity c #;
Read V3LUX From File KDATA Header "V3LX";
Update (All,c,COM)(All,h,HOU)
 V3LUX(c,h) = x3lux(c,h)*p3_s(c,h);

Coefficient (All,c,COM)(All,h,HOU) B3LUX(c,h)
 # supernumerary expenditure commodity c/total expenditure commodity
c #;
Zerodivide Default 0.5;
Formula (All,c,COM)(All,h,HOU)
 B3LUX(c,h) = V3LUX(c,h)/V3PUR_S(c,h);
Zerodivide Off;

Coefficient (All,h,HOU) V3LUX_C(h)
 # total supernumerary expenditure #;
Formula (All,h,HOU)
 V3LUX_C(h) = Sum(c,COM,V3LUX(c,h));

Coefficient (All,c,COM)(All,h,HOU)
 S3LUX(c,h) # Marginal household budget shares #;
Zerodivide Default NUMCOM;
Formula (All,c,COM)(All,h,HOU)
 S3LUX(c,h) = V3LUX(c,h)/V3LUX_C(h);
Zerodivide Off;
```

! Excerpt 23 of TABLO input file: !
! Commodity composition of household demand !

```
Equation E_x3sub # Subsistence Demand for composite commodities #
(All,c,COM)(All,h,HOU)
 x3sub(c,h) = q(h);

Equation E_x3lux # Luxury Demand for composite commodities #
(All,c,COM)(All,h,HOU)
 x3lux(c,h) + p3_s(c,h) = w3lux(h);

Equation E_x3_s # Total Household demand for composite commodities #
(All,c,COM)(All,h,HOU)
 x3_s(c,h) = B3LUX(c,h)*x3lux(c,h) + (1 - B3LUX(c,h))*x3sub(c,h);

Equation E_utility # Change in utility disregarding taste change
terms #
(All,h,HOU)
 utility(h) + q(h) = Sum(c,COM, S3LUX(c,h)*x3lux(c,h));

!******************************************************!
! Addups of Consumption !

Equation E_x3_h # Total Consumption Demands #
(All,c,COM)(All,s,SRC)(TINY + V3BAS_H(c,s))*x3_h(c,s) =
 Sum(h,HOU, V3BAS(c,s,h)*x3(c,s,h));

Equation E_x3mar_h # Total Consumption Demands #
(All,c,COM)(All,s,SRC)(All,m,MAR)(TINY +
V3MAR_H(c,s,m))*x3mar_h(c,s,m) =
 Sum(h,HOU, V3MAR(c,s,m,h)*x3mar(c,s,m,h));
```

! Excerpt 24 of TABLO input file: !
! Export and government demands !

```
Coefficient V4NTRADEXP # Total non-traditional export earnings #;
Formula     V4NTRADEXP = sum{c,NTRADEXP, V4PUR(c)};

Coefficient (all,c,COM) EXP_ELAST(c)
  # Export demand elasticities: typical value -20.0 #;
Read EXP_ELAST from file KDATA header "P018";

Equation E_x4A  # Traditional export demand functions #
(all,c,TRADEXP) x4(c) - f4q(c) = EXP_ELAST(c)*[p4(c) - phi - f4p(c)];

Equation E_x4B  # Non-traditional export demand functions #
(all,c,NTRADEXP) x4(c) = x4_ntrad;

Equation E_p4_ntrad  # Average price of non-traditional exports #
     V4NTRADEXP*p4_ntrad = sum{c,NTRADEXP, V4PUR(c)*p4(c) };

Coefficient EXP_ELAST_NT # Non-traditional export demand elasticity
#;
Read EXP_ELAST_NT from file KDATA header "EXNT";

Equation E_x4_ntrad # Demand for non-traditional export aggregate #
       x4_ntrad - f4q_ntrad   = EXP_ELAST_NT*[p4_ntrad - phi -
f4p_ntrad];
```

```
Equation E_x5  # Government demands #
(all,c,COM)(all,s,SRC) x5(c,s) = f5(c,s) + f5tot;

Equation E_f5tot # Overall government demands shift #
          f5tot = x3tot_h + f5tot2;
```

! Excerpt 25 of TABLO input file: !
! Margin demands !

```
Equation E_x1mar  # Margins to producers #
(all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
   x1mar(c,s,i,m)  = x1(c,s,i) + a1mar(c,s,i,m);

Equation E_x2mar  # Margins to capital creators #
(all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
   x2mar(c,s,i,m)  = x2(c,s,i) + a2mar(c,s,i,m);

Equation E_x3mar  # Margins to households #
(all,c,COM)(all,s,SRC)(all,m,MAR)(all,h,HOU)
   x3mar(c,s,m,h)  = x3(c,s,h) + a3mar(c,s,m);

Equation E_x4mar  # Margins to exports #
(all,c,COM)(all,m,MAR)
   x4mar(c,m)   = x4(c) + a4mar(c,m);

Equation E_x5mar  # Margins to government users #
(all,c,COM)(all,s,SRC)(all,m,MAR)
   x5mar(c,s,m)  = x5(c,s) + a5mar(c,s,m);
```

! Excerpt 26 of TABLO input file: !
! The price system !

```
Equation E_p1 # Purchasers prices - producers #
(all,c,COM)(all,s,SRC)(all,i,IND)
[V1PUR(c,s,i)+TINY]*p1(c,s,i) =
  [V1BAS(c,s,i)+V1TAX(c,s,i)]*[p0(c,s)+ t1(c,s,i)]
+ sum{m,MAR, V1MAR(c,s,i,m)*[p0dom(m)+a1mar(c,s,i,m)] };

Equation E_p2 # Purchasers prices - capital creators #
(all,c,COM)(all,s,SRC)(all,i,IND)
[V2PUR(c,s,i)+TINY]*p2(c,s,i) =
  [V2BAS(c,s,i)+V2TAX(c,s,i)]*[p0(c,s)+ t2(c,s,i)]
+ sum{m,MAR, V2MAR(c,s,i,m)*[p0dom(m)+a2mar(c,s,i,m)] };

Equation E_p3 # Purchasers prices - households #
(all,c,COM)(all,s,SRC)(all,h,HOU)
[V3PUR(c,s,h)+TINY]*p3(c,s,h) =
  [V3BAS(c,s,h)+V3TAX(c,s,h)]*[p0(c,s)+ t3(c,s)]
+ sum{m,MAR, V3MAR(c,s,m,h)*[p0dom(m)+a3mar(c,s,m)] };

Equation E_p4 # Zero pure profits in exporting #
(all,c,COM)
[V4PUR(c)+TINY]*p4(c) =
  [V4BAS(c)+V4TAX(c)]*[pe(c)+ t4(c)]
+ sum{m,MAR, V4MAR(c,m)*[p0dom(m)+a4mar(c,m)] };
! note that we refer to export taxes,not subsidies !

Equation E_p5 # Zero pure profits in distribution of government #
(all,c,COM)(all,s,SRC)
[V5PUR(c,s)+TINY]*p5(c,s) =
  [V5BAS(c,s)+V5TAX(c,s)]*[p0(c,s)+ t5(c,s)]
+ sum{m,MAR, V5MAR(c,s,m)*[p0dom(m)+a5mar(c,s,m)] };
```

```
Equation E_p0A # Zero pure profits in importing #
(all,c,COM) p0(c,"imp") = pf0cif(c) + phi + t0imp(c);
```

! Excerpt 27 of TABLO input file: !
! Market clearing equations !

```
Equation E_p0B # Demand equals supply for non margin commodities #
(all,n,NONMAR)
  DOMSALES(n)*x0dom(n) =
  sum{i,IND,    V1BAS(n,"dom",i)*x1(n,"dom",i)
  +             V2BAS(n,"dom",i)*x2(n,"dom",i) }
  +             V3BAS_H(n,"dom")*x3_h(n,"dom")
  +             V5BAS(n,"dom")*x5(n,"dom")    ! note exports omitted !
  +             100*LEVP0(n,"dom")*delx6(n,"dom");

Equation E_p0C # Demand equals supply for margin commodities #
(all,m,MAR)
  DOMSALES(m)*x0dom(m) =                 ! basic part first !
     sum{i,IND,  V1BAS(m,"dom",i)*x1(m,"dom",i)
  +              V2BAS(m,"dom",i)*x2(m,"dom",i) }
  +              V3BAS_H(m,"dom")*x3_h(m,"dom")
  +              V5BAS(m,"dom")*x5(m,"dom")    ! note exports omitted
!
  +              100*LEVP0(m,"dom")*delx6(m,"dom")    ! now margin
part !
  + sum{c,COM,   V4MAR(c,m)*x4mar(c,m)    ! note nesting of sum
parentheses !
  + sum{s,SRC,   V3MAR_H(c,s,m)*x3mar_h(c,s,m)
  +              V5MAR(c,s,m)*x5mar(c,s,m)
  + sum{i,IND,   V1MAR(c,s,i,m)*x1mar(c,s,i,m)
  +              V2MAR(c,s,i,m)*x2mar(c,s,i,m) }}};

Equation E_x0imp # Import volumes #
(all,c,COM)
   [TINY + V0IMP(c)]*x0imp(c) =
   sum{i,IND, V1BAS(c,"imp",i)*x1(c,"imp",i)
 +            V2BAS(c,"imp",i)*x2(c,"imp",i) }
 +            V3BAS_H(c,"imp")*x3_h(c,"imp")
 +            V5BAS(c,"imp")*x5(c,"imp")
 +            100*LEVP0(c,"imp")*delx6(c,"imp");

Equation E_x1lab_i # Demand equals supply for labour of each skill #
(all,o,OCC) V1LAB_I(o)*x1lab_i(o) = sum(i,IND, V1LAB(i,o)*x1lab(i,o)
);
```

! Excerpt 28 of TABLO input file: !
! Tax rate equations !

```
Equation
E_t1  # Power of tax on sales to intermediate #
 (all,c,COM)(all,s,SRC)(all,i,IND)  t1(c,s,i)  = f0tax_s(c) +
f1tax_csi;
E_t2  # Power of tax on sales to investment #
 (all,c,COM)(all,s,SRC)(all,i,IND)  t2(c,s,i)  = f0tax_s(c) +
f2tax_csi;
E_t3  # Power of tax on sales to households #
 (all,c,COM)(all,s,SRC)             t3(c,s)    = f0tax_s(c) +
f3tax_cs;
E_t4A # Power of tax on sales to traditional exports #
 (all,c,TRADEXP)                    t4(c)      = f0tax_s(c) +
f4tax_trad;
```

```
E_t4B # Power of tax on sales to non-traditional exports #
 (all,c,NTRADEXP)                        t4(c)       = f0tax_s(c) +
f4tax_ntrad;
E_t5  # Power of tax on sales to government #
 (all,c,COM)(all,s,SRC)                  t5(c,s)     = f0tax_s(c) +
f5tax_cs;
```

! Excerpt 29 of TABLO input file: !
! Indirect tax revenue !

```
Equation
E_w1tax_csi # Revenue from indirect taxes on flows to intermediate #
 [TINY + V1TAX_CSI]*w1tax_csi = sum{c,COM, sum{s,SRC, sum{i,IND,

V1TAX(c,s,i)*[p0(c,s)+x1(c,s,i)]+[V1TAX(c,s,i)+V1BAS(c,s,i)]*t1(c,s,i
) }}};

E_w2tax_csi # Revenue from indirect taxes on flows to investment #
 [TINY + V2TAX_CSI]*w2tax_csi = sum{c,COM, sum{s,SRC, sum{i,IND,

V2TAX(c,s,i)*[p0(c,s)+x2(c,s,i)]+[V2TAX(c,s,i)+V2BAS(c,s,i)]*t2(c,s,i
) }}};

E_w3tax_csh # Revenue from indirect taxes on flows to households #
 [TINY + V3TAX_CSH]*w3tax_csh = sum{c,COM, sum{s,SRC,sum{h,HOU,
   V3TAX(c,s,h)*[p0(c,s)+ x3(c,s,h)] +
[V3TAX(c,s,h)+V3BAS(c,s,h)]*t3(c,s) }}};

E_w4tax_c # Revenue from indirect taxes on exports #
 [TINY + V4TAX_C]*w4tax_c = sum{c,COM,
   V4TAX(c)*[pe(c) + x4(c)] + [V4TAX(c)+ V4BAS(c)]*t4(c) };

E_w5tax_cs # Revenue from indirect taxes on flows to government #
 [TINY + V5TAX_CS]*w5tax_cs = sum{c,COM, sum{s,SRC,
     V5TAX(c,s)*[p0(c,s)+ x5(c,s)] + [V5TAX(c,s)+V5BAS(c,s)]*t5(c,s)
}};

E_w0tar_c # Tariff revenue #
 [TINY+V0TAR_C]*w0tar_c = sum{c,COM,
   V0TAR(c)*[pf0cif(c) + phi + x0imp(c)] + V0IMP(c)*t0imp(c) };
```

! Excerpt 30 of TABLO input file: !
! Factor incomes and GDP !

```
Equation
E_w1lnd_i # aggregate payments to land #
 (TINY + V1LND_I)*w1lnd_i = Sum(i,IND,V1LND(i)*(x1lnd(i) +
p1lnd(i)));
E_w1lab_io # aggregate payments to labour #
 V1LAB_IO*w1lab_io =Sum(i,IND,Sum(o,OCC,V1LAB(i,o)*(x1lab(i,o) +
p1lab(i,o))));
E_w1cap_i # aggregate payments to capital #
 V1CAP_I*w1cap_i = Sum(i,IND,V1CAP(i)*(x1cap(i) + p1cap(i)));
E_w1oct_i # aggregate other cost ticket payments #
 (TINY + V1OCT_I)*w1oct_i = Sum(i,IND,V1OCT(i)*(x1oct(i) +
p1oct(i)));
E_w1sub_i # aggregate subsidies #
 (TINY + V1SUB_I)*w1sub_i = Sum(i,IND,V1SUB(i)*(x1sub(i) +
p1sub(i)));
E_w0tax_csi # aggregate value of indirect taxes #
 V0TAX_CSI*w0tax_csi = V1TAX_CSI*w1tax_csi + V2TAX_CSI*w2tax_csi
 + V3TAX_CSH*w3tax_csh + V4TAX_C*w4tax_c + V5TAX_CS*w5tax_cs +
```

```
V0TAR_C*w0tar_c;

E_w1prim_i # aggregate factor payments #
 V1PRIM_I*w1prim_i =V1LND_I*w1lnd_i +V1CAP_I*w1cap_i +
V1LAB_IO*w1lab_io;


E_w0gdpinc # aggregate nominal GDP from income side #
 V0GDPINC*w0gdpinc =V1LND_I*w1lnd_i +V1CAP_I*w1cap_i +
V1LAB_IO*w1lab_io
 + V1OCT_I*w1oct_i - V1SUB_I*w1sub_i + V0TAX_CSI*w0tax_csi;
```

! Excerpt 31 of TABLO input file: !
! GDP expenditure aggregates !

```
E_x2tot_i  # Total real investment #
  V2TOT_I*x2tot_i = sum{i,IND, V2TOT(i)*x2tot(i) };
E_p2tot_i  # Investment price index #
  V2TOT_I*p2tot_i = sum{i,IND, V2TOT(i)*p2tot(i) };
E_w2tot_i  # Total nominal investment #
  w2tot_i = x2tot_i + p2tot_i;

E_x3tot # real consumption #
(All,h,HOU) V3TOT(h)*x3tot(h) = Sum(c,COM, Sum(s,SRC,
V3PUR(c,s,h)*x3(c,s,h)));
E_p3tot # consumer price index #
(All,h,HOU) V3TOT(h)*p3tot(h) = Sum(c,COM, Sum(s,SRC,
V3PUR(c,s,h)*p3(c,s,h)));
E_w3tot # household budget constraint #
(All,h,HOU) w3tot(h) = x3tot(h) + p3tot(h);

E_x3tot_h # real consumption #
 V3TOT_H*x3tot_h = Sum(h,HOU, V3TOT(h)*x3tot(h));
E_p3tot_h # consumer price index #
 V3TOT_H*p3tot_h = Sum(h,HOU, V3TOT(h)*p3tot(h));
E_w3tot_h # nominal consumption #
 w3tot_h = x3tot_h + p3tot_h;

E_x4tot    # Export volume index #
  V4TOT*x4tot = sum{c,COM, V4PUR(c)*x4(c) };
E_p4tot    # Exports price index, $A #
  V4TOT*p4tot = sum{c,COM, V4PUR(c)*p4(c) };
E_w4tot    # $A border value of exports #
  w4tot = x4tot + p4tot;

E_x5tot    # Aggregate real government demands #
  V5TOT*x5tot = sum{c,COM, sum{s,SRC, V5PUR(c,s)*x5(c,s) }};
E_p5tot    # Government price index #
  V5TOT*p5tot = sum{c,COM, sum{s,SRC, V5PUR(c,s)*p5(c,s) }};
E_w5tot    # Aggregate nominal value of government demands #
  w5tot = x5tot + p5tot;

E_x6tot    # Inventories volume index #
  V6TOT*x6tot = 100*sum{c,COM, sum{s,SRC, LEVP0(c,s)*delx6(c,s) }};
E_p6tot    # Inventories price index #
  [TINY+V6TOT]*p6tot = sum{c,COM, sum{s,SRC, V6BAS(c,s)*p0(c,s) }};
E_w6tot    # Aggregate nominal value of inventories #
  w6tot = x6tot + p6tot;

E_x0cif_c  # Import volume index, C.I.F. weights #
  V0CIF_C*x0cif_c = sum{c,COM, V0CIF(c)*x0imp(c) };
```

```
E_p0cif_c  # Imports price index, $A C.I.F. #
  V0CIF_C*p0cif_c = sum{c,COM, V0CIF(c)*[phi+pf0cif(c)] };
E_w0cif_c  # Value of imports, $A C.I.F. #
  w0cif_c = x0cif_c + p0cif_c;

E_x0gdpexp  # Real GDP, expenditure side #
  V0GDPEXP*x0gdpexp = V3TOT_H*x3tot_h + V2TOT_I*x2tot_i + V5TOT*x5tot
  + V6TOT*x6tot + V4TOT*x4tot - V0CIF_C*x0cif_c;
E_p0gdpexp  # Price index for GDP, expenditure side #
  V0GDPEXP*p0gdpexp = V3TOT_H*p3tot_h + V2TOT_I*p2tot_i + V5TOT*p5tot
  + V6TOT*p6tot + V4TOT*p4tot - V0CIF_C*p0cif_c;
E_w0gdpexp  # Nominal GDP from expenditure side #
  w0gdpexp = x0gdpexp + p0gdpexp;
```

! Excerpt 32 of TABLO input file: !
! Trade balance and other aggregates !

```
Equation
E_delB     # (Balance of trade)/GDP #
  100*V0GDPEXP*delB = V4TOT*w4tot - V0CIF_C*w0cif_c
                    -(V4TOT-V0CIF_C)*w0gdpexp;

E_x0imp_c  # Import volume index, duty paid weights #
  V0IMP_C*x0imp_c = sum{c,COM, V0IMP(c)*x0imp(c) };
E_p0imp_c  # Duty paid imports price index #
  V0IMP_C*p0imp_c = sum{c,COM, V0IMP(c)*p0(c,"imp") };
E_w0imp_c  # Value of imports (duty paid) #
  w0imp_c = x0imp_c + p0imp_c;

E_x1cap_i  # Aggregate usage of capital,rental weights #
  V1CAP_I*x1cap_i = sum{i,IND, V1CAP(i)*x1cap(i) };
E_p1cap_i  # Average capital rental #
  V1CAP_I*p1cap_i = sum{i,IND, V1CAP(i)*p1cap(i) };

Equation E_employ # Employment by industry #
(all,i,IND) V1LAB_O(i)*employ(i) = sum{o,OCC, V1LAB(i,o)*x1lab(i,o)
};

E_employ_io  # Aggregate employment,wage bill weights #
  V1LAB_IO*employ_io= sum{i,IND, V1LAB_O(i)*employ(i) };

E_p1lab_io  # Average nominal wage #
  V1LAB_IO*p1lab_io = sum{i,IND, sum{o,OCC, V1LAB(i,o)*p1lab(i,o) }};

E_person_io # aggregate employment, persons weight #
 0 = Sum(i,IND, Sum(o,OCC, PERSON(i,o)*(person_io - x1lab(i,o))));

E_realwage  # Average real wage #
  realwage = p1lab_io - p3tot_h;

E_x1prim_i  # Aggregate output: value-added weights #
  V1PRIM_I*x1prim_i = sum{i,IND, V1PRIM(i)*x1tot(i) };

E_p0toft  # Terms of trade #
  p0toft = p4tot - p0cif_c;

E_p0realdev  # Real devaluation #
  p0realdev =  p0cif_c - p0gdpexp;
```

! Excerpt 33 of TABLO input file: !
! Investment equations !

```
! Follows Section 19 of DPSV - warts and all.  In particular, the
ratios Q and G are treated as parameters, just as in the original
ORANI implementation.  Attempts to improve the theory by updating
these parameters have been found to occasionally lead to perversely
signed coefficients !

Variable
(all,i,IND)  finv(i)    # Investment shifter #;
(all,i,IND)  r1cap(i)   # Current rates of return on fixed capital #;
              omega     # Economy-wide "rate of return" #;

Equation E_r1cap # Definition of rates of return to capital #
(all,i,IND) r1cap(i) = 2.0*(p1cap(i) - p2tot(i));
! Note: above equation comes from DPSV equation 19.7.  The value 2.0
  corresponds to the DPSV ratio Q (= ratio, gross to net rate of
  return) and is a typical value of this ratio.  !

Equation E_x2totA # Investment rule #
(all,i,ENDOGINV)
x2tot(i) - x1cap(i) = finv(i) + 0.33*[r1cap(i) - omega];
! Note: above equation comes from substituting together DPSV
  equations 19.8-9. The value 0.33 corresponds to the DPSV ratio
  [1/G.Beta] and is a typical value of this ratio.  !

Equation E_x2totB # Investment in exogenous industries #
(all,i,EXOGINV) x2tot(i) = x2tot_i + finv(i);
```

! Excerpt 34 of TABLO input file: !
! Indexing and other equations !

```
Equation E_p1lab # Flexible setting of money wages #
(all,i,IND)(all,o,OCC)
p1lab(i,o)= p3tot_h + f1lab_o(i) + f1lab_i(o) + f1lab(i,o);

Equation E_p1oct # Indexing of prices of "other cost" tickets #
(all,i,IND) p1oct(i) = p3tot_h + f1oct(i);   ! assumes full
indexation !

Equation E_p1sub # Setting of subsidy rates #
(All,i,IND) p1sub(i) = p1tot(i) + f1sub(i); ! ad valorem on output
cost !

E_delx6 # possible rule for stocks #
(all,c,COM)(all,s,SRC)
100*LEVP0(c,s)*delx6(c,s)=V6BAS(c,s)*x0com(c)+fx6(c,s);
```

! Excerpt 35 of TABLO input file: !
! Decomposition of Fan !

```
Set FANCAT # parts of Fan decomposition #
  (LocalMarket, ImportShare, Export, Total);

Variable
(all,c,COM) x0loc(c)  # real percent change in LOCSALES (dom+imp)  #;
(change)(all,c,COM)(all,f,FANCAT) fandecomp(c,f) # Fan decomposition
#;

Coefficient
 (all,c,COM) LOCSALES(c)  # Total local sales of dom + imp commodity
c #;
 (all,c,COM) INITSALES(c) # Initial volume of SALES at final prices
#;
```

```
Formula
 (all,c,COM) LOCSALES(c) = DOMSALES(c) + V0IMP(c);
 (initial) (all,c,COM) INITSALES(c) = SALES(c);
Update
  (all,c,COM) INITSALES(c) = p0com(c);

Equation E_x0loc # %growth in local market #
(all,c,COM) LOCSALES(c)*x0loc(c) =
 DOMSALES(c)*x0dom(c) + V0IMP(c)*x0imp(c);

Equation E_fandecompA # growth in local market effect #
(all,c,COM)  INITSALES(c)*fandecomp(c,"LocalMarket") =
DOMSALES(c)*x0loc(c);
! The local market effect is the % change in output that would have
occurred
if local sales of the domestic product had followed dom+imp sales
(x0loc) !

Equation E_fandecompB # export effect #
(all,c,COM) INITSALES(c)*fandecomp(c,"Export") = V4BAS(c)*x4(c);

Equation E_fandecompC # import leakage effect - via residual #
(all,c,COM) fandecomp(c,"Total") =
fandecomp(c,"LocalMarket") + fandecomp(c,"ImportShare") +
fandecomp(c,"Export");

Equation E_fandecompD # Fan total = x0com #
(all,c,COM) INITSALES(c)*fandecomp(c,"Total") = SALES(c)*x0com(c);



! Income Mapping Variables !
Variable
(All,o,OCC)(All,h,HOU) w1labinc(o,h)
          # labour income from occ (o) to households (h) #;
(All,o,OCC)   w1lab_i(o)    # Total Labour Bill (o) #;
(All,h,HOU)              w1labinc_o(h)    # Total Wages to Households
(h) #;
avetax_h        # Average Tax Factor: avedispwager - avewager #;


Coefficient (All,o,OCC)(All,h,HOU)
V1LABINC(o,h) # labour income from occ (o) to households (h) #;
Read V1LABINC From File KDATA Header "LINC";
Update (All,o,OCC)(All,h,HOU)
V1LABINC(o,h) = w1labinc(o,h);



Coefficient
(All,o,OCC) V1LABINC_H(o) # subtotal labour income to households (o)
#;
(All,h,HOU) V1LABINC_O(h) # total wage income to h'lds (h) #;
Formula
(All,o,OCC) V1LABINC_H(o) = Sum(h,HOU, V1LABINC(o,h));
(All,h,HOU) V1LABINC_O(h) = Sum(o,OCC, V1LABINC(o,h));


Coefficient (All,o,OCC)
CHECK3(o) # should be zero #;
Formula (All,o,OCC)
CHECK3(o) = V1LABINC_H(o) - V1LAB_i(o);
```

```
Display CHECK3;
```

! Excerpt 36 of TABLO input file: !

! Declare Income Mapping Data Coeffients and Associated Variables !

```
! Read in and Update Income Mapping Data Coeffients !

Coefficient
VGOSSAV # Capital Account: Gov #;
VGOSGOV # GOS income to gov + GOS transfers to gov #;
VGOVROW # GOV transfers to ROW #;
VGOSROW # GOS income to ROW + GOS transfers to ROW #;
VROWGOV # transfers from ROW to gov #;
VROWGOS # GOS from ROW #;
VGOVGOS # interest on public debt #;
(All,h,HOU) VGOSHOU(h)              # GOS to households #;
(All,h,HOU) VGOVHOU(h)              # gov transfers to households #;
(All,h,HOU) VHOUGOV(h)              # income tax + h'hold transfers
to gov #;
(All,h,HOU) VHOUROW(h)              # household transfers to ROW #;
(All,h,HOU) VROWHOU(h)              # ROW transfers to households #;
(All,hto,HOU)(All,hfrom,HOU)
        VHOUHOU(hto,hfrom)           # intra-h'hold trnsfrs  #;
(All,i,IND) GOVSHRINV(i) # gov share of investment by industry #;

Variable
wgosgov # GOS income to gov + GOS transfers to gov #;
wgosrow # GOS income to ROW + GOS transfers to ROW #;
wgovrow # GOV transfers to ROW #;
wgovgos # interest on public debt #;
wrowgos # GOS from ROW #;
wrowgov # transfers from ROW to gov #;
(All,h,HOU) wgoshou(h)     # GOS to households #;
(All,h,HOU) wgovhou(h)     # gov transfers to households #;
(All,h,HOU) whougov(h)     # income tax + h'hold transfers to gov #;
(All,h,HOU) whourow(h)     # household transfers to ROW #;
(All,h,HOU) wrowhou(h)     # ROW transfers to households #;
(All,hto,HOU)(All,hfrom,HOU)
        whouhou(hto,hfrom) # intra-h'hold trnsfrs  #;
(All,i,IND) s2gov(i) # gov share of investment by industry #;

Read
VGOSGOV From File KDATA Header "VGSG"; !GOS inc to gov+GOS trn to
gov!
VGOSROW From File KDATA Header "VGSR"; !GOS inc to ROW+GOS trn to
ROW!
VGOVROW From File KDATA Header "VGVR"; !GOV transfers to ROW!
VGOVGOS From File KDATA Header "VGVS"; !interest on public debt!
VROWGOS From File KDATA Header "VRGS"; !GOS from ROW!
VROWGOV From File KDATA Header "VRGV"; !transfers from ROW to gov!
VGOSHOU From File KDATA Header "VGSH"; !GOS to households!
VGOVHOU From File KDATA Header "VGVH"; !gov transfers to households!
VHOUGOV From File KDATA Header "VHGV"; !income tax + hous trnsfrs to
gov!
VHOUROW From File KDATA Header "VHRW"; !household transfers to ROW!
VROWHOU From File KDATA Header "VRWH"; !ROW transfers to households!
VHOUHOU From File KDATA Header "VHOH"; !intra-household transfers!
GOVSHRINV From File KDATA Header "GVSH"; !gov shares of investment!

Update
VGOSGOV = wgosgov;
VGOSROW = wgosrow;
```

```
VGOVGOS = wgovgos;
VGOVROW = wgovrow;
VROWGOS = wrowgos;
VROWGOV = wrowgov;
(All,h,HOU) VGOSHOU(h) = wgoshou(h);
(All,h,HOU) VGOVHOU(h) = wgovhou(h);
(All,h,HOU) VHOUGOV(h) = whougov(h);
(All,h,HOU) VHOUROW(h) = whourow(h);
(All,h,HOU) VROWHOU(h) = wrowhou(h);
(All,hto,HOU)(All,hfrom,HOU)
             VHOUHOU(hto,hfrom) = whouhou(hto,hfrom);
(All,i,IND) GOVSHRINV(i) = s2gov(i);
```

! Excerpt 37 of TABLO input file: !
! Work out total GOS (row) income !

```
Equation E_wgovgos # interest on public debt # wgovgos = w0gdpexp;
 !  temporary default assumption !

Equation E_wrowgos # GOS from ROW # wrowgos = w0gdpexp; !  default
assumption !

! find row total !

Coefficient VGOS # Total GOS #;
Formula     VGOS = V1CAP_I + V1LND_I + V1OCT_I + VROWGOS + VGOVGOS;
Variable    wgos # Total GOS #;
Equation  E_wgos # GOS from income side #
VGOS*wgos = V1CAP_I*w1cap_i + V1LND_I*w1lnd_i
          + V1OCT_I*w1oct_i + VROWGOS*wrowgos + VGOVGOS*wgovgos;
!We assume that SrvPrv industry does not pay tax on GOS!
Variable (Levels)
(All,r,RSIND) TXBGOS(r) #Taxable GOS# ;
Variable (Levels)
(All,r,RSIND) OTHGOS(r) #Other non-taxable GOS# ;
Formula(Initial)
(All,r,RSIND) TXBGOS(r) =0.75*(V1CAP(r) + V1LND(r) + V1OCT(r)) ;
Formula(Initial)
(All,r,RSIND) OTHGOS(r) =0.25*(V1CAP(r) + V1LND(r) + V1OCT(r)) ;
Display TXBGOS ;

Equation E_p_txbgos
(All,r,RSIND) TXBGOS(r)*p_TXBGOS(r)
=0.75*{V1CAP(r)*(x1cap(r)+p1cap(r))
                  + V1LND(r)*(x1lnd(r)+p1lnd(r))
                  + V1OCT(r)*(x1oct(r)+p1oct(r))} ;

Equation E_p_othgos
(All,r,RSIND) OTHGOS(r)*p_OTHGOS(r)
=0.25*{V1CAP(r)*(x1cap(r)+p1cap(r))
                  + V1LND(r)*(x1lnd(r)+p1lnd(r))
                  + V1OCT(r)*(x1oct(r)+p1oct(r))} ;

Variable (Levels)
TXBGOS_I #Total Taxable GOS# ;
Variable (Levels)
OTHGOS_I #Total Other Non-Taxable GOS# ;
Formula (Initial)
         TXBGOS_I  =Sum(r,RSIND, TXBGOS(r)) ;
Equation E_p_txbgos_i
         TXBGOS_I*p_TXBGOS_I  =Sum(r,RSIND, TXBGOS(r)*p_TXBGOS(r)) ;
Formula (Initial)
         OTHGOS_I  =Sum(r,RSIND, OTHGOS(r)) ;
```

```
Equation E_p_othgos_i
        OTHGOS_I*p_OTHGOS_I  =Sum(r,RSIND, OTHGOS(r)*p_OTHGOS(r)) ;

Variable (Levels)
NTXBGOS  #Total Non-Taxable GOS# ;
Formula (Initial)
NTXBGOS = V1CAP("SrvPrv") + V1LND("SrvPrv") + V1OCT("SrvPrv")
       + VROWGOS + VGOVGOS + OTHGOS_I  ;

Equation E_p_ntxbgos
NTXBGOS*p_NTXBGOS = V1CAP("SrvPrv")*x1cap("SrvPrv")
                  + V1LND("SrvPrv")*x1lnd("SrvPrv")
                  + V1OCT("SrvPrv")*x1oct("SrvPrv")
                  + VROWGOS*wrowgos + VGOVGOS*wgovgos
                  + OTHGOS_I*p_OTHGOS_I ;
Coefficient
CHKGOS #It should be zero # ;
Formula
CHKGOS = VGOS - TXBGOS_I - NTXBGOS ;
Write
CHKGOS to file SUMMARY header "CGOS" longname "GOSCHECK: should = 0";
```

! Excerpt 38 of TABLO input file: !
!Demand for Rent-Seeking!

```
Variable (Levels)
(All,r,RSIND)   RSGOS(r)
              #Expected net tax taxable GOS with RS (Phi(z)# ;
Variable (Levels)(All,r,RSIND)   PFINED(r)
              #Probability of incuring fine for tax evasion (J)# ;
Variable (Levels)(All,r,RSIND)   POLINF(r)
              #Endowment of political influence by industry (R) # ;
Variable (Levels)(All,r,RSIND)   TAXQUOT(r)
              #Effective tax quotient by industry after RS (B)# ;
Variable (Levels)(All,r,RSIND)   CAP_TAXRATE(r) #GOS tax rate by
industry (t)# ;
Variable (Levels)(All,r,RSIND)   LOFTQ(r)  #L of B#;
Variable (Levels)(All,r,RSIND)   LOFPF(r)  #L of J#;
Variable (Levels)(All,r,RSIND) TQPAR(r) #Designed to be equal to 1
(A)# ;
Variable (Levels)(All,r,RSIND) PFPAR(r) #Designed to be equal to 1
(Q)#  ;
Variable (Levels)(All,r,RSIND) E1TQ(r)
              #(Epsilon of B) 0 for CRTS and >1 for NCRTS# ;
Variable (Levels)(All,r,RSIND) E1PF(r)
              #(Epsilon of J) 0 for CRTS and >1 for NCRTS# ;
Variable (Levels)(All,r,RSIND) PFFL(r)
              #(Theta 2)Minimum probability of incuring fine# ;
Variable (Levels)(All,r,RSIND) TQFL(r)  #(Theta 1)Minimum tax
quotient# ;

Variable (Levels)
(All,r,RSIND) POLDPRC(r) #(Delta) Depreciation rate for political
influence# ;
Variable (Levels)
(All,r,RSIND) TQCOEF(r)  #(Gamma) Tech. coefficient in reducing tax
quotient# ;
Variable (Levels)
(All,r,RSIND)
        PFCOEF(r)  #(Alpha) Tech coef in reducing prob. of incuring
fine# ;
Variable (Levels)
```

```
(All,r,RSIND) FINEMP(r)  #(g) Fine Multiplier# ;
Variable (Levels)
(All,r,RSIND) PORSSRV(r)      #Price of Rent-seeking services by
industries# ;
Variable (Levels)
(All,r,RSIND) TINY1(r);
Formula(initial)
(All,r,RSIND) TINY1(r) = 0.0000000001 ;

Formula(initial)
(All,r,RSIND)TQPAR(r) = 1 ;
Formula (initial)
(All,r,RSIND) PFPAR(r) = 1  ;
Formula (initial)
(All,r,RSIND) E1TQ(r)  = 0 ;
Formula (initial)
(All,r,RSIND) E1PF(r)  = 0 ;
Formula (initial)
(All,r,RSIND) PFFL(r)  = 0.1 ;
Formula (initial)
(All,r,RSIND) TQFL(r)  = 0.2 ;


READ POLDPRC from FILE KDATA HEADER "RDPR" ;
READ TQCOEF from FILE KDATA HEADER "A1TQ" ;
READ PFCOEF from FILE KDATA HEADER "A1PF" ;
READ CAP_TAXRATE from FILE KDATA HEADER "TXRT" ;
READ FINEMP from FILE KDATA HEADER "FNMP" ;
READ RSGOS from FILE KDATA HEADER "RSGS" ;
READ PFINED from FILE KDATA HEADER "PFND" ;
READ TAXQUOT from FILE KDATA HEADER "TXQT" ;
READ LOFTQ from FILE KDATA HEADER "LFTQ" ;
READ LOFPF from FILE KDATA HEADER "LFPF" ;
READ PORSSRV from FILE KDATA HEADER "PORS" ;
Variable (Levels)
(All,r,RSIND)   NORSGOS(r)
                #Taxable GOS net tax with no rent-seeking(RS) Phi(0))#
;
Variable (Levels)(All,r,RSIND)   TAXLIAB(r) #Tax liability with no RS
(T) # ;
Variable (Levels)(All,r,RSIND)   VFINE(r) #Nominal Fine for tax
evasion (G) # ;
Variable (Levels)(All,r,RSIND)   RSUSE(r) #Rent-seeking use by
industry # ;
Formula (Initial)
(All,r,RSIND)   RSUSE(r)= V1BAS("RsSrv","dom",r) ;
!Equation E_p_RSUSE
(All,r,RSIND)   p_RSUSE(r)= x1("RsSrv","dom",r) ;!

Equation E_x1_sB  # Demands for commodity composites #
(all,rs,RSCOM)(all,r,RSIND)  x1_s(rs,r)  = p_RSUSE(r);


Formula & Equation E_p_taxliab #Tax liability by Industry(E6.3)#
(All,r,RSIND)  TAXLIAB(r) = TXBGOS(r)*CAP_TAXRATE(r) ;
Formula & Equation E_p_norsgos #After tax GOS with no rent-
seeking(E6.2)#
(All,r,RSIND)  NORSGOS(r) = TXBGOS(r) - TAXLIAB(r) ;
Formula & Equation E_p_vfine #The Value of fine for tax evasion
(E4.10)#
(All,r,RSIND)  VFINE(r) = FINEMP(r)*TAXLIAB(r) ;

Formula & Equation E_p_polinf #Stock of political influence (6.11)#
```

```
        (All,r,RSIND) POLINF(r) = RSUSE(r)/POLDPRC(r) ;

Equation (Levels) E_p_loftq #Normalized rent-seeking input (E6.6)#
        (All,r,RSIND) LOFTQ(r) =  RSUSE(r)*E1TQ(r)
                        + (1-E1TQ(r))*( RSUSE(r)/TXBGOS(r));

Equation (Levels) E_p_lofpf #Normalized political influence (6.9)#
        (All,r,RSIND) LOFPF(r) = POLINF(r)*E1PF(r)
                        + (1-E1PF(r))*(POLINF(r)/TXBGOS(r)) ;


Equation (Levels) E_p_TaxQuot #Tax quotion after RS (E6.5)#
(All,r,RSIND) TAXQUOT(r) = TQFL(r) + ((1-TQFL(r))*(1 + TQPAR(r)))
                      /(1 + TQPAR(r)*EXP(TQCOEF(r)*LOFTQ(r))) ;

Equation (Levels) E_p_pfined #Prob. of being fined due to RS (E6.8)#
(All,r,RSIND) PFINED(r) = PFFL(r) + ((1-PFFL(r))*(1 + PFPAR(r)))
                      /(1 + PFPAR(r)*EXP(PFCOEF(r)*LOFPF(r))) ;

Equation (Levels) E_p_RSGos # After-tax GOS with RS (E6.4)#

(All,r,RSIND) RSGOS(r)  = TXBGOS(r) - TAXQUOT(r)*TAXLIAB(r)
                        - PFINED(r)*VFINE(r) ;

Variable (Levels) (All,r,RSIND) BIT1(r) ;
Variable (Levels) (All,r,RSIND) BIT2(r) ;
Variable (Levels) (All,r,RSIND) BIT3(r) ;
Variable (Levels) (All,r,RSIND) BIT4(r) ;


Formula & Equation  E_Bit1EQ12 # First bit of E6.12 #
(All,r,RSIND) BIT1(r) = (TQCOEF(r)*((TAXQUOT(r)- TQFL(r))^2)
                        *TQPAR(r)*EXP(TQCOEF(r)*LOFTQ(r)))
                        /((1-TQFL(r))*(1 + TQPAR(r))) ;
Formula & Equation Bit2EQ12  # Second bit of E6.12 #
(All,r,RSIND) BIT2(r) = TAXLIAB(r)/TXBGOS(r) ;

Formula & Equation  E_Bit3EQ12  # Third bit of E6.12 #
(All,r,RSIND) BIT3(r) = (PFCOEF(r)*(((PFINED(r)+TINY1(r)) -
PFFL(r))^2)
                        *PFPAR(r)*EXP(PFCOEF(r)*LOFPF(r)))
                        /((1-PFFL(r))*(1 + PFPAR(r))*POLDPRC(r)) ;

Formula & Equation Bit4EQ12  # Fourth bit of E6.12 #
(All,r,RSIND) BIT4(r) = VFINE(r)/TXBGOS(r) ;

Equation (Levels) E_p_porssrv #First order condition for opt use of
RS (E4.12)#
(All,r,RSIND) PORSSRV(r) = BIT1(r)*BIT2(r) + BIT3(r)*BIT4(r) ;
Equation E_porssrv
(All,r,RSIND) p_PORSSRV(r) = p0("RsSrv","dom") ;

Variable (Levels)
(All,r,RSIND) RSGOSTAX(r) # GOS Tax paid after Rent-seeking #;
Variable (Levels)
(All,r,RSIND) FINEPAID(r) # Fine actually paid after Rent-seeking #;
Formula (Initial)
(All,r,RSIND) RSGOSTAX(r) = TAXQUOT(r)*TAXLIAB(r) ;
Equation E_p_rsgostax
(All,r,RSIND) p_rsgostax(r) = p_TAXQUOT(r)  + p_TAXLIAB(r);
Formula (Initial)
(All,r,RSIND) FINEPAID(r) = PFINED(r)*VFINE(r) ;
Equation E_p_finepaid # Fine actually paid after Rent-seeking #
```

```
(All,r,RSIND) p_FINEPAID(r) = p_PFINED(r)  + p_VFINE(r);

Variable (Levels)        RSGOSTAX_I   ;
Variable (Levels)        PORSSRV_I   ;
Variable (Levels)        FINEPAID_I   ;
Variable (Levels)        RSUSE_I   ;
Variable (Levels)        VFINE_I   ;
Variable (Levels)        NORSGOS_I   ;
Variable (Levels)        RSGOS_I   ;
Formula (Initial)
         RSGOSTAX_I  =Sum(r,RSIND, RSGOSTAX(r)) ;
Formula (Initial)
         RSUSE_I  =Sum(r,RSIND, RSUSE(r)) ;
Formula (Initial)
         FINEPAID_I  =Sum(r,RSIND, FINEPAID(r)) ;
Formula (Initial)
         VFINE_I   =Sum(r,RSIND, VFINE(r)) ;
Formula (Initial)
         NORSGOS_I  =Sum(r,RSIND, NORSGOS(r)) ;
Formula (Initial)
         RSGOS_I  =Sum(r,RSIND, RSGOS(r)) ;
Equation E_p_rsgostax_i
         RSGOSTAX_I*p_RSGOSTAX_I  =Sum(r,RSIND,
RSGOSTAX(r)*p_RSGOSTAX(r)) ;
Equation E_p_rsuse_i
         RSUSE_I*p_RSUSE_I  =Sum(r,RSIND, RSUSE(r)*p_RSUSE(r)) ;
Equation E_p_porssrv_i
         RSUSE_I*p_porssrv_i  =Sum(r,RSIND, RSUSE(r)*p_PORSSRV(r)) ;
Equation E_p_finepaid_i
         FINEPAID_I*p_FINEPAID_I  =Sum(r,RSIND,
FINEPAID(r)*p_FINEPAID(r)) ;
Equation E_p_vfine_i
         VFINE_I*p_VFINE_I  =Sum(r,RSIND, VFINE(r)*p_VFINE(r)) ;
Equation E_p_norsgos_i
         NORSGOS_I*p_NORSGOS_I  =Sum(r,RSIND,
NORSGOS(r)*p_NORSGOS(r)) ;
Equation E_p_rsgos_i
         RSGOS_I*p_RSGOS_I  =Sum(r,RSIND, RSGOS(r)*p_RSGOS(r)) ;
Coefficient VDISPGOS #Disposable GOS# ;

Formula VDISPGOS = VGOS - RSGOSTAX_I ;
Variable wdispgos #Disposable GOS # ;
Equation  E_wdispgos #Disposable GOS #
          VDISPGOS*wdispgos = VGOS*wgos - RSGOSTAX_I*p_rsgostax_i ;
Equation  E_wgosgov # GOS to gov # wgosgov = wdispgos;
Equation  E_wgosrow # GOS to ROW # wgosrow = wdispgos ;
Equation  E_wgoshou # GOS to households #
(All,h,HOU)     wgoshou(h) = wdispgos;

Coefficient VGOSEXP;
Formula VGOSEXP = Sum(h,HOU, VGOSHOU(h))
                + VGOSGOV + RSGOSTAX_I + FINEPAID_I + VGOSROW;
Variable wgosexp #GOS expenditure # ;
Variable delisav # Industry's retained earning # ;
Equation E_wgosexp # GOS Expenditure #
VGOSEXP*wgosexp = Sum(h,HOU, VGOSHOU(h)*wgoshou(h)) +
          VGOSGOV*wgosgov + RSGOSTAX_I*p_RSGOSTAX_I +
FINEPAID_I*p_FINEPAID_I
          + VGOSROW*wgosrow ;

Formula VGOSSAV = VGOS - VGOSEXP;
```

```
Equation E_delisav # find industry retained earnings as residual #
 100*VGOS*delisav =  VGOS*wgos - VGOSEXP*wgosexp
                     - (VGOS -VGOSEXP )*wgos ;

Write
VGOSSAV to file SUMMARY header "GSSV" longname "GOS Saving";
VGOS to file SUMMARY header "VGOS" longname "Ttal GOS";


! Define useful addup variable !
Coefficient VGOSHOU_H # total GOS to households #;
Formula     VGOSHOU_H = Sum(h,HOU, VGOSHOU(h));
Variable    wgoshou_h # total GOS to households #;
Equation  E_wgoshou_h # total GOS to households #
VGOSHOU_H*wgoshou_h = Sum(h,HOU, VGOSHOU(h)*wgoshou(h));
```

! Excerpt 39 of TABLO input file: !
! Wages row is given already by main model !

```
! now fill in wages column !
! Distribute labour income between households and ROW !

Equation E_w1lab_i # all-industry labour bills #
(All,o,OCC) (TINY+V1LAB_I(o))*w1lab_i(o) =
 Sum(i,IND, V1LAB(i,o)*{p1lab(i,o)+x1lab(i,o)});

Variable (All,o,OCC) labslack(o) # employment rate #;

Equation E_w1labinc # labour income to households #
(All,o,OCC)(All,h,HOU)
w1labinc(o,h) = q(h) + w1lab_i(o) + labslack(o);

!  Assumption of above equation is that labour income (by HYTPE and
occ)
 is proportional to population(HYTPE) and to wages(occ) and
that the constant of proportionality (labslack) is independent of
HYTPE.
Think of labslack(occ) as the 'employment rate' - same for all HOU.
It is determined by the next equation !

! Implicit data assumption
Imagine matrix V showing wage income by  IND, OCC and HOU
ie              V(i,o,h)
we have only two subtotals of this
V1LABINC(o,h) and V1LAB(i,o) [ignoring migrants]

for o we have

V1LABINC(h) and V1LAB(i) [ignoring migrants]

It is a necessary feature of the data base that the sums of these
vectors are equal (See CHECK3 formula). Say Sum = T.

to find (for each o) the full V(i,h) matrix we assume

V(i,h) = V(i)*V(h)/T

or, in the full notation

V(i,o,h) = V1LABINC(o,h)*V1LAB(i,o)/T(o)

where T(o) = V1LABINC_H(o) = V1LAB_I(o);
```

```
Of interest is the subtotal  over OCC

V(i,h) = Sum(o,OCC,  V1LABINC(o,h)*V1LAB(i,o)/T(o)    )

!

Equation E_labslack # adding up constraint #
(All,o,OCC)
Sum(i,IND, (TINY+V1LAB(i,o))*(x1lab(i,o)+p1lab(i,o))) =
  Sum(h,HOU, V1LABINC(o,h)*w1labinc(o,h));

Equation E_q # rule of population growth #
(All,h,HOU) q(h) = q_h;

Equation E_w1labinc_o # total labour income to households #
(All,h,HOU)
(TINY+V1LABINC_O(h))*w1labinc_o(h) =
  Sum(o,OCC, V1LABINC(o,h)*w1labinc(o,h));

Coefficient VLABROW # wages to ROW #;
FORMULA      VLABROW = 0;
Variable wlabrow # wages to ROW #;
Equation E_wlabrow # wages to ROW #
                wlabrow = w0gdpinc;
```

! Excerpt 40 of TABLO input file: !
! Fill in household row (income) !

```
! Find total household (pre-tax) income !

Coefficient (All,h,HOU) VHOUINC(h) # pre-tax h'hold income #;
Formula      (All,h,HOU) VHOUINC(h) = VGOSHOU(h)
+ V1LABINC_O(h)
+ Sum(hfrom,HOU, VHOUHOU(h,hfrom)) + VGOVHOU(h) + VROWHOU(h);

Coefficient (All,h,HOU) VHOUINCA(h) # pre-tax h'hold income #;
Formula      (All,h,HOU) VHOUINCA(h) = V1LABINC_O(h)
+ Sum(hfrom,HOU, VHOUHOU(h,hfrom)) + VGOVHOU(h) + VROWHOU(h);

Variable     (All,h,HOU) whouinc(h) # pre-tax h'hold income #;
Equation E_whouinc # pre-tax household income #
(All,h,HOU)
VHOUINC(h)*whouinc(h) = VGOSHOU(h)*wgoshou(h)
  + V1LABINC_O(h)*w1labinc_o(h)
    + Sum(hfrom,HOU, VHOUHOU(h,hfrom)*whouhou(h,hfrom))
      + VGOVHOU(h)*wgovhou(h) + VROWHOU(h)*wrowhou(h);
Variable     (All,h,HOU) whouinca(h) # pre-tax h'hold income #;
Equation E_whouinca # pre-tax household income #
(All,h,HOU)
VHOUINCA(h)*whouinca(h) = V1LABINC_O(h)*w1labinc_o(h)+ p1cap_i
    + Sum(hfrom,HOU, VHOUHOU(h,hfrom)*whouhou(h,hfrom))
      + VGOVHOU(h)*wgovhou(h) + VROWHOU(h)*wrowhou(h);


! RHS variables wgoshou and w1labinc_o already determined above.
the remainder, wgovhou, whouhou and  wrowhou, determined as follows !

Variable whouinc_h  # total pre-tax h'hold income #;
Equation E_whouinc_h # total pre-tax household income #
Sum(h,HOU, VHOUINC(h)*{whouinc(h) - whouinc_h}) = 0;

Variable whouinca_h  # total pre-tax h'hold income #;
```

```
Equation E_whouinca_h # total pre-tax household income #
Sum(h,HOU, VHOUINCA(h)*(whouinca(h) - whouinca_h)) = 0;


Equation E_wgovhou # gov transfers to households #
(All,h,HOU) wgovhou(h) = w0gdpexp; ! default assumption !

Equation E_wrowhou # ROW transfers to households #
(All,h,HOU) wrowhou(h) = w0gdpexp; ! default assumption !

Variable    (All,h,HOU) wdispinc(h) # post-tax h'hold income #;
Variable    (All,h,HOU) wdispinca(h) # post-tax h'hold income #;

! ie, transfer proportional to post-tax donor income !
```

! Excerpt 41 of TABLO input file: !
! Apportion household col (expenditure) !

```
! First, find total household (post-tax) income !
! by taking income tax away from whousinc !

Coefficient (All,h,HOU) VDISPINC(h) # post-tax h'hold income #;
Formula     (All,h,HOU)
 VDISPINC(h) = VHOUINC(h) -  VHOUGOV(h);
Equation E_wdispinc # post-tax household income #
(All,h,HOU) VDISPINC(h)*wdispinc(h) =
    VHOUINC(h)*whouinc(h) - VHOUGOV(h)*whougov(h);

Coefficient (All,h,HOU) VDISPINCA(h) # post-tax h'hold income #;
Formula     (All,h,HOU)
 VDISPINCA(h) = VHOUINCA(h) -  VHOUGOV(h);
Equation E_wdispinca # post-tax household income #
(All,h,HOU) VDISPINCA(h)*wdispinca(h) =
    VHOUINCA(h)*whouinca(h) - VHOUGOV(h)*whougov(h);

Equation E_whouhou # inter-household transfers #
(All,hto,HOU)(All,hfrom,HOU)
        whouhou(hto,hfrom) = wdispinc(hfrom);

Variable wdispinc_h  # total post-tax h'hold income #;
Equation E_wdispinc_h # total post-tax h'hold income #
Sum(h,HOU, VDISPINC(h)*(wdispinc(h) - wdispinc_h)) = 0;

Equation E_avetax_h  # average tax factor #
   wdispinc_h = whouinc_h + avetax_h;

Variable
(All,h,HOU)
            f_inctaxrate(h)   # income tax shifter: by income  #;
Variable
           f_inctaxrate_h   # income tax shifter: overall #;

Equation E_whougov # households to gov: income taxes and transfers #
(All,h,HOU) whougov(h) = whouinc(h)
              + f_inctaxrate(h) + f_inctaxrate_h;
! note: f_inctaxrate(h), and  f_inctaxrate_h
  are % changes in ad valorem rates !

Equation E_whourow # household transfers to ROW #
(All,h,HOU) whourow(h) = wdispinc(h); ! default rule !

! Find Household Savings as residual !
```

```
Coefficient (All,h,HOU) VHOUSAV(h) # household saving #;
Coefficient (All,h,HOU) VHOUEXP(h) # household expenditure #;
Formula     (All,h,HOU) VHOUEXP(h) = V3TOT(h) + Sum(hto,HOU,
VHOUHOU(hto,h))

                                  + VHOUGOV(h) + VHOUROW(h);
Formula     (All,h,HOU) VHOUSAV(h) = VHOUINC(h)- VHOUEXP(h) ;

Variable (Change) (All,h,HOU) delhsav(h) # household saving/household
income #;
Variable (All,h,HOU) whouexp(h) # household expenditure #;
Equation E_whouexp # household expenditure #
(All,h,HOU) VHOUEXP(h)*whouexp(h) = V3TOT(h)*w3tot(h)
           + Sum(hto,HOU, VHOUHOU(hto,h)*whouhou(hto,h) )
           + VHOUGOV(h)*whougov(h) + VHOUROW(h)*whourow(h);
Equation E_delhsav # household saving/household income #
(All,h,HOU) 100*VHOUINC(h)*delhsav(h) = VHOUINC(h)*whouinc(h)
                                  - VHOUEXP(h)*whouexp(h)
)*whouinc(h);                     - (VHOUINC(h) -VHOUEXP(h)

Write
VHOUSAV to file SUMMARY header "HSAV" longname "HOU Saving";
VHOUINC to file SUMMARY header "HINC" longname "HOU Income";
VHOUEXP to file SUMMARY header "HEXP" longname "HOU Expenditure";
```

! Excerpt 42 of TABLO input file: !
! Fill in government row (income) !

```
! Apart from VROWGOV, all entries are already determined !

Equation E_wrowgov # transfers from ROW to gov #
         wrowgov = w0gdpexp; !  default rule !


Coefficient VGOVINC # government income #;
Formula     VGOVINC = V0TAX_CSI + VGOSGOV + RSGOSTAX_I + FINEPAID_I
                    - V1SUB_I + Sum(h,HOU, VHOUGOV(h)) + VROWGOV;

Variable wgovinc # government income #;
Equation E_wgovinc # government income #
VGOVINC*wgovinc = V0TAX_CSI*w0tax_csi + VGOSGOV*wgosgov
+ RSGOSTAX_I*p_RSGOSTAX_I + FINEPAID_I*p_FINEPAID_I - V1SUB_I*w1sub_i
  + Sum(h,HOU, VHOUGOV(h)*whougov(h)) + VROWGOV*wrowgov;
```

! Excerpt 43 of TABLO input file: !
! Find current gov expenditure and capital gov expenditure !

```
! Hence find gov saving - might be negative in levels !

Coefficient VGOVCUR # current gov expenditure #;
Formula     VGOVCUR = V5TOT + VGOVGOS  + VGOVROW
+ Sum(h,HOU, VGOVHOU(h) );
Variable    wgovcur # current gov expenditure #;
Equation  E_wgovcur # current gov expenditure #
VGOVCUR*wgovcur = V5TOT*w5tot + VGOVGOS*wgovgos + VGOVROW*wgovrow
+ Sum(h,HOU, VGOVHOU(h)*wgovhou(h));

Equation E_wgovrow # GOV transfers to ROW #
wgovrow = w0gdpexp; ! default rule !

Coefficient VGOVINV # investment gov expenditure #;
Formula     VGOVINV = Sum(i,IND, GOVSHRINV(i)*V2TOT(i) );
```

```
Variable    wgovinv # investment gov expenditure #;
Equation  E_wgovinv # investment gov expenditure #
VGOVINV*wgovinv =
         Sum(i,IND, GOVSHRINV(i)*V2TOT(i)*{s2gov(i) + p2tot(i) +
x2tot(i)} );

! assume exogenous s2gov(i) # gov share of investment by industry # !

Coefficient VGOVEXP # total gov expenditure #;
Formula      VGOVEXP = VGOVCUR + VGOVINV;
Variable     wgovexp # total gov expenditure #;
Equation   E_wgovexp # total gov expenditure #
VGOVEXP*wgovexp = VGOVCUR*wgovcur + VGOVINV*wgovinv;

Coefficient VGOVSAV # gov (income - expenditure) #;
Formula      VGOVSAV = VGOVINC - VGOVEXP;
Variable (Change)  delgsav # gov saving/ gov income ) #;
Equation   E_delgsav # gov saving/ gov income) #
 100*VGOVINC*delgsav =  VGOVINC*wgovinc - VGOVEXP*wgovexp
                      - (VGOVINC -VGOVEXP )*wgovinc ;

Write
VGOVEXP to file SUMMARY header "GEXP" longname "GOV Expenditure";
VGOVINC to file SUMMARY header "GINC" longname "GOV Income";
VGOVSAV to file SUMMARY header "GSAV" longname "GOV Saving";
```

! Excerpt 44 of TABLO input file: !
! Find investment private expenditure !

```
! Private investment finance requirement is just the negative of this
!

Coefficient VPRIVINV # investment private expenditure #;
Formula      VPRIVINV = V2TOT_I - VGOVINV + V6TOT ;
Variable     wprivinv # investment private expenditure #;
Equation   E_wprivinv # investment private expenditure #
         VPRIVINV*wprivinv = V2TOT_I*w2tot_i - VGOVINV*wgovinv
         + V6TOT*w6tot ;
```

! Excerpt 45 of TABLO input file: !
! Find ROW row and column sums !

```
Coefficient VROWEXP # total ROW expenditure #;
Formula VROWEXP = V4TOT + VROWGOV + VROWGOS
             + Sum(h,HOU, VROWHOU(h));
Write
VROWEXP to file SUMMARY header "REXP" longname "ROW Expenditure";

Variable     wrowexp # total ROW expenditure #;
Equation   E_wrowexp # total ROW expenditure #
VROWEXP*wrowexp = V4TOT*w4tot + VROWGOV*wrowgov + VROWGOS*wrowgos
         + Sum(h,HOU, VROWHOU(h)*wrowhou(h));

Coefficient VROWINC # total ROW income #;
Formula VROWINC =  Sum(h,HOU, VHOUROW(h))
            + VGOVROW + V0CIF_C + VGOSROW + VLABROW;
Write
VROWINC to file SUMMARY header "RINC" longname "ROW Income";

Variable     wrowinc # total ROW income #;
Equation   E_wrowinc # total ROW income #
VROWINC*wrowinc = Sum(h,HOU, VHOUROW(h)*whourow(h))
```

```
+ VGOVROW*wgovrow + VOCIF_C*w0cif_c + VGOSROW*wgosrow +
VLABROW*wlabrow;

Coefficient VROWSAV # ROW (income - expenditure) #;
Formula      VROWSAV = VROWINC - VROWEXP;
Write
VROWSAV to file SUMMARY header "RSAV" longname "ROW Saving";

Variable (Change)  delrsav # row saving/ row income ) #;
Equation  E_delrsav # row saving/ row income) #
 100*VROWINC*delrsav =  VROWINC*wrowinc - VROWEXP*wrowexp
                      - (VROWINC -VROWEXP )*wrowinc ;
```

! Excerpt 46 of TABLO input file: !
! Data forhecking Identities !

```
Coefficient                          ! coefficients for checking !
 (all,i,IND) PURE_PROFITS(i) # COSTS-MAKE_C : should be zero #;
 (all,c,COM) LOST_GOODS(c)   # SALES-MAKE_I : should be zero #;

Formula
 (all,i,IND) PURE_PROFITS(i) = V1TOT(i) - MAKE_C(i);
 (all,c,COM) LOST_GOODS(c)   = SALES(c) - MAKE_I(c);

Write
PURE_PROFITS to file SUMMARY header "PURE" longname "COSTS-MAKE_C:
should = 0";
LOST_GOODS to file SUMMARY header "LOST" longname "SALES-MAKE_I:
should = 0";
```

! Excerpt 47 of TABLO input file: !
! Components of GDP from income and expenditure sides !

```
Set EXPMAC # Expenditure Aggregates #
 (Consumption, Investment, Government, Stocks, Exports, Imports);
Coefficient (all,e,EXPMAC)  EXPGDP(e) # Expenditure Aggregates #;
Formula
 EXPGDP("Consumption") = V3TOT_H;
 EXPGDP("Investment")  = V2TOT_I;
 EXPGDP("Government")  = V5TOT;
 EXPGDP("Stocks")      = V6TOT;
 EXPGDP("Exports")     = V4TOT;
 EXPGDP("Imports")     = -V0CIF_C;
Write EXPGDP to file SUMMARY header "EMAC" longname "Expenditure
Aggregates";

Set INCMAC # Income Aggregates # (Land, Labour, Capital, OCT,
IndTaxes);
Coefficient (all,i,INCMAC)  INCGDP(i) # Income Aggregates #;
Formula
 INCGDP("Land")     = V1LND_I;
 INCGDP("Labour")   = V1LAB_IO;
 INCGDP("Capital")  = V1CAP_I;
 INCGDP("OCT")      = V1OCT_I;
 INCGDP("IndTaxes") = V0TAX_CSI;
Write INCGDP to file SUMMARY header "IMAC" longname "Income
Aggregates";

Set TAXMAC # Tax Aggregates #
  (Intermediate,Investment,Consumption,Exports,Government,Tariff);
Coefficient (all,t,TAXMAC)  TAX(t) # Tax Aggregates #;
```

```
Formula
 TAX("Intermediate") = V1TAX_CSI;
 TAX("Investment")   = V2TAX_CSI;
 TAX("Consumption")  = V3TAX_CSH;
 TAX("Exports")      = V4TAX_C;
 TAX("Government")   = V5TAX_CS;
 TAX("Tariff")       = V0TAR_C;
Write TAX to file SUMMARY header "TMAC" longname "Tax Aggregates";
```

! Excerpt 48 of TABLO input file: !
! Matrix of Industry Costs !

```
Set COSTCAT # Cost Categories #
 (IntDom, IntImp, Margin, IndTax, Lab, Cap, Lnd, ProdTax); ! co !
Coefficient (all,i,IND)(all,co,COSTCAT) COSTMAT(i,co);
Formula
(all,i,IND) COSTMAT(i,"IntDom") = sum{c,COM, V1BAS(c,"dom",i)};
(all,i,IND) COSTMAT(i,"IntImp") = sum{c,COM, V1BAS(c,"imp",i)};
(all,i,IND) COSTMAT(i,"Margin") =
            sum{c,COM, sum{s,SRC, sum{m,MAR, V1MAR(c,s,i,m)}}};
(all,i,IND) COSTMAT(i,"IndTax") = sum{c,COM, sum{s,SRC,
V1TAX(c,s,i)}};
(all,i,IND) COSTMAT(i,"Lab") =V1LAB_O(i);
(all,i,IND) COSTMAT(i,"Cap") =V1CAP(i);
(all,i,IND) COSTMAT(i,"Lnd") =V1LND(i);
(all,i,IND) COSTMAT(i,"ProdTax") =V1OCT(i);
Write COSTMAT to file SUMMARY header "CSTM" longname "Cost Matrix";
Formula (all,i,IND)(all,co,COSTCAT) ! convert to % shares and re-
write !
            COSTMAT(i,co)= 100*COSTMAT(i,co)/(TINY+V1TOT(i));
Write COSTMAT to file SUMMARY header "COSH" longname "Cost Share
Matrix";
```

! Excerpt 49 of TABLO input file: !
! Matrix of domestic commodity sales with total imports !

```
Set ! Subscript !
SALECAT # SALE Categories #
(Interm, Invest, HouseH, Export, GovGE, Stocks,Margins, Total,
Imports);

Coefficient (all,c,COM)(all,sa,SALECAT) SALEMAT(c,sa);

Formula
(all,c,COM) SALEMAT(c,"Interm") = sum{i,IND, V1BAS(c,"dom",i)};
(all,c,COM) SALEMAT(c,"Invest") = sum{i,IND, V2BAS(c,"dom",i)};
(all,c,COM) SALEMAT(c,"HouseH") = V3BAS_H(c,"dom");
(all,c,COM) SALEMAT(c,"Export") = V4BAS(c);
(all,c,COM) SALEMAT(c,"GovGE") = V5BAS(c,"dom");
(all,c,COM) SALEMAT(c,"Stocks") = V6BAS(c,"dom");
(all,c,COM) SALEMAT(c,"Margins") = MARSALES(c);
(all,c,COM) SALEMAT(c,"Total") = SALES(c);
(all,c,COM) SALEMAT(c,"Imports") = V0IMP(c);
write SALEMAT to file SUMMARY header "SLSM" longname
    "Matrix of domestic commodity sales with total imports";

Formula
 (all,c,COM)(all,sa,SALECAT) SALEMAT(c,sa) =
100*SALEMAT(c,sa)/[TINY+SALES(c)];
 (all,c,COM) SALEMAT(c,"Imports")=
100*V0IMP(c)/[TINY+DOMSALES(c)+V0IMP(c)];
```

```
Write SALEMAT to file SUMMARY header "SLSH" longname
    "market shares for domestic goods with total import share";
```

! Excerpt 50 of TABLO input file: !
! Weight Vectors for use in aggregation and other calculations !

```
Write
V1TOT     to file SUMMARY header "1TOT" longname "Industry Output";
V2TOT     to file SUMMARY header "2TOT" longname "Investment by
Industry";
V1PUR_SI to file SUMMARY header "1PUR" longname "Interm.Usage by com
at PP";
V2PUR_SI to file SUMMARY header "2PUR" longname "Invest.Usage by com
at PP";
V3PUR_S  to file SUMMARY header "3PUR" longname "Consumption at
Purch.Prices";
V4PUR     to file SUMMARY header "4PUR" longname "Exports at
Purchasers Prices";
V1LAB_O  to file SUMMARY header "LAB1" longname "Industry Wages";
V1CAP     to file SUMMARY header "1CAP" longname "Capital Rentals";
V1PRIM    to file SUMMARY header "VLAD" longname "Industry Factor
Cost";
```

! Excerpt 51 of TABLO input file: !
!Sales Matrix !

```
Set
SALECAT2 # SALE Categories # (Interm, Invest, HouseH, Export, GovGE,
Stocks);
FLOWTYPE # type of flow # (Basic, Margin, Tax);

Coefficient
(all,c,COM)(all,f,FLOWTYPE)(all,s,SRC)(all,sa,SALECAT2)
SALEMAT2(c,f,s,sa)
    # Basic, margin and tax components of purchasers' values #;

Formula
(all,c,COM)(all,f,FLOWTYPE)(all,s,SRC)(all,sa,SALECAT2)
SALEMAT2(c,f,s,sa)=0;

(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"Interm") =
sum{i,IND,V1BAS(c,s,i)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Tax"   ,s,"Interm") =
sum{i,IND,V1TAX(c,s,i)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Margin",s,"Interm") =
                                         sum{i,IND, sum{m,MAR,
V1MAR(c,s,i,m) }};

(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"Invest") =
sum{i,IND,V2BAS(c,s,i)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Tax"   ,s,"Invest") =
sum{i,IND,V2TAX(c,s,i)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Margin",s,"Invest") =
                                         sum{i,IND, sum{m,MAR,
V2MAR(c,s,i,m) }};

(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"HouseH") = V3BAS_H(c,s);
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Tax"   ,s,"HouseH") = V3TAX_H(c,s);
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Margin",s,"HouseH")= sum{m,MAR,
 sum{h,HOU, V3MAR(c,s,m,h)}};
```

```
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"GovGE") = V5BAS(c,s);
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Tax"   ,s,"GovGE") = V5TAX(c,s);
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Margin",s,"GovGE")=
sum{m,MAR,V5MAR(c,s,m)};

(all,c,COM) SALEMAT2(c,"Basic","dom","Export") = V4BAS(c);
(all,c,COM) SALEMAT2(c,"Tax"   ,"dom","Export") = V4TAX(c);
(all,c,COM) SALEMAT2(c,"Margin","dom","Export")=
sum{m,MAR,V4MAR(c,m)};

(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"Stocks") = V6BAS(c,s);

write SALEMAT2 to file SUMMARY header "MKUP" longname
    "Basic, margin and tax components of purchasers' values";
```

! Excerpt 52 of TABLO input file: !
! Check Accounting !

```
! It is a mathematical necessity that the sum of all saving = 0 !
! Check if this is so, both in levels and in changes !

Coefficient VSAMCHECK # Global (income - expenditure) #;
Coefficient SAVINGTOT # Global Saving #;
Formula SAVINGTOT = Sum(h,HOU, VHOUSAV(h))
             + VGOSSAV + VGOVSAV + VROWSAV;

Formula VSAMCHECK = SAVINGTOT - VPRIVINV ;
Write
VSAMCHECK to file SUMMARY header "SCHK" longname "SAM Balance Check";

! note wsamcheck is expressed as a % of GDP: it should be tiny !

Write
VPRIVINV to file SUMMARY header "PINV" longname "Private Investment";
VGOVINV to file SUMMARY header "GINV" longname "Government
Investment";
VGOVCUR to file SUMMARY header "GCUR" longname "Government Current
Spending";
VGOSHOU_H to file SUMMARY header "TGSH" longname "Total GOS to
Households";
FINEPAID_I to file SUMMARY header "FINE" longname "Total Fine
Actually Paid";
RSGOSTAX_I to file SUMMARY header "RSTX" longname "Total Tax Actually
Paid";
V3TOT to file SUMMARY header "V3TT" longname "Total Househols
Consumption";
V4TOT to file SUMMARY header "V4TT" longname "Total Export";
V5TOT to file SUMMARY header "V5TT" longname "Total GOV Consumption";
V1TOT to file SUMMARY header "V1TT" longname "Total Cost";
SALES to file SUMMARY header "SALE" longname "Total Sales";
```

! Excerpt 53 of TABLO input file: !
! Household consumption function and GDP at social cost!

```
Equation
E_f3tot # consumption function used in SIM2#
(All,h,HOU)
 w3tot(h) = f3tot(h) + f3tot_h + wdispinc(h);
```

```
E_f3tota # consumption function used in SIM3 #
(All,h,HOU)
 w3tot(h) = f3tota(h) + f3tot_h + wdispinca(h);

Coefficient V0GDPSC #Real GDP social cost, expenditure side# ;
Formula # Real GDP social cost, expenditure side #
V0GDPSC  = V0GDPEXP - RSUSE_I;
Equation
E_x0gdpsc  # Real GDP social cost, expenditure side #
  V0GDPSC*x0gdpsc =  V0GDPEXP*x0gdpexp - RSUSE_I*p_RSUSE_I;
Equation
E_p0gdpsc  # Price index for GDP, expenditure side #
 V0GDPSC*p0gdpsc =  V0GDPEXP*p0gdpexp - RSUSE_I*p_PORSSRV_I;

E_w0gdpsc  # Nominal GDP from expenditure side #
  w0gdpsc = x0gdpsc + p0gdpsc;

! End of Tablo Input File !
```

Appendix B:
The Stored Input File Used to Condense ORANI-RSA

```
BPR
BAT
F1
L3
sco
in2


ORANIRSA

c
o
a1
a2
a1_s
a2_s
a1mar
a2mar
a3mar
a4mar
a5mar
a1oct
f1lab
f1lab_o
p_tqpar
p_pfpar
p_e1tq
p_e1pf
p_pff1
p_tqf1
p_TINY1
f3tot_h

b
p1lab_o
E_p1lab_o
b
x1lab_o
E_x1lab_o
s
x1sub
E_x1sub
```

s
p1sub
E_p1sub
s
p3_s
E_p3_s
s
x3_s
E_x3_s
s
p1lab
E_p1lab
s
x3mar_h
E_x3mar_h
s
p1_s
E_p1_s
s
p2_s
E_p2_s
s
p1
E_p1
s
p2
E_p2
s
p3
E_p3
s
p5
E_p5
s
t1
E_t1
s
t2
E_t2
s
t3
E_t3
s
t5
E_t5
s
x1lab
E_x1lab

s
x1
E_x1
s
x1mar
E_x1mar
s
x2
E_x2
s
x2mar
E_x2mar
s
x2_s
E_x2_s
s
x3
E_x3
s
x3mar
E_x3mar
s
x4mar
E_x4mar
s
x5
E_x5
s
x5mar
E_x5mar
s
x1oct
E_x1oct
s
p1oct
E_p1oct
s
x3sub
E_x3sub
s
x3lux
E_x3lux
s
p_polinf
E_p_polinf
s
p_loftq
E_p_loftq

```
s
p_bit1
E_bit1eq12
s
p_bit2
bit2eq12
s
p_bit3
E_bit3eq12
s
p_bit4
bit4eq12
s
p_lofpf
E_p_lofpf
e
a ! make code
wfp
```

ORANIRSA

Appendix C: Examples of Percentage-Change Form

Table E1 Examples of Percentage-Change Forms*

Example	(1) Original or Levels Form	(2) Intermediate Form	(3) Percentage-Change Form
1	$Y = 4$	$Yy = 4*0$	$y = 0$
2	$Y = X$	$Yy = Xx$	$y = x$
3	$Y = 3X$	$Yy = 3Xx$	$y = x$
4	$Y = XZ$	$Yy = XZx + XZz$	$y = x + z$
5	$Y = X/Z$	$Yy = (X/Z)x - (X/Z)z$	$y = x - z$ *or* $100(Z)\Delta Y = Xx - Xz$
6	$X_1 = M/4P_1$	$X_1x_1 = (M/4P_1)m - (M/4P_1)p_1$	$x_1 = m - p_1$
7	$Y = X^3$	$Yy = X^3 3x$	$y = 3x$
8	$Y = X^\alpha$	$Yy = X^\alpha \alpha x$	$y = \alpha x$ (α assumed constant)
9	$Y = X + Z$	$Yy = Xx + Zz$	$y = S_x x + S_z z$ where $S_x = X/Y$, etc
10	$Y = X - Z$	$Yy = Xx - Zz$	$y = S_x x - S_z z$ *or* $100(\Delta Y) = Xx - Zz$
11	$PY = PX + PZ$	$PY(y+p) = PX(x+p) + PZ(z+p)$ *or* $PYy = PXx + PZz$	$y = S_x x + S_z z$ where $S_x = PX/PY$, etc
12	$Z = \sum X_i$	$Zz = \sum X_i x_i$ *or* $0 = \sum X_i(x_i - z)$	$z = \sum S_i x_i$ where $S_i = X_i/Z$
13	$XP = \sum X_i P_i$	$XP(x+p) = \sum X_i P_i(x_i+p_i)$	$x+p = \sum S_i(x_i+p_i)$ where $S_i = X_i P_i/XP$

*This Table has been taken from Horridge *et al.* (1993) p. 137.

Appendix D: Percentage-Change Equations of a CES Nest*

Problem: Choose inputs X_i (i = 1 to N), to minimise the cost $\sum_i P_i X_i$ of producing given output Z, subject to the CES production function:

$$Z = \left(\sum_i \delta_i X_i^{-\rho}\right)^{-1/\rho}. \tag{A1}$$

The associated first order conditions are:

$$P_k = \Lambda \frac{\partial Z}{\partial X_k} = \Lambda \delta_k X_k^{-(1+\rho)} \left(\sum_i \delta_i X_i^{-\rho}\right)^{(1+\rho)/\rho}. \tag{A2}$$

Hence $\frac{P_k}{P_i} = \frac{\delta_k}{\delta_i}\left(\frac{X_i}{X_k}\right)^{1+\rho}$, (A3)

or $X_i^{-\rho} = \left(\frac{\delta_i P_k}{\delta_k P_i}\right)^{-\rho/(\rho+1)} X_k^{-\rho}$. (A4)

Substituting the above expression back into the production function we obtain:

$$Z = X_k\left(\sum_i \delta_i \left[\frac{\delta_k P_i}{\delta_i P_k}\right]^{\rho/(\rho+1)}\right)^{-1/\rho}. \tag{A5}$$

This gives the input demand functions:

$$X_k = Z\left(\sum_i \delta_i \left[\frac{\delta_k P_i}{\delta_i P_k}\right]^{\rho/(\rho+1)}\right)^{1/\rho}, \tag{A6}$$

or $X_k = Z\, \delta_k^{1/(\rho+1)} \left[\frac{P_k}{P_{ave}}\right]^{-1/(\rho+1)}$, (A7)

where $P_{ave} = \left(\sum_i \delta_i^{1/(\rho+1)} P_i^{\rho/(\rho+1)}\right)^{(\rho+1)/\rho}$. (A8)

Transforming to percentage changes (see Appendix E) we get:

$$x_k = z - \sigma\left(p_k - p_{ave}\right), \tag{A9}$$

and $p_{ave} = \sum_i S_i p_i$, (A10)

where $\sigma = \frac{1}{\rho+1}$ and $S_i = \delta_i^{1/(\rho+1)} P_i^{\rho/(\rho+1)} \Big/ \sum_k \delta_k^{1/(\rho+1)} P_k^{\rho/(\rho+1)}$. (A11)

Multiplying both sides of (A7) by P_k we get:

$$P_k X_k = Z\, \delta_k^{1/(\rho+1)} P_k^{\rho/(\rho+1)} P_{ave}^{1/(\rho+1)}. \tag{A12}$$

Hence $\frac{P_k X_k}{\sum_i P_i X_i} = \delta_k^{1/(\rho+1)} P_k^{\rho/(\rho+1)} \Big/ \sum_i \delta_i^{1/(\rho+1)} P_i^{\rho/(\rho+1)} = S_i$, (A13)

i.e., the S_i of (A11) turn out to be cost shares.

Technical Change Terms

With technical change terms, we must choose inputs X_i so as to:

$$\text{minimise } \sum_i P_i X_i \text{ subject to: } Z = \left(\sum_i \delta_i \left[\frac{X_i}{A_i}\right]^{-\rho}\right)^{-1/\rho}. \tag{A14}$$

Setting $\widetilde{X}_i = \dfrac{X_i}{A_i}$ and $\widetilde{P}_i = P_i A_i$ we get: (A15)

$$\text{minimise } \sum_i \widetilde{P}_i \widetilde{X}_i \text{ subject to: } Z = \left(\sum_i \delta_i \widetilde{X}_i^{-\rho}\right)^{-1/\rho}, \tag{A16}$$

which has the same form as problem (A1). Hence the percentage-change form of the demand equations is:

$$\widetilde{x}_k = z - \sigma\left(\widetilde{p}_k - \widetilde{p}_{ave}\right), \tag{A17}$$

and $$\widetilde{p}_{ave} = \sum_i S_i \widetilde{p}_i. \tag{A18}$$

But from (A15), $\widetilde{x}_k = x_i - a_i$, and $\widetilde{p}_i = p_i + a_i$, giving:

$$x_k - a_k = z - \sigma\left(p_k + a_k - \widetilde{p}_{ave}\right). \tag{A19}$$

and $$\widetilde{p}_{ave} = \sum_i S_i\,(p_i + a_i). \tag{A20}$$

When technical change terms are included, we call $\widetilde{x}_k$, $\widetilde{p}_k$ and $\widetilde{p}_{ave}$ *effective* indices of input quantities and prices.

*This appendix has been taken from Horridge *et al.* (1993) p. 133-134.

Appendix E The Data Base of ORANI-RSA

The diskette contains two HAR file: SHORTRUN.HAR and LONGRUN.HAR. The first data base is used for short-run simulations, while the second is for long-run simulations. The two differ in the value of substitution elasticities between labour types and among primary factors. Larger values are assigned for long-run simulations.

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